Mario Arnaldi

TEMPUS ET REGULA

Orologi Solari Medievali Italiani

LE ORIGINI
&
LA STORIA

OPUS DEI PROJECT
Un archivio per lo studio e la tutela del patrimonio gnomonico medievale in Italia

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Volume 1

Con testi di

Sh. Adam - M. Cowham - W. Hoffman - J. Lush - H. Rau - K. Schaldach
D. Schneider - M. Tadić - M. Mª Valdés Carracedo - J. A. Wikander

AM Arte

Capitolo 8 - La ex Iugoslavia

Medieval Sundials in former FPR Yougoslavia (SFRJ)

Milutin Tadić
University of Belgrade – Faculty of Geography

There are only few preserved medieval sundials in the territory of the former Yugoslavia (which is now the territory of six countries) (Tadić, 1999). In this text we will focus only on the sundial on the Virgin Mary church of Studenica monastery (Serbia) (Tadić, 2004). Talking about it, we will talk about them all.

There are two reasons for choosing Studenica sundial: 1) it is the oldest preserved Serbian and South Slavic sundial; 2) its geographical latitude is approximately the same as Livorno's geographical latitude, so the analyses of its functioning can be applied on similar sundials in Italy.[1]

8.1 Sundial of manastery Sudenica

("sundial which was using letters instead of numbers")

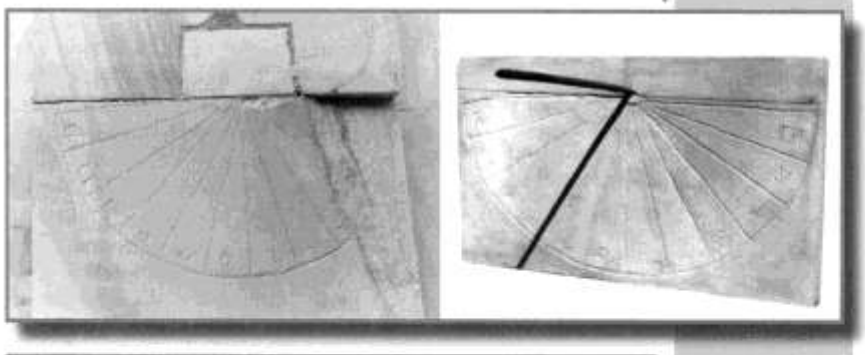

Fig. 8.1
Studenica. Medieval sundial, the oldest sundial in Serbian lands: original (left) and reconstruction (right)

1 In Dalmatia (now Croatia) there are few old sundials which could be interesting to gnomonic historians in Italy. It would be interesting to investigate the Italian influence in construction of the old sundials in Dubrovnik (Ragusa), on Korčula island (Curzola), on Hvar island (Pharia), etc.

The only preserved Serbian medieval sundial is the one on the Virgin Mary church of Studenica monastery (43° 29' N, 20° 37' E) (*Fig. 1*). Of all the Serbian monasteries Studenica has always been held in the highest respect. The church of the Virgin Mary was built in the last two decades of the 12th century. In architectural conception and execution it ranks among the finest examples of what is known as the Raška style of church building.

The sundial is carved on the left pilaster next to the doorway of the south church vestibule, at about 4 m height (*Fig. 1*, left). The semi-circlular-shaped hour plate (r = 21 cm) is divided into 12 equal hour sectors. The sectors are numerated in Byzantine fashion by letters а, в, г, д, є, ѕ, з, и, ѳ. The last quadrant of the sundial – the one with the denotations і, аі, ві – is missing. There is no gnomon either, which must have been fixed perpendicularly to the wall, in the centre of the semi-circular shaped hour plate of the sundial (*Fig. 8.1*).
Old Church Slavonic letters are written in the common order. In Old Church Slavonic language there were no special symbols (numerals) for numeric values, and letters were used for that purpose. Some letters of that Cyrillic alphabet did not represent particular sounds but only numbers, first of all the Greek symbol for number 90 (kopa). At first, kopa and two other symbols – ѕ (6), ҁ (90) and ѱ (900) – had only numerical values, before they became alphabetical symbols too. So it is obvious that Greek way of marking numbers with letters influenced the structure and characteristics of Cyrillic alphabet.
The shape of the letters-numerals of the Studenica sundial suggests that it was constructed at the end of the 12th or at the beginning of the 13th century.
It is believed that the Byzantine tradition of sundial making was brought to Serbia by St. Sava (1175–1236). St. Sava, the first Serbian archbishop, was the expert in Byzantine art and culture. When he came to Studenica monastery – the memorial of his father, the famous Serbian ruler Stefan Nemanja – he already had significant experience of church building and equipment. That knowledge also included the knowledge of dialling, which explains the presence of the sundial on the south church facade.

