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Editorial

Chairman's Message

Last year, my interest in the history of scientific instruments led me to become a Freeman of the Worshipful Company of Spectacle Makers in the City of London. From the second half of the eighteenth century, when London was arguably the capital of the world scientific instrument trade, through into the nineteenth century, such makers as Edward Scarlett, James Ayscough, Francis Watkins, Edward Nairne and Thomas Blunt (of Nairne & Blunt), Peter, John and George Dollond, all served as Masters of the Company. Unlike today, when there is a Worshipful Company of Scientific Instrument Makers for modern-day practitioners to join, makers of instruments then had to choose one of the pre-existing livery companies if they wanted to practise their trade within the City walls unmolested by the City authorities. For manufacturers of optical instruments, the Spectacle Makers must have seemed a natural choice.

However, this didn't prevent that other livery company involved in the high technology of the day, the Worshipful Company of Clockmakers, from feeling that instrument makers should be applying to become freemen of their own company instead. Things came to a head in the 1810s when Robert Bate (familiar now as Bate of the Poultry) applied to be made free of the Spectacle Makers, and the Clockmakers were moved to petition the City's Court of Aldermen to block Bate's application. The Spectacle Makers entered a counter-petition, and after several years of ill will between the two companies, Bate's application was eventually allowed. He went on to become Master of the Spectacle Makers in 1828-9.

These days, relations between the Spectacle Makers and the Clockmakers are far more friendly, and there is even an annual Four Liveries Lecture jointly organized between the Spectacle Makers, the Clockmakers, the Worshipful Company of Scientific Instrument Makers and the Lightmongers' Company to hear an eminent speaker on a topic of mutual interest.

Our Society may be international, but my own recent involvement with the Spectacle Makers has shown that some members of the SIS have links with the City of London that are just as strong. SIS Committee members Neil Handley and Charles Miller are both Liverymen of City Companies. Neil, who in his professional capacity is Curator of the British Optical Association Museum at the College of Optometrists, is (naturally enough) a Liveryman of the Spectacle Makers, whereas Charles exercises one of his many interests by being a Liveryman of the Worshipful Company of Tobacco Pipe Makers and Tobacco Blenders. Our congratulations to Charles, who will be taking over as Master of his Company in 2016-17!

Both Neil and Charles have served as Secretary of the SIS at different times, and we are very grateful to them both for their valuable contributions to the Society. But Neil will be retiring from the Committee in June and Charles will probably be too busy to continue when he becomes Master of his own Company. We are always on the lookout for new volunteers, so if you would like to help keep the Society running, please do not hesitate to offer. Happy reading!

Marcus Cavalier

Cover Illustration

Sergei Maslikov describes one of the most remarkable instruments from Peter the Great's collection of scientific instruments - a planispheric astrolabe made in 1614 and purchased in France at the behest of the 14-year old Tsar. The suitably named Dutch joiner Franz Timmerman (the name means 'carpenter') was brought to the palace to teach the young Peter arithmetic, geometry, fortification, and the use of this astrolabe. Peter I's sheer physical presence at nearly 7 feet tall, ruthless and hugely energetic, earned him the title of Peter the Great. He was keen to turn Russia into a modern European state by centralizing the government and modernizing the army. In his endeavor to create a powerful navy he appreciated the strategic importance of the Baltic and found a new capital, Saint Petersburg, at the mouth of the Neva at the east end of the Gulf of Finland. One of the countries he visited was the Netherlands in particular to learn about shipbuilding. In Moscow Peter had in his employ the Dutch blacksmith Gerrit Kist who came from Zaandam a region with many small ship yards so when he arrived in the Netherlands in 1697 he insisted on staying with Kist in his home (Fig. 1), despite Kist's protests that his house was a mere hovel, shared with the widow of one of his workers. The widow was paid to move out, and Peter spent 8 days as Kist's houseguest. As is shown in this old engraving of the visit, Peter was a very hands-on guest and insisted in being shown how to use the tools of the shipwrights. He then moved to Amsterdam to see the building of larger ships in the yard of the Dutch East Company. In 1698, the ship on which the Tsar had worked was launched. Peter was not satisfied by the Dutch method of shipbuilding and travelled to England in the hope of learning more about theory. In 1717, Peter returned to the Dutch Republic a second time. Kist initially refused the visit of his erstwhile lodger as the Tsar had not paid his rent - but this story may well be apocryphal.

