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CLASSIFICATION CRITERIA FOR HISTORICAL ASTRONOMICAL INSTRUMENTATION

1. Introduction

The interest towards inventorying scientific instruments has largely grown in the last half century and different national inventories have been carried out, most of them under the patronage of the *Scientific Instrument Commission of the International Union of the History and Philosophy of Science* (the former *Commission pour l'Inventaire Mondial des Appareils Scientifiques d'Intérêt Historique de l'Union Internationale d'Histoire et de Philosophie des Sciences*). The last inventory, which was undertaken in 1967 and finished in 1992, was performed by the *British National Committee for the History of Science, Technology and Medicine*.[1] An early inventory of instruments in Italy was made by the *Museo Nazionale della Scienza e della Tecnica Leonardo da Vinci* in 1961-1963[2], following the suggestions made by Henry Michel in 1958[3] and 1959[4].
A few years ago the Italian *Consiglio Nazionale delle Ricerche (CNR)* supported a project proposed by the *Commissione per la Storia dell'Astronomia* of the *Società Astronomica Italiana (SAIt)* in order to catalogue the historical astronomical instruments belonging to the Italian astronomical institutions.
All these inventories are in paper form, but the development of computers and international networks suggests a fast growing of computerized databases. In fact, today is already possible to have a virtual look at objects from a large number of Museums, collections and exhibits. The on-line availability of a vast number of inventories gives great importance to the possibility, for scholars aiming to search for particular objects or groups of objects, to obtain undoubted, complete and, above all, without losing any item, answers to their queries to the databases. Hence the opportunity to use the same names for the same objects, i.e. the well known, but not completely resolved, problem of "vocabulary control".
Here we intend to present the approach used towards this problem - with regard to historical astronomical instrumentation - and the criteria that guided us in defining a proposal for a scheme of classification, derived from previous experiences gained in different instruments cataloguing. Having in mind those experiences we agree that a precise classification of the objects to be catalogued is needed for two main purposes:

* to give the the possibility of **working interactively** with the catalogue;

* to have an **efficient data retrieval system**
both for the **curator** in charge of inserting data **in** the database,
and for the **scientist** interested in obtaining data **from** the database

2. The classification criteria

Let us start with a few examples of the above mentioned problems. Figure 1 shows five different instruments which can be found in astronomical collections. Objects of the same kind of those shown are classified in different inventories using names which can vary from horizontal plate to horizontal circle, miner's dial, miner's compass, len's dial, Holland circle, surveying circle, graphometer, circumferentor, theodolite and even astrolabe. For instance, the name "astrolabe" for objects like the upper-left one is clearly wrong: the object is a circumferentor and the suggestion it could be an astrolabe merely derives from its shape. The term "theodolite" for some of the objects is not wrong, but it could not be always correct.
Scholars who would like to authomatically search for astrolabes or for theodolites will obtain, from their query, objects which do not belong to the requested category. In the contrary, the search for circumferentors will lose the object shown and classified as "astrolabe".
Many different examples of this kind could be presented, just in order to emphasize the problem of the "subject classification" or, as we called it before, of the "vocabulary control". More confusion, of course, can derive working with inventories written in different languages.
These difficulties could be resolved by the definition of an "authority list" for historical objects in astronomical collections, but: who defines the authority list?
In the course of time a lot of people engaged themselves in this hard work. Leaving out the XVIII-century *Encyclopédie* by Diderot and d'Alembert, one can obtain some aids by more modern dictionaries, subject headings, thesauri and so on, as, e.g..:

* *Art and Architecture Thesaurus*

* *Library of Congress Subject Headings*

* *Subject Headings for Graphic Materials*

* *The Revised Nomenclature for Museum Cataloging*

* *Social History and Industrial Classification*

* *McGraw-Hill Dictionary of Scientific and Technical Terms*

as well as more specifical nomenclatures, most of which are quoted in the References. Nevertheless, in this respect, David Bearman, editor of *Archives and Museum Informatics*, remembers that:

*"In a critique of controlled vocabularies for subject retrieval, which I wrote several years ago (*American Archivist, vol. 52, no. 3, 1989*), I presumed that appropriate terminology existed in a controlled list somewhere. ....*
What I did not consider was what to do when no vocabularies accurately describe the concept we want to represent. ....
It is obvious that if we have to adopt terms that distort the meaning of the objects we are describing, any benefits with respect to information retrieval, such as improved precision, that could accrue from control of terminology are a hardly an advantage. ....
***At least I'll never again assume that a vocabulary for a given domain of description actually has the terms required to describe that domain**."* [5]

