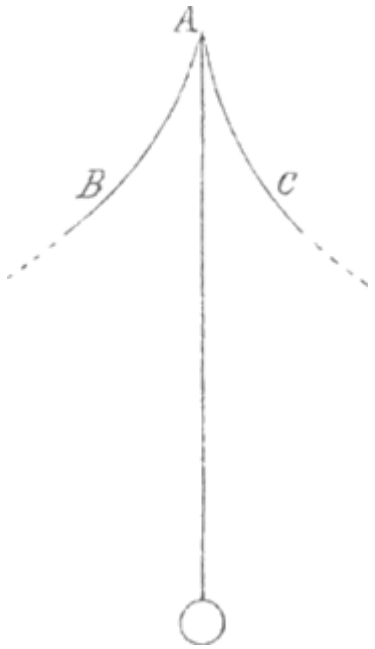
The invention of the pendulum Clock

A collaboration on the real story



Hans van den Ende, Ben Hordijk, Victor Kersing, Rob memel

The invention of the pendulum Clock

A collaboration on the real story

The exhibition *Innovation & Collaboration: The early development of the pendulum clock in London* was held at Bonhams London from 3 till 14 September 2018.

First and foremost, the initiators, organisers and anyone involved in the collecting and exhibiting of these magnificent early clocks deserve our utmost respect and gratitude.

Despite the beautiful exhibition, we however strongly object to the poor research method, the text and conclusions of Richard Garnier's and Leo Hollis' research as well as to the new interpretation of the famous Coster-Fromanteel contract. As a result hereof, the attribution of exhibit numbers 23 and 24 to specifically John Fromanteel is unjustified.

Garnier's and Hollis' research is predominantly based upon assumptions, interpretations and probabilities and not on historical facts and scientific evidence.
They have tried to clarify the specific role of Christiaan Huygens, Salomon Coster and John and Ahasuerus Fromanteel in relation to the history of Drebbel, Hartlib and Wallis and their mutual relations.

Due to a combination of language barrier, insufficient archive research, lack of Dutch historical archive knowledge and Fromanteel tunnel vision, they failed to make their new theory credible.

Notwithstanding the fact that there is no or almost no evidence of Fromanteel's involvement in the early development of the pendulum clock, there is on the other hand an overwhelming amount of historical as well as scientific evidence of Salomon Coster's involvement.

Sadly enough, this casts a shadow over what was intended to be a once in a lifetime exhibition.

The conclusion of Garnier's and Hollis' research calls for a well-founded scientific reply. Our four articles published here are written in relation to their publication and meant to put the historical puzzle pieces back into their rightful place.

Content

Part 1: The invention of the pendulum clock – The real story page 1 - 20
Part 2: The workshop of Salomon Coster page 21 - 37
Part 3: Contemplations on innovation & collaboration in research page 38 - 46
Part 4: The invention of the pendulum clock – The Sequel, more inventions page 47 - 63

Authors

Hans van den Ende MSc

Brought up between clocks and educated by his father, a passionate horological and historical teacher on all aspects within the field, Hans could not but follow in these footsteps and share this passion.
Educated in Strategic Management and Business Administration, currently working as IT Manager at a large international company, he has learned to look beyond the obvious and take a scientific approach in research.
Currently he is chairman and conservator of one of the prime collections in early pendulum clocks in the world. He is also board member of the Zaandam based Museum of the Dutch Clock and the Dutch Time Museum (STCN).

Ben Hordijk

As son of a clockmaker from an early age interested in horology.
Till 2009 member of the board of a large private investment company.
After retirement:
Chairman of the board of the *Stichting Museum en Archief van Tijdmeetkunde* (SMAT);
One of the initiators and founding members of the *Stichting Tijdmeetkundige Collectie Nederland* (STCN);
Recently published a book '*The Life and Work of Nicolas Hanet'*.

Victor Kersing

Is an historian, originally specialised in medieval history.
Through his activities as a researcher and editor at the department of Archaeology of the municipality of The Hague. He specialised and immersed himself in the history of The Hague, among other things resulting in an editorship of the yearbook of the Historical Association *Die Haghe* and *TIJDschrift*, the quarterly magazine of the *Federatie Klokkenvrienden* (federation of several Dutch clock associations). In addition, he is working on a synopsis on Hague clockmakers.

Rob Memel BA

Is a professional certified clock restorer since 1984. Focussed on early clocks and complicated pendulerie. After a 20 year break, working successfully in the international Human Resources area, he returned back to his roots and started his own company "de Klokkenmaker van Heemstede". Published many articles where his specialism is 17th century archive research.

The invention of the pendulum clock

Part 1 - The real story

Preface

One of the best documented inventions in history is the invention of the pendulum clock. At the same time it is one of the most disputed ones, especially so from the English side. For some reason this invention is of such importance that continuously claims are launched to appropriate it. We will represent here the real course of events, based on facts, scientifically accepted sources, archival documents, circumstances and events during the time of the invention.

The immediate reason to do this now is the magnificent and overwhelming exhibition '*Innovation & Collaboration – The early development of the pendulum clock in London*', held at Bonhams in London between 3 and 14 September 2018; and particularly the catalogue published on the occasion of the exhibition. Where the exhibition exceeded all imagination on visualising early clock making in England, the catalogue falls short of any sense of reality. An actual falsification of history is presented, based on half-truths, interpretations, speculations, suggestions and simply untruths.

Four quotes form the basis of our criticism and illustrate the above allegations:

"*The evident circumstances within which Fromanteel and Huygens senior were conceivably acquainted are compelling and the lack of evidence to this within Christiaan Huygens's autobiography or papers cannot be taken as evidence of absence of any contact between them; generally Huygens does not refer to craftsmen*."[I]

"*And if credibility is given to the revised succession of events advanced at this exhibition, namely that Fromanteel was working on pendulum deployment with Christiaan Huygens from at least 1656, then by the time of the pendulum's commercial launch in autumn 1658, marked by the distribution of Huygens's Horologium in September (*Cat*. 25) and Fromanteel's advertisement in October, Fromanteel would have passed the development stage and would have worked through a number of stages of movement design and layout.*"[II]

"*A central revisionary tenet of this exhibition, namely that John Fromanteel, notwithstanding that he was technically still an apprentice, arrived at Coster's in The Hague in September 1657 to teach (rather than be taught by) the Dutchman the mysteries of pendulum clock making, …*"[III]

"*Under the new interpretation advanced in this exhibition, in which Huygens the inventor employed Ahasuerus Fromanteel, as the practical technician, to develop, construct, and perfect working models incorporating the Dutchman's pendulum invention for the domestic*

market (as opposed to scientific market), it would seem expected, rather than merely coincidental, that the cases of the earliest pendulum clocks made in London and The Hague were so similar."[IV]

There are many unfounded and unverified theories published in the last decades, but, as Christiaan Huygens himself wrote to the Lords of the States of The Netherlands when publishing *Horologium* in 1658:
"It is certain that elsewhere also will arise men, who will envy our little fame and perhaps try to convince themselves, but certainly the whole world, that this invention is not due to the acuteness of our compatriots, but rather long before was brought to light by the zeal of themselves or one of their own"[V].

In this article we will set out the real story of the invention of the pendulum clock, based on all currently known sources.
We will do this by discussing the main characters: Christiaan Huygens as inventor, Ahasuerus Fromanteel I, the maker of the first pendulum clocks in England; his eldest son John Fromanteel; Salomon Coster, maker of the very first pendulum clock; the 'Contract' between Salomon Coster and John Fromanteel. And also by reproducing the historical context and developments, situations, sources, artifacts, clocks and how it all fits together.

All data will be discussed in chronological order as much as possible, but sometimes we have to jump back- or forward because of simultaneous developments in Holland or England. Obviously the playing field of the invention of the pendulum clock is much wider than discussed here, especially in relation to the developments between Holland and France and in France itself, but this part of the story is omitted here on purpose.

Introduction
The start of the 80 year war between Spain and The Northern Dutch Provinces and especially the capture of Antwerp in 1585 by the Spanish troops, caused a stream of protestant 'Flemish' refugees to the north, but also a large group crossed over to England. Among them were the ancestors of Ahasuerus Fromanteel, who was born in Norwich in 1607[VI]. In 1631 Ahasuerus joins the Blacksmiths' Company, and in 1632 he becomes 'Free brother' with the newly founded Worshipful Company of Clockmakers.[VII]
He seems to have set up a flourishing workshop as instrument maker and lens grinder; he also produced clocks commissioned by other makers.[VIII]

We do not know exactly when Salomon Coster is born. Coster was a Mennonite, so there is no birth certificate. Several sources mention a date of 1622, which is an accepted guess by subtracting 21 years[IX] from his marriage date: Coster married Jannetje Harmens on March the 22nd, 1643.[X]

Christiaan Huygens was born 14 April 1638, in a prosperous and distinguished family living in The Hague. His father, Constantijn Huygens (1596-1678), was a diplomat, secretary to the Princes of Orange, and also a poet and a composer. Christiaan had one older brother, Constantijn jr., two younger brothers and a younger sister.

Christiaan studied law and mathematics at Leiden University from 1645 to 1647, amongst others with the stimulating mathematician Frans van Schooten, with whom he would continue to correspond intensively until the death of the latter in 1660. After his time in Leiden Christiaan and his younger brother Lodewijk continued their education at the 'Breda College of Orange', the Illustrious school and *Collegium Auriacum*, where his father was a curator[1].
As early as in 1649 Huygens publishes his first scientific work on hydrostatics. In the following years Huygens focuses on multiple mathematical issues (calculation of the length of curves and quadrature (area) of hyperboles, ellipses and circles), physical issues and astronomy (Jupiter's Moons, Saturn's Rings).[XI]

Johannes (John) Fromanteel is born ca. 1638 and first becomes apprenticed by his father. The notes of the Worshipful Company of Clockmakers of 5 April 1652 indicate, that '*John Fromanteel before the Court is bound to Ahasuerus Fromanteel as apprentice*'. On 5 April 1659 '*John Fromanteel becomes journeyman*' and on 6 July 1663 '*John is freed and becomes Freeman'.*[XII]

Correspondence
In the run up to the publication in 1656 of Wallis' book *Arithmetica infinitorum,* Christiaan Huygens and John Wallis have an extensive correspondence between June 1655 and September 1656. The last letter of Wallis to Huygens is from 22 August 1656 and Huygens' answer to Wallis is from September 1656. No mention at all in the entire correspondence of anything horological. At this moment Wallis is the only Englishman Huygens is corresponding with.[XIII] It takes over two years for another letter from John to Christiaan.[XIV]

Confirmed by recently rediscovered and published information from English archives Ahasuerus Fromanteel I appears to have developed more and more into a technical instrument and apparatus maker. He produces pumps and fire engines, but also telescopes, boxes, lenses, hydrometers, blown glass 'laboratory' tools, automata, dredgers, etc. etc. Beside all this he also makes clocks.[XV]

From the correspondence of Samuel Hartlib we now know that in the 1650's Fromanteel is concentrating on the duration of clocks and their running as accurately as possible. In Fromanteels' catalogue or list we can order '*A watch or standing clock to goo a weecke or a month or a year with once winding up and yet to goo as true as one that is wound up every day'*. He even makes a 'rolling ball clock[XVI]. In 1657 we read *'… A clock of Fromantils … his new invented Clock of Motion to goe without being wound up a weeke or month or longer*'.[XVII] Later the same year there is an announcement that '*Fromantil hath made a clock that needs not be wound up within a month*'.[XVIII]

Ahasuerus Fromanteel I receives the Freedom of the City of London on 14 January 1656 and subsequently, after intervention of Cromwell, the Lord Protector, also the Freedom of the Clockmakers' Company. Only then he is allowed to make, sign and sell clocks himself in the City of London.[XIX]

[1] A member of the Supervisory Board of a higher educational institution.

In the period before the invention of the pendulum clock Christiaan Huygens is primarily concerned with mathematics and astronomy (see the correspondence in *Oeuvres Complètes*). He is mainly corresponding with people in Holland and France, like Frans van Schooten, Claude Mylon, Blaise Pascal, Gilles Personne de Roberval, Johannes Hevelius, Jean Chapelain.[XX]

Between 28 June and 19 December 1655 Christiaan is in Paris, together with his brother Lodewijk and cousin Philips Doublet[XXI]. All 1656 and 1657 he is residing in Holland (The Hague)[XXII].

On 25 December 1656 Christiaan Huygens has his Eureka moment by finding the application of the pendulum to the clock. On 26 December of the next year, he writes in a letter to Ismael Boulliau '*Yesterday it was exactly a year ago that I made the first model of this type of clock…'.*[XXIII]

In a letter of the 12th of January 1657 to his tutor the mathematician Professor Frans van Schooten we read '*These days I found the construction of a clock of a new generation, with times so exact as the diameter, with its help I have no small hope to be able to determine the longitude at sea'*.[XXIV]

Christiaan writes to Claude Mylon on 1 February 1657 '*I will also share with him a new invention, that must be of great use in astronomy, and that I hope to successfully use finding the longitudes. You will hear of it soon.*' With him is meant Monsieur Bulliaut - Ismaël Boulliau, at that moment secretary of the French ambassador in The Dutch Republic.[XXV]

Claude Mylon writes back to Christiaan on 12 April 1657 that his invention of the clock is found very beautiful by all whom he has told about it, and this will be even more so if Huygens can make it independent of weight or spring. Then nothing would stand in the way of solving the problem of longitude.[XXVI]

On 18 May 1657 Claude Mylon writes Huygens again that he is glad that Huygens is continuously perfecting his clock further, he fervently hopes it will be just as good at sea as in the room, and changes from dry to humid do not change it more than the change in weights.[XXVII]

Boxing Day 1657 Christiaan Huygens asks Boulliau, by then back in Paris, more details about the clock Ferdinando de' Medici, Grand Duke of Tuscany allegedly had made, which shows a resemblance to Huygens' invention, and whether this clock also has a pendulum.
This is the same letter in which Huygens tells it was exactly a year ago he made the first model of a pendulum clock, and started in June to show everyone interested the construction. He also writes he is busy with the conversion of the turret clock in Scheveningen. The pendulum is almost seven meters long (21 feet) and weighs approximately 20 kilo's (40 or 50 pounds). By now he also urges Boulliau not to do anything in Paris, not by his own instructions or by anyone else's …[XXVIII]

Subsequently Huygens writes on 13 June 1658 in another letter to Boulliau he wants to apply for a patent in Paris as well. The application is prepared by the French ambassador in The

Hague, so Boulliau can present it to the French Chancellor.[XXIX] One week later (21 June) Boulliau answers Huygens that the French Chancellor Seguier has refused his request up to three times, as he does not want all French clockmakers coming after him screaming.[XXX]
On 16 July 1658 Simon Douw applies for a patent for 'his own invention'. Huygens and Coster together file a lawsuit against Douw[2] because of infringement of their patent.[XXXI]

On 6 September Huygens sends '*Horologium*' to more than 60 scientists at home and abroad.[XXXII] The list includes two copies for Salomon Coster. Fromanteel is not on the list.

From the foregoing we can conclude Christiaan Huygens had a number of possible reasons to publish *Horologium*:

- *Rumours of a pendulum clock in Tuscany, the claim Galileo had invented this and Treffler made a clock following this principle.*
- *The application for a patent by Douw and the process against him.*
- *Refusal of the French Chancellor Seguier to grant Huygens his patent for the pendulum clock.*

In the meantime, on 16 June 1657 Coster gains the privilege by the States General of the Dutch Republic. This means he is the only one allowed to use and sell a pendulum clock, invented by Christiaan Huygens and made available to Coster, in the Dutch Republic for a period of 21 years.[XXXIII] This is officially ratified by the States of Holland and West-Friesland, the most important province, on 16 July 1657.[XXXIV] Huygens tells us later this is also the time he starts showing the construction to everyone interested.[XXXV]
On 3 September 1657 the 'Contract' between John Fromanteel (then still apprenticed to his father) and Salomon Coster, Master Clockmaker, is signed.[XXXVI] The agreement runs until May (*meydage*) 1658. Afterwards John returns to London.

