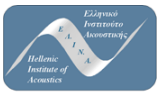

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ON THE RELATION BETWEEN VITRUVIUS VASES AND MEDIEVAL ACOUSTIC POTTERIES: LITERARY ANALYSIS OF ANCIENT TEXTS AND COMPARISON WITH RECENT OBSERVATIONS IN SITU

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Abstract

During the last decade, the acoustic potteries inserted into the walls and roofs of medieval and modern churches became again the focus of scientific curiosity after a long time of relative silence. Traditionally, authors from Middle Ages to present time, considered that Vitruvius established the relation between the “vasa aerea” (bronze vessels) in ancient Greek theatres and the “fictilibus doliis” (earthen vessels).

In the presentation, we will analyze the Vitruvius’s in relation with his philosophy with regards to acoustics. Then, an analysis of medieval, modern and contemporary texts talking about acoustic potteries will be achieved in relation with the Vitruvius recommendations. At the end, the conclusion of the text analysis will be compared with recent measurements and observations of acoustic potteries which still remain in churches.

Keywords

Vitruvius vases, Acoustic potteries, Architectural acoustics

1. Introduction

The question of the origins of the acoustic potteries in the medieval churches is a crucial point which quickly appeared during our research on this subject. This interrogation on the source and the filiations of this architectural device are recurring in the literature of the XIXth century, time to which the potteries were discovered in the walls and the vaults of the medieval churches. The genesis of this device and its heritage do not appear anywhere in the contemporary sources of the installation of the pots, and the textbooks of architecture of the late Middle Ages is silent on this matter.

In the XVIIth century, Mersenne and Kircher used the texts available [1,2], such as that of Vitruvius [3], which contains a considerable amount of information on architecture and practical acoustics. Consequently, the scholars looked into an ancient acoustic device, namely *echea*, a kind of bronze vessels, that Vitruvius describes within his description of Greek theatres (V,5).

In the XIXth century, these early works on *De Architectura* of Vitruvius were the only relations making possible to assign an architectural origin and basis to the potteries discovered in the churches. All the researchers (archaeologists as well as acoustics experts) will seize this opportunity with more or less thoughts, comprehension and critical attitude.

This paper proposes, in a first part, to analyze how this relation was perceived at the time of the discovery of the medieval potteries, particularly in France. In a second part, the acoustical knowledge of Vitruvius is exposed. Lastly, the descriptions of Vitruvius are analyzed in terms of acoustics and are put in relation to the potteries still inserted in the walls of the European churches.

2. Historiography

The historiography of the XIXth century (in France), devoted to the study of acoustic potteries, illustrates the genesis of the comparison, at that time, between the ancient bronze vases and the medieval acoustic pots. Among the articles available for this period, Didron [4], in 1862, makes already the relations with the device which was placed in the church of the convent of Célestins of Metz, attested by its chronicle [5]. He supposes that the use of acoustic potteries were abandoned in the medieval churches because of their insufficient effect on acoustics of the churches, as the author of the chronicle denounces it. The same year, Cochet [6] publishes an article on the acoustic potteries and refers to Vitruvius, but without developing relation with the medieval pots. In 1886, Vachez [7], develops this question in connection with the first acoustic pots discovered in France in 1842, in the medieval church of Saint-Blaise of Arles. On their subject, he declares “the use of the *echea* is quite old”, before developing on the use of the earthen or bronze vessels placed in the theatres Greek and intended “to reinforce the voice of the actors, but still to give more softness and harmony to the sound of music”. Despite the scepticism of the contemporary archaeologists, the author tries to show, that the echea existed in the Greek theatres. Filiations between the ancient *echea* described by Vitruvius and the medieval acoustic pots are not thus any doubt for Vachez, declaring “the transition was very natural, and we should not astonish us that they were introduced into our countries with Byzantine architecture. Moreover, recent discoveries in a great number of Russian churches prove this origin”.

In 1902, when Enlart publishes his handbook of French archaeology [8], he quite naturally presents the medieval acoustic pots like a technical recovery of the ancient model of the *echea* described by Vitruvius.

In connection with the potteries found in the walls of the Saint-Victor church of Marseilles, Drocourt, in 1971, speaks about "resonators" and takes up the idea of Vachez, according to which "the Middle Ages perhaps adopted vases according to traditions coming from Antiquity or Byzantium".

