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## THE THEATER OF EPIDAUROS AND THE MYSTERIOUS VANISHING VASES

A coincidence? A mystery? An insoluble problem?

### I. From Epidaurus to Cornell University

Once more, I recently visited the incredible theater of Epidaurus, which I have studied zealously and systematically. I saw the *Electra* of Euripides (480-406 B.C.), a psychological drama which examines Princess Electra's tormented soul, since good and evil often dominate both divinities and humans, the oracle of Delphi thus deserving a most devastating attack. I also examined, once more, the architecture of the theater. But, as always, the mystery remained unsolved!

On the way home, I stopped at Cornell University. I heard something about another theatrical wonder, at Cornell, but, unfortunately, I had insufficient time to examine this matter.

Back in Toledo, I found a mountain of mail waiting for me, including many back issues of *Science*. As usual, I began to scrutinize the latter religiously. Incredible! Anne Moffat's «New Graphics Program Debuts in Concert Hall» (September 29, 1989, p. 1452) dealt with what I was anxious to learn. «By simulating sound in visual form,» she began, «two Cornell computer scientists are helping design acoustically perfect concert halls» (*ibid.*).

Obviously, I expected Donald Greenberg, a graphics researcher, and Adam Stettner, his graduate student, to thrill me as much as the theater of Epidaurus does. Well, they certainly did. The latter, however, remains mysterious and enigmatic. But let me present a synopsis of its fascinating architecture and history. (See, also, Evangelos Stamatis, «The Acoustics of the Ancient Greek Theater,» *Plato*, 1983, pp. 3-7).

### II. A Lasting Masterpiece

An interesting description of Epidaurus itself is given by Pausanias (170 A. D.), the Greek topographer and traveler, in his *Periegesis of Greece* (II, xxvi, 1-xxix, 11).

A brief analysis of Greek theaters in general is found in *De Re Architectura* (V, vii-x), by Vitruvius (first century B.C.), the Roman architect and Julius Caesar's military engineer. Chapter viii is especially interesting, since he writes about acoustics and mentions the *synechountes*, «in which the voice reinforced from the ground rises with greater fullness, and reaches the ear with clear and eloquent accents.» He also mentions that the location of the Greek theater is exceedingly important.

Pausanias (*op. cit.*, II, xxvii, 5) discusses the theater of Epidaurus itself, which began as a playhouse designed by Polyclitus (370-336 B.C.), a sculptor and architect, about 350 B.C., and was modified in the third and second centuries B.C. Pausanias writes: «And the Epidaurians have a theater in the sanctuary [of Asclepius, the god of medicine] which, it seems to me, is very well worth seeing; for,

although the Roman theaters are superior to any others anywhere in beauty, and the theater of the Arcadians in Megalopolis is unequaled in size, what architect could seriously rival Polyclitus in harmony and beauty? For it was Polyclitus who constructed both this theater and the circular building.» Unfortunately, this artist is often confused with Polyclitus of Argos (470-400 B.C.), the great sculptor who created the chryselephantine colossus of *Hera* (Pausanias, *ibid.*, II, xvii, 4); The *Diadumenus*; the *Doryphorus*, known as a *canon*, namely, a standard for later artists (Pliny, *Historia Naturalis*, XXXIV, 55); the *Wounded Amazon*, which was superior even to that of Phidias (born 490 B.C.), the most famous sculptor—Polyclitus of Argos was second; and so forth.

Modern research still proves that the Epidaurus theater remains the most important, the most magnificent theater in ancient Greece (Stamatis, *op. cit.*). Indeed, all the components of this open-air masterpiece represented purely Greek elements. It is no wonder, then, that Epidaurus influenced Roman theaters substantially, and that, even today, there is an annual thespian festival in the same theater of Polyclitus!

### III. A Pin and Antigone's Whispers

The main components of the theater of Epidaurus were as follows:

1. The number of seats was, and still is, 14,000 (Stamatis, *op. cit.*). As in the past, these seats also function as steps.
2. The *skene* (Latin *scaena*, English scene) was a structure containing dressing rooms for actors.
3. The *proscenium* was the facade of the *skene* building which depicted the scene of the play.
4. The *orchestra*, as its name indicates, was a dancing place. Here, the chorus and actors performed. In Epidaurus it was circular, but in Hellenistic and Roman theaters it was semicircular or not used. The Epidaurus orchestra was 40 feet in diameter and in the middle was a fountain serving as the altar of Dionysus (Lydian name: Bacchus), the son of Zeus and god of wine at whose festival the dithyrambic choruses gave birth to the Greek drama.

The greatest mystery of the theater, however, remains: its startling acoustics! Vitruvius and many modern scholars have attributed this unique phenomenon to the structure of the theater. But the evidence is still inconclusive.