Hartlib mentions in the early summer of 1658 *'A Clock newly invented in the Low Countries that need only once to bee wound in 7 days and hath not failed to go exactly for many months together. It is made without a balance so that it will never change by any weather? Fromantil hearing of it, is endeavouring to make the selfe-same Clock. His clock presented to my Lord Protector is returned upon his owne hands'.*[XXXVII]

On 3 June the same Hartlib mentions in a letter to Robert Boyle (Irish philosopher and chemist/alchemist): *'Sir Robert Honeywood, lately arrived out of the Low Countries, tells of a singular invention found out there, of a clock that goes most exactly true without a balance, which needs not to be wound up but once in eight days, the price being 7lb sterling. Mr Palmer, who hath a shop as it were of all manner of inventions, is to have one shortly: and Fromantile hearing of it gives out confidently, that he is able to make the like, or rather to exceed it'.*[XXXVIII]

On 28 October 1658 Fromanteel publishes his famous advertisement in the *Mercurius Politicus* about the availability of a new type of clock. Right below this advertisement, there

[2] Simon Douw (ca.1620-1663) 'Horlogiemaecker der Stadt Rotterdam', clockmaker of the city of Rotterdam. Amongst others he built the movement for the clock of the Rotterdam Exchange (1660-1663) and converted the turret clocks of the 'Geertekerk' in Utrecht (1659) and the 'Grote Kerk' of Dordrecht (1663) to pendulum.

is a second one in which he recommends his new pump, that not only can quench fire, but also can spray pests from trees and hops, watering the gardens, clothes and the like.[XXXIX]

The contract and the learning agreements

As already mentioned, the agreement between John Fromanteel and Salomon Coster is signed on 3 September 1657. At this time John is still apprenticed to his father for five years and is 19 years of age. Next to care for his employee (beer, fire and light), as a good employer should, to make his employee as productive as possible, Coster will pay John 20 Guilders for every completed piece of work and no more than 18½ Guilders if Coster supplies the copper and steel.[XL] This is not a bad cost price if one considers the selling price of the Coster clocks then was minimal 80 Guilders.[XLI]

Pieter Visbagh, another renowned Dutch clockmaker, is apprenticed to Coster from 1 May 1645 onwards for nine years. This is documented in the learning agreement between them, drafted and signed almost a year later, on 31 January 1646. It is agreed that during the first three years of the agreement Pieter is not residing at Coster's. After these three years Coster will provide board and lodging. In the 8th year Pieter will additionally receive a wage of 100 Guilders, doubled to 200 Guilders the next and last year. At the end of this apprenticeship Pieter is 21 years of age.[XLII]

In the learning agreement of Christiaan Reijnaert, aged 12 at the start (November 1655), we read: "… to live with and taken care of by the same, through food, drink, clothing, clean washing, everything that is needed for nourishment"[3]. Coster will receive from the uncles of Christiaan 50 Guilders for the entire apprentice period of ten years. After completion of these ten years of apprenticeship Christiaan is not sent away just like that. He receives from Coster 100 Guilders and as much clothing as belongs to a 'moral trousseau'.
After Salomon Coster's death, when Pieter Visbagh takes over the workshop, he will also take over this agreement.[XLIII]

Conclusions

From the above mentioned historical resources, we learn that Christiaan Huygens is in The Hague all of 1656 and 1657. Ahasuerus Fromanteel I is the entire same period in London. We know Ahasuerus' son John was also in The Hague from 3 September 1657 until 1 May 1658. However no correspondence, no connection and no other proof of anything else between Huygens and the Fromanteels can be found. The name Fromanteel does not occur even once in one of the first four volumes of *Oeuvres Complètes* (spanning 1638-1663). In contrast other 'craftsmen' are mentioned by Huygens frequently:

> ***OC Huygens Vol.2 (1657-1659), pages:***
> *Coster (Salomon). 125, 209, 235, 236, 241, 244, 245, 246, 247, 272, 281, 289, 290, 291, 314, 317, 327, 331, 372, 382, 419, 420, 439, 440, 473, 483, 486, 527, 540.*
> *Hanet. 281, 294, 319, 372, 381, 382, 419, 454, 473, 483, 486, 527.*
> ***OC Huygens Vol.3 (1660-1661), pages:***
> *Coster (Samuel). 4, 11, 84*
> *Coster (Veuve Samuel) → Hartloop (Jannetje Hartmans) 4, 98, 284.*
> *Hanet. 4, 8, 10, 16, 19, 23, 25, 50.*
> *Treffler (Filippus). 483, 484.*

[3] "te woonen ende van denselven besorcht te werden van cost, dranck, cleedinge, ende reyne bewassen, bewrevingen, alle 'tgeene wes tot onderhout sal vereisschen"

OC Huygens Vol.4 (1662-1663), pages:
Hooke (Robert). 218, 221, 275, 320, 359, 366, 437,438.
Oosterwyk (Severyn). 324, 411, 418, 424, 430, 434, 452, 456, 460, 477, 478.
Thuret. 110, 270.

If Fromanteel would have been involved in the very early development of the pendulum clock, right after the invention, some reference should have been found in the very extensive collection of correspondence of Christiaan Huygens in *Oeuvres Complètes* or in the Dutch and English Archives.
Even if an apprentice of 19 years of age, John Fromanteel, needed a period of 8 months to explain how to make a pendulum clock to Salomon Coster, more than 12 years a Master Clockmaker, where did John Fromanteel get this knowledge? His father? Without any demonstrable connection to Christiaan Huygens?
There is only the 'Contract' between John Fromanteel and Coster, which is not much different from any of the other learning or apprenticeship agreements. It also does not differ much from and is very comparable with a modern internship towards the end of a training, with the benefit for Coster of an already more experienced assistant and for Fromanteel to learn about the new sensation: the pendulum clock.

By all means, Fromanteel seems too commercial, certainly in view of his list and the advertisements, to settle only for the very minimal and even nowadays unknown and unproven benefit of scientific satisfaction. Was it not just the information his son John brought back from The Hague, that he needed to make a pendulum clock?
Do we not get a very logical sequence of events, also substantiated by all historical sources: End of 'Contract' in May 1658 → John and Ahasuerus build their own version of the pendulum clock during the summer → Huygens publishes and circulates Horologium in September 1658 → Fromanteel publishes his advertisement in October 1658.

Huygens' invention of the pendulum clock, in the form of Coster clocks, spreads at a tremendous 'commercial' pace all over Europe, well before the advertisement by Fromanteel. We know that before the end of 1657 a 'Coster clock' is in Tuscany. In an inventory of 1690 a clock signed by Coster is mentioned to have arrived on 25 September 1657, as the first pendulum clock in Italy. Treffler used this clock as example to make his own. The movement of this latter clock is still existent today.[XLIV]
From Huygens' correspondence we know a great many pendulum clocks are shipped from The Hague to Paris, mainly by mediation of Nicolas Hanet.

We know nothing, no clock or movement, description, correspondence, nor any other source or anything else that would give a reason to put the very first development of the pendulum clock with Fromanteel. There is no direct proof at all. Moreover, any activity regarding pendulum clocks from Huygens and/or Holland to England dates only after 1660, when the trials with pendulum clocks at sea start. Christiaan Huygens comes over to England for the first time in 1661.[XLV] Only on this trip, in 1661, Christiaan visits the workshop of Fromanteel, together with John Evelyn.[XLVI] But even then several of these 'regulators' are being imported from The Hague to England.[XLVII]

On the other hand we know Coster and Huygens immediately after the invention started to work on further improvements and applications of the pendulum clock. One of their

common projects is the turret clock of the church in Scheveningen. On Boxing Day 1657 Huygens indicates he is working on the conversion of the clock. On 23 January 1658 Coster writes to Huygens that he is busy working on the clock in Scheveningen, the clock has run all night, the pendulum weight is 50 pounds, but Coster wants to make several changes, as the movement runs a quarter of an hour slow in 14 hours. He will take a look again next day.[XLVIII]

Of the currently known early pendulum clocks, none, neither from Coster nor from Fromanteel, are 'scientific' clocks. The earliest known clocks with a 'three foot pendulum' all have a 'scientific dial' (large minute ring, small hour ring, and a (small) seconds ring) all date from around or just after 1670, when this layout was first seen on the second edition of sea clocks. The movements of all these scientific clocks are all in line with the design presented in letters from Huygens around that time and, a bit later, also published in Horologium Oscillatorum. The well-known drawing exactly represents the layout of the movement of all presently known clocks of this type.[XLIX] The movement of Huygens' own clock, signed *Thuret à Paris*, currently in the collection of Museum Boerhaave, fully meets this requirement. Again, no sign of Fromanteel being involved in any of this; never does he anywhere claim the invention. He also never applies for a patent in England.

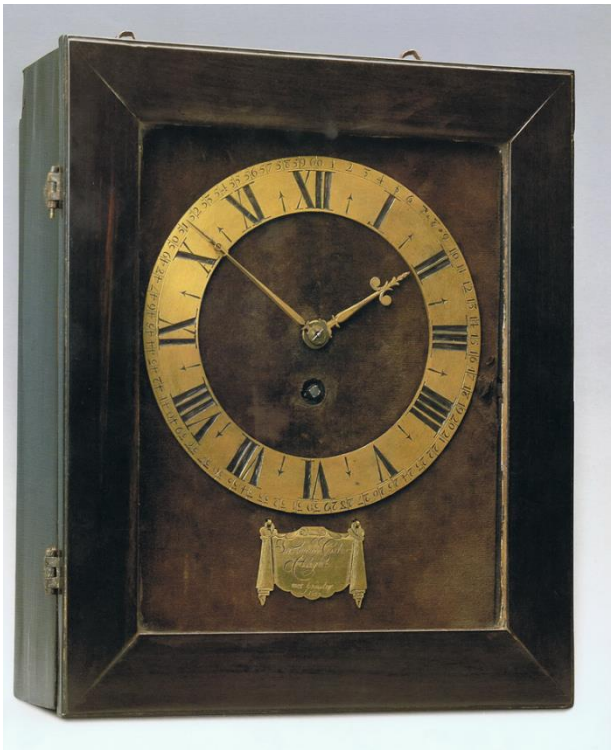
Also the connection between the Huygens family and Ahasuerus Fromanteel through Cornelius Drebbel is unlikely and illogical. Constantijn Huygens sr. and Drebbel have met when they were both in London in 1621/22.[L] As a result Huygens sr. developed and kept a more than average interest in Drebbel's inventions. In 1622 Fromanteel was only 15 years of age, while Christiaan was not even born. Drebbel died in 1633. From the 'Hartlib Papers' we know no more than that Fromanteel once made a box for Drebbel's lenses and later started to make lenses himself.[LI] No more, no less. Even more far-fetched is the claim Fromanteel was in Prague with Drebbel to study German clock making. When we know for certain Drebbel was in Prague in 1610, Fromanteel was only 3 years of age, far too young to show already any signs of a promising clockmaker. Later trips are nowhere confirmed and also then Fromanteel would not have reached the apprentice age yet. Anything here is purely speculative.
Both father and son Huygens do not mention the name Fromanteel anywhere in their extensively recorded correspondence. Once again any relation is purely speculative.

The Clocks
The early pendulum clocks still existent today are all of the same, nowadays well known type. A wooden case with a single chapter ring and central hour and minute hands.
In Holland we see a continued adherence to the principles of the first clocks, one single barrel for both going and striking train, a velvet covered dial plate, signature below the chapter ring (creating a rectangular dial plate) on a tip-up signature shield hanging over an access hole in the dial plate for starting the pendulum. The pendulum is suspended from a small wire and trapped in a crutch connected to the verge escapement. The entire movement is hanging on the dial plate which turns out to the front, there is no backdoor.
In England, fairly quickly after the invention makes the crossing, there is an independent development. There is no velvet on the square dial plate. We see spandrels in the corners around the chapter ring and a quick return of the use of a fusee next to the spring barrel, in combination with a pendulum directly fixed to the verge. The signature is engraved directly on the dial plate. The movement will almost immediately get a separate barrel for both

going and striking train. After the first 'box' clocks the movement is mounted in the case and soon after the case is also provided with a back door.
Every artefact, made in a certain period, inherits innovations, customs and developments from an earlier period. All clocks in the 2nd half of the 17th century have to do with the legacy and influence of Italy and the German empire of the 16th and early 17th century. The renaissance clocks, arts and objects from this era and area influence all subsequent developments or these later developments revert to these. For instance the use of wooden cases, spring barrels and architectural designs are a direct illustration of this.
Less clear but certainly remarkable are the 'square pillars' used by Coster for his movements and the rapid change to 'turned pillars' by Fromanteel (we know only five Fromanteel signed clocks with 'square pillars').[LII] Then anew the application of a fusee in combination with a spring barrel by Fromanteel, and his making use of iron hands are other examples of this influence, while Coster switches to silver or gilded brass hands.

When we compare the movements of this period, we cannot miss the obvious developments in time. Coster dies too early to say anything about the further development from *his* part and we also do not see much development of the movements from his successors (Oosterwijck, Visbagh, Hanet en Reijnaert). But we clearly do see rapid developments at the English side. Here the movements evolve immensely in increasing duration, in the addition of striking and musical works, calendars and other complications and of course, after a few years, the introduction of the anchor escapement.

Therefore we can only conclude we have to use another dating of the earliest pendulum clocks as used in the exhibition and catalogue. This different dating, by the way, is generally used and accepted in most other sources and literature as well.



Salomon Coster (Museum Boerhaave)

A Fromanteel (Private collection)

Salomon Coster (Museum Boerhaave)

A Fromanteel (Private collection)

Salomon Coster (Collection John Taylor)

A Fromanteel (Collection National Trust)

Renaissance clocks and movements with ‘square pillars’

1657		*Salomon Coster Haghe met privilege 1657* (N1) Museum Boerhaave, Leiden
1657		*Salomon Coster Haghe met privilege 1657* (N2) Collection Zuylenburgh - Bert Degenaar
1658		*Salomon Coster Haghe met privilege 1658* (N5) Collection John C. Taylor
1658		*Salomon Coster Haghe Met privilege* (N4) Science Museum, London

1658		*A Fromanteel London Fecit 1658* “Lyme Park Fromanteel” Collection The National Trust
1659		*A Fromanteel Londini* Collection John C. Taylor
1659		*A Fromanteel Londini* “Bass Fromanteel” Private collection
1659		*Salomon Coster Haghe Met privilege* (N8) Collection Museum of the Dutch Clock

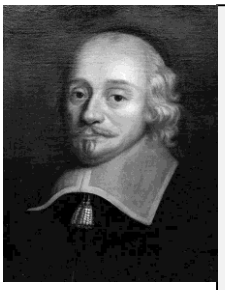
1659		*Simon Bartram* Collection John C. Taylor
1659 **-** **1660**		*Salomon Coster Haghe* *Met privilege* (N10) Former collection Mario Crijns
1659 **-** **1660**		*Ahasuerus Fromanteel* *Londini fecit* Private collection
1659 **-** **1660**		*Ahasuerus Fromanteel* *Londini Fecit* Collection John C. Taylor

Timeline

25 Feb. 1607	Ahasuerus Fromanteel I born in Norwich
Ca. 1622	Salomon Coster born in Haarlem
14 Apr. 1628	Christiaan Huygens born in The Hague
1631	Ah. Fromanteel I joins the Blacksmiths' Company
Nov. 1632	Ah. Fromanteel I joins the Clockmakers' Company by redemption (purchase) as Free Brother
Ca. 1638	Johannes (John) Fromanteel born
31 Jan. 1646	Salomon Coster is named as a 'master clockmaker' (*meester horologiemaecker*) in a notarial document
5 Apr. 1652	John Fromanteel is bound before the Court to his father as apprentice
Jun. 1655 – Sep. 1656	In the run up to the publication in 1656 of Wallis' book *Arithmetica infinitorum*, Christiaan Huygens and John Wallis have an extensive correspondence on Mathematics. At that moment Wallace is the only Englishman Christiaan is corresponding with.
28 Jun. 1655 – Dec. 1655	Chr. Huygens is in Paris (together with his younger brother Lodewijk and cousin Philips Doublet)
1656 & 1657	Chr. Huygens is in Holland (The Hague). Ah. Fromanteel I is in London.
14 Jan. 1656	Ah. Fromanteel I receives the Freedom of the City of London and subsequently, after intervention of Cromwell, the Lord Protector, also the Freedom of the Clockmakers' Company. Only then he is allowed to make, sign and sell clocks himself in the City of London.
25 Dec. 1656	Chr. Huygens invents the application of the pendulum to the clock.
1657 1st half	Hartlib records, *'Mr Palmer of Gray's Inn hath Mr. Fosters new invented Dial. A clock of Fromantils of 200lb who will have ready within 6 weekes his new invented Clock of Motion to goe without being wound up a weeke or month or longer'*.
12 Jan. 1657	Christiaan Huygens writes his former tutor, the mathematician Professor Frans van Schooten '*These days I found the construction of a clock of a new generation, with times so exact as the diameter, with its help I have no small hope to be able to determine the longitude at sea*'
1 Feb. 1657	Chr. Huygens writes to Claude Mylon '*I will also share with him[1] a new invention, that must be of great use in astronomy, and that I hope to successfully use finding the longitudes. You will hear of it soon.'* ***[1] With him is meant Ismaël Boulliau, at that moment secretary of the French ambassador in The Dutch Republic.***
25 Feb. 1657	The Clockmakers' Company still at loggerheads with Thomas Loomes, he being ordered by the Lord Mayor, at the Company's behest, to desist from having five apprentices; Ahasuerus Fromanteel attended the meeting, afterwards feeling the need to apologise for his intemperate language in a letter of March 3, 1657
12 Apr. 1657	Claude Mylon writes to Christiaan Huygens that his invention of the clock is found very beautiful by all whom he has told about it, and this will be even more so if Huygens can make it independent of weight or spring. Then nothing would stand in the way of solving the problem of longitude.
18 May 1657	Claude Mylon writes Huygens that he is glad that Huygens is continuously perfecting his clock further, he fervently hopes it will be just as good at sea as in the room and changes from dry to humid do not change it more than the change in weights.