Thus the studies of XIXth and XXth centuries led to that filiations between Greek echea and acoustic pots are anchored in the collective unconscious without a real proof being brought.

3. Vitruvius's knowledge on theatre acoustics

Vitruvius understood that sound propagates by setting air in movement. Vitruvius compares this setting of the air in movement with the setting of water in movement by a stone: "It is propelled by an infinite number of circles similar to those generated in standing water when a stone is cast therein, which, increasing as they recede from the centre, extend to a great distance, if the narrowness of the place or some obstruction do not prevent their spreading to the extremity; for when impeded by obstructions, the first recoil affects all that follow (V,3,6). In the same manner the voice spreads in a circular direction. But, whereas the circles in water only spread horizontally, the voice, on the contrary, extends vertically as well as horizontally. Wherefore, as is the case with the motion of water, so with the voice, if no obstacle disturb the first undulation, not only the second and following one, but all of them will, without reverberation, reach the ears of those at bottom and those at top (V,3,7)". The analogy was not well understood in classical times, and the passage was interpreted as sound "go up stepwise". This misconception is hard-lived, because the belief that sound goes up is still common today.

He understood the masking effect, by which an obstacle, such as a spectator sitting in front, attenuates the sounds behind. Thus Vitruvius advises to align all the steps of the theatre: "whatever its effect might be on the stage (scena), to make it fall on the ears of the audience in a clear and agreeable manner." (V,3,8)

Very probably, the observation of the masking effect is at the origin of the belief that sound goes up. Indeed, the spectators assembled on a horizontal plane, as was the case on the agora, mask each others, so that one hears badly at the back. Whereas spectators assembled on a tilted plane do not mask each others any more if the source is moved away from the, as was the case in ancient theatres. Thus, starting from a correct technical observation and despite correct analysis of the phenomenon – the importance of obstacles - an erroneous theoretical concept was deduced from it: sound goes up.

He classified the various acoustics places according to a classification that is still valid today. Thus, he distinguished between deaf places; "circonsonant" places where sound turns round - in today's words: reverberating; "resonant" places, where a frank echo is heard; and "consonant" places which amplify sounds (V,8,2). Once again, despite a sharp ear enabling him to hear the phenomena correctly, he adds explanations that are often right, but sometimes completely erroneous and even in contradiction with preceding observations. Thus Vitruvius reckons that, in deaf places ("dissonant"), "The dissonant places are those in which the voice, rising first upwards, is obstructed by some hard bodies above, and, in its return downwards, checks the ascent of its following sounds." (V,8,1). Whereas some pages earlier, in connection with the curia, the same effect is analyzed differently: "The walls, moreover, at half their height, are to have cornices run

round them of wood or plaster. For if such be not provided, the voices of the disputants meeting with no check in their ascent, will not be intelligible to the audience. But when the walls are encircled round with cornices, the voice, being thereby impeded, will reach the ear before its ascent and dissipation in the air. " (V,2,2). The same effect, the casting back of sounds downwards by a solid obstacle, gives different results: today we know that the last analysis is the correct one, and this effect is put at contribution by the side balconies in theatres.

4. Acoustic analyses of the Vitruvius text of sounding vessels (V.5)

In the XVIth century, Mersenne and Kircher and more recently R. Floriot [10] and P. Liénard [11], agree to say that this text raises many questions. Without discussing the principle of the relation between the two devices, all these authors observe very little resemblance in the basic principles of the ancient *echea* and the potteries inserted in the medieval and modern churches.

Considering recent researches, Vitruvius idealized the ancient Greek civilization and had a bad opinion of his own period of life (Roman Empire) in terms of architecture. "The ten books of Architecture" is a work to the glory of ancient Greek architecture and he encouraged Roman builders to copy them. Vitruvius had the ambition to influence its Romains contemporaries, in the objective to assimilate the Greek architectural techniques considered as quite higher [12].