My family and some students of mine never accepted my acoustic analysis until I took them to Epidaurus. I asked them to occupy the highest seats of the theater. I stood in the center of the orchestra.

I tore a piece of paper. They all heard it!

I held a penny and then dropped it. They all heard it!

I let a pin fall. They all heard it!

I whispered Antigone's immortal verses 450-457 from Sophocles's (497-405 B.C.) *Antigone*. And, unbelievably, they all heard every single word!

### IV. The Conqueror and the Strange Vases

A major catastrophe occurred in 146 B.C. Mummius, a Roman consul, defeated the Greeks in the Isthmus of Corinth, burned the city, conquered the entire country, and thus established the province of Achaia (his new name became Mummius Achaicus). Countless vessels carried his treasures (statues, paintings, and «theatrical vases») to Rome, but Mummius took bonds from their masters in order to oblige

them to replace every single masterpiece lost or destroyed during the voyage! The consul even believed that the theatrical vases (*echeia* in Greek, *vasa aerea* in Latin) were secret weapons! Hilarious and fascinating accounts regarding this episode are found in the *Histories* (XXXIX, 3) of Polybius (205-125 B.C.), the *Geography* (VIII, vi, 23) of Strabo (63 B.C. - 21 A.D.), and the *Philopoemen* (21) of Plutarch (100 A.D.).

The innocuous *vasa aerea* are described by Vitruvius in his *De Re Architectura* (V, v). «*Mathematicis rationibus,*» he explains, «*fiant vasa aerea pro ratione magnitudinis theatri,*» thus suggesting a mathematical relationship between theater size and bronze vases on the basis of relevant musical principles. Archeologists, however, have only found earthen vases, never bronze ones. At any rate, Vitruvius asserts, these can make a sound from one to another on a fourth, a fifth, and so on to the the second octave. This is achieved by placing the vases, which are open on one end, upside down, among the seats and under the spectators' feet, without touching the wall, with an empty space above and around them (*ibid.*). All this, Vitruvius avers, intensified sound. He further mentions Aristoxenus (330 B.C.), a Greek musician and philosopher, and one of Aristotle's (384-322 B.C.) students, especially Book I of his *Principles and Elements of Harmonics*. Aristoxenus was an encyclopedic and prolific author who wrote 453 books, especially on music! Whereas the Pythagoreans stressed half-mystical number relations exclusively, Aristoxenus asserted that music is based on variation in human acoustic perception.

These explanations by Vitruvius seem plausible. But the theater that influenced the other theaters of Greece remains acoustically perfect. Although the *skene* has disappeared, sound is still a wonder! Although the *proscenium* is gone, sound is still a miracle! Although the *vasa aerea* have vanished in the maelstrom of Mummius, sound is still a marvel! Perhaps, then, the vases had intensified the melody of sound, not sound itself. Modern theorists usually agree on this point, but they emphasize the geometrical structure of the theater. They may be right but, unfortunately, nothing is certain!

### V. An Ancient David Defies Modern Goliaths

Myriads of modern scientific efforts have failed miserably.

A Greek archeologist and Athens University professor (1904-1922) Panagiotis Kabbadias (1849-1928), was so successful that he established and organized the Archeological Museum of Athens and the Museums of the Acropolis and Epidaurus. He even excavated so many sites in Epidaurus itself that he was able to publish a brilliant volume on the subject, *The Sanctuary of Asclepius in Epidaurus*, 1900. Still, he never solved the problem of the theater!

During the Nazi occupation of Greece in 1941-1944, a team of German experts went to Athens in order to investigate the principles of the construction of the monuments on the Acropolis. Their findings are still secret, since they remain unpublished. The only publication deals with the discovery that the Parthenon is based on the golden section in geometry, which may be obtained by dividing a segment in such a way that the larger segment is the mean proportional between the complete segment and the smaller segment. In other words, the ratio of the complete segment to the larger segment is equal to the ratio of the larger segment to the smaller. Thus, if a segment is equal to 1, the two sections are approximately 0.618 and 0.382. But we know nothing about the team's possible study of Epidaurus.

In 1947, Basil Papathanasopoulos, a civil engineer and professor at Athens

Polytechnic, studied Epidaurus most systematically. His spectacular research, however, never solved the problem of the theater's construction (cf. Stamatis, *op. cit.*).

E. Fiechter, a German architect and archeologist, asserted that Greek theaters were constructed on the basis of geometrical principles and forms. His explanation emphasized combinations of triangles, squares, circles, and so forth. His daughter Charlotte, an able archeologist, published her own findings in *The Theater of Dionysus* (Stuttgart, 1950). Thus, like many other modern investigators, the Fiechters concluded that the Greek theater in general was designed geometrically for acoustic purposes. Again, the evidence was inconclusive. (Incidentally, the Fiechters studied every Greek theater except for Epidaurus!).