16 Jun. 1657	Salomon Coster gains the privilege by the State General of the Dutch Republic. This means he is the only one allowed to use and sell a pendulum clock, invented by Christiaan Huygens and made available to Coster, in the Dutch Republic for a period of 21 years.
16 Jul. 1657	The States of Holland and West-Friesland officially ratify the patent.
3 Sep. 1657	Contract signed at The Hague, The Netherlands, between John Fromanteel of London (then still nominally an apprentice to his father) and Salomon Coster of The Hague. Fromanteel under the contract to remain at Coster's expense, making clocks, until May 1658, a secret meanwhile to be revealed.
26 Dec. 1657	Christiaan Huygens asks Boulliau, by then back in Paris, more details about the clock Ferdinando de' Medici, Grand Duke of Tuscany allegedly had made, which shows a resemblance to Huygens' invention and whether this clock also has a pendulum. This is also the letter in which Huygens indicates it was exactly a year ago he made the first model of a pendulum clock, and he started to show everyone interested the construction in June 1657. He also indicates he is busy with the conversion of the turret clock in Scheveningen; the pendulum is almost 7 meters long and weighs about 20 kilos. By now he also urges Boulliau not to do anything in Paris, not by his own instructions or by anyone else's …
1658 early May	John Fromanteel returns to London from Coster's workshop in The Hague, The Netherlands
1658 early summer	Hartlib reports '*A Clock newly invented in the Low Countries that need only once to bee wound in 7 days and hath not failed to go exactly for many months together. It is made without a balance so that it will never change by any weather? Fromantil hearing of it, is endeavouring to make the selfe-same Clock. His clock presented to my Lord Protector is returned upon his owne hands*'
3 Jun. 1658	Hartlib letter to Robert Boyle, saying, *'Sir Robert Honeywood, lately arrived out of the Low Countries, tells of a singular invention found out there, of a clock that goes most exactly true without a balance, which needs not to be wound up but once in eight days, the price being 7lb sterling. Mr Palmer, who hath a shop as it were of all manner of inventions, is to have one shortly: and Fromantile hearing of it gives out confidently, that he is able to make the like, or rather to exceed it*'
13 Jun. 1658	Christiaan Huygens writes in a letter to Boulliau that he wants to apply for a patent in Paris too. The application is prepared by the French ambassador in The Hague, so Boulliau can present it to the French Chancellor ...
21 Jun. 1658	Boulliau answers Huygens that the French Chancellor Seguier has refused up to three times his previous request, as he does not want all French clockmakers coming after him screaming.
16 Jul. 1658	Simon Douw applies for a patent for 'his own invention'. Huygens and Coster together file a lawsuit against Douw because of infringement of their patent.
6 Sep. 1658	Publication and distribution of *Horologium* by Christiaan Huygens;
28 Oct. 1658	Ahasuerus Fromanteel advertises availability of newly-invented pendulum clocks in *Mercurius Politicus*

John Wallis (Ashford, 22 November 1616 - Oxford, 28 October 1703) was an English mathematician. The most important of Wallis's works, *Arithmetica infinitorum*, was published in 1656. In this treatise he showed how algebraic methods could be applied to geometrical situations (after Descartes), like the calculation of the area under the curve. He did preparational work in differential and integral calculus. Using patterns in finite processes, he sought formulas for infinite processes. He was an example for many mathematicians,



Samuel Hartlib or Hartlieb (c. 1600 – 10 March 1662) was a versatile German-British scientist. As an active promoter and expert writer in many fields, he was interested in science, medicine, agriculture, politics and education.
Hartlib had the purpose of "registering all human knowledge and making it available for study to all mankind". Before that, he had contact with anyone in the age of the Commonwealth who meant intellectual matters and was responsible for patents, disseminating information and promoting education, passing on designs for calculators, double-script instruments, seed machines and siege machines. His letters, in German and English, are still the subject of study ...

Cornelis Jacobszoon Drebbel (1572 – 7 November 1633) was a Dutch engineer and inventor. He was the builder of the first navigable submarine in 1620 and an innovator who contributed to the development of measurement and control systems, optics, chemistry, and the 'perpetuum mobile', a device with eternal movement.
In 1598 he obtained a patent for a water-supply system and a sort of perpetual clockwork.
Around 1605 the Drebbel family moved to England, probably at the invitation of the new king, James I of England (VI of Scotland). He was accommodated at Eltham Palace. Drebbel worked there at the masques, that were performed by and for the court. He was attached to the court of young Renaissance crown-prince Henry. He astonished the court with his inventions.
Between 1610 and 1613 Drebbel resides on invitation of Rudolf II at the court in Prague.
When Rudolf II was stripped of all effective power by his younger brother Archduke Matthias, Drebbel was imprisoned for about a year. After Rudolf's death in 1612, Drebbel was eventually set free and went back to London.
In 1619 Drebbel showed a composite microscope to the Dutch ambassador in London, Willem Boreel.
When in England, Constantijn Huygens, father of Christiaan, was a regular visitor to Drebbel. Between 1618 and 1624 Huygens sr. visited England several times, as a diplomat in training. From Drebbel he bought a camera obscura and a microscope.
Constantijn Huygens transferred his interest in optics to his two oldest sons. Christiaan had a booklet from Drebbel.
After the death of King James I, Drebbel was employed in the service of the navy between 1626 and 1628 by Charles I, but without much success. As a result of which he lost his job and income in 1628. Towards the end of his life, Drebbel was working as innkeeper an brewer. He died in 1633.

Rules of the Worshipful Company of Clockmakers

- Minimum age ‘apprenticeship’ is 14 years
- Duration of the ‘apprenticeship’ is 7 years
- After completion of the 7th year ‘apprenticeship’ the apprentice becomes a ‘journeyman’ for a period of minimum 2 years
- After the ‘journeyman’ period the ‘journeyman’ can become a ‘Freeman’ by paying the ‘entry fee’.
- During the ‘apprenticeship’ the apprentice is bound to his ‘master’, but is allowed to service another ‘master’ during this period.
- In the ‘journeyman’ period the ‘journeyman’ had to work for one single ‘master’ as ‘workman’, for a period of 2 years, before he could set up a business himself. During the ‘apprenticeship’ and ‘journeyman’ periods he is not allowed to sign under his own name, the clock had to be signed under the name of the 'master' that was served.

Notes

[I] Richard Garnier & Leo Hollis, "Innovation & Collaboration, The early development of the pendulum clock in London", 2018, 63
[II] Richard Garnier & Leo Hollis, "Innovation & Collaboration, The early development of the pendulum clock in London", 2018, 70
[III] Richard Garnier & Leo Hollis, "Innovation & Collaboration, The early development of the pendulum clock in London", 2018, 83
[IV] Richard Garnier & Leo Hollis, "Innovation & Collaboration, The early development of the pendulum clock in London", 2018, 84
[V] Christiaan Huygens, "Horologium", Preface, Translated from Latin: Tijdschrift voor Horlogemakers, 1e Jaargang No.5 1 Maart 1903
[VI] Anita McConnell, "Fromanteel, Ahasuerus (bap. 1607, d. 1693)", Oxford Dictionary of National Biography, Oxford University Press, 2004, online reference / Richard Garnier & Leo Hollis, "Innovation & Collaboration, The early development of the pendulum clock in London", 2018, 72
[VII] Brian Loomes, "Country Clocks and their London origins", 1976, 34-35
[VIII] Hans Kreft, "Rediscovering the Fromanteel Story", article in the Dutch Kunst & Antiekjournaal (August 2003), lecture at Schoonhoven NL (September 2003), published Horological Foundation website, where translated and adapted by R.K.Piggott.
[IX] Marriage certificate Salomon Coster - Jannetje Harmens, Gemeentearchief Delft, Collection DTB nr. 14, inv. 125, fol 109, Archive research and transcription performed by Victor Kersing and Rob Memel.
[X] Victor Kersing en Rob Memel, "Salomon Coster, de Haagse periode", lecture AHS-DS 10 May 2014; article Tijdschrift 4, December 2014
[XI] Charlotte Lemmens, Constantijn & Christiaan, "Een Gouden Erfenis - Het leven van Christiaan Huygens 1629-1695", 139-159
[XII] Jeremy Lancelotte Evans, "Clockmakers' Company Masters and their Apprentices.", Transcribed from Atkins' list of 1931, 56.
[XIII] Oevres Complètes de Christiaan Huygens, Tome Premier, correspondance 1638-1656, Martinus Nijhoff, 1888
[XIV] Oevres Complètes de Christiaan Huygens, Tome Deuxième, correspondance 1657-1659, Martinus Nijhoff, 1889, No. 497
[XV] Rebecca Pohancenik, "The Intelligencer and the Instrument Maker: Early communications in the development of the pendulum clock", Antiquarian Horology, Volume 31 no 6, (December 2009), 750.
[XVI] HP 71/19/1A. In this article I made use of the work and the article of Rebecca Pohancenik, "The Intelligencer and the Instrument Maker: Early communications in the development of the pendulum clock", Antiquarian Horology, Volume 31 no 6, (December 2009), 756.
[XVII] HP 29/6/1A-12B. In this article I made use of the work and the article of Rebecca Pohancenik, "The Intelligencer and the Instrument Maker: Early communications in the development of the pendulum clock", Antiquarian Horology, Volume 31 no 6, (December 2009), 753.
[XVIII] HP 29/6/13A. In this article I made use of the work and the article of Rebecca Pohancenik, "The Intelligencer and the Instrument Maker: Early communications in the development of the pendulum clock", Antiquarian Horology, Volume 31 no 6, (December 2009), 753.
[XIX] Brian Loomes, "Country Clocks and their London origins", 1976, 38-39
[XX] Oevres Complètes de Christiaan Huygens, Tome Premier, correspondance 1638-1656, Martinus Nijhoff, 1888
[XXI] Oevres Complètes de Christiaan Huygens, Tome Premier, correspondance 1638-1656, Martinus Nijhoff, 1888, p. 335 note 1 and Oevres Complètes de Christiaan Huygens, Tome Quinzième, Observations Astronomiques. 1658-1666, Martinus Nijhoff, 1925, p. 193
[XXII] Oevres Complètes de Christiaan Huygens, Tome Premier, correspondance 1638-1656, Martinus Nijhoff, 1888
[XXIII] Oevres Complètes de Christiaan Huygens, Tome Deuxième, correspondance 1657-1659, Martinus Nijhoff, 1889, No. 443
[XXIV] Oevres Complètes de Christiaan Huygens, Tome Deuxième, correspondance 1657-1659, Martinus Nijhoff, 1889, No. 368
[XXV] Oevres Complètes de Christiaan Huygens, Tome Deuxième, correspondance 1657-1659, Martinus Nijhoff, 1889, No. 370

[XXVI] Oevres Complètes de Christiaan Huygens, Tome Deuxième, correspondance 1657-1659, Martinus Nijhoff, 1889, No. 382
[XXVII] Oevres Complètes de Christiaan Huygens, Tome Deuxième, correspondance 1657-1659, Martinus Nijhoff, 1889, No. 388
[XXVIII] Oevres Complètes de Christiaan Huygens, Tome Deuxième, correspondance 1657-1659, Martinus Nijhoff, 1889, No. 443
[XXIX] Oevres Complètes de Christiaan Huygens, Tome Deuxième, correspondance 1657-1659, Martinus Nijhoff, 1889, No. 490
[XXX] Oevres Complètes de Christiaan Huygens, Tome Deuxième, correspondance 1657-1659, Martinus Nijhoff, 1889, No. 492
[XXXI] Oevres Complètes de Christiaan Huygens, Tome Deuxième, correspondance 1657-1659, Martinus Nijhoff, 1889, Appendice IV bij No. 523
[XXXII] Oevres Complètes de Christiaan Huygens, Tome Deuxième, correspondance 1657-1659, Martinus Nijhoff, 1889, No. 511
[XXXIII] Oevres Complètes de Christiaan Huygens, Tome Deuxième, correspondance 1657-1659, Martinus Nijhoff, 1889, Appendice II bij No. 523
[XXXIV] Oevres Complètes de Christiaan Huygens, Tome Deuxième, correspondance 1657-1659, Martinus Nijhoff, 1889, Appendice III bij No. 523
[XXXV] Oevres Complètes de Christiaan Huygens, Tome Deuxième, correspondance 1657-1659, Martinus Nijhoff, 1889, No. 443
[XXXVI] Haags Gemeentearchief - Toegangsnummer Oud notarieel 0372-01, inv. 322, fol. 409. Archive research and transcription performed by Victor Kersing and Rob Memel.
[XXXVII] Rebecca Pohancenik, "The Intelligencer and the Instrument Maker: Early communications in the development of the pendulum clock", Antiquarian Horology, Volume 31 no 6, (December 2009), 753.
[XXXVIII] The works of the Honourable Robert Boyle, ed T. Birch (London. 1744), Vol. VI, pp.110-11. In this article I made use of the work and the article of Rebecca Pohancenik, "The Intelligencer and the Instrument Maker: Early communications in the development of the pendulum clock", Antiquarian Horology, Volume 31 no 6, (December 2009), 754.
[XXXIX] Mercurius Politicus, issue number 439, October 21-28, 1658; as reproduced in Penney, op.cit., 619-620. In this article I made use of the work and the article of David Penney, "The Earliest Pendulum Clocks: A Re-Evaluation", Antiquarian Horology, Volume 31 No 5, (September 2009), 614-620.
[XL] Haags Gemeentearchief - Toegangsnummer Oud notarieel 0372-01, inv. 322, fol. 409. Archive research and transcription performed by Victor Kersing and Rob Memel.
[XLI] Oevres Complètes de Christiaan Huygens, Tome Deuxième, correspondance 1657-1659, Martinus Nijhoff, 1889, No. 565
[XLII] Haags Gemeentearchief - Toegangsnummer Oud notarieel 0372-01, inv. 20, fol. 321. Archive research and transcription performed by Victor Kersing and Rob Memel.
[XLIII] Haags Gemeentearchief - Toegangsnummer Oud notarieel 0372-01, inv. 110, fol. 63. Archive research and transcription performed by Victor Kersing and Rob Memel.
[XLIV] R. Plomp, "Spring-driven Dutch pendulum clocks 1657-1710", Interbook (Schiedam), 1979, 15
[XLV] Oevres Complètes de Christiaan Huygens, Tome Troisième, correspondance 1660-1661, Martinus Nijhoff, 1889 No. 852 note 1
[XLVI] John Evelyn, "The Diary of John Evelyn", 1901, 346
[XLVII] Oevres Complètes de Christiaan Huygens, Tome Troisième, correspondance 1660-1661, Martinus Nijhoff, 1889, No. 868
[XLVIII] Oevres Complètes de Christiaan Huygens, Tome Deuxième, correspondance 1657-1659, Martinus Nijhoff, 1889, No. 452
[XLIX] Christiaan Huygens, "Horologium Oscilatorum", 1673, Pars Prima
[L] "Briefwisseling van Constantijn Huygens" edited by J.A. Worp (old edition) - Part 1, 1608-1634, GS 15 p. LIV
[LI] Worsley to Hartlib, 22 June 1648, HP 42/1/1 A. In this article I made use of the work and the article of Rebecca Pohancenik, "The Intelligencer and the Instrument Maker: Early communications in the development of the pendulum clock", Antiquarian Horology, Volume 31 no 6, (December 2009), 750.
[LII] Richard Garnier & Leo Hollis, "Innovation & Collaboration, The early development of the pendulum clock in London", 2018, 144.