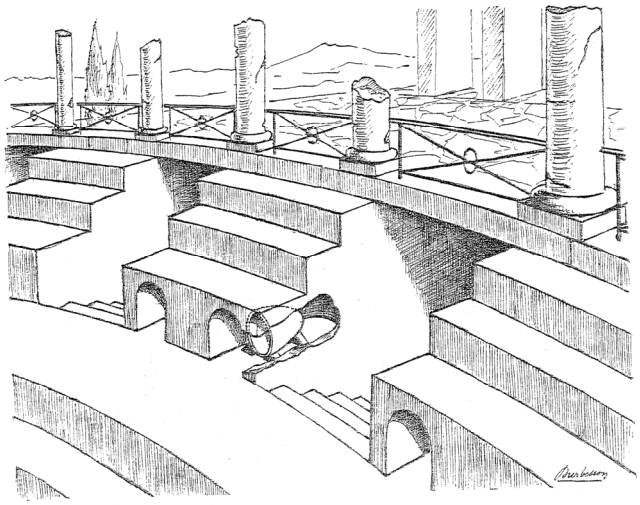

Figure 1 – Device reconstitution according to R. Floriot, after Panckoucke 1847's edition of Vitruvius

The text falls into three parts. The first one is descriptive and presents the ancient device which consists of cavities located at various places of the Greek theatres, sufficiently broad to include sort of "vessels". A reconstitution is proposed in figure 1 by R. Floriot. The second part gives an interpretation of the functioning of this device with a musical approach, according to the Roman-Greek culture. Lastly, Vitruvius seeks evidences of the ancient Greek technique at his own time.

4.1 Physical description

If we take again the description of Vitruvius interpreted by R. Floriot, these vases would be, in fact, of the kinds of metal "bells" since Vitruvius speaks of striking

them: they "are formed so as when struck, to give sounds, whose intervals are a fourth, fifth, and so on consecutively to a fifteenth" [12]. These "bells" are located in niches laid out between the steps of the theatres with a long neck of two feet (60 cm) and a height of a half foot (15 cm). The "bell" is inserted in the cavity and is supported by wedges of a half foot, which is the same height as the neck. The niche must thus be quite higher, about two or three feet (60 - 90 cm) what makes an internal volume larger than the volume of the neck. It is interesting to notice that only the niches are similar to the medieval resonator (with a frequency of resonance much lower!) but not the "bell" which seems to be vibroacoustic resonator. We can notice than Kircher represents also the device in the form of bell as shown in the figure 2.

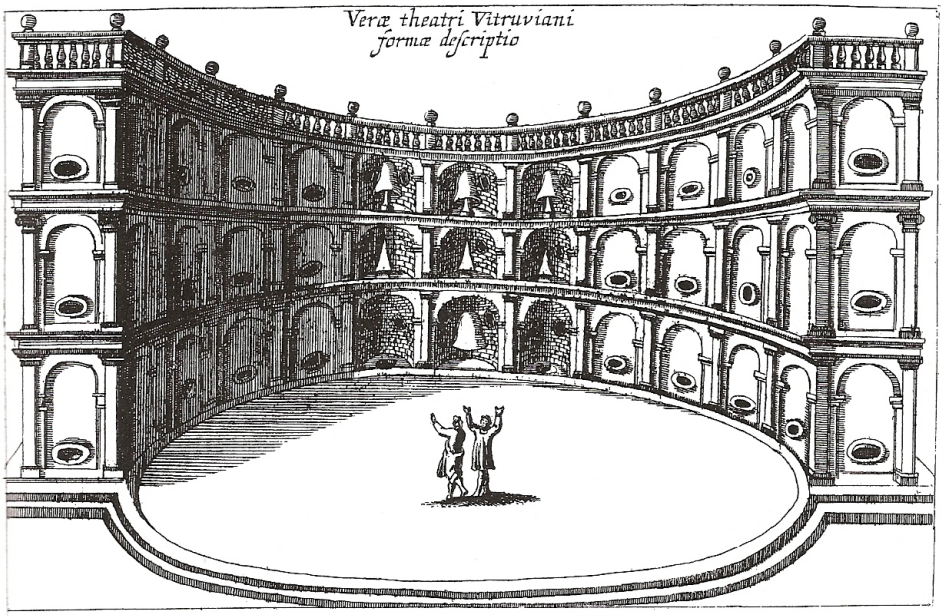

Figure 2 – Device reconstitution according to A. Kircher [2]

Mersenne mentions already that "it is difficult that they (the vessels) are powerful enough to make their *consonances* heard by the listeners, when they are struck only by voices". Thus right from the start of the acoustic studies, the effectiveness of the device described by Vitruvius is already doubtful. Authors represent it like a vibratory system excited by the voice. Actually, Liénard notices that the system described by Vitruvius is the coupling of two resonators in cascade: the niche and the bell.