8.2 Sundials similar to the Studenica sundial

No other medieval sundials have been preserved in the areas of Serbia and Serbian lands (TADIĆ, 1998). It is understandable: the sundials were usually placed on church buildings, which were often demolished and burned to the ground by the foreign conquerors.[2] The nearest preserved sundials similar to the Studenica sundial are in Dalmatia (Croatia) – in Korčula (town on Korčula island), Trogir (Tragurium) and Orebić on Pelješac peninsula (Sabbioncello).

The Korčula sundial is located on the bell tower of the Cathedral of St. Mark. It is in a completely unexpected place: the view of it is blocked by the part of the church that was built later (*Fig. 8.2*).

2 Nevertheless their existence is indicated by numerous exact hour specifications in the medieval Serbian manuscripts, and also by two sundials of "Studenica design" found on Hungarian territory. One of these is at the locality Rackeve (Serbian Kovin) on the wall of the Orthodox church whose foundations were laid by Serbs. In their northward mass migrations before the Turks, the Serbs carried with themselves the Byzantine "recipe" for sundial making.

The Trogir sundial is located on the Cathedral of St. Lawrence and it was made two hundreds years after cathedral had been built. The sundial above Orebić is located on the south wall of the church of the Franciscan monastery of The Lady of Angels. It is interesting because it is divided into six equal sectors.[3] All three sundials date to the 15th century. Another medieval sundial is recorded on the St. Sofija church in Ohrid (Macedonia) (ZINNER, 1964), but it seems that the hole and the groove on the block had some other function.[4]

Beside the sundials of Studenica's type, on the territory of the former Yugoslavia there is another type of conditional medieval sundial – this type is in the shape of scaphe hollowed in the stone (TADIĆ, 1997). The frontal part of the scaphe is divided into equal sectors, over which falls the shadow of the long horizontal gnomon. These sundials are located in Dalmatia, in the monasteries of the former Franciscan province – in Rožat, Slano (Islana), Orebić and Badija island (*Fig. 8.3*). They were all originally fixed at the top of the south walls of the church courtyards. The sundials in Rožat and Badija are fragmental, but the sundials in Slano and Orebić are fully functional.

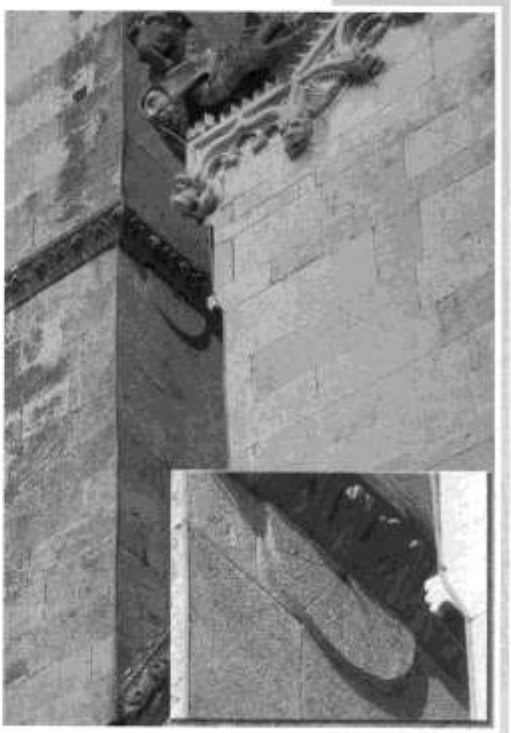

Fig. 8.2

KORČULA, *cathedral*. Medieval sundial on the bell tower.