The invention of the pendulum clock

Part two - The workshop of Salomon Coster

In the period between mid-1657, when Coster got the Patent (Privilege) to make pendulum clocks according to Huygens' invention, and end-1659, when Coster suddenly died, several clockmakers worked in Coster's workshop. His coworkers were Christiaan Reijnaert (apprenticed from November 1655), John Fromanteel (apprenticed from September 1657 till May 1658), Nicolas Hanet, and Severijn Oosterwijck.

Over the past decades there has been an on-going and interesting debate about the involvement of particularly one of these apprentices, John Fromanteel, in the development and production of the clocks in Coster's workshop. The paramount question is: Is it possible to attribute any of the Coster clocks to one specific clockmaker in his workshop?

On the basis of historical facts and by comparing technical details of clocks and movements we hope to bring more clarity in this matter.
The Coster clocks discussed in this article are limited to Coster clock N1, N2, N4, N5 and N10[I]. Coster clocks N3 and N8 are being disregarded in this article, for reasons of uncertain authenticity.

Salomon Coster (N5) Timepiece with alarm. Duration 30 hours.
The only known Coster clock with alarm work.

1

2

3

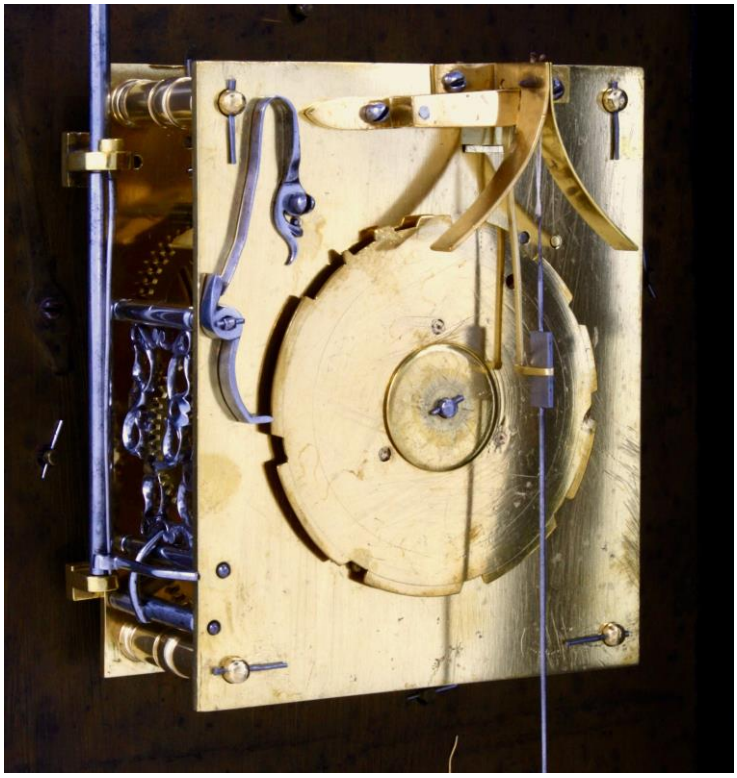
Salomon Coster (N10) going and striking on one barrel. Duration 30 hours.

4

5

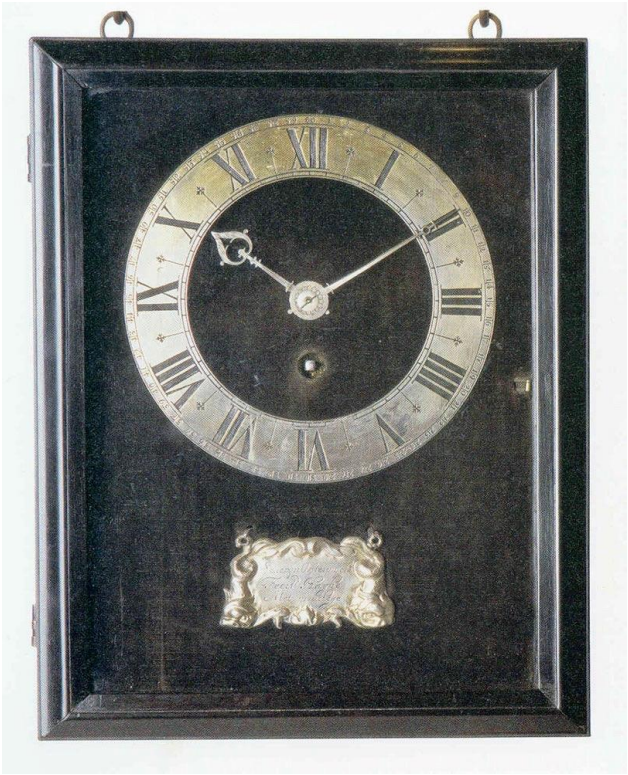
Nicolas Hanet going and striking on one barrel. Duration 2 days.

6



7

Severijn Oosterwijck N9 going and striking on one barrel. Duration 30 hours.



8

9

Fromanteel or Coster ?

John Fromanteel[II], born in 1638, was apprenticed to his father Ahasuerus Fromanteel, on the 5th of April 1652, for a period of seven years. During his apprenticeship he served, according to the rules of the Clockmakers' Company, under master clockmaker Salomon Coster for a period of eight months starting in September 1657 and ending in May 1658. In the period after his departure in 1658 until the death of Coster in December 1659 no reference to John Fromanteel is found In the *Oeuvres Complètes*[III] nor in the public archives in the Netherlands. We may therefore assume, that John Fromanteel was not involved in the further development of the pendulum clock in Holland.

There are three early clocks known by Fromanteel, which show features resembling Coster clocks: the so-called 1658 Lyme Park Movement, the 1658/1659 Bass Fromanteel and the 1658/1659 Taylor Fromanteel.

Lyme Park Movement

The oldest known movement, the Lyme Park Movement (National Trust)[IV], was discovered in about 1940, in a very bad condition. The case was lost, the movement had been converted to anchor and only a small section of the original dial remained with its original hands.
The movement was restored and reconstructed by Mr Charles Hobson[V]. All parts above the contrate pinion were replaced in the style of Dutch work with a new horizontal crown wheel and verge. A silk suspended pendulum and cycloid cheeks were added. According to Mr. Ronald A. Lee, during the restoration Hobson had to drill and tap extra holes to mount cheeks in the style of Dutch work that had not been there originally[VI]. Mr. J.W. Parkes made a new dial similar to the original. The chapter ring was copied from an authentic Dutch ring, but unfortunately wrong engraved with the figures 0-60 twice. The new case was constructed in the Architectural style in the tradition of the 1660's. The movement is signed *A Fromanteel London fecit 1658*. The date is not placed centrally giving the impression, that it was an afterthought.

10

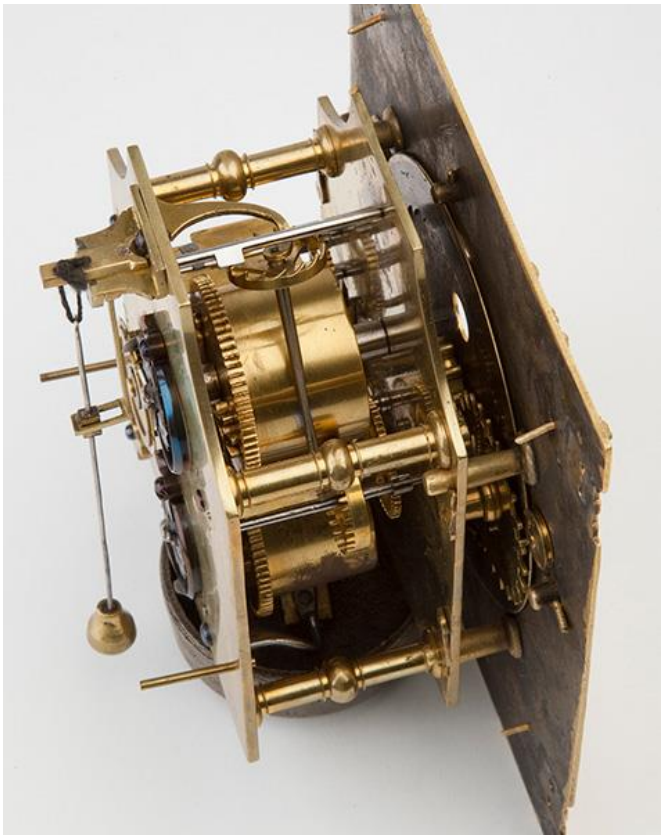
11

Bass Fromanteel

The verge is pivoted on the front plate and back cock: the latter being original but modified to accept a silk suspended pendulum with the original bob[VII]. The minute hand is a replacement copied from the Taylor Fromanteel.

12

13



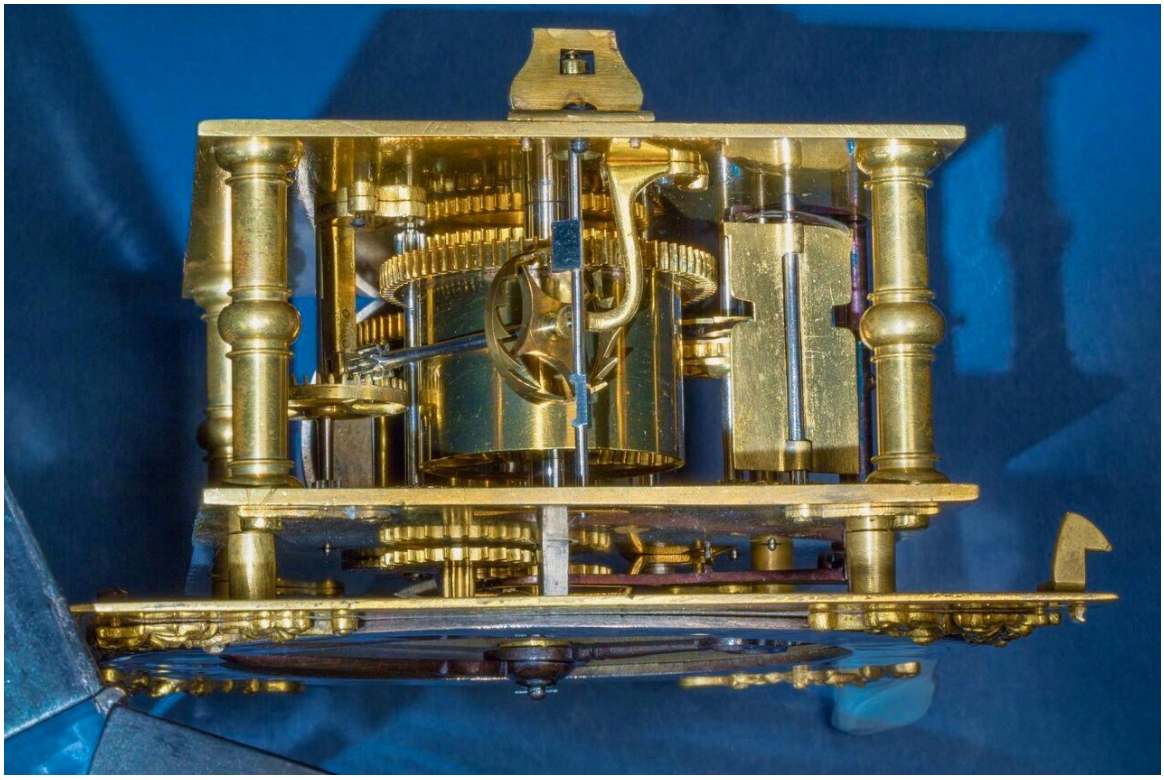
14

Taylor Fromanteel

The Taylor Fromanteel[VIII] is the most authentic of the three clocks. The pallet arbor is a replacement[IX] and there is an unidentified hole in the top of the back cock. The engraved cartouche above the chapter ring with initials *16 E+W 87* is a later addition.

15

16



17

Comparison: Coster N1, N2, N4, N5, N10 – Fromanteel Lyme Park, Bass, Taylor

The Similarities

1. Coster: pillars square (except N10).
   Fromanteel: pillars square Lyme Park.
2. Coster: barrel(s) without fusee.
   Fromanteel: barrel(s) without fusee.
3. Coster: case in the shape of a simple box.
   Fromanteel: case in the shape of a simple box (except Lyme Park).
4. Coster: movement attached to the dial plate and turning on hinges at the left hand side (except N5 which turns on pins).
   Fromanteel: movement attached to the dial plate and turning on hinges at the left hand side (except Lyme Park).

The Differences

Case

1. Coster: rectangular.
   Fromanteel: square (except Lyme Park)

	Height
Coster N1	27,2 cm
Coster N2	26,4 cm
Coster N4	23,4 cm
Coster N5	27,5 cm (32,5 cm bell included)
Coster N10	26,1 cm
Fromanteel Lyme Park	40,7 cm
Fromanteel Bass	19,7 cm
Fromanteel Taylor	20,7 cm

2. Coster : side panels closed (except N10).
   Fromanteel: side panels glazed, the right sight panel slides up (except Lyme Park).
3. Coster: wall clocks.
   Fromanteel: table clocks.

Dial

1. Coster**:** dial plate rectangular.
   Fromanteel: dial plate square (except Lyme Park).
2. Coster: dial plate covered with dark velvet.
   Fromanteel: dial plate not covered with velvet, but instead a matted centre and corner spandrels (except Lyme Park).
3. Coster: chapter ring gilt brass or solid silver.
   Fromanteel: chapter ring silver face soldered to a brass under-ring with 12 solder holes in the brass ring[X].
4. Coster: hands silver or gilt.
   Fromanteel: hands iron.

5. Coster**:** signature on a signature shield in the form of a lambrequin.
   Fromanteel: signature engraved on the dial plate (except Lyme Park).
6. Coster: a hole in the dial plate behind the signature shield directly in front of the pendulum.
   Fromanteel: no hole.

Movements

1. Coster: pillars square (except N10).
   Fromanteel: pillars ringed round instead of square (except Lyme Park.
2. Coster: pillars pinned on the back plate.
   Fromanteel: pillars latched to the front plate.
3. Coster: verge with a silk suspended pendulum with cycloid cheeks.
   Fromantee**l**: verge pivot directly connected to the pendulum (except Lyme Park). The bridge of the Bass Fromanteel is adapted and now has a silk suspended pendulum.
4. Coster: crown wheel set in a horizontal position of 90 degrees.
   Fromanteel: crown wheel set in an angle of 70 degrees (except Lyme Park).
5. Coster**:** a hole in the back plate to facilitate the escapement wheel.
   Fromantee**l**: no hole.
6. Coster : ratchet N1, N2, N4 on the front plate. N5: ratchet visible at the back plate. N10: ratchet hidden behind the back plate on the barrel.
   Fromanteel: ratchets visible on the back plate.
7. Coster: timepieces with one barrel (except N10).
   Fromanteel: two vertically positioned barrels, one for going and one for striking (except Lyme Park).
8. Coster: 30 hour's duration.
   Fromanteel: Bass and Taylor: 3 days duration. Lyme Park: 8 day's duration.
9. Coster: movement elongated rectangular shape (except N10).
   Fromanteel**:** movement rectangular with curved shoulders (except Lyme Park) and of a heavier, larger and sturdy construction.