4.2 Explanation of functioning

Actually, based on Aristoxenus's theory, the physical explanation of "vasa aerea" given by Vitruvius is related to musical harmony because he states that " … the voice which issues from the scene, expanding as from a centre, and striking against the cavity of each vase, will sound with increased clearness and harmony …" (V,5,3) . Aristoxenus considers that musical harmony must be dependent on the ear, and not on mathematics as considered by Pythagoras and his disciples.

However, the bronze vessels should have a sharp resonance as usual for metallic structures. Supposing that they could be excited by the voice, we can wonder which could be the interest of such a device for the audience. It should have maintained a har-

monic background but not created sound correction nor local amplification. R. Floriot underlines, that locally, for a spectator, the device can "only generate annoying resonances".

The explanation provided by Vitruvius can also be studied under the angle of a symbolic system, as proposed by B. Poulle [13]. The author considers, indeed, that the acoustic effect would come "only in second place in the intentions of the ancient architects" and he supposes there would be "behind the musical system of the acoustic vases, the theory according to which the theatres give an indication of the universe […]". In this interpretation, the author defends the assumption according to which the ancient acoustic vases would be, above all, a whole celestial representation, where the moon holds a privileged place.

4.3 Relation with earthen vessels

In a last part, Vitruvius establishes the relation between some practices of his time and those of the ancient Greek epoch. He remarks, first of all, that the theatres in Rome are built in wood and that wood resounds. He notices then that the actors spontaneously turn towards the doors which resound and amplify their voice. The relation between wood panels and bronze vases is really surprising. The acoustic properties of the metal vases and the wood slats are really different. Considering modern acoustical knowledge, the logic of Vitruvius could be: if the theatres are built with stones (which do not resound), it is necessary to help the singers (actors, musicians) with a particular device.

The text ends with an open question: « Multi autem solertes architecti, qui in oppidis non magnis theatra constituerunt, propter inopiam fictilibus doliis ita sonantibus electis, hac ratiocinatione compositis perfecerunt utilissimos effectus», which could be translated as "Many clever architects who have built theatres in small cities, have made use, from the want of other resources, of earthen vessels, yielding the proper tones, and have introduced them with considerable advantage*"*(V,5,8). We can see that Vitruvius established himself the relation between the "*echea*", known with the Vth-IVth century BC and the potteries inserted in the walls at -25 BC. The rationale of his demonstration is, nevertheless, quite surprising.

5. Comparison and conclusion

The filiations suggested by numerous authors between Antiquity and the Middle Ages cannot be based on acoustic factors. Many elements basically differentiate the *echea* of the Greek theatres and the acoustic potteries placed in the churches. The Greek theatre is an open space, where the search for amplification of the sound can be justified, but which does not have constraints of reverberation for example. Conversely, the medieval churches constitute closed spaces and are governed by the laws of room acoustics.

Another technical difference appears important. Concerning the devices, the bronze vases, described by Vitruvius, they are placed in niches so as to vibrate inside their stone housing. The medieval acoustic potteries, inserted in the vaults and walls are generally drowned in masonry, and consequently they cannot vibrate freely as the devices described by Vitruvius. Thus, their acoustic behaviour is not based on the vibration of the wall, but on the volume of the air included in the potteries.

Lastly, the question of the number of devices also distinguishes the ancient *echea* from the medieval pots. If the number of the bronze vases in the theatres is precisely de-

termined according to Vitruvius, the number of pots inserted in the walls and the vaults of the churches is very variable.

Thus, although the ancient *echea* have few relations in term of acoustics, with the medieval potteries, attentive reading of the text of Vitruvius yields two essential teachings for our research. On the one hand, earthen pots were already present in the walls of certain buildings (theatres and temples) in the Ist century BC. Furthermore, his text probably influenced the architects and the builders durably, in particular during the Middle Ages, in taking into account the acoustic dimension for the construction of the religious buildings. In particular, when two types of potteries are present in the walls of a church, they are often tuned a fourth or a fifth apart [14].

Until today, the problem of "aerum vasis" as described by Vitruvius in ancient Greek theatres is still an open question for specialists of antiquity but the relation with medieval potteries is not so obvious. For our concern, the main teaching of the testimony of Vitruvius is the evidence that potteries inserted in walls were already used at the first century before J.C.

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