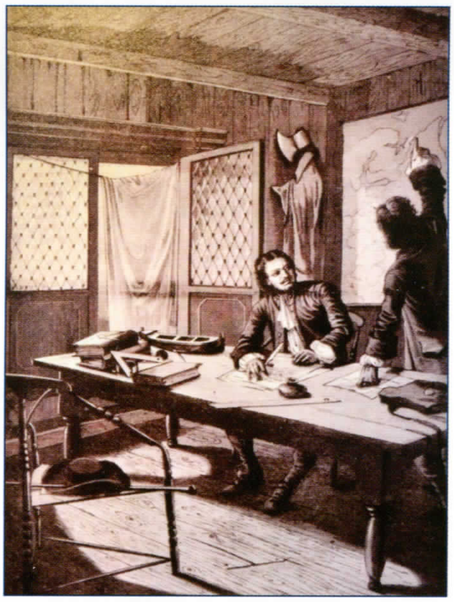


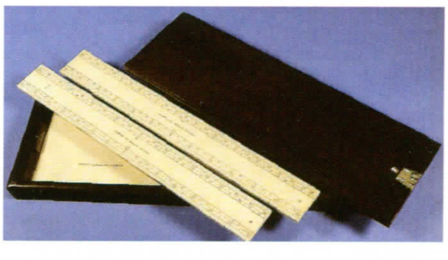
Fig. *1 Learning the practical arts of the shipwright in Gerrit Kist's little wooden house.*

Besides shipbuilding, Peter also learned about watch-making, about making coffins, etchings, book printing, post-mortems, paper making and silk spinning. The anatomist Frederik Ruysch showed Peter how to pull teeth, and he visited a dissection performed by Herman Boerhaave at Leyden.

Kist's small wooden house known as the 'Czar Peter House' is now a popular tourist attraction and is preserved by a brick cover built in 1895.

WDH

Book Review



Ivory Marquois scales, stamped 'ELLIOT, 449 STRAND LONDON'. *This set of fine scales dated 1854-1866 is illustrated in* Mr. Marquois's Most Useful Pair of Scales, *by James M. Gaynor, edited by Jane Rees, and reviewed by David M. Riches on page 9).*

Peter the Great's Astrolabe Celebrates 400th Anniversary

Sergei Maslikov

The Winter Palace of Peter I of Russia is a part of the State Hermitage Museum (St. Petersburg).This building holds a collection of objects and items related to the life and work of Tsar Peter, and here some rooms of his residence are reproduced. Most of the collection of Peter the Great's scientific instruments was compiled in the Kunstkamera immediately after Peter's death in 1725 and for the past three centuries the collection has repeatedly been moved from one bank of the Neva River to the other - from the Kunstkamera to the Hermitage and back.[1]

This article describes only one exhibit from the Tsar Peter's collection of scientific instruments - a planispheric astrolabe manufactured in 1614. According to the extant evidence, this astrolabe was used by the young Tsar in his studies. So far, this instrument has not been investigated in detail. Now it is the time to do it, all the more so because in 2014 we celebrated the 400th anniversary of its making.

Fig. 1 *An exterior view of the astrolabe.*

The famous Russian historian Nikolai Kostomarov described how Peter I got this astrolabe: "Being fourteen years old [in 1686], he heard from Prince Jacob Dolgoruky [1639–1720] that the latter had a tool 'that can take a distance to an object before reaching the place.'"[2] The young Tsar wished to see the instrument, but Dolgoruky replied that it had been stolen. The Tsar ordered Dolgoruky to buy such an instrument in France where he was sent as an ambassador. In 1688, Prince Dolgoruky brought from France an astrolabe and a set of drawing and mathematical instruments. There was not a single person around the Tsar who knew how to use the astrolabe. Then a Dutch joiner Franz Timmerman was found in Sloboda who explained to the Tsar the use of the instruments brought to him. Peter I assigned Timmerman to the castle as close to his residence and possible and the Dutchman began to teach the young Tsar arithmetic, geometry, and fortification. This story is also described in foreign publications.[3]

It should be noted that Dolgoruky had successfully completed Peter's assignment because the astrolabe, which he brought, had been made for the latitude of Moscow and Preobrazhenskoye village located 8 km away from the Kremlin where the Tsar resided, i.e., 55 degrees 45 minutes. Apparently, it was not easy to find such an instrument. Both Paris and London lie further south than Moscow. The previous owner and the customer of this instrument could have lived in the north of Germany or Poland, or in Denmark.