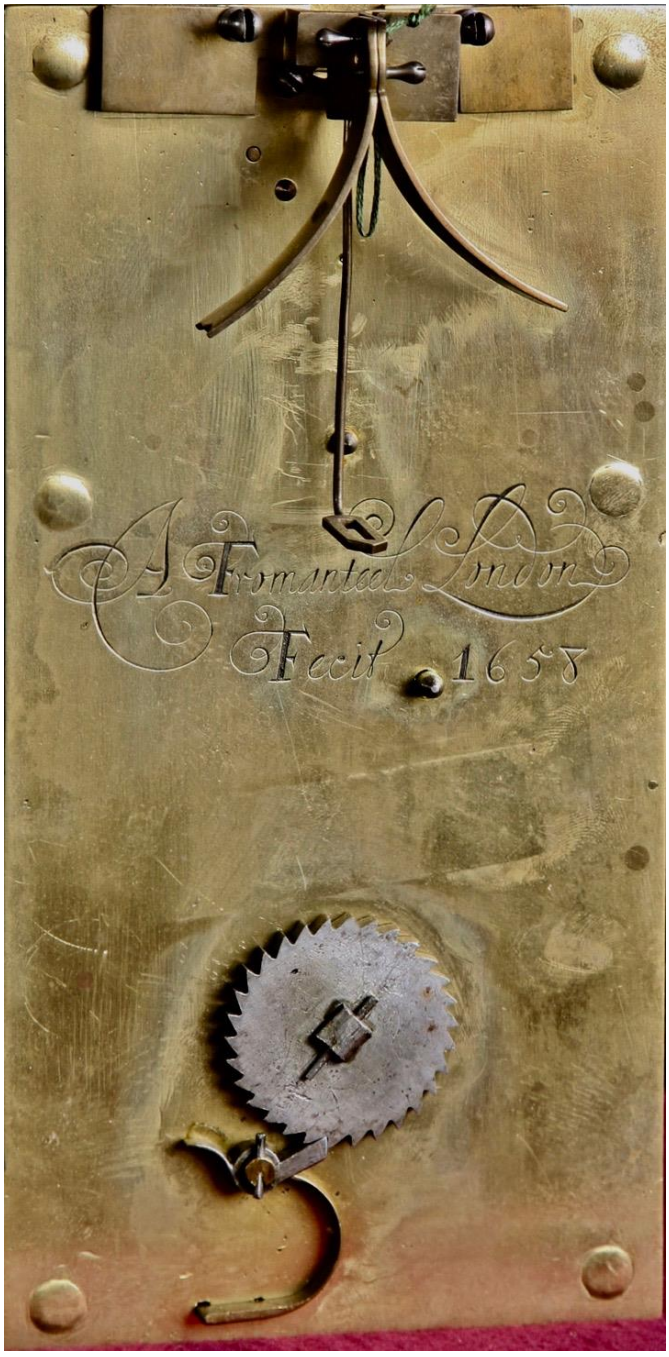
	Height	**Width**
Coster N1	110 mm	59 mm
Coster N2	109 mm	58 mm
Coster N4	109 mm	59 mm
Coster N5	110 mm	59 mm
Coster N10	109 mm	84 mm
Fromanteel Lyme Park	220 mm	110 mm
Fromanteel Taylor	139 mm	107 mm

10. Coster: movement not signed.
    Fromanteel: movement Lyme Park signed.

Special characteristics

There are two movements with special characteristics, different from all other Coster movements.

1. **The Lyme Park movement** is considered to be the earliest movement made by Fromanteel and most similar to Coster's. The Lyme Park movement has square pillars like the Coster movements, which are latched to the front plate instead of pinned on the back plate. The ratchet is visible on the back plate. The movement is not attached to the hinged dial plate[XI] and is much larger than the Coster movements and very sturdy.[XII] The dimensions of the Lyme Park movement are 220 mm height and 110 mm width;[XIII] the dimensions of the early Coster movements are 109/110 mm height and 59/58 mm width.



Lyme Park

Coster

2. **The Taylor Coster clock N5** movement has square pillars pinned on the back plate like all other Coster movements. However, the dial plate is turning on pins instead of hinges and the ratchet is visible on the back plate in the Fromanteel manner in contrast to all other Coster movements. This is the only Coster clock with an alarm and bell on top of the case. The alarm is presumably a slightly later addition.

Pillars

R.D. Dobson[XIV] states that the square pillars of the movements from the Coster workshop were produced under the influence of John Fromanteel. After John's departure in May 1658 not Coster, but the Fromanteels exclusively used square pillars. However, the way the pillars are attached to the movements is different, all Coster movements having the pillars pinned on the back plate, while the pillars in the Fromanteel movements are latched to the front plate. Moreover, in the late 16th century/early 17th century, square pillars were already used extensively in Germany by master clockmakers in the well-known renaissance table clocks[XV]. For instance, master clockmaker Johann Sayller used square pillars in several of his clocks.

In the catalogue Innovation & Collaboration[XVI], page 56, the pillar depicted in fig. 3.3 is designated as '*Ahasuerus Fromanteel square pillar'*. This type of pillar is commonly known and designated as an 'Egyptian pillar'; it was widely used in watches of that period.

Conclusion

The only true resemblances between the Coster and Fromanteel clocks are:

1. The shape of the simple box type case (except the Lyme Park movement).
2. The dial hinged, turning on the left hand side (except the Lyme Park movement).
3. No fusee in the movements.

According to the rules of the Clockmakers' Company, in the apprenticeship and journeyman period the clock had to be signed by the serving master, not by the apprentice. So the Taylor clock (N5), although signed by Coster, may well have been made by John Fromanteel. However, because of the lack of historical evidence, and in view of the aforementioned technical differences in movements and cases, it is not justified to attribute Coster clocks N1, N2, N4, N10 and N5 with certainty to any of the clockmakers in Coster's workshop (Coster, Fromanteel, Hanet, Reijnaert or Oosterwijck).

Photo 1,2,3	: Courtesy of Dr. John C. Taylor, Isle of Man
Photo 4,5	: Courtesy Mario Crijns, Breda
Photo 6,7	: Courtesy Mentink & Roest, Ingen
Photo 8,9	: Courtesy Stichting Boom-Time
Photo 10,11	: Courtesy of The National Trust Images, Swindon
Photo 12,13,14	: Courtesy of Ben Wright, Tetbury
Photo 15,16,17	: Courtesy of Dr. John C. Taylor, Isle of Man

[I] N1 1657 - Rijksmuseum Boerhaave Leiden
N2 1657 - Collection Zuylenburg/Bert Degenaar former Vehmeyer Collection
N4 1658 - Science Museum former Dr. R. Plomp
N5 1658 - Dr. John C. Taylor former P.C. Spaans Collection
N10 1659/1660, - Private Collection former Mario Crijns

[II] The Worshipfull Company of Clockmakers, *Minutes of 1652*, James Nye Chairman A.H.S.

[III] Oeuvres Complètes de Christiaan Huygens, Tome II, correspondance 1657-1659, Martinus Nijhoff 1889 – Tome XVII, l'horloge à pendule 1656-1666, Martinus Nijhoff 1932

[IV] Ronald A. Lee, *The first twelve years of the English Pendulum Clock*, London 1969

[V] Percy G. Dawson, C.B. Drover & D.W. Parkes, *Early English clocks*, Aberdeen 1982, page 75

[VI] Dr.John C. Taylor, *The Coster Fromanteel contract 3rd September 1657 Changes made during drafting*, Isle of Man 2018, page 1 footnote 7

[VII] Ben Wright, *Exceptional Clocks*, Tetbury 2018

[VIII] Ronald A. Lee, *The first twelve years of the English Pendulum Clock*, London 1969

[IX] Percy G. Dawson, C.B. Drover & D.W. Parkes, *Early English Clocks,* Aberdeen 1982, page 84

[X] Ben Wright, *Exceptional Clocks*, Tetbury 2018

[XI] Dr. R. Plomp, *Spring-driven Dutch pendulum clocks 1657-1710*, Schiedam 1979, page 24

[XII] Percy G. Dawson, C.B. Drover & D.W. Parkes, *Early English Clocks*, Aberdeen 1982, page 75

[XIII] Amey Carney, House and Collections Manager National Trust

[XIV] R.D. Dobson, *De slinger als tijdmeter*, Bocholt 1999, page 43A

[XV] Klaus Maurice, *Die deutsche Räderuhr*, Munich 1976, page 600

[XVI] Richard Garnier & Leo Hollis, *Innovation & Collaboration*, Isle of Man 2018, page 56

The invention of the pendulum clock

Part 3 - Dealing with and interpreting historical sources

The year 1657

In parts 1 and 2 we have identified the main characters, mentioned in the book *Innovation & Collaboration - The early development of the pendulum clock in London* (Garnier & Hollis) , based on historical facts and available artefacts. This third part deals with the year 1657 in which the invention of Christiaan Huygens, the application of the pendulum in a clock movement, was made into a working and commercial product. In addition, we will discuss and denounce the research method that, especially from England, has been used now for decades. It is striking, that this method always has a particular underlying strategy: to reduce the role of Salomon Coster, and to a lesser extent the role of Christiaan Huygens, to increase the role of the English makers and in particular that of John or Ahasuerus Fromanteel.
As an example of this method, we want to examine the new theory of Garnier & Hollis, based on facts, as documented in the archives. This theory was widely promoted during the beautiful exhibition Innovation & Collaboration, held at Bonhams in London from 3 to 14 September 2018 and also recorded in the aforementioned book. The surprising conclusion of Garnier & Hollis is that John Fromanteel came from London to The Hague to teach Salomon Coster, between September 1657 and May 1658, how to make a pendulum clock.

The experimental phase

Before we go into the story of Garnier & Hollis first the facts at a glance: the patent for the application of the pendulum in a clock movement was granted by the States General to Salomon Coster on 16 June 1657.[I] With this, Coster had the (exclusive) right for 21 years to make pendulum regulated clocks in Holland and West-Friesland. Unfortunately, the patent application itself has not yet been found or has been lost altogether, but it obviously had been submitted some time before the conferment on 16 June.
This implies there was only a period of at most a few months between the actual invention of Christiaan Huygens (December 25, 1656) and the conferment of the patent. In the experimental phase from January 1657 to the patent application, work will have been done to make a functioning pendulum clock. Although nowhere has been recorded who assisted Huygens during this first phase, the most likely candidate is Salomon Coster. After all, he was the applicant for the patent. Also at a later stage (December 1657), during the works in the church tower of Scheveningen, Coster was obviously the right man to call upon when it involved experiments with pendulum movements.[II] No other clockmakers assisting Huygens are mentioned in this first period.

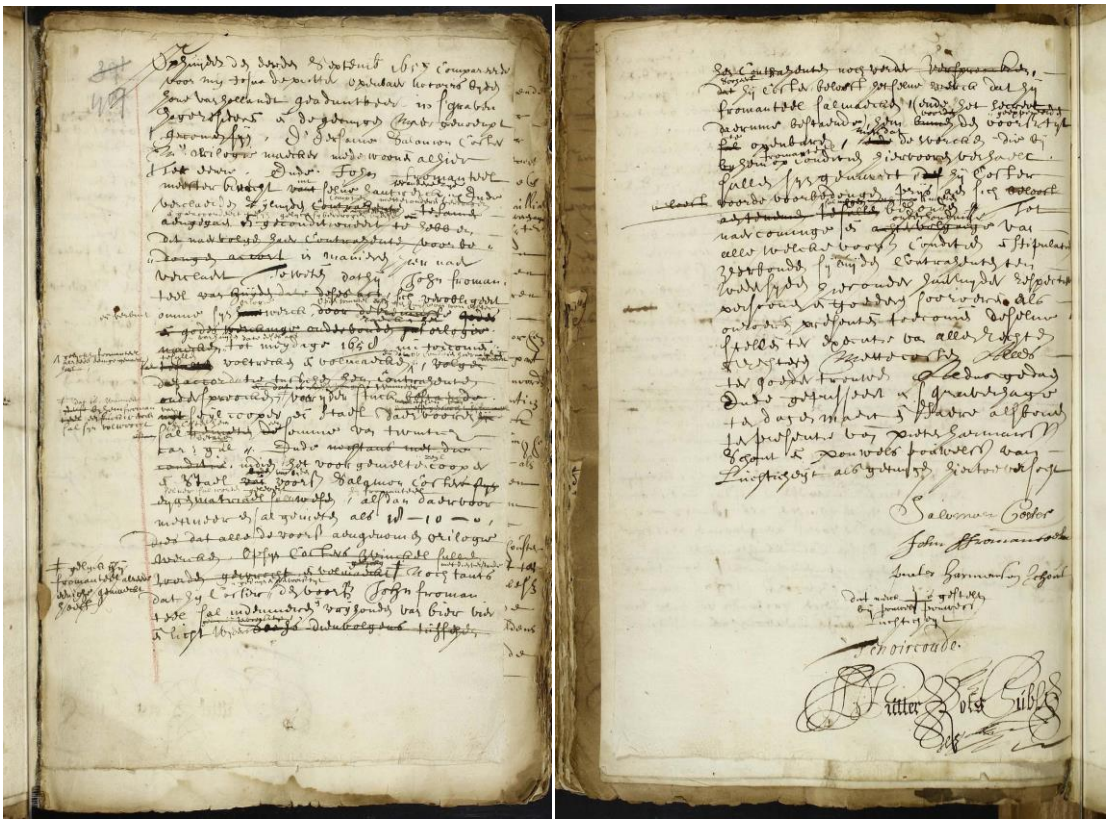
The patent

Salomon Coster was at that time one of the most important clock- and watchmakers in the Netherlands, having made complicated box clocks and watches. Given the short time span between the simple but brilliant invention of Huygens and the application of the patent, it was apparently easy for Coster to construct four gearwheels between two plates, a pendulum suspension and motion work. This new construction was much simpler than the movements Coster had made so far.

After obtaining the patent in June 1657, Coster will soon have found out that he had opened a new market and that the expansion of labour capacity was desperately needed. He will have sought cooperation in order to enlarge the current production and to be able to serve the new market of the pendulum clock.

As an advanced apprentice John Fromanteel fitted well in this picture. He was a 5th-year apprentice, not yet a journeyman, so not yet an accomplished clockmaker. On the other hand Fromanteel was not a starting inexperienced student, still taking up a lot of time from Coster to teach all the principles of clockmaking, but immediately a productive employee. John was hired and in September 1657 an employment agreement was drawn up for the duration of 8 to 9 months. This agreement, nowadays also known as the *Coster-Fromanteel contract*, has already for decades been a source of the most peculiar theories.[III]

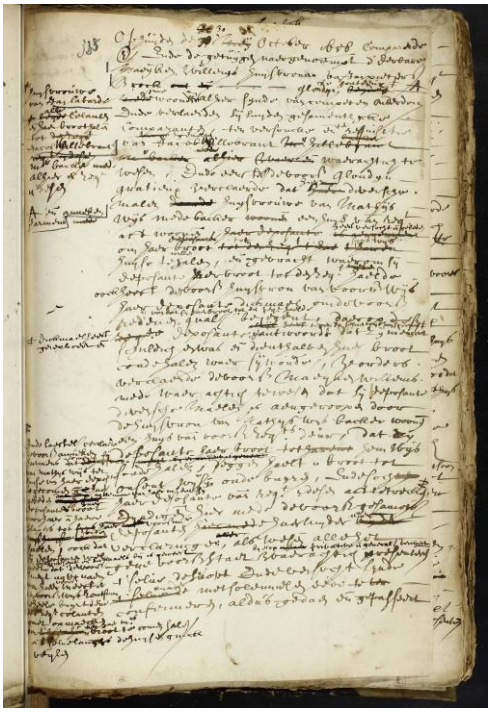
When we look at the facts in the contract, we see little more than a fixed-term employment agreement with performance-based pay, between master clockmaker Salomon Coster and skilled apprentice John Fromanteel.



