The Adler Planetarium and Astronomical Museum of Chicago

By PHILIP FOX, Director

The Astronomical Museum*

What might one expect to find in an astronomical museum? Certainly apparatus to show the fundamental laws so far as they can be so illustrated,—laws of dynamics, optics, spectroscopy, photometry, etc.; apparatus to show methods of observing; collections of instruments to show their development to modern forms; portrayal of results of observations so far as they can be brought to reveal the nature of the Sun, Moon, Planets, Comets, Stars, and Nebulae, the scale and architecture of stellar systems.

This museum is particularly fortunate in the possession of a superb collection of antique instruments. Some four hundred years ago the Strozzi family of Florence began a collection of scientific instruments, gathering and preserving things of worthy achievement. About forty years ago this collection passed into the hands of Raoul Heilbronner in Paris, after the War to Ant. W. M. Mensing in Amsterdam, and from him to the Chicago museum. It contains an unexcelled collection of astrolabes, nocturnals, armillae, globes, sundials, early telescopes, etc., by the most skilful craftsmen of the fifteenth, sixteenth, seventeenth, and eighteenth centuries. The items are marvellous not only for the learning and mechanical skill they display but for the beauty of workmanship. This collection of about six hundred pieces, to which generous friends have made recent additions, forms the background of the Museum.

It is remarkable that so many choice instruments have survived intact the shocks of the many years. The astonishment increases when one follows the quest of modern instruments which have figured prominently in scientific progress. So many have fallen victim to what Dr. Gunther has so charitably characterized as the “adaptive ingenuity of the younger scientists.”

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Dr. J. Wirth of Franckurt am Main, in an engraving made in 1768 from a painting by Joseph Wright, presented to the Museum by "The Philosopher Reading a Lecture on the Orrery."
Heilbronner had added some pieces to the collection while it was in his hands. Like accretions took place after the acquisition by Mensing, approximately thirty per cent in number of pieces. Mr. Ant. W. M. Mensing is a dealer and connoisseur in art treasures with a wide and detailed knowledge of old books, matters pertaining to navigation and exploration, and makers of maps, globes, and ancient instruments.

Mensing made a fine contribution to the literature on ancient instruments in the preparation and publication of a detailed, descriptive, analytical, richly illustrated catalogue. In the preparation of this work he was fortunate in having the assistance of Max Engelmann of the Mathematisch-Physikalischen Salon of Dresden, whom Dr. Bassermann-Jordan\(^1\) characterizes as “ein so vollkommenen und vielseitigen Kenner.” The notes of this catalogue have been of inestimable value in the study of the various pieces described and for an extension of the study to the uncatalogued items acquired also from Mensing and to pieces added later from other sources. From this catalogue it is at once apparent that the collection in its special field is of extraordinary charac-

\(^1\)Die Uhrmacherkunst, Halle (Saale) 12 Dec. 1924, p. 776.
ter, worthy to be compared with those of the Ashmolean Museum at Oxford, the Science Museum in South Kensington, London, the Conservatoire National des Arts et Métiers in Paris, or the Deutsches Museum in München, or with that gem-like collection in the jewel-box setting of the Mathematisch-Physikalischer Salon in Dresden. Its installation here puts this institution in an enviable position among scientific museums.


It is a collection of such character that Professor Bassermann-Jordan in a review of the Catalogue wrote, “Wenn die Sammlung Mensing auf den Markt kommen sollte, so werden die deutschen Museen sehr darauf zu achten haben, dass die wichtigsten deutschen Stücke Deutschland erhalten bleiben.” (If the Mensing Collection should be placed on the market the German museums must have care that the most important German pieces remain in Germany). The collection was offered to sale only in its entirety: through the generosity of Mr. Max Adler it came to Chicago intact. Those who with reluctance see such masterpieces of technical skill and artistic merit depart from their shores may be assured that this institution recognizes equally with them the solemn obligation to preserve and cherish the best work of past generations, that our respect for the knowledge and achievements of ancient masters may be enhanced and that the course of development of instrumental design may be revealed, both of these factors to serve as an inspiration for progress. Moreover, on seeing these treasures one’s mind turns irresistibly, and with growing admiration, to contemplation of the culture of the cities where they were made.