With Timmerman's help Peter at the age of 16 learned to determine the latitude of the locality by measuring the noon altitude of the Sun, which is confirmed by his own hand-written record:

> *When you want to select a polo* (i.e., when you want to find the altitude of the pole) *and when you do it and how many degrees ... the Sun will point to the astrolabium and you write it and then take the declination of that day* (i.e., declination of the Sun) *and take it* (i.e., deduct it) *from the number, which the Sun will show, and the rest that had remained after taking out deduct from 90, and what remains after this is the number of degrees of the latitude. The declination is must be decreased in winter and increased in summer.*[4]

Actually, this record describes the formula $\varphi = 90 - (h - \delta)$,

where φ is the latitude of the locality, h is the altitude of the Sun in the upper culmination, and δ is the declination. Note: Perhaps it was during Peter's training period that terms, explaining the meaning of the scales - MINVTA and HORA - were scratched on the front side of the astrolabe at its upper edge.

Description of the Astrolabe and its Parts

The astrolabe (Fig. 1 and cover) is made of brass and consists of eight separate pieces. The main part is the mater 257 mm in diameter with a small eyelet for hanging the tool. The eyelet is so small that it can hardly be called by the conventional term 'throne'. The ring for holding the astrolabe was lost. There is a plate (also called a 'tympan') fixed by two pins to prevent it from turning. On the surface of the tympan there are engraved lines of altitude and azimuth - the

Fig. 2 *Central figure with a caliper and a ruler in his hands, surrounded by an inscription.*

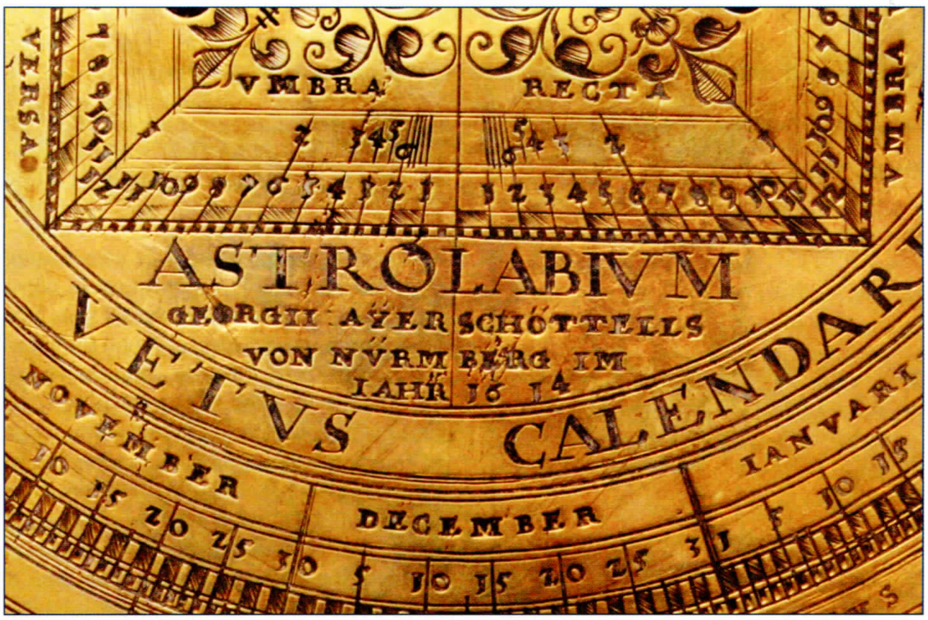


Fig. 3 *Detail of the Shadow square.*

projection of the horizontal coordinate system. Over the plate, a freely rotating disk is fitted called a 'rete' (Fig. 4), which is actually a stereographic projection of the sky. The properties of such projections were known to the ancient Greeks - to Apollonius (3rd century BC) and Hipparchus (2nd century BC) and had been used successfully for two thousand years. A narrow rule rotates over the rete, it facilitates the operation of the astrolabe and is often used as an hour hand. It is marked with a scale of declinations and bears inscriptions - 'DECLINATIO SEPTENTRIO: nalis' (boreal declination) and 'DECLINATIO AVSTRALIS' (austral declination) the scale is graduated in degrees. On the reverse side of the mater, an alidade is attached to the axis, at the ends of which sights were supposed to be provided for angular measurements. The sights themselves have not been preserved, but the places of their attachment are visible.