The Coster Fromanteel contract

These ‘job titles’ are historically correct, since Coster has been named as such since 1645 and John Fromanteel, in the fifth year of his apprenticeship, was still an advanced student, also according to the rules of the Worshipful Company of Clockmakers. Moreover, these job titles are exactly defined in the employment agreement between Coster and Fromanteel. The work of skilled apprentice Fromanteel takes place in the workshop of the master clockmaker Coster and a pay rate per piece is agreed. On the basis of either the currently still existent Coster pendulum clocks, or archival documents, it is not possible to determine who did what in the production process. Even the agreement between Coster and Fromanteel only mentions the general words "werck" and "orlogiewerck" (i.e. movement or clock/watch movement), which implicates that any type of movement could be meant. However, it is becoming increasingly clear that the Coster workshop had a much larger production than was thought for a long time, and that also several other clockmakers were working for Coster.[IV]

Many stories have been written and thoughts expressed zooming in on the smallest parts (even up till collet level!). Just the same, we will stay away from these micro level discussions, because evidence on who did what exactly, can never be delivered.
It would be better to have the metal and wood of the clocks scientifically examined by experts using the most modern equipment.
If scientifically proven authentic, the fact that these are Salomon Coster clocks is evident, just because the clocks are signed with his name, just as *The Nightwatch* was signed by Rembrandt, being a collaboration of several painters under the wings of the master. Or a Fromanteel signed clock, on which several clockmakers will have participated.
Other matters in the agreement, such as the supply of materials, explaining single phrases, points and commas in the text, can all be interpreted in various ways, but without additional irrefutable evidence, they are good for a rainy afternoon discussion, but scientifically uninteresting.


Same notary book, more erasures

One good example of the lack of historical knowledge and thorough research in these discussions is the fact that by some authors a lot of significance and various explanations are attributed to the numerous erasures in the agreement between Coster and Fromanteel.If these authors would simply study the same notary book, or other 17th century Dutch notarial protocols, they would see that many deeds contain the same number or even more erasures. Unfortunately, this is conveniently overlooked here.

Nevertheless, in the absence of any important and unambiguous English archives about the first pendulum clocks, especially our English clock friends for decades now are trying to find evidence in this contract in favour of Fromanteel in particular.

Speculations versus historical documents

Whereas previous English speculations assumed an important role for John Fromanteel in the manufacture of the first pendulum clocks, Garnier added a new chapter to the Coster-Fromanteel discussion in the book *Innovation & Collaboration*. In chapter 3, Garnier & Hollis try to build a story in which is stated that apprentice John Fromanteel came to The Hague to explain to master clockmaker Coster, in eight to nine months, how to make a pendulum clock. At critical moments, where the reader expects an important archive piece or other conclusive evidence, remarkably often the words "suggest", "maybe" and "strongly possible" are used.

Although we stick to archival documents as much as possible, it sometimes is unavoidable to propose a highly probable theory. Be that as it may, this theory then must be firmly supported by facts. When a theory aims to demonstrate a major change in historiography, the evidence must be strong and conclusive.

As an example: in *Tijdschrift 18/2*[V] it is said that the brother of Jannetje Hartloop (Coster's wife) presumably learned the trade at Coster's. The proof for this is not conclusive, but it is plausible. Moreover, and this is important, it is a theory that does not turn history upside down.

When the attribution of the first pendulum clocks and the role during the experimental phase is moved from Coster to Fromanteel, this is of a different order and the evidence must be strong and supported by multiple archival records.

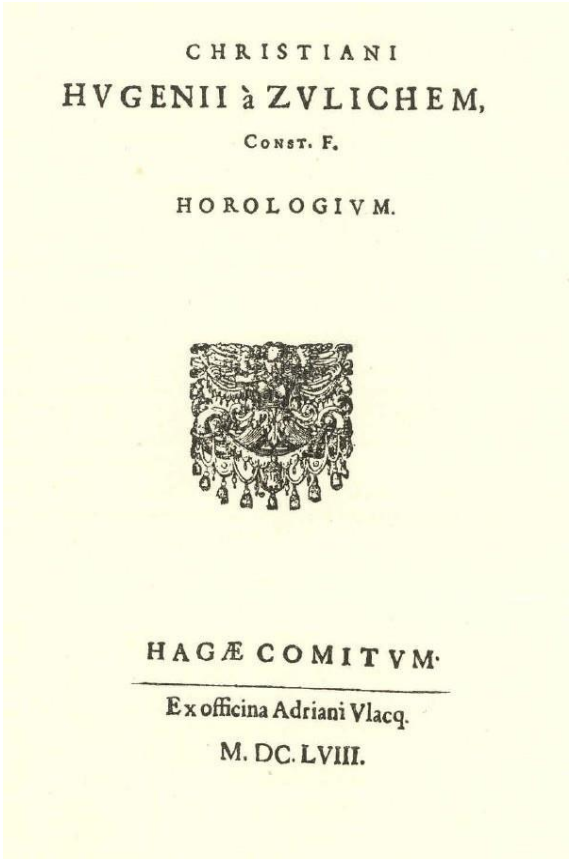
In their book, Garnier & Hollis have proclaimed the remarkable theory that Fromanteel taught the making of a pendulum clock to Coster, instead of the other way around. For this conclusion they use the following structure:

1. The weight driven clocks with seconds indication were the basis of the patent application. Thuret[1] was the one who assisted Huygens in this experimental period and in the first quarter of 1657 was responsible for making the pendulum clocks driven by weights.
2. In *Horologium* (1658) Huygens speaks about 'manufacturers'. This word is in the plural, so if Thuret assisted Huygens, there must have been another clockmaker assisting Huygens in this experimental phase. Who was this other clockmaker?
3. The Coster-Fromanteel agreement has a sensational phrase that shows that Fromanteel demonstrates the making of a pendulum clock to Coster, instead of the other way around.
4. In addition to Thuret, Fromanteel therefore was the other one assisting Huygens in the experimental phase of the pendulum clock. Where Thuret was responsible for the weight driven clocks, Fromanteel was responsible for the 'commercial' spring driven movements.

In the run-up to Garnier & Hollis' new discovery in the Coster-Fromanteel agreement (more on this later in this article) they immediately make a huge mistake. They state that we should realise that a weight driven clock with a seconds indication was the basis for the patent

[1] Isaac Thuret (ca. 1630 – 1706), *horloger ordinaire du roi*, was one of the most productive makers in Paris in the 2nd half of the 17th century. He was also the clockmaker responsible for the maintenance of the *machines* of the *Académy des Sciences* and the Paris observatory. In 1675, Christiaan Huygens asked the help of Thuret to produce the first spiral spring watch. In January 1686, Thuret moved into the 'Galleries du Louvres'.

application. The main shortcoming is, the patent application has so far not been found in the archives and the grant of the patent itself does not mention a weight clock.
Garnier & Hollis then draw a wrong conclusion from *Horologium* (September 1658)(Fig. 2). Huygens writes in his concluding speech about the uniformity and the firmness of the pendulum.


CHRISTIANI
HVGENII à ZVLICHEM,
CONST. F.
HOROLOGIVM.
HAGÆ COMITVM.
Ex officina Adriani Vlacq.
M. DC. LVIII.

Horologium

The translation[VI] from Latin is as follows:
'*Much that I could add to this, I leave to the ingenuity of the manufacturers, who, once they have understood my invention, can easily find out how it can be applied to the different types of movements and also to those that have been made according to the old system*'.

Huygens concludes his *Horologium* with the remark that his invention will be further developed and that manufacturers (among others clockmakers) will accomplish this. Huygens also states, with the then current insight, the existing balance/foliot movements are easily converted to a pendulum. Huygens made this statement more than a year and a half after his invention, after many pendulum clocks had already been produced. Garnier & Hollis mistakenly see this as the evidence that several people were involved during the experimental phase of the pendulum clock (early 1657). Here the story can actually stop, but we will take you into some other curious next steps.

Reference is made to a publication by Sebastian Whitestone stating that Thuret was the clockmaker helping Huygens with the experimental pendulum clocks in early 1657.[VII] However, Thuret only comes into the picture in the *Oeuvres Complètes* of Huygens from 1662 onwards. Up till now, no document has shown Huygens knew Thuret before this date, let alone they were working together during the early phase of the pendulum clock. Probably, the confusion arose because the editor of *Oeuvres Complètes*, suggests in the margin of a letter from Huygens to Chapelain of 20 August 1659, , Thuret may be meant by the word 'he'. Unfortunately, the *Oeuvres Complètes* do not show the basis for this suggestion. Nor have we been able to find anything in this regard elsewhere.
We do know some still existing wall clocks with long pendulum signed by Thuret.[VIII]
On the basis of various characteristics of both case and movement, these clocks need to be dated much later than 1657.

Garnier & Hollis then return to September 1657 to explain the new major discovery by quoting the Coster-Fromanteel agreement. The following sentence appears in the Coster-Fromanteel contract:

soo heeft hij Coster belooft hetselve werck dat hij Fromanteel sal maecken I (ende het secreet daerinne bestaende), hem voor den voorsz. geexpereerden tijt te openbaeren, mits dat de wercken die bij hem Fromanteel hem op conditien hiervooren verhaelt sullen sijn gemaeckt hij Coster voor de voorbedongen prijs aen sich belooft sal mogen ende moeten behouden.[IX]

This is translated to:
... Further so has he Coster promised to reveal the same work that he Fromanteel will make (and the secret therein existing) to him before the aforementioned expired time, provided that the works which by him Fromanteel on conditions aforementioned will have been made, he Coster for the stipulated price will be allowed and obliged to keep.[X]

Or in plain English: Coster will tell Fromanteel the secret that is in the (pendulum) movement and Coster will also take the manufactured movements for the pre-agreed price.

The handwriting of notary Josua de Putter is not always clear and his commas and other punctuation marks sometimes differ. However, Garnier & Hollis see two punctuation marks as extra parenthesis and the text according to Garnier & Hollis gets a completely different meaning (Fig. 3). The new sentence now becomes (see new brackets) as follows:

soo heeft hij Coster belooft hetselve werck dat hij Fromanteel sal maecken ***(****(ende het secreet daerinne bestaende), hem voor den voorsz. geexpereerden tijt te openbaeren****)*** *mits dat de wercken die bij hem Fromanteel op conditien hiervooren verhaelt sullen sijn gemaeckt hij Coster voor de voorbedongen prijs aen sich belooft sal mogen ende moeten behouden.*

Which then suddenly is translated to:
... furthermore during the aforementioned time so has he Coster contracted the same work that he Fromanteel will make - (and the secret incorporated therein) him to explain before the aforementioned expired time - provided that the works which by him Fromanteel on conditions previously cited shall be made the same he Coster for the pre-stipulated price to himself promised will be allowed and obliged to keep...[XI]

So we see a larger part of the sentence in brackets. In this Garnier & Hollis see proof that Coster did not tell the secret to Fromanteel, but the other way around: Fromanteel taught Coster how to make a pendulum clock!

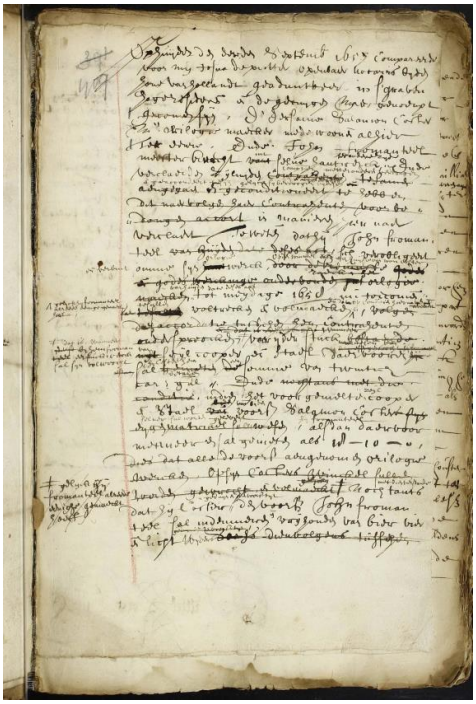
We, and various experts, once again have looked at the meaning of this new sentence structure and into the scope of the entire agreement. Unanimously we come to the conclusion that this new theory, in which punctuation marks are seen as extra brackets, does not result in any change in the meaning of the text. In no way it is comprehensible or possible to follow the conclusions of Garnier & Hollis.

Fact findings
The tales on the new Fromanteel story are based on far-fetched assumptions and theories. It actually entails a recommendation to investigate in the future on the basis of facts laid down in dated deeds and to take note of the 17th century Dutch manuscripts, the use of language and the course of events at 17th century notaries.

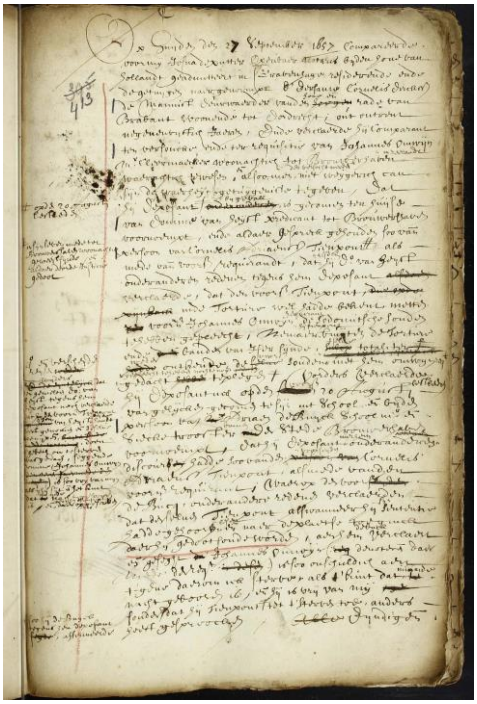
Of course one can put forward ideas and thoughts at certain moments, but when the authors think to have made great discoveries, as is the case with *Innovation & Collaboration*, they will have to come better prepared than bring a theory built on quicksand.

Two G's

On the occasion of the exhibition *Innovation & Collaboration*, Dr. John C. Taylor published and commented a facsimile edition of the '*Coster-Fromanteel contract*'.[XII]
The facsimile looks beautiful and well cared for; clearly, a lot of attention has been paid to this, as well as to the contents of the contract itself. The document has no less than 67 notes with comments. This enormous number alone already suggests the author is not accustomed to reading seventeenth-century Dutch notarial protocols, let alone interpreting them. This is immediately apparent for note 1. The author sees two lines in the top left hand corner, drawn through the original text. That's right, but they are not just lines or erasures. This are two G's indicating two copies, two neat copies, have been made of this deed, which may or may not have been certified by the notary.



two G's in the top left corner



one G in the top left corner

Notarial practice

This clarifies point I of the introduction. Here the author states, according to the authority of Prof. Lisa Jardin, that no legal system would have such a sloppy document filed.
However, this was common in 17th century Holland. And where were they archived? At the Court of Holland. After all, this body admitted the notaries in Holland. So the archives were in custody with the State. And how did they end up at the municipality of The Hague?
We quote from the introduction of the inventory of the notarial archive in The Hague:

'Pursuant to the authority from the Royal Decree of 23 August 1907 (Bulletin of Acts and Decrees no. 237), given to municipalities, that meet certain conditions, to keep the archives of the notaries, who have had their place of employment within those municipalities, from

the central government in custody, on November 1910, the municipality of The Hague received all archives of notaries who had resided at its territory in the years 1597-1811 at its request on loan.'[2]
This is just an aside, for a better understanding of the author, who asks himself in note 9 '*How this contract can be viewed as draft minutes and where the protocol is stored remains unclear*'. On the contrary, that is as clear as daylight.
Besides, in contrast to nowadays, notarial deeds were not always drawn up at a chic notary office. Also changes in the text were not initialled as they are today. A lot of these procedures even happened in the pub. The world really looked a lot different in the 17th century.