Today the skilful instrument maker is the essential right hand of
the investigator and this has been the case since first the observer took to instrumental aid in his search for greater precision and wider horizons. Then, even as now, both investigator and instrument designer and maker are often found in one individual. In our day we find the investigator keen in the design and development of new equipment. We may mention Rowland and the grating, Michelson with the echelon and interferometer, Nichols and the radiometer, Langley and the bolometer, Talcott and the zenith telescope, Herschel and his telescopes, Hale and Deslandres with the spectroheliograph. And so it was in the past. Blaeuw was the greatest cartographer of his time. Bion's "Traite de la Construction et des principaux Usages des Instruments de Mathematique" went through many editions, was translated into many languages. Galileo, maker of telescopes, founded modern mechanics and the experimental method in physics. Regnier Gemma (Gemma Frisius), professor of medicine in Louvain, suggested the method of triangulation in survey operations. Georg Hartmann, mathematician and theologian, was Vicar of St. Sebaldus in Nürnberg. Heiden was professor of mathematics at St. Agidien.

The fundamental problems of practical astronomy are the determin-
ation of time, geographical position, direction, star positions, motions of the Sun, Moon, and planets. Most of the pieces of the Mensing Collection bear directly on these problems for purposes of observation, recording, or explanation. There are some pieces not strictly astronomical.
cal mapping, etc., contributes clinometers, geodetic instruments, various scales, calipers, range finders, etc. Nicolas Bion in the preface to one edition of his work mentions the dual applicability of the various instruments in peace and war.

The instruments will be listed and described under various classifications but many of them are composite and might equally well fit into any one of two or more groups.

_Planetaria._ The Museum has three mechanical planetaria of early date which are noteworthy. The first, A.M. 392 (Fig. 3), was constructed by Pieter Isenbroek in 1737-8 and is therefore among the earliest. It stands 78 cm high and is 81 cm in diameter. The stand of walnut is very handsomely designed and finished. The celestial circle for the Tropic of Cancer bears the inscription “Door Pieter Isenbroek is dit Planetarium Uitgevonden den 5 Octob. 1737; en door den zelve Volmaakt primo Zeptembr, 1738. En Verbeetert Door Jan Pereste Haarlem 1793.” It was rather badly shaken in its long voyage but with some attention to the clock-work it may even now be kept in operation.

The second, A.M. 391 (Fig. 4), is by Benjamin Martin (b. Worple- don, Surrey in 1704, d. London 1781). Martin was a prolific writer and an instrument maker of skill and ingenuity. Mr. R. S. Whipple of the Cambridge Instrument Co., himself the possessor of an admirable collection of antique instruments, in an address\(^1\) for the Royal Institution 23 May 1930 characterizes Martin as “the first outstanding English instrument maker in the eighteenth century.” Among Martin's publications is a tract of date 1771 “The Description and Use of an

\(^1\) _Science N.S._, 72, p. 209, 29 Aug. 1930.
Orrery of a New Construction.”

The third is a Tellurion Clock, (Fig. 5), exhibited as a loan from Mrs. V. G. Malmstrom-Klaas of Chicago. It was constructed by Count Nils Filip Gyldenstolke with the aid of the watchmaker J. J. Sauter in Stockholm in the years 1795-1805. It is of brass, steel, and silver, height 22 cm. The globe is by R. B. Bate, London 1809. It gives the position of the Earth and Moon day by day, gives the hour, the day, the month. It is of superb workmanship. (See Fig. 28, A.M. 302, a Sauter ring dial.)

![Fig. 5. A Tellurion Clock by Count Nils Filip Gyldenstolke and J. J. Sauter, Stockholm, 1795-1805.]

Besides these antique planetaria, a modern electrically-driven planetarium by the Eastern Science Supply Company is exhibited and has been in almost constant operation for more than a year. The Museum acknowledges also the gift from the makers of a hand-driven Trippensee planetarium.

Globes. It may seem curious that the idea of a spherical Earth came to acceptance far later than the idea of the celestial sphere for the former is a fact, the latter a convenient fiction. Yet the stars and constellations were pictured on a globe centuries earlier than the construction of the first terrestrial globe. The nightly wheeling of the heavens brought the stars to recurrent appearance. The circumpolars directed the minds of the observant to the idea of the celestial sphere with the stars studded thereon. On the other hand the general acceptance of the globular Earth came only with the age of great explorations.
The earliest celestial globe extant is the marble Atlante Farnese preserved in the Royal Museum of Naples. Its date can be roughly estimated by the location of the equinoxes and seems to be about 300 B.C. It may even be by Eudoxus of Cnidus (409-356 B.C.) whose globe was described by the Cilician Aratus (c. 270 B.C.) in his poem "Phaenomena." Contrast the date of this early globe with that of the oldest extant terrestrial globe, that of Martin Behaim of the year 1492, the so-called Erdapfel, of the German Museum in Nürnberg.