All the above-mentioned units, i.e., the rule, rete, plate, mater, and alidade, have a central hole and are pinned together with a cup-square bolt and a square nut. A sleeve is fitted on the bolt for a smoother rotation of the movable parts; it also serves as an abutment for the nut, preventing the instrument from overtightening. Brass sheets 1.5 mm thick were used for making the mater, tympan, rule and alidade. Only rete has a smaller thickness - 0.9 mm.

Mater

The diameter of the mater is 257 mm. This value is close to 10 English inches - 254 mm, and 10 Prussian inches - 261 mm, a little different from the both of them. The mater consists of three interconnected plates, each 1.5 mm thick (the traces of the possible riveting are only visible on the face side), and thus the total thickness is 5 mm. The eyelet for hanging is a continuation of the middle plate.

The limb of the mater bears several scales. The outer ones - time scales - are minute and hour scales. The circumference is divided into 24 hours; each hour is designated by a Roman numeral and duplicated by the usual numbers - twice from 1 to 12. Every hour is divided into 15-minute, 5-minute, and 1-minute parts.

The internal degree scale is graduated into 5, 1, and 1/3-degree divisions. The divisions increase from 0 to 360 degrees starting from the left edge of the astrolabe marked as ORIENS (east). The scale is duplicated by the marks originating from the points ORIENS and OCCIDENT (west) in the both directions from 0 to 90 degrees. The vertical diameter is marked by MERIDIES (south) at the top and SEPTENTRIO (north) at the bottom.

At the Back of the astrolabe there are four scales. One is the outer degree scale with divisions of 5, 1, and 1/3 degrees and numerical indication from 0 to 90 up and down from LINEA HORIZONTALIS. It is followed by a zodiacal and two calendar scales showing Julian and Gregorian calendars.

The zodiacal scale starts from the right edge, on which the signs run counterclockwise: ARIES ♈, TAVRVS ♉, GEMINI ♊, CANCER ♋, LEO ♌, VIRGO ♍, LIBRA ♎, SCORPIVS ♏, SAGITTARIVS ♐, CAPRICORNVS ♑, AQVARIVS ♒, PISCES ♓. Each sign is divided into 5, 1, and 1/3 degrees.

The internal calendar scale is such that 0 degrees Aries corresponds to March 10 1/3 - this is the old or Julian style, which is confirmed by an inscription VETVS CALENDARIVM. On the other scale, zero point corresponds to March 20 1/3 (new, or Gregorian style). The number of days in February is 28 ¼. Months are designated as IANVRIVS, FEBRVARIVS, MARTIVS, APRILIS, MAIVS, IVNIVS, IVLIVS, AVGVSTVS, SEPTEMBER, OCTOBER, NOVEMBER, and DECEMBER. The presence of two calendar scales can be attributed to the fact that Prussia passed to the new style in 1610 but Nuremberg belonged to the Protestant union where the new calendar was only adopted in 1700. Thus, in 1614 when the astrolabe was made there were two calendars in Germany. The difference between them was 10 days, which was reflected on the scales of the astrolabe.

In the upper half of the back of the astrolabe, an unequal hour diagram is located with numbers from 1 to 12. These lines are a relic of the past when day and night were divided into 12 equal parts. In this case, the length of day and night hours was different. More relevant in the 17^{th} century were equal hours scales located on the tympan.

In the central part, there is a maker's figure with a caliper and a ruler in his hands (Fig. 2). The figure is surrounded by an inscription "Bei diesem Werck Das Beste thutt Linial Grabstückell Zirckell Gutt," which in modern German reads as 'Bei diesem Werk das Beste tut Lineal Grabstichel Zirkel gu' (which can loosely be translated as 'High quality is ensured by using a ruler, pen, and divider').

In the bottom half, the so-called 'Shadow Square' (Fig 3) is located. Its horizontal scale VMBRA RECTA (direct shadow or 'shadow of the gnomon standing vertically') is a cotangents scale; the vertical scales on the right and left of the VMBRA VERSA (the 'shadow of the gnomon on the wall') are scales of tangents. Both of those are divided into 12 parts. For instance, tg 30° = 7 divisions, which means $7/12 \approx 0.58$. The scale VMBRA RECTA has auxiliary divisions numbered from 1 to 6. For example, the 4 main divisions make up 1/3 of the scale, 6 divisions are ½ of it, etc.

An inscription engraved below the Shadow Square reads 'ASTROLABIVM GEORGII AŸERSCHÖTTELLS VON NURMBERG IM IAHR 1614' and informs about the name of the maker and the year when the instrument was produced.