Being these preliminary remarks and warnings, the solution of the "authority list" problem must derive from a different approach and the following example, in our opinion, can explain

Figure 1 - The instruments shown are from: M. Holbrook, *Science Preserved. A directory of scientific instruments in collections in the United Kingdom and Eire*, HMSO (London, 1992).

the approach we used.
Figure 2 shows a splendid instrument made by Arnoldus Scherpenselensis in 1595 for Giovanni Antonio Magini, teacher of Astronomy at Bologna University. It could be classified as "quadrant", "astronomical quadrant", "astrolabe quadrant", "surveyor's quadrant", "Magini's quadrant" - following the use, sometimes misleading, of classifying objects with the name of the craftsman, of the owner or of the user - or, which is clearly uncorrect, merely "astrolabe". In any way, asking the database for "quadrant", one can obtain all the objects of this kind, leaving out the last uncorrect classification. Having in mind the many activities made by the former owner, this example can help us. Magini, as we said, was teacher of Astronomy, but he was also envolved in geography, topography, sailing problems and calculus. His instrument can be used to solve problems in all these fields, both as an "angle measuring instrument" and as a "computing instrument".
Hence the suggestion not to use the "supposed object name" in classifying objects, but to subdivide them according to their "type of use". As a consequence, all the instruments shown in figure 1 - anyhow the curator could have been named them: horizontal plates, miner's or len's dials or compasses, Holland's or surveying or horizontal circles, graphometers, circumferentors, theodolites, astrolabes and so on - can easily be recognized in every database by scholars querying simply for: "angle measuring instruments".
Moreover, "angle measuring instruments" are used in different fields of science, as the Magini's quadrant example suggests. As a consequence, a different approach in classifying scientific artifacts is to distinguish between the different applications the same instrument could have had inside each section of science, instead of try to identify a name which could be recognized by every researcher all around the world, without any mistake.

3. The classification

The previously discussed points, i.e. the "type of use" and the "kind of specialization" of historical instruments - together with the presence, for astronomical objects, of few entries, with very few horizontal associated relations, the vast majority of which are hierarchical - suggested us the use of an "**indexed hierarchical classification**".
Organizing the classification we followed in principle the criteria defined by the above mentioned *Commission pour l'Inventaire Mondial des Appareils Scientifiques d'Intérêt Historique*, with the later suggestions by M. Calisi[6]. We defined a hierarchical classification of each instrument divided in three main levels: "**section**", "**type**" and "**object**". Starting from the division of science into the 27 categories defined by the Commission, we selected the first 15 categories and added the section Geology and Geophysics, not previously defined, thus obtaining 16 "**sections**" in which the instruments could be classified according to **the main field of science for which the instrument was designed and realized by the maker**, i.e. Mathematics, Navigation, Astronomy, Optics and so on. Table 1 shows the 16 sections.

After that, we divided the instruments in "**types**", according to **the particular application and specialization of use inside every section of science**. As a consequence we have, for instance, in the section Mathematics the types "drawing instruments", "analog measuring instruments and computing machines", "digital computers" and "models". In the section Astronomy we have the types "astrometric instruments", "refracting telescopes", "reflecting telescopes", "solar telescopes", "eyepieces", "micrometers", "focal plane photographic instruments" and so on. Table 2 shows the sections and the lower level subdivions in types.

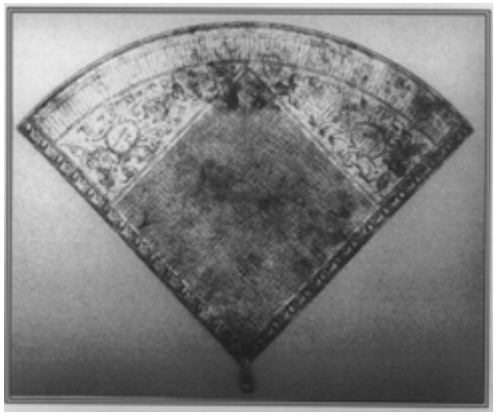

Figure 2 - Quadrant made *"Per Arnoldum Scherpenselensem, Anno 1595, Bononiae"* for *"Io: Antonius Maginus, in Exm. Gymnasio Mathematicarum Professor"*. Giovanni Antonio Magini (1555-1617) held the chair of Astronomy in Bologna University from 1588 to 1617. Among the candidates for the chair vacated by Ignatio Danti was the 23 year-old Galilei. The Bolognese Senate, however, went for the older and better known Giovanni Antonio Magini from Padua. (Courtesy of Gunnar Pipping, *National Museum of Science and Technology*, Stockholm)