The Behaim globe does not embody the first idea of an Earth globe for Crates of Mallos (d. 146 B.C.) made a terrestrial globe about 150 B.C. and Strabo (c. 63 B.C.-24 A.D.) refers to this in writing, "Whoever would represent the real Earth as real as possible by artificial means, should make a sphere like that of Crates." But this early idea was long lost to view.
Willem (Guilielmus) Janszon Blaeuw of Amsterdam (1571-1638), pupil and friend of Tycho Brahe, among the most distinguished of the long line of Dutch cartographers, is represented in the Mensing Collection by a great celestial globe, diameter 67 cm, engraved for the equinox 1640. (A.M. 440, Fig. 6). This globe came originally from the old Rubens House in Antwerp. Mensing purchased it from the famous library of the Duke of Gotha. It is a brilliant example in excellent pre-

A.M. 15.
A.M. 12.

FIG. 8. TWO SILVER GLOBES. DIAMETERS 58 MM. SOUTH GERMAN OF SEVENTEENTH AND SIXTEENTH CENTURIES.

servation. Stevenson\(^4\) mentions but one other of this size and date and that is in the Royal Library, Madrid.

The Arabs, preservers of learning, are represented by a beautiful bronze globe, diameter 174 mm, delicately engraved, the brighter stars inlaid in silver, with careful regard to relative brightness. (A.M. 14, Fig. 7). Inscriptions giving the star names resemble in modified form those of the globe of Mohammed ben Muyid el—Ordh 1279 in Dres-

\(^4\) Stevenson, Terrestrial and Celestial Globes, New Haven, 1921.
den. Other inscriptions have not yet been deciphered. From the location of the equinoxes the date appears to be about 1650.

Two beautiful silver globes, A.M. 12 and 15 (Fig. 8), engraved in low relief, each 58 mm in diameter, at first glance seem to form a pair. But judging by the pedestal and supporting figure (Herme) the celestial globe is of earlier design, from the middle of the sixteenth century. On the terrestrial globe the continents are well formed thus placing the date in the middle of the seventeenth century. The artist has engraved ships and creatures of the land and deep on the surface. He has drawn somewhat on his imagination in the matter of giraffes in South America, and crocodiles in Canada. Both globes are probably of South German origin.

In Stevenson's interesting volumes it is stated that the only known globe by Christian Heiden (1527-1576) is in Dresden.4 A.M. 16 closely resembles the work of this master. It will be examined carefully to see if it may gratify Stevenson's "pleasurable hope" that his published list might serve to bring to light other globes not included, by adding one by Heiden.

Two silver globes, one signed DeMongenet, gifts to the Museum from Dr. Harry S. Gradle of Chicago, are extensions to the Stevenson list. The Terrestrial Globe bears no maker's name but the Celestial has two inscriptions:

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\begin{align*}
\text{ELABORABAT} & \quad \text{EXIMO VIRO} \\
\text{FRANCISCUS} & \quad \text{D. GABRIE} \\
\text{DE MONGENET} & \quad \text{LI A} \\
\text{ANNO} & \quad \text{TIESBACH} \\
1605 & \quad \text{(Mark)}
\end{align*}
\]

Since the globes are of identical size, 86.5 mm, and design of mounting they are evidently a pair by the same cartographer. The known work of François DeMongenet of Vesoul and Besançon is of the years 1541 and 1552. There can be no error in reading the date 1605; moreover the equinox places the date in that neighborhood, perhaps a little earlier. The dates on the mountings are in both old and new calendars; therefore they are later than 1582. François DeMongenet died before 1592 so these globes are by a later engraver either a descendant or a copyist. The meagerness of information on DeMongenet and his career illustrates very well the difficulty of tracing various instrument makers. Also it exemplifies the word of Disraeli that: "Posterity is a most limited assembly. Those gentlemen who reach posterity are not much more numerous than the planets."

The Museum contains several other globes. An undated and unsigned celestial globe (A.M. 485) of silver finish, diameter 117 mm, ecclesiastically mounted. The location of the equinoxes fixes the date at

4 Stevenson, Terrestrial and Celestial Globes, Vol. I, p. 157. (The size given in the text should be corrected to 72 mm.)
c. 1500. This is confirmed by the March 12 date of the equinox on the mounting. It bears two pairs of letters NE and OC. A pair by Cary 1806 and 1835; a celestial globe from Weimar of date 1837, a gift of Mr. G. H. Jones of Chicago from the library of his father-in-law, Elias Colbert; and lastly, a celestial globe of date 1930 from Rand McNally.