The gnomon of this type of sundial is placed in meridian line, with its free end aiming at the south point. The gnomon had to be long enough to enable its shadow to fall – sharp and clear – over the frontal edge of the sundial during the whole year. The date 1586 was carved on the sundial in Slano, and the other sundials are also dated to the 16th century. The sundial in Badija is considered to be the oldest and the sundial in Orebić to be the most recent.

Scaphe sundials are the products of medieval naive gnomonics or, in other

3 Higher on the same wall there is another sundial divided in unequal sectors, but it is not a medieval sundial.

4 The similar block was also built on the west church wall. Both blocks are located in places that seem illogical for sundials and the holes are too big to be places where the gnomons were fixed.

words, the products of a naive understanding of the classical sundial of Berossos' type[5].

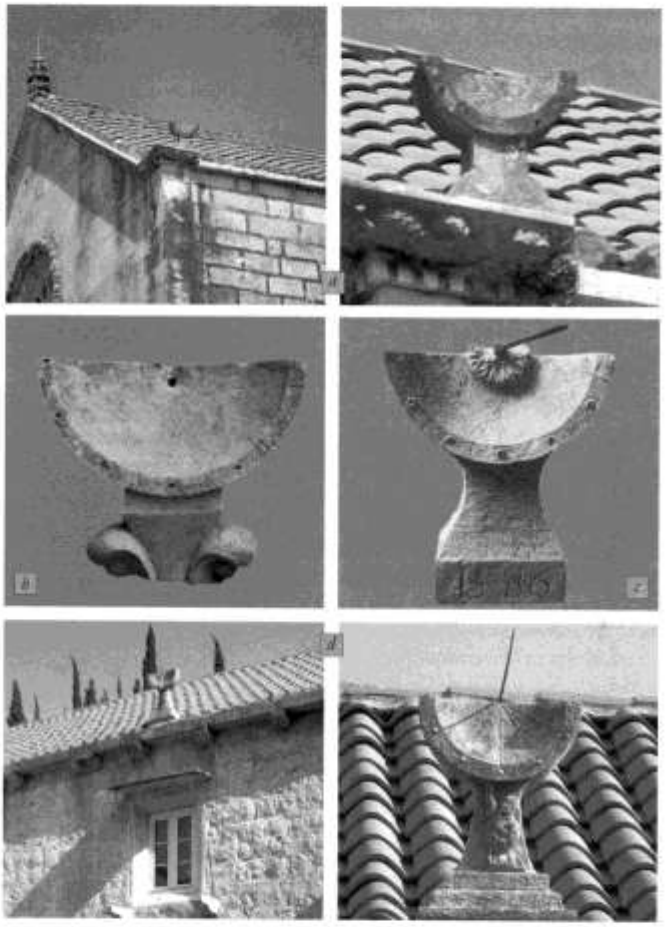

Fig. 8.3
Scaphe Sundials
A – Slano
B - Badija
C - Rožat
D - Orebić

8.3 Sundials which dictated their own hourly system

Studenica's type sundials are spread across Europe, from the Meditarranean to Scandinavia and from

5 Compare with the sundial of the Ponte Vecchio in Florence.

the Black Sea to the British Isles. They are typical for the European Middle Ages, but they are neither a European nor a medieval invention. The oldest preserved sundials are constructed in the same way, and they survived through the entire classical period, in spite of numerous constructional forms of Greek and Roman sundials (*Fig. 8.4*). Because they appear in the same form in all geographical latitudes, they can be conditionally called "the sundials for every place".[6]

Fig. 8.4
ŠARIĆA STRUGA (Croatia). Roman sundial "for every place" (2nd/3rd century)

Literature about the sundials of Studenica's type is very voluminous and various in the researchers' approach. We will leave culture historians to deal with the medieval understanding of the time (and to wonder if those sundials were more than just a clocks) and we will try to answer the following question – Which hourly system did those sundials serve for?