Finally, at the third level of classification there are "**objects**". First of all it is important to define the so called "catalographic unit", bearing in mind that the instrument to be classified must be **an autonomous unit worth of being catalogued**. A telescope supplied with a given lens, a given eyepiece and a given mounting is an object to be classified, for instance, as a "refracting telescope with achromatic object glass, galilean optical system, in equatorial German mounting", whereas a micrometer built to be used at various telescopes must be catalogued independently like, for instance, a "heliometer". The choice between cataloguing different single objects as part of a "complex object" or as different "simple objects" depends on the knowledge of the history of the instrument itself and of its use and applications. In particular, in experimental physics and chemistry many examples of experiments made using a lot of instruments can be found. Usually objects and not experiments are catalogued, unless the historical importance of the overall apparatus is wider than that of its single parts.
At this level of classification the curator in charge of cataloguing instruments could be **completely free of inserting the "supposed name" of the object**. Anyway, we tried to identify most of the historical instruments one can usually find in the astronomical institutions, without claiming any level of completeness, but bearing in mind to suggest a preliminary list of objects and preferred nomenclature just as a cataloguing help. In a preliminary presentation of our proposal[7,8] we reported the whole suggested list of ~ 400 objects we identified as autonomous units to be catalogued inside the subdivision in types and sections, following our experience and referring to international catalogues and inventories [9-44].
We do not report here the suggested list of "objects" with the index relative to the various types and sections in which the object could be classified with regard to the main type and/or section for which the instrument was intended or in which the instrument was used. This is made both for space reasons and, above all, for stressing the main criteria which guided us in the definition of the "indexed hierarchical classification". Table 3 reports, *exempli gratia*, the subdivision in sections, types and objects only for a few types of section 6 "Astronomy".
Table 4 lists the same objects from table 3 alphabetically. Together with every object we report the index relative to the various types and sections in which the object could be classified with regard to the main type and/or section for which the instrument was intended or in which the instrument was used. A quadrant, for instance, could have been built or used as an "angle measuring instrument" in the section Topography and Geodesy, or as a "celestial body altitude measuring instrument" in the section Navigation, or, finally, as an "astrometric instrument" in Astronomy. It is the cataloguer's responsibility to decide the main section in which the instrument should be classified, based on a good knowledge of the instrument's history.
The use of a glossary which defines terms would permit a "free vocabulary", whereas the use of hierarchic descriptors and subject headings suggests a "controlled vocabulary": clearly the difference between the two choices is a basic one and a lot of literature is available. Our aim, many times previously stated, is not to give a contribution to this kind of discussion (even if we prefer, of course, a controlled vocabulary), but a help to classify scientific artifacts. We have not the presumption to solve all problems presented, but we "tried to avoid" them defining a logical tree and subdividing instruments in Types.

In fact, the hierarchical scheme "Section, Type, Object" forms the carrier axis of the suggested classification and, in our opinion, foresees the above widely discussed problems:

*** giving a particular importance to the subdivision in "types", according to the technological and usage purposes of the historical astronomical artifacts in the various disciplines,**

*** leaving the possibility of assigning more classification indexes to the same instrument, classifying it in different types (being different its uses),**

*** suggesting (if requested) an 'object authority file' or leaving the cataloguer free to use what he thinks to be the 'correct name' of the instrument to be classified.**