Very little is known about the maker of the astrolabe. According to two records in Bd. II of the reference media[5], it is clear that in 1606 Jörg Airschöttl (Ayerschettel) originally hailing from Grefenberg (north of Nuremberg) was an apprentice of the famous Nuremberg goldsmith Fridrich Hillebrand. In Bd. III of the same edition, Georg Ayerschettel (Aiershötel) is referred to as a jeweler. So far, the astrolabe of 1614 has been known to be the only instrument made by this maker.

Fig. 4 *The rete. The inset numbers designate the stars from Table 1.*

Tympan

Tympan is a stereographic projection of the observer's horizontal coordinate system on a flat surface. As the pole height is different at different latitudes the tympans had to be specially made for individual latitudes. Arabic astrolabes were equipped with a set of up to seven plates, each engraved on both sides. Our astrolabe has only one tympan, engraved on both sides for latitudes 54 and 55 degrees: 'LATITUDO LIIII GRAD' and 'LATITUDO LV GRAD'.

There are the following inscriptions on the tympan: 'LINEA CREPVSCVLI ET AVRORAE' (twilight and dawn), 'HORIZON RECTVS' (straight horizon), 'HORIZON OBLIQVVS' (sloping horizon), 'TROPICVS CANCRI' (tropic of Cancer), 'AEQVINOCTIALIS' (equinox), 'TROPICVS CAPRICORNI' (tropic of Capricorn), 'Horae ab Ortu Solis' (hours for the morning sun), 'Horae ab Occasu Solis' (hours for the setting sun).

Of the greatest interest are here the last two inscriptions accompanying two sets of curves – the so-called scales of 'equal hours'. They correspond to the time reference system, under which the day and night were divided into 24 equal hours. The initial time reference might have been the moment of the sunrise for the so-called Italian hours - *Horae ab Ortu Solis*. The eastern part of the horizon (on the left) corresponds to 0 (or 24) o'clock.

Another way of calculating the time is using equal hours from the time of sunset - Babylonian hours - *Horae ab Occasu Solis*. The zero (initial) point coincides with the western part of the horizon (it is on the right). There are hour (solid) and half-hour (dotted) lines on the tympan for both methods of time reference. These lines intersect to form a grid rather complicated for practical use. It is all the more so, that the user had to consult it through the rete superimposed on the tympan. In determining the time, it was necessary to find the position of the Sun on the ecliptic on the relevant day of the year and then find the matching hour line. The hour lines are located below the horizon. Therefore, in the daytime, when the Sun was above the horizon, time was measured with respect to the point opposite to the Sun.[6]

Most of the tympan is covered by the lines of the horizontal coordinate system. Lines of equal altitude (almucantars) are drawn around the zenith point with 5-degree steps. The horizon is highlighted by a double line broken into small divisions of 1 degree. Lines of equal azimuth are drawn from the zenith line to the horizon line also with 5-degree steps.

From the north point on the middle line of the horizon (below the centre) there is a set of lines of the so-called 'houses of Heaven'. This is a system for the division of the celestial sphere into 12 astrological 'houses', six of which are above the horizon, and six are below it, which was first presented in the publication of Regiomontanus (1436–1476) in 1467, although it might have been actually developed by his teacher George Peurbach.[7] The system is based on the division of the equator into 12 equal parts. The lines of the houses are drawn through the points of the north and south, and the appropriate division on the equator. The houses are numbered with Roman numerals on the edge of the disk from I to XII starting from the eastern horizon and increasing counterclockwise. Each house has a symbolic significance in astrology, for example, I signify a person, II – money, etc. Division into 'houses' has never been found in Arabian astrolabes.

Rete

The rete (Fig. 4) is a stereographic projection of the sky on a flat surface. According to the ancient conception of the world, the earth was fixed (stationary tympan), and the heavens (rete) rotated.

The rete structure in this astrolabe is very unusual. It is based on two circles – the circle of the ecliptic and the circle of the equator – and the semicircle of the Tropic of Capricorn. The reference point is the vernal equinox – the beginning of the Aries sign – where the two circles intersect and the numbering increases counterclockwise. The center of the ecliptic is marked by a small hole. Several blank "windows" look strange in the overall pattern. Most likely, it was the first and only instrument made by this maker who had made serious mistakes in making these segments. As a result, he was forced to remove them completely to avoid complete revamping of the rete. This hypothesis is corroborated by the fact that the alleged sites of attachment of the missing elements are well treated and do not stand out either on the front or on the back side of the rete.