Armillae. On the earliest celestial globes the systems of astronomical reference circles were inscribed. Diurnal circles, the equator, meridians, and the ecliptic appear on the Atlante Farnese. From these it is an easy stride to the armillary sphere (from armilla, a bracelet) in the midst of which the Earth or solar system might be placed. Ptolemy

(c. 100-170 A.D.) in the Syntaxis, or Almagest, describes the method of its construction and use. The Armillary Sphere may serve to represent the reference circles and their relation to the Earth, may serve for the transformation of coordinates, and to determine the actual positions of celestial objects and geographical position. Before the invention of the telescope the armillary sphere vied with the astrolabe and quadrant as the principal instrument of observation.

The collection contains thirteen armillae, each of great interest and artistically wrought. The cabinet where they are displayed is shown in Fig. 9.

Six are signed and dated:
A.M. 1 Gualterus Arsenius, Louvain........1562  Brass
A.M. 2 Alex Ravilius .........................1542  Brass
A.M. 4 Hironimus Vulparia, Florence........1582  Bronze
A.M. 5 Michael Coignet, Antwerp ..........1591  Brass
A.M. 8 Fran. Aldinus ................1660 Iron
A.M. 9 Eile Christian Högh Danicus ...... Brass

In Fig. 10 to the left is the sphere by Ravilius, A.M. 2. All numbers and letters are stamped into the metal. It is inscribed "Io. Thomae Manfredo MDXLII Alex Ravilius F." The support may be of later date, height 470 mm. To the right is an unsigned sphere, A.M. 7, a French or Italian work which stands 670 mm high. There are separate rings for the Sun and Moon. On the legs of the support is inscribed "Cabinet Du Roy Versailles." If this piece was made for the king at Versailles it cannot be earlier than 1627 for in that year the chateau was started, and probably not earlier than 1661 when additions were made. Mansart built the two wings, the chapel, the Galerie des Glaces in 1678. In 1682 Louis XIV took up residence there. The inscription on the instrument may of course be of later date than its construction. While these two armillae are fairly representative, A.M. 1 by Arsenius and A.M. 9 inscribed "Eile Christian Högh Danicus fecit" are of finer workmanship. The first, of the year 1562, shows several stars on small
arms projecting from the celestial circles reminding one of the Rete of an astrolabe, many of which were made by Arsenius. It shows also the Earth in the center with the continents in rather crude form. Sir Francis Drake’s voyage up the west coast of America came in 1577. Tasman (1603-59) came even later. The Danish sphere is of the seventeenth century. While the continents are more accurately delineated, the peninsula of Lower California is still represented as an island.

_Cleopatra_. The name astrolab [αστρον — star, λαμβανω (λαβεω) — to take] has been applied to a great variety of instruments from a planisphere to an armillary sphere. Here the meaning will be restricted to the flat or planispheric astrolabe described by Messahalla and by Chaucer. The essential features are two stereographic projections on the plane of the celestial equator or the meridian, one of the sky or universal sphere bearing the stars and the ecliptic for the Sun’s position; the other of the local sphere with vertical circles and almucantar. Due to the Earth’s rotation the local sphere and celestial sphere revolve with respect to each other, comparison of coordinates in the two systems providing means for the solution of various problems of practical astronomy.

In the astrolabe the projection of the sky is rotated about the pole; the relations between the projected systems reproduce their relationships of the sky and provide means for almost instantaneous solution of the spherical triangle, Zenith-Pole-Star. In addition there is a rule or alidade with sights for observing the altitude of Sun or stars. In general the instrument is provided with several projections of local spheres applicable for various latitudes. These are called tablets and are contained in fixed position in the outer receptacle called the Mother. The rim of the Mother is engraved for hour angles to be used in connection with the Rete and in degrees for altitude determinations. The tablet in use is on top and immediately under the Rete (from Reticulum, net) or Ankabut, a pierced metal plate, filigree, on which the universal sphere is engraved. The number of stars varies with the size and delicacy of the work. The Rete is rotated about a central pin representing the pole; Rete and tablets and alidade are held on the pin by a wedge called the Horse.

In use the astrolabe is suspended from a ring held on the observer’s thumb, the face of the instrument is in the plane of the vertical circle of the Sun or star, the alidade is pointed to the object and the altitude is read on the divided rim of the Mother. With the altitude read, the object on the Rete is brought to the observed almucantar and thereby local and celestial spheres are in adjustment for that moment. The positions of the Sun and all stars can be read at once; the zeniths, azimuthe, hour angles, the time,—all read directly.