We want to stress the importance of the fact that the definition of types has not been induced by a collation of objects, but has

been deduced from the analysis of the technological and usage purposes in the various disciplines. As a consequence, the cataloguer must classify the object from both a historical and technological point of view, using all the relative knowledge in his possession. In fact, a precise instrument is to be classified and not a generic one: the classifier must (or should) know the main purposes that instrument was used for, or for which was built and, as a consequence, assign it to that particular Section and Type. In this way one has the possibility to "mark the history" of that instrument, assigning it to a defined Section and to a defined Type, and extracting from the data base only the instruments used or realized for that Section or all the instruments having the same usage characteristics classified. It depends on the scientist's purposes.
It is our opinion that the cataloguer and the scientist interested in information retrieval could not be completely dark about the "object" they are classifying or they are looking for. For instance, cataloguing or searching for a "compass", one has to know if he is looking for "an instrument for indicating a horizontal reference direction relative to the earth" (e.g. in our classification: section Navigation, type Compasses) or for "an instrument used for describing arcs or circles with pencil or pen" (e.g.: section Mathematics, type Drawing instruments). Being these differences not known to the cataloguer and to the scientist, it is not clear how to help both of them unless giving a descriptive "fiche" and a photo for each "object". Not knowing the "correct name" of the object, one can classify it without assigning a name, just putting it inside a type or even, in the most hopeless case, only inside a section. Not knowing the name nor the kind of use nor the field of science in which the instrument could have been used .... there is no hope for a solution.

The suggested classification is intended for the historical instruments in the astronomical collections. Bearing in mind all the non-astronomical instruments used in a certain section of discipline, and our poor knowledge of disciplines different from astronomy, our list is naturally incomplete. Paying attentiont to which kind of collection and/or museum we are dealing with, i.e. "general", "semi-specialized", "specialized", our case is, of course, the third one. Nevertheless, the use of hierarchical descriptors leaves this kind of classification extremely flexible and easily expansible to "general" and "semi-specialized" collections. Adding a Section (e.g. Medicine or Chemistry) to our suggested list, and creating a hierarchical classification inside the section itself, based on the same criteria, more indexes can simply be added to those we defined. A hiearchical description can be specialized exploding one Section or one Type.
Therefore, our hope is that curators and scholars, analyzing the above defined criteria which guided us in the hierarchical scheme of the classification, will contribute to improve our work by pointing out mistakes, new or revised types, new objects and synonyms, or by applying our criteria to the classification of historical instruments in more fields of science.

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Table 1: Sections

1. MATHEMATICS
2. METROLOGY
3. TOPOGRAPHY AND GEODESY
4. GEOGRAPHY
5. NAVIGATION
6. ASTRONOMY
7. METEOROLOGY
8. GNOMONICS
9. CHRONOMETRY
10. MECHANICS
11. OPTICS
12. ACOUSTICS
13. TERMOPHYSICS
14. ATOMIC PHYSICS
15. ELECTRICITY AND MAGNETISM
16. GEOLOGY AND GEOPHYSICS

Table 2: Sections and Types

1. MATHEMATICS
1. Drawing instruments
2. Analog measuring instruments and computing machines
3. Digital computers
4. Models

2. METROLOGY
1. Lenght measuring instruments
2. Mass and/or weight measuring instruments
3. Volume measuring instruments
4. Comparators

3. TOPOGRAPHY AND GEODESY

1. Direct distance measuring instruments
2. Aligning instruments
3. Angle measuring instruments
4. Drawing instruments
5. Measuring and computing instruments
6. Instruments for photographic surveys
7. Models

4. GEOGRAPHY
1. Terrestrial globes
2. Maps and atlases
3. Mapping instruments

5. NAVIGATION
1. Charts and portolanos
2. Plotting instruments
3. Compasses
4. Celestial body altitude measuring instruments
5. Hourglasses
6. Chronometers
7. Instruments for hydrometric measures
8. Ship's telescopes and binoculars
9. Models

6. ASTRONOMY
1. Astrometric instruments
2. Refracting telescopes
3. Reflecting telescopes
4. Solar telescopes
5. Eyepieces
6. Micrometers
7. Filters
8. Focal plane photographic instruments
9. Stellar photometers and bolometers
10. Solar photometers and bolometers
11. Stellar spectrometers
12. Solar spectrometers
13. Polarimeters
14. Radiotelescopes and detectors
15. Gamma-ray, X-ray and Infrared radiation detectors and telescopes
16. Photographic observations reduction instruments
17. Photoelectric observations reduction instruments
18. Celestial and planetary globes
19. Sky maps, planetary maps, atlases, celestial phenomena representations, calendars
20. Celestial and/or planetary representation instruments
21. Domes
22. Slide rules or machines for astronomical reductions
23. Furniture
24. Models