In 1961, two other Germans who were architects, Armin von Gerkan and Wolfgang Müller-Wiener, finally published a major study on Epidaurus in Stuttgart. Unfortunately, the authors merely attacked the Fiechters' geometrical theory without offering a valid theory of their own.

In 1966, George Giannoulis, a University of Salonica professor who died in 1980, measured the intensity of sound in Epidaurus, but he was unable to complete his work. In the same year, Alexander Kousoulakos, of the same university, used an extremely sensitive instrument for the same purpose. But the angry ghosts of Polyclitus and the Three Tragedians raised up such a violent storm, such a furious tempest that his experiments failed miserably.

The last investigations I know about were conducted by John Sakas, an engineer. Sakas is well known mainly because his recent experiment proved that the burning of Roman ships, with mirrors, by Archimedes (287-212 B.C.), was quite possible. His studies of 1976 and 1980 were conducted in Epidaurus, but I have not seen a solution to the persistent mystery of the remarkable, renowned theater.

## VI. From Archytas to the Space Age

Thus, the theater of Epidaurus remains a great mystery.

And, since modern man prefers bullhorns and megaphones to more methodical studies of the legendary theater, let me close with a reference to Archytas of Tarentum (375 B.C.). Archytas was a titan who founded mechanics. He used two half-cylinders to solve the problem of doubling the cube. He was practically the first to discuss sound scientifically - he even stated the ratios of enharmonic, chromatic, and diatonic scales. And he employed mathematics to study sound. Is it any wonder, then, that Plato (427-347 B.C.) himself visited Archytas in boundless humility? But the language of Archytas is so nebulous that we find it difficult to ascertain his exact subject. «It seems to me,» he writes, «that mathematicians have shown true insight.» After additional ambiguous statements, he concludes: «It is obvious [!], then, from many proofs that high notes move faster and low notes move slowly» (Fragment 1).

Does this recall the Polyclitus Problem and today's vain efforts to solve the arcanum hovering over the temple of Asclepius? Yes.

Does Cornell University's new graphics program, with its emphasis on simulating sound in visual form, suggest the dawn of promising new efforts? Perhaps.

For now, however, the theater of Epidaurus refuses to reveal its Maddening Conundrum!

## ΠΕΡΙΛΗΨΙΣ

Τὸ παρὸν ἄρθρον ἀναφέρεται εἰς τὸ μυστήριον τῶν ὑπολογισμῶν, ἐπὶ τῶν ὁποίων ἐστηρίχθη ὁ ἀρχαῖος ἀρχιτέκτων Πολύκλειτος διὰ τὴν κατασκευάσῃ τὸ θέατρον τῆς Ἐπιδαύρου, τοῦ ὁποίου ἡ ἀρχιτεκτονικὴ τελειότης τεκμαίρεται καὶ ἀπὸ τῆν εἰς ἀπίστευτον βαθμὸν εὐαίσθητον ἀκουστικὴν του, μαρτυρουμένην καὶ ὑπὸ τῶν ἀρχαίων συγγραφέων. Ἐνδεχομένως οἱ ὑπολογισμοὶ τῆς κατασκευῆς του ἐσχετίζοντο πρὸς ὁμοίους τῆς μορφῆς τῶν σιδηρῶν ἡχείων (*vasa aerea*), ἅτινα περιγράφει ὁ Βιτρούβιος.

Δεδομένου ὅτι εἰς τὸ **Cornell University** ἔχει ἐσχάτως κατασκευασθῆ ἐπὶ τῆ βάσει ἠλεκτρονικῶν ἡχητικῶν ὑπολογισμῶν θέατρον ἔχον ἀκουστικὴν θαυμαστήν, καὶ γνωστοῦ ὄντος ὅτι πρῶτος Ἀρχύτας ὁ Ταραντῖνος εἶχεν ἐπιχειρήσει διὰ μαθηματικῶν μεθόδων τὴν διανομὴν τοῦ ἤχου καὶ τῶν κλιμάκων αὐτοῦ, ἐκφράζει ὁ συγγραφεὺς τὴν ἐλπίδα, ὅτι ἀπὸ τὰς ἡχητικὰς διὰ ἠλεκτρονικῶν μέσων ἐρεύνας εἰς τὸ **Cornell University** θὰ ἡδύνατο νὰ χυθῆ φῶς καὶ εἰς τὸ μυστήριον τῆς Ἐπιδαύρου.