Twenty-two star pointers are decorated by curls resembling a floral pattern. Another eight stars on the elements of the rete are marked with an asterisk (*). Almost all stars are identified by inscriptions located on the pointers or near them. Some stars indicated by asterisks have no inscriptions at all, e.g., three stars of the Ursa Minor and β Aquilae.

Several stars on this astrolabe are rather rare for such instruments, e.g., ε Per, β Aql, κ Ori, ε Vir, and β Cyg. At the same time, the maker failed to show some bright stars *sine qua non* such as Betelgeuse, Aldebaran, Procyon, Spica, Antares. All of them seem to be missing from the blank segments of the rete.

In studying stars on astrolabes, the main problem is to find the source. What coordinates did the maker take for his work and where did he get them? After all, the maker himself, as a rule, was not an astronomer. Fortunately, the source for the investigated astrolabe has been found! This is a book written by a priest and mathematician

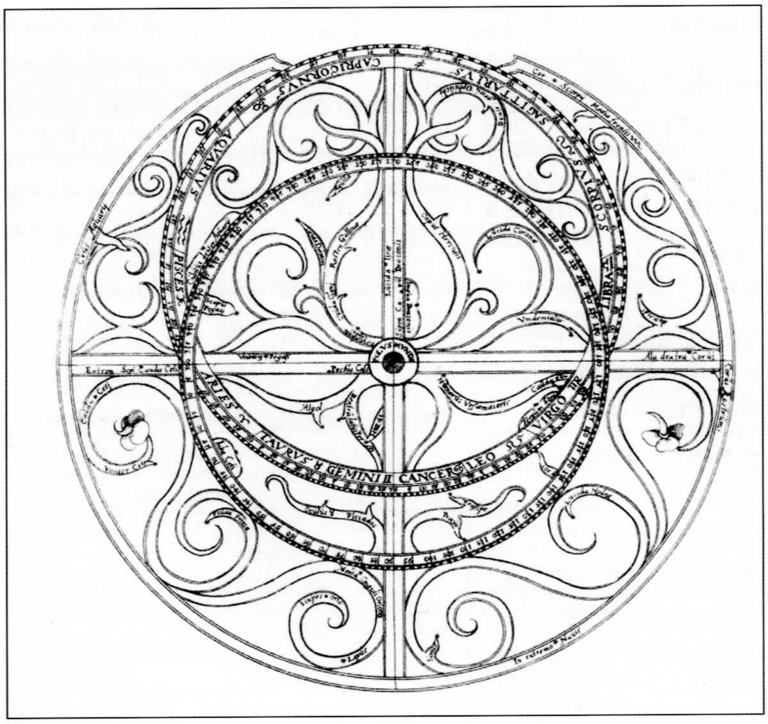


Fig. 5 *Engraving of the rete from Franz Ritter's book (1613).*

Lateinische Namen der Stern.	Teutsche Namen.	Declinatio ab Aequat. abweichung von Aequin.		Ascensio Recta Gerade auffsteig:		Mediatio Coeli. Mittle deß Himmels.
		Grad Min.		Gr. Min.		Gr. Min
e Arcturus	Lanceator	21 48	B	309 33	♒	1 43
Lucida Cynosurae in quadr. Austr.	Heller stern am groß: Bärn Mittag	75 29	B	214 59	♒	7 21
Lucida Cynosurae in quadr: Borea	Heller stern am groß: Bern Mittn:	72 49	B	221 35	♒	14 3
Lucida Corona	Heller Stern an der Cron	28 24	B	229 21	♒	21 47
Cor Scorpij	Scorpions Hertz	24 57	M	241 29	♐	3 31

Fig. 6 *A fragment of Franz Ritter's star list (epoch 1620). The sign of Aquarius instead of Scorpio is erroneously assigned to four stars and for Arcturus there is an evident error – the right ascension of 309 degrees instead of 209. Because of this error Ayerschottel put Arcturus in an entirely different part of the sky.*