7. METEOROLOGY
1. Temperature measuring instruments
2. Atmospheric pressure measuring instruments
3. Atmospheric umidity measuring instruments
4. Wind measuring instruments
5. Rainfall measuring instruments
6. Atmospheric electricity measuring instruments
7. Sunshine recorders and solar radiation measuring instruments
8. Weather stations
9. Furniture

8. GNOMONICS
1. Meridian lines
2. Fixed sundials
3. Portable sundials

9. CHRONOMETRY
1. Hourglasses and water clocks
2. Mechanical weight-driven clocks
3. Mechanical spring-driven clocks
4. Electrically-driven clocks
5. Atomic and molecular clocks
6. Time signal receivers and chronographs

10. MECHANICS
1. Mechanical phenomena studying and measuring instruments
2. Materials processing machines
3. Engines and pumps
4. Models

11. OPTICS
1. Optical benches, supports, fittings
2. Lenses, mirrors and eyepieces
3. Prisms, gratings, polarizers and filters
4. Laboratory photometers, spectrometers and polarimeters
5. Sources
6. Photographic cameras and darkroom equipments
7. Optical projection systems
8. Camerae obscurae and camerae lucidae
9. Refractometric measuring instruments
10. Spherometric measuring instruments
11. Microscopes
12. Interferometers
13. Models

12. ACOUSTICS
1. Acoustic phenomena studying and measuring instruments
2. Sound reproducers
3. Models

13. TERMOPHYSICS
1. Thermal radiation measuring devices
2. Heat quantities measuring devices

14. ATOMIC PHYSICS
1. Particle sources
2. Particle detectors
3. Models

15. ELECTRICITY AND MAGNETISM
1. Magnetic and electric phenomena studying and measuring instruments
2. Laboratory instruments
3. Electronic or electrotechnical components
4. Models

16. GEOLOGY AND GEOPHYSICS
1. Instruments for seismic surveys
2. Terrestrial gravitation measuring instruments
3. Instruments for measuring the deviation from the vertical line
4. Electric and magnetic terrestrial phenomena measuring instruments
5. Instruments for hydrometric and hydrographic measures

Table 3: Example of the subdivision in Types and Objects, for Section 6 'Astronomy':
Types 1-3

6. ASTRONOMY
1. Astrometric instruments
1. astrolabe
2. cross-staff also Jacob's staff
3. baculus also arbaletum
4. diopter
1. Hipparchus' diopter
5. nocturnal
6. altitude quadrant
7. astronomical ring
8. triquetrum also Ptolemy's ruler also parallactic ruler
9. torquetum also turquet
10. movable astronomical quadrant
11. ring dial also armilla
1. equatorial ring dial
2. zodiacal ring dial
3. universal equinoctial ring dial
12. meridian circle
13. repeating circle
14. theodolite
1. circumferentor
2. repeating circle

15. astronomical compendium
16. octant
17. mural quadrant
18. mural semicircle
19. transit telescope
20. zenith telescope
21. parallactic telescope
2. Refracting telescopes
1. astrograph
2. Baker-Nunn camera
3. hand held telescope
1. astronomical telescope also Keplerian telescope
2. Galilean telescope also terrestrial telescope
4. refracting telescope
1. with non achromatic object glass
2. with achromatic object glass
- the following divisions are not associated to the last entry, but they are hierarchical combinations of all the preceding entries -
1. with astronomical optical system also with Keplerian optical system
2. with Galilean optical system also with terrestrial optical system
1. in aerial mounting
2. in altazimuth mounting
3. in ecliptic mounting
4. in zenith mounting
5. in equatorial
1. English mounting
2. German mounting
3. fork mounting
3. Reflecting telescopes
1. reflecting telescope
1. with spherical mirror
2. with parabolic mirror
3. with hyperbolic mirror
4. multi-mirror telescope
5. Schmidt telescope also Schmidt camera
6. Ritchey-Chrétien telescope
- the following divisions are not associated to the last entry, but they are hierarchical combinations of all the preceding entries -
1. with primary focus
2. with Cassegrain focus
3. with Newtonian focus
4. with Gregorian focus
5. multi-focus
1. in herschelian mounting
2. in altazimuth mounting
3. in equatorial
1. English mounting
2. German mounting
3. fork mounting
4. yoke mounting