Reading errors
Next to mistakes due to lack of historical knowledge, there are also reading errors. The author is forced to make use of an English translation, where the danger is that there are differences in nuance or even differences in meaning. An example: in point K of the introduction, the author says: '*The contract does not spell out normal issues which are taken for granted; for example, the cost of John's travel to The Hague is paid by John: Salomon will provide John's board and lodging. So why are beer, fire and light mentioned if they were normally supplied by masters to their workers?*'
Indeed, the agreement does not include things that are normal. But what was normal back then? That really was not fixed. Subsequently the author claims that Salomon would provide John '*board and lodgings*'. But that is not what it says. It does only say that Coster will '*indemnify and defray Fromanteel [usually to put synonyms in succession] with beer, fire and light*'[3]; so he will provide him with beer, heating and light to be able to do his work. This also means Coster does not provide him with accommodations and meals. So, Fromanteel stays/sleeps elsewhere.

Historical knowledge
But there is more, maybe even more serious. Let us again limit ourselves to some examples, because there are a lot of mistakes and there is no room to cover everything.
Dr. John C. Taylor, an entrepreneur and inventor, who has registered more than 400 patents worldwide, states he has never yet lost a lawsuit about a patent worldwide. Truly a formidable achievement that certainly commands respect. But this look-and-see statement suggests that he also has knowledge of patent law and contracts in 17th century Holland. This is nothing more than a suggestion, because apparently he does not have that knowledge. He looks at 17th century Holland through biased 20th and 21st century international glasses.
An important example of this is the introduction of the necessary existence of a *Heads of Agreement*. Quote: '*Parties coming for a lawyer usually have at the very least a Heads of Agreement worked out between them, together with a wish to compromise to some degree to achieve a final Agreement*'.[XIII]

[2] 'Ingevolge de bevoegdheid in het Koninklijk Besluit van 23 augustus 1907 (Staatsblad no. 237), gegeven aan gemeenten, die aan zekere voorwaarden voldoen, om de archieven van de notarissen, die hun standplaats binnen die gemeenten gehad hebben, van het Rijk in bewaring te ontvangen, heeft de gemeente 's-Gravenhage in november 1910 alle archieven van op haar toenmalig grondgebied geresideerd hebbende notarissen over de jaren 1597-1811 op haar verzoek in bruikleen ontvangen.'
[3] 'sal indemneeren ende vrijhouden van bier, vuur ende licht'

That may be customary nowadays, but was this so in the 17th century? The author states it is very common - '*at the very least*' - so he does assume it was so at the time. In this way he's working towards a larger role of Fromanteel.
What did the authors want to achieve with their entire exercise? They wanted to show that a normal agreement of employment between Coster and Fromanteel is in fact a learning agreement between Fromanteel and Coster, i.e. a 180 degrees rotation of roles, together with a change in the value of the agreement itself. In our opinion the authors have not succeeded. Too few arguments have been put forward for this radical change, and at the same time the authors have disqualified themselves by showing that they have no knowledge of 17th century notarial practice in Holland. As they are unable to read archival documents, they for instance would have done themselves and all readers a favour to have first been informed first by Prof.dr. Brugmans, Professor of General History, He more than a century ago published a collection of 180 work and student agreements from the Hague protocols.[XIV]
These very quickly show that the world then did not look as unambiguous and tightly organised as the authors suggest.

[I] Nationaal Archief, tnr. 3.01.04.01, Staten van Holland, inv.nr. 1611, nr. 22, d.d. 16-07-1657.
[II] O.a. in *Oeuvres Complètes de Christiaan Huygens, Tome Deuxième, correspondance 1657-1659*. p. 108. Nr. 433.
[III] Haags Gemeentearchief, tnr. 0372-01, Notarieel archief Den Haag, inv.nr. 322, folio 409.
[IV] Although it was drafted two years later, the estate statement, drawn up immediately after Salomon Costers' death, shows that there was a huge stock in the Coster workshop and that Coster also outsourced work to Severijn Oosterwijck. See: Victor Kersing and Rob Memel, 'In de voetsporen van Salomon Coster. Van Hagestraat naar Wagenstraat' in: *TIJDschrift* 18/2. p. 4-9.
[V] Kersing en Memel, 'In de voetsporen van Salomon Coster Van Hagestraat naar Wagenstraat' in: TIJDschrift 18/2. p. 4-9.
[VI] Translation from *Tijdschrift voor horlogemakers*, 1 maart 1903.
[VII] O.a. in *Going Dutch. The invention of the pendulum clock. Proceedings of a symposium at Teylers Museum, Haarlem, 3 december 2011* ([Zaandam], 2013). p. 29.
[VIII] For more on this topic and Thuret see part 4 of these articles: *Part 4: The invention of the pendulum clock – The Sequel, more inventions*.
[IX] Haags Gemeentearchief, tnr. 0372-01, Notarieel archief Den Haag, inv.nr. 322, folio 409.
[X] Richard Garnier & Leo Hollis, Innovation & Collaboration, The early development of the pendulum clock in London, Fromanteel Ltd., Isle of Man, 2018, pp. 67
[XI] Richard Garnier & Leo Hollis, Innovation & Collaboration, The early development of the pendulum clock in London, Fromanteel Ltd., Isle of Man, 2018, pp. 68
[XII] John C. Taylor, *The Salomon Coster John Fromanteel contract 3rd september 1657. Changes made during drafting* (s.l., s.a.).
[XIII] John C. Taylor, The Salomon Coster John Fromanteel contract 3rd september 1657. Changes made during drafting (s.l., s.a.), pp. 2 point E.
[XIV] H. Brugmans, 'Uit de protocollen der Haagsche notarissen' in: *Die Haghe. Bijdragen en mededeelingen* 1908, p. 1-124; H. Brugmans, 'Uit de protocollen der Haagsche notarissen II' in: *Die Haghe. Bijdragen en mededeelingen* 1909, p. 1-78; H. Brugmans, 'Uit de protocollen der Haagsche notarissen III' in: *Die Haghe. Bijdragen en mededeelingen* 1910, p. 1-113.

The invention of the pendulum clock

Part 4 - The sequel: more inventions

Setting the scene
As discussed in part 1 the invention of the pendulum clock is a revolution. It is the new thing taking Europe by storm. Everyone has to have one! Within a very short period clocks according to the new application are spread all over Europe, not only exported from The Hague, but also copied and made locally.
We know that before the end of 1657 a 'Coster clock' is in Tuscany. In an inventory of 1690 a clock signed by Coster is mentioned to have arrived on 25 September 1657, as the first pendulum clock in Italy. Treffler used this clock as example to make his own. The movement of this latter clock is still existent today[I].
On 28 October 1658 Fromanteel publishes his famous advertisement in the *Mercurius Politicus* about the availability of a new type of clock[II]. From then on pendulum clocks also take England by storm.

From Huygens' correspondence we know a great many pendulum clocks are shipped from The Hague to Paris, mainly by mediation of Nicolas Hanet[III].
When Huygens is in Paris again in 1660, he mentions in a letter to his brother Lodewijk in The Hague, there are three or four masters in Paris who make pendulum clocks and that even some are starting to convert turret clocks[IV].

In his diary of that same trip we read he meets up several times with clockmaker Gilles Martinot[1], who resides in *Les Galeries du Louvre* at that moment. They already discuss applying a spring to the balance wheel of a watch and the application of the '*boxhoorns*'[V] (cycloidal cheecks).

Even though we know Visbagh takes over Coster's shop end of 1660, Huygens, when in Paris in the spring of 1661 (Saturday 12 March), still talks on behalf of the widow of Salomon Coster to Petit, bookseller and reseller of pendulum clocks in Paris. In the further developments, experiments and other inventions Visbagh does not play a prominent role.

From early 1662 Christiaan and his brother Lodewijk, who is in Paris at that time, are mediating in the supply of clocks made in The Hague and sent to Paris. We learn Claude Pascal starts making a pendulum clock for Mr. Chaise in the third week of January[VI]. By the end of February the clock by Pascal is almost ready and previewed by Huygens[VII].

[1] Giles Martinot (I), Aux Galeries du Louvre; °1622 - †1669; From 1658 he works together with his son Henri Martinot (°1646 - †1725), who takes over after his father's death.

Huygens and Thuret

Early April 1662 Huygens is very much taken by the comment from his father that he would readily give ten to twekve Pistoles[2] more for a clock made in Paris by Thuret[3] than he would for his own 'Dutch' clock. He would very much like to know what the French do differently, so it could perhaps also be done like that in The Hague[VIII].

About half a year later we learn Thuret is making clocks with a 3 foot pendulum, indicating seconds. This clock, made for Monsieur Cheureusse[4], goes very well, just like Petit's own clock with a 3-foot pendulum (1-second pendulum). The smaller clocks with a pendulum of 9 or 10 inches (½-second pendulum) are not as good as the ordinary ones [IX].

On 28 March 1663 Huygens leaves for another journey to Paris and London. He arrives in Paris 6 April, where he stays until 2 June. He then leaves for London where he arrives eight days later on 10 June. The first of October he is back in Paris, where he will stay until June the next year. He returns to The Hague on 27 June 1664. While in Paris, Christiaan, together with his brother Lodewijk now in The Hague, continues mediating in ordering pendulum clocks from Pascal for French clients[X].

Early 1664 he is not too satisfied by the work of Pascal and as he does not want to lose face himself nor damage the reputation of Pascal, he gives a '*rather long lesson to Sieur Pascal*'. We also learn something about packaging of the clocks, as he urges Lodewijk to make sure they are packed better and all the pieces well attached, because in one of these last he had found the 'countwheel' disconnected and this had broken one of the side windows, and some of the pegs rolled through the box[XI].

Three months later Huygens is still not satisfied with the work Pascal has done. He does keep writing with affection towards Pascal. We also see Huygens now makes use of the services of Thuret to fix the broken clocks[XII].

The next day three earlier ordered clocks arrive, but two of the three are in terrible state: the one with tortoise and the one going for eight days. '*All kinds of pieces of the first came loose, and the axes of three or four wheels were broken. In the end the whole thing was upside down and mixed with the broken glass powder, that has scratched all the copper in a strange way.*
With the one of eight days the bell is in pieces, the tail of the hammer and some other parts broken, because the movement has detached from the dial plate, and rolled thus through the case, which is also very damaged at the sides. The third clock miraculously remained intact, lying between the two others'[XIII].
Huygens mostly blames customs in Peronne[5], but partly also Lodewijk and Pascal as they did not provide each clock with its own box.

[2] One pistole was worth approximately ten livres or three écus
[3] This is the first time Huygens mentions Thuret by name in his Oeuvres Complètes
[4] Claude de Lorraine, Duke of Chevreuse, husband of Marie de Rohan, Duchess of Chevreuse (1600 – 1679). In 1659 (16 January) DuGast orders a clock for Marie with Huygens and Coster (OC, No 567)
[5] Péronne, on the banks of the river Somme. In 1664 it was near the French – Netherlands border.

Huygens brings the first clock (with tortoise) to Thuret with whom he looks for all the loose pieces, and leaves it with Thuret to fix. The other of eight days was ordered for Mr. Merat and Huygens leaves it up to him to decide what to do with that one.
Huygens is now very fed up with ordering clocks from The Hague and promises never to order any clock again from Holland[XIV].

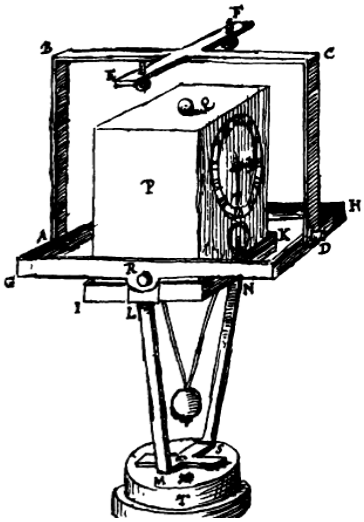
Some two weeks later things are not as bad as they first seemed and Huygens has calmed down a bit. At least he does not want Pascal to suffer any loss by what has happened to both damaged clocks. This risk should be entirely for those who have ordered them.
Two of the clocks, the one that was not damaged and the one going for eight days were ordered by 'Mareschal de Grammont'[6]. Where the first one has already been delivered and paid for, the other one is still with Thuret to be repaired, but '*should be ready any day now*'. The Mareschal is very happy to pay the additional repair costs as the clock is more beautiful than the one he already has.
Huygens did not hear anything yet from Mr. Merat, who ordered the eight-day clock.
In the end, after some financial indications, Huygens asks Lodewijk to let Pascal, or rather the 'Genevois'[7] know all this.

Sea clocks
Mid-March 1665 Chapelain writes to Huygens that Thuret came to see him to offer Huygens his services for the construction, sale and distribution of pendulum sea clocks. Thuret proposes to pay Huygens for each clock he builds in his workshop and for a term that he thinks appropriate to exercising his privilege.
'He (Thuret) *hopes for your kindness that you will give him the preference, decided on his part to give you all the satisfaction that you want to keep up the reputation of the pendulum clocks as they deserve and for the price that will be agreed between you and signed before a notary. I believe you know his reputation and his work so well I* (Chapelain) *will not waste time in making sure of it or recommending it to you' [XV]*.

Jean Chapelain is mediating on behalf of Huygens for his privilege for sea clocks in France. We have just seen that Chapelain also recommends Thuret to be the 'preferred one' as clockmaker to execute this and make the new type of pendulum clocks. They are thinking of a 'transport of privilege' to Thuret for a period of five or six years. The first step to apply for the privilege is to publish in the *Journal des sçavans* of which Chapelain takes care by the end of March.
Huygens in turn verifies the invention in Amsterdam with some of the 'seafarers', but also with cartographers like Blaeu[8], and several navigators, who all confirm the usefulness of the new type of clock[XVI].

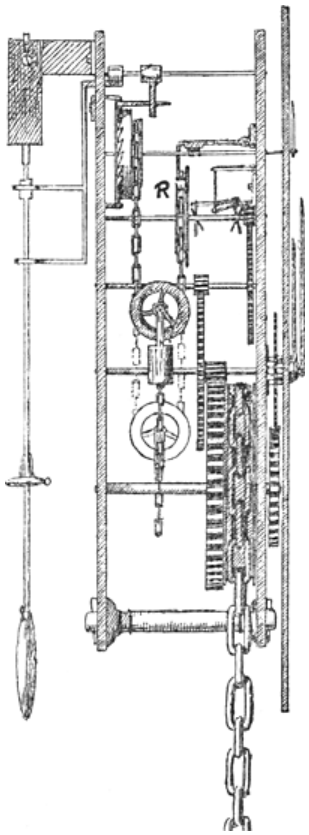
[6] Antoine III Agénor de Gramont, Duke of Gramont, etc. (1604 – 1678) was a French military man and diplomat, and from 1641 Marshal of France.
[7] The Genevois is a former province of the Duchy of Savoy. Its capital is Annecy. Although the province took its name from the city of Geneva, the city itself is not part of it.
[8] Dr. Joan Willemsz. Blaeu (Amsterdam, 1596 - Amsterdam, 1673). In 1620 he became a doctor of law but he joined the work of his father, a cartographer. In 1635 they published the Atlas Novus. Joan became the official cartographer of the Dutch East India Company.

Two types of new ‘privileged’ clocks are being made, one to be used ‘in a room’ and one ‘in a box’ to be used suspended in ships.
The first type we now know already for some years from letters, with a 3-foot (1 meter) pendulum with horizontal verge escapement and with ‘boxhoorns’ (the ‘cycloidal cheeks’; and subsequently without the O-P construction). The large dial with two hands coming from the center point, the smallest one indicating the hours, the largest one the seconds and a smaller dial under the large dial, indicating the minutes. The sea clocks have the same dial layout, but they are placed in a gimballed and suspended box and fitted with a triangle pendulum, all to deal with the rocking of a ship. We do not know any surviving sea clocks.