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The astrolabe is variously ascribed to Hipparchus of Bithynia (c. 150 B.C.), to Apollonius of Perga (c. 240 B.C.), and to others. Hipparchus invented the stereographic projection and used also the armillary sphere. From these two ideas the flat astrolabe was derived, whether by Hipparchus himself, or in India, Persia, or Arabia, is not known. The Arabs certainly appreciated it, preserved, and perfected it, a “Mathematical Jewel.” It was not until the latter part of the fifteenth century that it was simplified for use on ship board sailing in various latitudes. Though every great ship during the sixteenth and seventeenth centuries must have been provided with such instruments few have survived the buffeting of time and tide. The deep sea or the bottoms of quiet harbors where rest the hulks of old ships must be their resting places. The astrolabe gave way to the octant and sextant.

It seems curious in our day to learn that Geoffrey Chaucer directed his description of the astrolabe to his son Lowys (Lewis) at age of ten years. It is consoling to know that the great poet put the Latin text into English conceding the Latin treatises too difficult and moreover containing “conclusions that will not in all things perform their promises.” Children must have been precocious in those days. But perhaps this quality has carried on and may have been as rare then as now. One is reminded of the verse by the genial Turner linking ancient and modern times.

“A tiny but precocious babe
Was playing with an astrolabe
Her younger brother did prefer
A large interferometer.”

The cabinet containing the astrolabes is shown in Fig. 9. There are twenty-eight astrolabes in the collection with perhaps six or eight related instruments. Of the twenty-eight, nineteen are of European construction, seven oriental, and one has both Turkish and French inscriptions. The inscription on the oriental instruments have not yet been deciphered but the locations of the equinox place them in the sixteenth century. Eight of the European pieces are signed.

A.M. 21 Bernardini Zabei, Padova........1559, 120 mm
A.M. 22 Georgius Hartmann, Nürnberg .......1540, 140 mm
A.M. 23 Gualterus Arscenius, Lauvain (Louvain).1558, 395 mm
A.M. 24 Gualterus Arscenius, Lauvain ........1564, 340 mm
A.M. 31 Ludovicus Martinot, Agendici (Sens)...1598, 265 mm
A.M. 33A Ioannes Bos (Roma) ..................1597, 125 mm
A.M. 463 P. Sevin, Paris .......................1682
A.M. 464 C. Emmanuel, Paris

Of these names Zabei, Martinot, Bos, Sevin, Emmanuel are not included in the list of names noted by Gunther.*

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Fig. 11. A.M. 36. An Oriental Astrolabe.

Fig. 12. A.M. 41. An Oriental Astrolabe.
Fig. 13. A.M. 33. A LARGE ENGLISH ASTROLABE. DIAMETER 475 MM.

None of the four astrolabes shown in Figs. 11, 12, 13, 14, are of known authorship though the oriental dials may perhaps bear signatures. Two of them are represented both in front and reverse. A.M. 36 (Fig. 11), diameter 150 mm, shows the almucantars at six-degree intervals. This astrolabe is provided with five tablets. A.M. 41 (Fig. 12), diameter 133 mm, is handsomely engraved with patterns of flowers and vines. Almucantars are at three-degree intervals. There are four
silver tablets making it adaptable to eight different latitudes.

A.M. 33 (Fig. 13) presents a different type of projection, like that described as the Astrolabio Malcotij in the translation of Regnier Gemma's, De Astrolabo (1556), a small volume "Astrolabiorum" published in Bologna in 1610. This particular instrument is unusually large, having a diameter of 475 mm. The inscriptions are in Latin and English. It is undoubtedly of English origin. Dr. Gunther suggests John
Blagrave as a probable maker. If so, its date is prior to 1611 for in that year he died. The equinox is given as March 21; therefore the instrument is later than 1582.

Gunther indicates that Habermel, renowned as maker of instruments for Tycho Brahe, constructed an astrolabe for the Strozzi family. An unusual piece in that it is made of copper, and though unsigned, resembles the work of Habermel is present in this collection through the hands of the Strozzi. Engelmann notes “Vermuthlich Werkstatt des Erasmus Habermehl, Prag.” From his shop perhaps but not by Habermel for the piece bears the date 1620 and shows the comet of 1618. Habermel died in 1606. This astrolabe, A.M. 34 (Fig. 14), is unique in showing the positions of the “Nova Stella 1600” (P Cygni) and Kepler’s “Nova Stella A1604.”