Table 1. Stars on the rete

Item no.	Inscription on the instrument	Meaning	Designation
1	Pect$_9$[us] cassiope[a]	Cassiopeia's breast	α Cas*
2	[Stella polaris]	Pole (star)	α UMi*
3	Venter Ceti	Whale's belly	ζ Cet
4	[Caput] algol	Monster's [head]	β Per
5	Dex[tru] lat s Persej	Perseus's right side	α Per
6	Si[nistrum]: Ge[nu]: persej	Perseus's left knee	ϵ Per
7	Sin[i]st[er] Pes Orio[nis] :	Orion's left leg	β Ori
8	Media Cing li Ori[onis]	The middle of the Orion's belt	ϵ Ori
9	D[extrum] : G[enu] : Orionis	Orion's right knee	κ Ori
10	Canis Ma[jor] Siri s	Greater Dog	α CMa
11	[Cor Leonis Regulus]	The Heart of the Lion	α Leo*
12	Humerus Vrse Maioris	Larger Bear's shoulder	α UMa
13	Tergu[m Leonis] : ♌	The Hip of the Lion	δ Leo
14	Rostr m Corvi	Beak of the Crow	α Crv
15	Vindemiator	Grape-picker	ϵ Vir*
16	Vltima : cau[da] : urs[a] : maio[ris]	Last in the tail of Larger Bear	η UMa
17	[Lucida Cynosure in quadr. Austr.]	Southern in the bucket of Smaller Bear	β UMi*
18	[Lucida Cynosure in quadr. Borea]	Northern in the bucket of Smaller Bear	γ UMi*
19	L cida Corone	Star in the crown	α CrB
20	Capùt : Herc lis	Head of Hercules	α Her
21	Dracon[is] : lin[gua] :	Dragon's Tongue	μ Dra
22	Lucida lire	Star in Lira	α Lir*
23	Rostr m galline	Hen's beak	β Cyg
24	Aquila	Eagle	α Aql
25	[Caput Antinoj]	The head of Antinous	β Aql*
26	Ca da delph[inj]	Dolphin's tail	ϵ Del
27	Caúda cÿgni	Swan's tail	α Cyg
28	Arctur[us]	Guardian of the Bear	α Boo
29	Hume[rus] sinist[er] κ ≈	Left shoulder	β Aqr
30	Dex[ter] h mer[us]. Peg[asj].	Pegasus' right shoulder	β Peg

* eight stars are not designated by traditional pointers but rather by asterisks, i.e., symbols of stars.

Franz Ritter (1579–1641) and published a year before the instrument was made, i.e., in 1613.[8] Franz Ritter was a native of Nuremberg; while studying in Altdorf (1592–1595) he was influenced by another well-known master – Johann Pretorius (1537–1616).[9]

In his book, Ritter describes the design of an astrolabe and the rules of using it. The description includes drawings of the face of the instrument, of the tympan, and the back. The drawings show a lot in common with the rete of our maker i.e., similar patterns, the full equator circle (Fig. 5). It is best reflected in the similarity between the drawing and the tympan – Ayerschottell's instrument exactly copies the illustration in Ritter's book. There are two calendars on the back; same as for the studied astrolabe.

Ritter's list included 52 stars (Fig. 6). Due to the precession, longitudes of stars in Ritter's list were increased by 21°37' as compared with the Ptolemy's longitudes. Latitudes of stars were, basically, the same as Ptolemaic ones[10], although not without inaccuracies.

The average errors of stellar coordinates are about 1 degree. And this was at the time when Tycho Brahe had already conducted (in 1598) his precise measurements of stars (with an error not exceeding a few arc minutes)!

Table 1 presents a complete list of stars indicated on the astrolabe. In order to save the scarce space on the rete the maker abbreviated some names. Missing elements are shown in square brackets.

There is a hint on the rete to another star. The word '*hircus*' ('goat') on the vertical axis of the rete refers to Capella but the star itself is not indicated at all.

All 30 stars from the astrolabe are included in Ritter's list. The names of the stars also coincide with the only exception: in the star #4 *algol* on the astrolabe is called *Meduse* in Rittert's list. This confirms the assumption that the list compiled by Ritter was the original source for the maker.

In order to assess the quality of the rete we analyzed the accuracy of the star pointers. For this purpose we measured the position of the star pointers with a ruler of the instrument. The right ascension is easily obtained on the equator scale, and declination can be directly found read off using the scale on the ruler. For example, for the star no.7 *Sinister Pes Orionis* (β Ori) the right ascension $\alpha = 73.5^{\circ}$ and the declination $\delta = -8{,}5^{\circ}$.

The measured values were compared with values from a table compiled by Franz Ritter and generally showed good agreement - the error is less than 1, rarely it was 2 degrees. For the same star β Ori the table gives the following values: $\alpha = 73^{\circ}\ 29'$, the declination $\delta = -9^{\circ}\ 12'$.