In the Middle Ages the Church took over a classical temporary hour system which differentiated between day and night hours. The day hour was one twelfth of the daytime period and night hour was one twelfth of the night. The duration of the day temporary hour was therefore changing during the year the same way as the duration of the daytime – in the summer they were longer and in the winter they were shorter.

One does not have to be an expert in gnomonics to prove that shadow of the sundial of Studenica's type could not show exact hours in either the temporary or equinoctial system. In the temporary hour system, the day arcs of the Sun's apparent orbits are divided into twelve equal parts, and the hour circles connecting those parts do not have the common axis in which gnomon can be placed. That is why the sundial constructed for this hourly system points to hours with the end of the shadow, while the Studenica sundial points to the hours with the direction of the shadow.

In the modern equinoctial hour system hour circles are secondary circles of the celestial equator. If we place the gnomon in the axis of celestial sphere its shadow direction will point to the equinoctial hours. Only the gnomon of a sundial located exactly on the equator can have the horizontal position like the gnomon of Studenica sundial.

Therefore, the European Middle Ages were characterised by a paradoxical simultaneous existence of a formal temporary hour system and devices which were not constructed according to that system.

6 Not in the sense of universal sundials "for every angle of the axis of celestial sphere", mentioned by Vitruvius.

If the sundial of Studenica's type was not constructed for the temporary nor the equinoctial hour system, what was it constructed for? What was indicated by its shadow?
To answer this question, we must use spherical trigonometry formulas to solve the problem, which can be formulated in this way: *Find the hour angle of the Sun (t), if you know the angle between the shadow of the Studenica sundial and the vertical (s), geographical latitude of the place (ϕ) and declination of the Sun (δ).*
This time we will use already prepared formulas (TADIĆ, 2002):

$$tg\frac{t}{2}=\frac{\sin\dfrac{\varphi-\delta+90^\circ}{2}}{tg\dfrac{s+\beta}{2}\sin\dfrac{\varphi+\delta-90^\circ}{2}},$$

where is:

$$\sin\beta=\frac{\sin s\cdot\sin\varphi}{\cos\delta}.$$

Using given values of shadow angle (s) in intervals of 15° (from 0° to 180°), for the geographical latitude of Studenica monastery (43° 29' N), for the time of solstices and equinoxes, and later for the 21st day

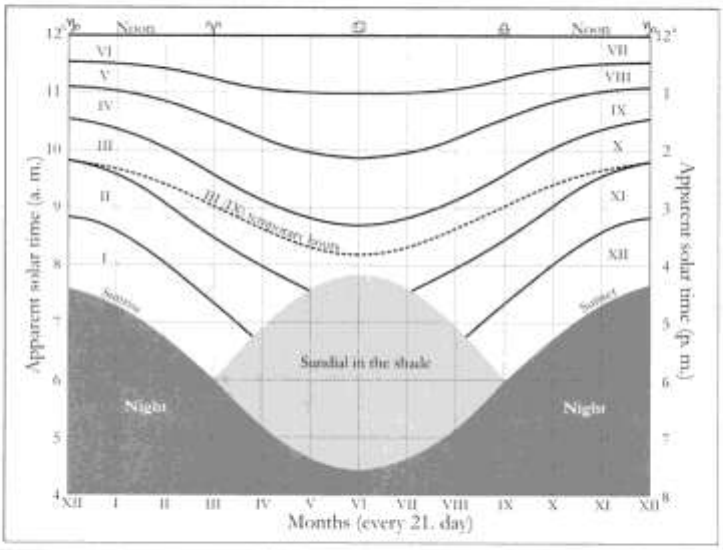

Fig. 8.5 Parallel description of the annual circle of time intervals, which was indicated by shadow on the sundial of Studenica Monastery, and hours of the temporary hourly system.

of every month, we have found the hour angles of the Sun – and by that corresponding moments of apparent solar time. The results are given on the diagram (*Fig. 8.5*). The discontinuous lines are showing yearly change of daytime temporary hours. The discord between the time intervals shown by the shadow of Studenica sundial and the hours of the temporary and the equinoctial systems are obvious. Using the differences of the hour angles of the Sun, we have found the duration of each of the 12 time intervals during the year at the geographical latitude of Studenica monastery (*Fig. 8.6*). The shadow of that type of sundial needs a different time to move over the different 15° sectors. By that it determines six pairs of time intervals which are symmetrical about the noon. Time intervals are getting shorter from sunrise to noon; from noon to sunset they are becoming longer in the opposite way. The same hours are the shortest at winter solstice and the longest at summer solstice. These dials can only work throughout the whole day during the winter half of the year.