As the planisphere is the basis of the astrolabe it is not out of place to mention here a large tilt-top table from the library of Professor H. H. Turner of Oxford, whose rhyme on the astrolabe was quoted above. The table top (diameter 108 cm) has a most exquisitely inlaid planisphere. The top is of satin wood, the stars are brass inlay, the lines connecting the principal stars of the constellations and marking the hour circles, equator, and ecliptic are inlaid maple strips as fine as the most delicate purfling of violins. The zodiacal figures are sketched about the edge. All inscriptions are in French. A French work, and judging by location of the equinox, of date about 1840. As a piece of furniture it would be placed fifty to seventy-five years earlier.

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![Diagram](image)

**Fig. 15. The Principle of the Nocturnal.**

*Nocturnals.* The nocturnal seems to have been described first in 1533 by Apianus⁷ (Peter Bemewitz 1495-1552). It consists of a disk with a central perforation through which the observer looks at Polaris with the plane of the instrument perpendicular to the Earth’s axis, the meridian of the instrument in the plane of the celestial meridian, (Fig. 15).

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⁷Instrument Buch durch Petrum Apianum, Ingolstadii An. MDXXXIII.
A protruding arm is rotated about the center until it is directed toward the star for which the instrument is constructed, generally α Ursae Majoris (Dubhe) or β Ursae Minoris (Kochab). If for α Ursae Majoris, the instrument is graduated to read 11 hours when that star is at upper culmination. When a setting is made, the sidereal time is then read directly. This can be transformed to solar time either by mental calculation or by instrumental means. The instrument does not permit of accuracy, so never attained great vogue.

Suppose the hour angle of Dubhe to be 15 hours. Since the right ascension is 11 hours, the sidereal time, (right ascension plus the hour angle) is 2 hours. If at the time of the above observation the Sun’s right ascension is 18 hours then the hour angle of the Sun (the apparent solar time) is 8 hours.

The Collection contains eight instruments primarily nocturnals but the nocturnal also appears as an auxiliary in several other pieces, for exam-
ple the Cole calendar, A.M. 363, to be mentioned later. Seven nocturnals are illustrated in Fig. 16. The only signed nocturnal of the collection, A.M. 331, "Antonius Giamin fecit Romae Anno Dm 1592" is not shown in the figure. Three others are dated—A.M. 330 “Romae 1578,” A.M. 333 “1589,” and A.M. 334 “1572.” The largest one shown, A.M. 329, diameter 125 mm, bears also a Moon calendar and diagrams for astrological purposes. Four of them, A.M. 332, 334, 335, 336, have so many features in common that they are probably from the same master. They resemble that illustrated in Fig. 136 of Rohde’s "Wissenschaftliche Instrumente." A.M. 330, lower left in Fig. 16, is the most beautiful nocturnal of the collection.

**Quadrants, Octants, Sextants.** The Collection contains several quadrants, octants, and sextants. All of the instruments of Fig. 17 may be used for measurement of altitude; A.M. 179 in the center of the upper row is primarily for this purpose. This instrument, radius 149 mm, is of fine gilt or ormulu finish, unsigned but resembles the work of Habermel. Instruments of this character in enlarged form with fixed quadrant and pivoted alidade (or, later, telescope) mounted in the meridian as a mural quadrant or in a vertical circle with motion also in azimuth, were the principal observational equipment for position astronomy of the most prominent observatories until near the end of the eighteenth century and this in spite of the fact that Roemer had invented the meridian transit instrument and pointed out the advantage of a full circle at the end of the seventeenth century. Some of the mural

**Fig. 17. Six Quadrants of Various Forms.**

A.M. 159. 
A.M. 158. 
A.M. 179. 
A.M. 143. 
A.M. 182. 
A.M. 183.
quadrants were very large; that of Tycho 9-foot radius, of Bradley 8-foot radius.

A.M. 180 (Fig. 18) is a beautifully engraved octant inscribed "C T D E M 1618," Christoph Trechsel der (Dresden?) Edler Mechanikus. (.....-1624). The diagonal scale provides direct reading to 10'. It is prior to the invention of the vernier. There are four other pieces by this master in the collection. In the engraved ornamentation of the
octant is a coat-of-arms "Johan Wilhelm Herzog zu Sachsen Gulich Cleve und Bergk" but of greater interest for science are the types of mathematical instruments to the right of the arms. The juxtaposition of instruments of war and peace brings to mention that Trechslar made a machine gun (mitrailleuse) in 1595-8. It was not put into use for it was said that 5000 musketeers were cheaper than 500 of the weapons. This decision does not seem so antiquated when compared with the preparedness programs of modern legislators.