Two stars, however, demonstrate serious errors; those are α Leo (9 degrees) and α Boo (Arcturus). Especially obvious is an error for Arcturus - it was put in a completely different part of the sky. The reason lies in the misprint in Franz Ritter's table where the true value of the right ascension equal to 209 degrees had been erroneously indicated as 309. This value was used by Ayerschottell. He did not even pay attention to the fact that the stars were ordered by right ascension and Arcturus apparently dropped out of the sequence.

Conclusion

The performed study has revealed some features of the Peter the Great's astrolabe. A source of information for the drawing of stars was found, the instrument manufacturing precision was assessed and a gross error was detected in the position of one star (Arcturus). At the same time, the available information about the maker is very scarce. The spider's strange shape continues to baffle. The former owners of the astrolabe remain unknown, probably forever. We have little chance to find out exactly where and from whom Jacob Dolgoruky bought the instrument and whose advice he had used to acquire the astrolabe for the latitude of Moscow. The author hopes, nevertheless, that now that the astrolabe turned 400 years old, he was able to uncover some of its secrets.

Acknowledgements

The author is grateful to the staff members of the State Hermitage Mariam Dandamaeva and Grigorii Yastrebinskii for providing the opportunity to study the astrolabe of Peter the Great, as well as to the German researcher Professor Paul Kunitzsch for consultations on the set of stars.

Notes and References

1. *Russian historical artefacts of the first quarter of XVIII[th] century in the collection of the State Hermitage*. Catalogue edited by V.N. Vassiliev and V.M. Glinka (Leningrad, Sovetskii Khudozhnik, 1966), pp. 8-25.

2. N.I. Kostomarov, 'Russian History in the Lives of its Principal Figures', second section: *Reign of the House of Romanovs to the accession to the throne of Catherine II*, Chapter 15, pp. 539–540. Peter the Great.

3. See, for instance, 'Peter the Great and the Astrolabe', *Northern Messenger*, May 17, 1907, Vol. XLII. No. 21. Montreal.

4. D.O. Svyatskiy, 'Essays on the History of Astronomy in Ancient Russia'. Part III, *Historical and Astronomical Research*, Issue IX (1966), pp 5–124, see p. 78.

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Solution to the Double-Dovetail 'Problem'

Allan Mills

At the end of my paper on Mathematical Problems[1], I showed what appears to be a completely impossible joint made of light and dark wood (Fig. 1) and asked how this could be achieved. How could dovetails be inserted at right angles to each other? Well here is the solution.

Consider a block of dark wood bearing two parallel dovetail grooves, as shown in Fig.2. A matching piece is then made from a light-coloured wood, and slid into the first block. It may be secured with adhesive, but a taper peg inserted at the centre is better.

Now imagine the corners of the compound block to be sawn off, leaving a central square as indicated by shading. This new compound block will exhibit a dovetail on each of its four sides, although these will be of slightly different included angles to the originals. The two components may be separated by sliding diagonally. However, we are misled by our expectation that any dovetail will be at right angles to the groove behind it. A removable taper peg will enable the construction to be demonstrated.

I have no information on the origin of this puzzle, but suspect it may be associated with the craftsman-made 'puzzle boxes' of Japan.

Reference

1. Allan Mills, 'Mathematical Models', *Bull. Sci.Inst. Soc.*, No. 122 (September 2014), p. 25

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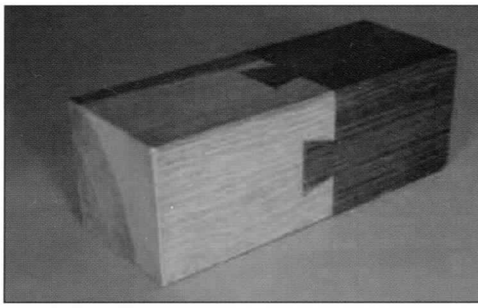

Fig.1 *Not a Photoshop montage but a real puzzle joint.*

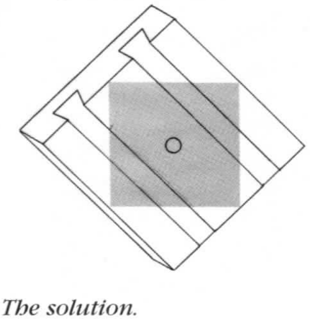

Fig. 2 *The solution.*

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