Table 4: Example of the list of objects, which appear in section 6 'Astronomy' (types 1-3), alphabetically, and indexes related to sections and types

arbaletum ... use baculus
armilla ... use ring dial
astrograph ... 6.2.1
astrolabe ... 3.3.13--5.4.7--6.1.1
eclipse computing astrolabe ... 6.22.4
Danjon's astrolabe ... use impersonal astrolabe
impersonal astrolabe also prismatic astrolabe also Danjon's astrolabe ... 3.3.14
mariner's astrolabe ... 5.4.8
pendulum astrolabe ... 3.3.15
prismatic astrolabe ... use impersonal astrolabe
astronomical compendium ... 6.1.15
astronomical ring ... 6.1.7
Baker-Nunn camera ... 6.2.2
backstaff also Davis's quadrant ... 5.4.3
baculus also arbaletum ... 6.1.3
cross-staff also Jacob's staff ... 3.3.4--5.4.1--6.1.2
diopter ... 3.2.6--6.1.4
Hipparchus' diopter ... 3.2.6.1--6.1.4.1
Jacob's staff ... use cross-staff
meridian circle ... 6.1.12

mural semicircle ... 6.1.18
octant ... 5.4.9--6.1.16
parallactic ruler ... use triquetrum
Ptolemy's ruler ... use triquetrum
quadrant ... 1.2.2--3.5.2
sinical quadrant ... 1.2.8
altitude quadrant ... 3.3.5--5.4.4--6.1.6
Davis's quadrant ... use backstaff
mariner's quadrant ... 5.4.5
movable astronomical quadrant ... 6.1.10
mural quadrant ... 6.1.17
nocturnal ... 5.4.6--6.1.5
repeating circle ... 3.3.10--6.1.13
ring dial ... 6.1.11
equatorial ring dial ... 6.1.11.1
universal equinoctial ring dial ... 6.1.11.2
zodiacal ring dial ... 6.1.11.2
telescope, hand held ... 6.2.3
astronomical telescope also Keplerian telescope ... 6.2.3.1
Galilean telescope also terrestrial telescope ... 6.2.3.2
Keplerian telescope ... use astronomical telescope
ship's telescope ... 5.8.1
terrestrial telescope ... use Galilean telescope
telescope, parallactic ... 6.1.21
telescope, reflecting ... 6.3.1
- the following divisions are not associated to the last entry, but they are hierarchical combinations of all the preceding entries, therefore only indexes subsequent to the first one (6.3.1) are reported here -
with spherical mirror ... .1...
with parabolic mirror ... .2...
with hyperbolic mirror ... .3...
multi-mirror telescope ... .4...
Schmidt telescope also Schmidt camera ... .5...
Ritchey-Chrétien telescope ... .6...
with primary focus ... .1...
with Cassegrain focus ... .2...
with Newtonian focus ... .3...
with Gregorian focus ... .4...
multi-focus ... .5...
in herschelian mounting 1
in altazimuth mounting 2
in equatorial ... .3...
English mounting 1
German mounting 2
fork mounting 3
yoke mounting 4
telescope, refracting ... 6.2.4
- the following divisions are not associated to the last entry, but they are hierarchical combinations of all the preceding entries, therefore only indexes subsequent to the first one (6.2.4) are reported here -
with non achromatic object glass ... .1...
with achromatic object glass ... .2...
with astronomical optical system also with Keplerian optical system ... .1...
with Galilean optical system also with terrestrial optical system ... .2...
in aerial mounting ... .1...
in altazimuth mounting ... .2...
in ecliptic mounting ... .3...
in zenith mounting ... .4...
in equatorial ... .5...
English mounting 1
German mounting 2
fork mounting 3
telescope, zenith ... 6.1.20
theodolite ... 3.3.12--6.1.14
circumferentor ... 3.3.12.1-- 6.1.14.1
repeating thedolite ... 3.3.12.2--6.1.14.2
torquetum also turquet ... 6.1.9
transit telescope ... 6.1.19
triquetrum also Ptolemy's ruler also parallactic ruler ... 6.1.8
turquet ... use torquetum

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