There are two large reflecting octants in wood, (Fig. 19). A.M. 478 has the circle engraved on wood with a diagonal scale for readings to 2'. In A.M. 479 the circle is of ivory and is read by a vernier to 1'. The fact

![A.M. 478 and A.M. 479.](image)

A.M. 478.  A.M. 479.

Fig. 19. Early Octants and Reflecting Sextant.

that one of these has a diagonal scale and the other a vernier does not fix the relative date, for both of these devices far antedated the octants. The inventor of the diagonal scale, or transversal, is not known, though the names of Homelius of Leipzig, teacher of Tycho Brahe, and Kantzler of London are mentioned in this connection. It is probably contemporary with the nonius, for Tycho Brahe (1546-1601) adopted it after trying the nonius. The nonius was the invention, 1542, of the Portuguese writer on mathematics and navigation, Pedro Nunez (1492-1577), who also is credited with the invention of the loxodromic line. The vernier is later, 1631, by the Frenchman Pierre Vernier of Ornans (1580-1637). The small sextant, A.M. 184, which stands above the
octants is signed "Brander und Hörschel in Augsburg" (c. 1760). To whom belongs priority in the invention of the reflecting octant, or sextant into which it developed, is somewhat debatable. Newton's description of the invention was communicated to Halley in 1699 but was not published until 1742, after Newton's death. Thomas Godfrey (b. 1704 Bristol Township, Philadelphia; d. 1749 Philadelphia) seems to have anticipated John Hadley (1682-1743) by a year or more. His instrument was in use in 1730\(^a\) while that of Hadley was described to the Royal Society in its meeting of 13 May 1731. The Royal Society awarded the two equally.\(^b\) This invention is probably the first of an important scientific instrument to come out of America.

The Museum has also a sextant by Cary, No. 3379, gift of Mr. Harry Oppenheimer of Chicago, and one by Brandies and Sons, Brooklyn, N.Y., gift from the U.S. Navy, marked "No. 1736."

Time-keepers. All appreciation of time is related to motion. The pulse marking the rhythmic surge of blood through the arteries, the shortening of the burning taper, the creeping shadow of a gnomon, the discharge of water or sand through an orifice, the oscillation of a pendulum or balance wheel,—may be used to measure the rotation of the Earth and give the time of day. The history of the development of devices for indicating time is told in many museums. Comments on the various instruments here will be made in the order Dials, Hour-Glasses, Clocks.

Sun-Dials. The invention of the Sun-dial at least in its spherical form is attributed to both Eudoxus (404-356 B.C.) and Apollonius (250-180 B.C.). The flat dial came into use with Aristarchus of Samos (310-230 B.C.). In later developments the Dial has taken many forms: multiple-faced or polyhedral, pillar or chilindre, sometimes called Shepherd's dial, ring, cruciform, compass dial, equatorial, horological ring, universal ring dial, but all depend on the position of the Sun in its daily course; its hour angle, or its altitude. All of these forms and numerous special forms are represented among the hundred or more dials of this Museum. Some are large, intended for fixed mounting; others are small portable dials, pocket dials such as that mentioned in "As You Like It":

"And then he drew a dial from his poke
And looking on it with lack-lustre eye
Says very wisely, 'Tis ten o'clock:
Thus we may see,' quoth he, 'how the world wags.'"

A general view of one of the dial cabinets (Fig. 20) will indicate the variety. Fully half of the dials are signed and among the names are

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found those of the most celebrated instrument makers of the years when dialling was at its best. No attempt will be made here to trace the development,—the transition from the scaphe to the horizontal dial;

Fig. 20. Cabinet with an Assortment of Sun-dials of Various Forms.

Fig. 21. A.M. 288. A Sun-dial Signed “MARIA HILFVNSNA 1479.”
the displacement of the unequal or temporary hours by equal hours; the introduction of the inclined style, parallel to the Earth's axis, the Polus, by Puerbach, von Gmunden, Regiomontanus; the introduction of the compass by Puerbach; the equatorial dial; ring dial, and universal ring dial developed especially in England—but rather we shall be content here to discuss briefly a few of the specimens, reserving for another occasion a more complete treatment.

Fig. 22. A.M. 289. Horizontal Dial with Armorial Devices.