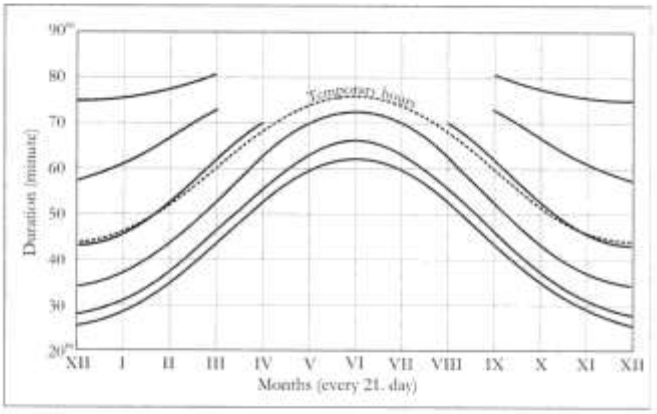

Fig. 8.6

The duration of the time intervals (in minutes) which are shown by shadows during the year on the sundial of Studenica monastery (φ = 43°29')

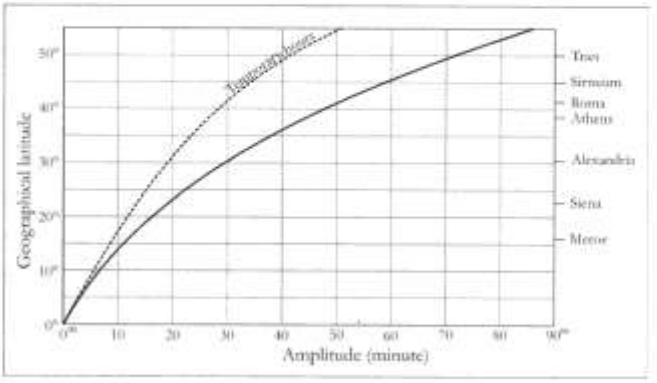

Fig. 8.7

Changes of hourly amplitude at different geographical latitudes (in accordance with geographical latitude, the ancient towns are marked on the right side)

The difference between the longest time interval and the shortest time interval can be an indicator of the functionality of these sundials at different geographical latitudes. The changes of the yearly amplitude for latitudes from 0° to 55° are shown on the diagram (*Fig. 8.7*). The amplitude is getting longer with the increase of the latitude (φ): at the equator – zero; φ = 30° – 29, 5 minutes; φ = 45° – 59 minutes; φ = 55° – it is already 86 minutes.

Conclusion

The sundials of the Studenica's type – and the other medieval sundials on the territory of the former Yugoslavia – are the products of **naive gnomonics**.
These sundials were not constructed exactly in a manner of gnomonic rules and they did not indicate hours of the formal temporary hour system. The hour system did not dictate the constructed form of these sundials, but the hour scale dictated a particular division of the day which – considering its duration of several centuries – might be taken as a special hourly system: a "visual-temporary hourly system". The units of this hourly system can be exactly determined and their length and changes during the year can be analyzed.
The sundials of Studenica's type originated in the area about 30° north geographical latitude, where the disharmony with the temporary hour system was not huge. Later, they were spread by inertia all over Europe. Going to the north, the disharmony with the temporary hour system was becoming more expressive, and numerous variations were the results of tendencies in reducing that disharmony.
The sundials of Studenica's type and hourly system which were dictated by sundials are typical characteristics of the European Middle Ages. It can be said, approximately, that the end of construction of these sundials marks the end of the Middle Ages in this specific area.

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