The ring dial, A.M. 307, on which all inscriptions are in Gothic, is probably one of the oldest of the Collection, but the dial which bears the earliest date is A.M. 288 (Fig. 21). It bears the signature "MARIA HILFVNSNA 1479" also the statement of the adaptability of the dial to all latitudes, "ISTVD OPVS AD OMNEM REGIONEM." The figures are Gothic, as may be seen in the table of co-latitudes for PARISIVS (Paris) 42, REMIS (Reims) 41, LVGDVNV (Lyon) 43,
BLEGIS (Blois) 42, BAIONA (Bayonne) 47, etc. I find no reference to other dials with this signature.

A.M. 280 (Fig. 22) carved on stone and colored (360x340 mm) is of especial interest because of the armorial devices. I. Above to the left is the coat-of-arms of the Casa Savoia with the motto \textit{"FERT-FERT-FERT"} (Ready) derived from Fortitudo Eius Rhodum Tenuit. II. On its left is found the same combined with the fleur-de-lis of France, the union of the House of Savoy and the House of Orleans. Louise of Savoy married Charles d'Anjouleme of the House of Orleans. Their son (1494-1547) became king of France, Francis I. III. The coat-of-arms above the style bears dexter the three crescents of the Strozzi, sinister is unknown. The dial bears the inscriptions \textit{"SOLO MVTATVR ASPECTV"} and \textit{"GEMINO PRAESIDIO TVTVS."} This dial is undated and unsigned but was probably engraved for the Strozzi family who so long fostered this collection of instruments.
A.M. 277 (Fig. 23) is faultily described in the Mensing Catalogue. The inclination of the style and the bearings of the hour-lines place the latitude at about 28°. This together with the engraved monkey places this dial in India, possibly Jaipur or Delhi. It is the most southern dial of this collection. The style is faultily placed; its foot is not in the prime vertical. The morning hours VI, VII, VIII are incorrectly inscribed. A well-nigh illegible device seems to give the year as MDXI. (325x330 mm).

Fig. 24. A.M. 249. A Carved Ivory Dial of the Sixteenth Century.

A.M. 249 (Fig. 24) is a beautifully engraved ivory dial of South Germany of the sixteenth century. The top is carved in high relief showing the scourging and bearing of fagots for the immolation pyre. The height is 84 mm.

Increase of accuracy over that attained by Martin, Rugendas, Vogler, etc. (see in Museum dials by these makers or that by Delure loaned by Mrs. James G. S. Orchard of Evanston) was accomplished in the dials by Claude Dunod of Dusseldorf (French origin) in 1710-15.
He added an auxiliary indicator with a minute hand. This was geared with the main dial (which stood in the equatorial plane) but was attached to an alidade to be directed toward the Sun, the minute-hand rotating through the sixty minutes with each 15° change of hour angle. Dunod is not represented in the collection but there are two dials of other makers which illustrate the type. A.M. 300 (Fig. 25) signed "I. Stöckl" resembles the work of Dunod very closely. A.M. 297 (Fig. 26) signed "Joh. Georg Wernle Presburg" (c. 1750) does not have the auxiliary dial but the hands are geared to a rotating disk carrying the alidade. The dial face is enameled. A more elaborately developed dial of this type is seen in Fig. 28.

A.M. 314 (Fig. 27) presents an example of universal ring dial in its perfected form. The elevation of the pole and the motion in azimuth effected by rack and pinion are read with verniers to the nearest minute.

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Rohde, loc. cit., p. 30, Abb. 34, 35, 36.
of arc. The pinnule is movable with an accurate scale for its adjustment for the date. There is an excellent compass, a pair of levels also in the compass box, height 432 mm. It is signed: "Edw. Nairne, London." Nairne was a versatile instrument maker; Repsold\(^\text{11}\) cites an equatorial mounting by him of the year 1771.

\[\text{Fig. 26. A.M. 297. A Dial by Wernle of Pressburg.}\]

A.M. 302 (Fig. 28) is one of the most beautifully constructed dials in the Collection. It is the work of "J. J. Sauter, Stockholm" whose tellurion clock is shown in Fig. 5. It is a ring dial with the adaptation of the geared clock face to yield the minute. The graduated plate which receives the solar image bears also curves to permit allowance for the equation of time. It is a close replica of the instrument shown in Fig. \(^3\)

\(^3\) Repsold, Astronomische Messwerkzeuge, Leipzig, 1908, Fig. 98.

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Courtesy Maria Mitchell Observatory • Provided by the NASA Astrophysics Data System
Fig. 27. A.M. 314. An elaborately developed universal ring dial by Edward Nairne, London.