Type 1 sea clock (1665)

Part of the invention is a remontoir Huygens is using to get the clocks keeping time more exactly. A remontoir is not something new, but was already known in all kinds, shapes and forms. Indeed, in the text of the patent granted by the States-General, we find the words: *'In welcke een cleyn gewicht binnen het werck is, alleen het schakelradt omdrijvende,' t welck t'elckens door het groote gewicht wert opgewonden*'[9]. The Dutch privilege only incorporated the weight driven remontoir[XVII].
In the same year in France King Louis XIV granted Huygens the privilege '*for the use of pendulum clocks at sea*'[XVIII].



Although other clockmakers also ask Huygens for the privilege to make and sell sea clocks, he remains loyal to Thuret[XIX].

Huygens also mentions something about the pocket watches regarding the new edition to the invention (the remontoir) and that it is not new at all here, as already watches exist that rewind every hour. He will not apply for a privilege on this, because if it would be successful it would ruin the clockmakers and he would not be able to embrace so many new things[XX].

With a Power of Attorney from Huygens, Chapelain negotiates the conditions of the manufacture and distribution of the sea clocks. As said before this is considered for five or six years. Huygens prefers a fee per sold clock, instead of a yearly one or one big sum at once. They also create a ‘stamp’ or punch mark to separate the privileged clocks from possible fakes[XXI].

[9] 'In which is a small weight within the movement, only entwining the escapewheel, which is always wound by the big weight'

The suggested retail price for the sea clocks is 300 Livres and Huygens will take a third or 3 Louis d'Or as fee (± 100 livres)[10]. We do not know the retail price for the land clocks, but the fee here is only two Louis d'Or[XXII].

Thuret at this time is also experimenting to compensate the inaccuracy at the beginning and the end of the springs which drive the clock. He uses two barrels of which one each hour rewinds the other, so the primary driving spring winds down only one hour, which greatly reduces the inaccuracy of the springs worn down from beginning to end greatly[XXIII].

There is still quite a good deal of trust between Thuret and Huygens as they do discuss swindling by selling clocks without the privilege punch by Thuret and by others[XXIV].
The manual of how to use the sea clocks in operation[11] is now also being translated into French[XXV].
In August 1665 Huygens sends two new sea clocks to Paris, one for P. de Carcavi and one for H.L.H de Montmor. Some improvements have been made in the suspension to cover for the movement of a ship, but the main change is the addition of the remontoir[XXVI].

Early September De Montmor lets Christiaan know the clocks have arrived and are installed by Thuret to show to a large group of interested people[XXVII].

We also see some try-outs of what later becomes the spiral balance spring in watches, but for now is applied to the escape wheel of a long pendulum clock: '*I saw therefore in his machine that he had engaged in the inner turn of the wheel which moves the one of encounter a small very narrow spring, which at each turn of the wheel went up and returned to the same point by the force of the great spring of matter that the little one only spreading itself with a very small median, it could not fail to maintain such a vigor, whence the parity of the movement of the pendulum was necessarily necessary, and thus the equality of the hours by the parity of the moments*' [XXVIII].

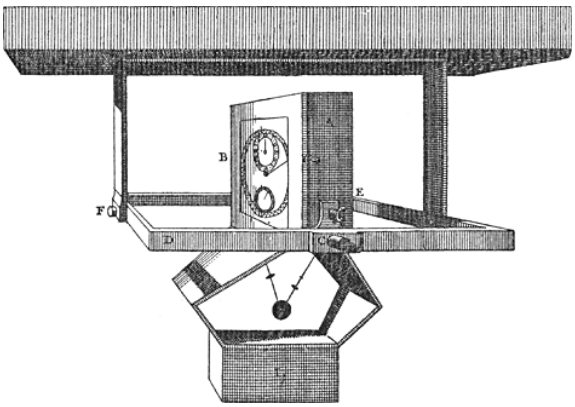
This is acknowledged by Huygens in his reply: '*That the invention of Thuret perfectly matches the one that by my opinion has been made here to regulate a pocket watch, where I had tried to attach the small spring on the axis of the escape wheel, but that it would require too much delicacy in the spring and in the movement. So I advised that it is attached to the axis of the next wheel, and that this is fine.*
The clockmaker is after the ability to advance or delay the movement. This invention is only a subsidiary to mine, using springs where I have used weights, but that if we wanted it to be used for the big sea clocks. I would be very wrong if we find the same correctness as with the counterweights to satisfy the fact of the Longitudes, as the springs must operate all days with the same force as the weights. Mr. Thuret will be able to see by experience that this is the case if he wants to make such horologies that show the seconds'[XXIX].

[10] The actual value of the coins fluctuated according to monetary and fiscal policy, but in 1726 the value was stabilised and set to 20 livres. In 1740 it was revalued to 24 livres, thereby effecting a 20% devaluation of the livre.
[11] KORT ONDERWYS Aengaende het gebruyck Der HOROLOGIEN Tot het vinden der Lenghten van Oost en West, Christiaan Huygens, 1665

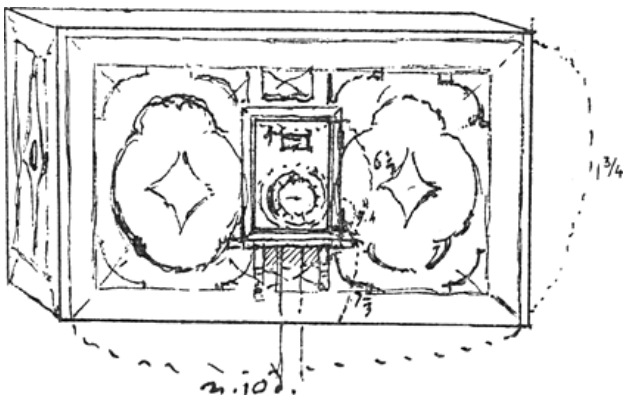
Unfortunately we do not know of the existence of any of these clocks, nor do we get any more information on the continuation of the sea clocks until several years later.
Thuret's name is mentioned in account books from 1669 onwards for works made for the *Académie Royale des Sciences* and, three years later, also for the maintenance of all pendulum clocks of the observatory and the academy[XXX].

Christiaan leaves for Paris 21 April 1666 where he stays for ten years[12], except for a return to The Hague for nine months between 9 September 1670 and 12 June 1671. In 1673, still in Paris, Huygens publishes *Horologium Oscillatorium* and dedicates this to Louis XIV.

Next to the very challenging task of keeping a pendulum clock going at sea with the required accuracy, the trials at sea bring up another, quite unexpected drawback of using a pendulum. The trip to the America's of 1672-3 revealed that the length of a one-second pendulum is not a universal measure but depends on latitude, mainly caused by differences in gravity in different places on the earth[XXXI]. Huygens had to face the fact that the pendulum as a timekeeper at sea had not only practical but also more fundamental disadvantages.



Type 2 sea clock (1672)

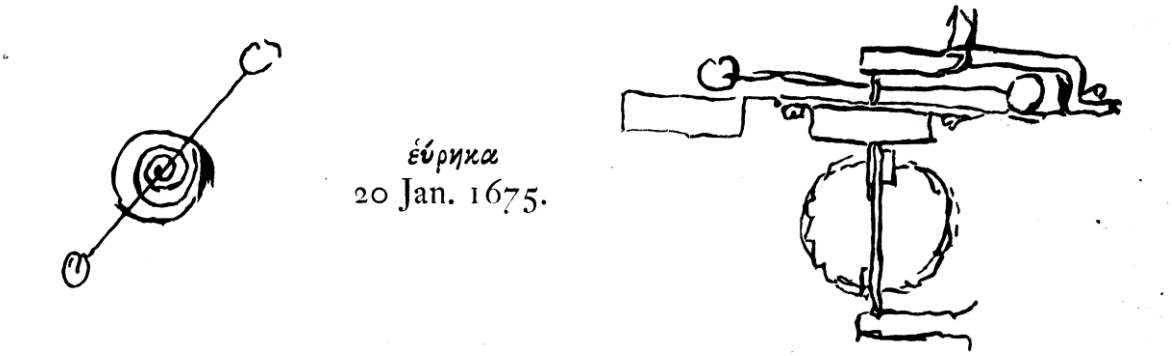


Type 3 sea clock (1694)

From 1675 Huygens shifts his attention to the spiral balance spring in watches. Another invention with quite some controversy, contending rivals and turmoil.
In England Hooke made claims and in France we see Thuret claiming the invention.

The spiral balance spring in watches
The pocket watches of this type were at the time called: 'pendulum watches'. This stems from the regularity of their strokes and motion, which were supposed not to be inferior to those of a real pendulum. This exactness is effected by the government of a small spiral spring running around the upper part of the verge of the balance [XXXII].

[12] Christiaan leaves Paris with Philips Doublet, his brother in law, on 1 July 1676 to arrive back in The Hague on 14 July 1676



The idea of applying a spring to regulate a clock was not new in 1675. We have to step back in time to the first indications in records on a spring-equipped balance wheel.

First we hop to 1665 when Moray reports on one of Hooke's lectures on Mechanics for the Royal Society where he shows "*an entirely new invention, or rather about twenty, to measure time just as accurately as your pendulum movements do, both at sea and at land, which cannot be hindered at all by its changes of state or even of the air. In short, it is by attaching to the balance, instead of a pendulum, a spring, which can be done in a hundred different ways, and even he has sustained us with an argument in which he has undertaken to prove that it is possible to adjust the deviations so that, either small or large, they will be Isochronous*"[XXXIII].

In his answer Huygens takes us even further back to 1660 when he was in Paris when the Duke of Roannais[13] spoke of the same and even took him to the clockmaker to whom he and Mr. Pascal [14] had communicated this invention, but under oath and promise for the Notary not to reveal it or to appropriate it.
Huygens however did not really like their way of application, and learned much better since then, but besides that its practice is not as simple as that of pendulum movements, one cannot expect as much accuracy as can be found in the latter, since the movements of the ship must cause minor irregularities in the movement of the spring, which would be difficult to correct. And it is not yet known whether a change of temperature would influence the vibrations[XXXIV].

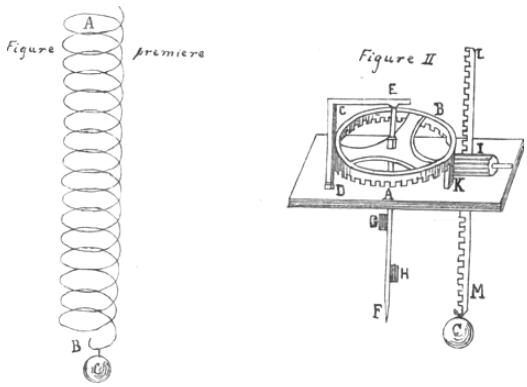
Having stepped back to 1660, let's stay there for a moment.

At the end of 1660 Huygens is in Paris and on 4 November he mentions in his diary[XXXV] for the first time a visit to Martinot, *l'horloger*[15].
We can read in the same diary he meets up several times with Gilles Martinot, who resides in *Les Galeries du Louvre* at that moment. Already they discuss the application of a spring to the balance wheel of a watch.
Huygens later does call him '*one of the biggest braggarts in the world, otherwise quite competent in his field*'[XXXVI]

[13] François d'Aubusson de La Feuillade, known as 6th duc de Roannais (1631 – 1691) was a French military officer and noble who served in the wars of Louis XIV and became a Marshal of France.
[14] Blaise Pascal (1623 – 1662) was a French mathematician, physicist, inventor, writer and Catholic theologian.
[15] Giles Martinot (I), Aux Galeries du Louvre; °1622 - †1669; from 1658 he works together with his son Henri Martinot (°1646 - †1725), who takes over after his father's death.

So, it is very likely that even before 1673 Huygens had thought of dealing himself with the question of the regulating spring, since he said in September 1675 (T. V, 486) that *as early as 1660 he did not find the way to apply the spring he had seen in France and that he already knew at that time 'much better'*.
We unfortunately do not know exactly on what Martinot, inspired by the Duke of Roanais and Bl. Pascal, was working on in 1660, or what other French watchmakers, or R. Hooke, had been able to conceive. We do kow that until then the application of a spiral spring in the regulation of watches had hardly been considered, and we do not know of any practical use of a balance spring prior to 1675.

Jean de Hautefeuille[16] makes a claim on the balance spring regulation of watches. His principle of using helical springs is however completely different from the radial spring. Even more, if De Hautefeuille had knowledge of the application of a spiral spring to the balance before 1675, he would surely have mentioned this in the *Factum touchant les Pendules de poche*. The charges made by De Hautefeuille were not further prosecuted[XXXVII].



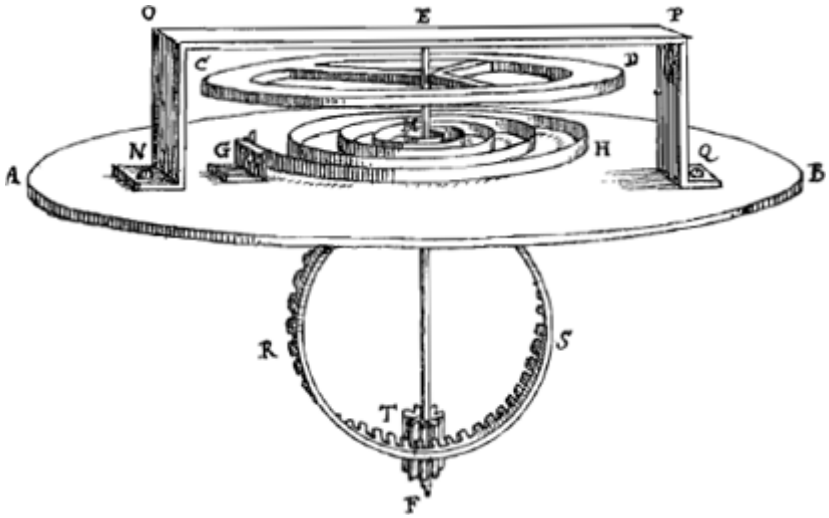
Huygens obtained the privilege for 'portable clocks both on land and at sea' for France on 15 February 1675 [XXXVIII]. The States of Holland and West-Friesland granted him this on 4 October 1675 for 15 years, 'for newly invented marine clocks, but not yet built'[XXXIX].

The privilege Huygens had obtained remained however useless. All the watchmakers of Paris made spiral spring regulated watches, without paying the fee of a 'Louis d'Or' - which some had already paid[XL].

Huygens invents the spiral spring-regulated pendulum on 20 January 1675. He works together with Thuret to make a model two days later, later also shown to Colbert himself. Huygens denies Thuret a share in the benefits of the invention. On the first of February Thuret shows the new invention and makes it look like he did have a very large share in it[XLI].

The secret of Huygens' invention consists of a spring turned in a spiral, attached at its inner end to the shaft of a balance beam, but larger and heavier than usual, which turns on its pivots; and by its other end to a piece attached to the (back)plate of the clock. This spring, when one sets the pendulum in motion, alternately squeezes and loosens its turns, and keeps, with the little help coming from the wheels of the clock, the pendulum moving, so despite irregular turns of the balance, the pendulum oscillations are equal.

[16] Jean de Hautefeuille, son of a baker, was born on March 20, 1647 in Orléans, where he died October 18, 1724. He was abbot and entered, in 1686, in the service of the Duke and Duchess of Bouillon.



In the figure the top plate of the clock is AB; The circular pendulum (balance wheel) CD; whose axis is EF. The spiral spring GHM, attached to the balance axis in M, and to the piece that holds the plate of the clock, in G; all the turns of the spring are up in the air without touching anything. NOPQ is the cock in which turns one of the pivots of the pendulum (balance). RS is one of the cogwheels of the clock, having a rocking motion that passes it on to the escape wheel. And this RS wheel intervenes in pinion T, which is attached to the balance axis, which by this means the movement is kept going as much as necessary[XLII].

By the end of February Thuret already several times had made his excuses to have claimed more honour than was his. In April, as a final propitiation, he proposes to write a formal letter of excuse to the Duke de Chevreuse (Charles Honoré d'Albert, duc de Luynes[17])[XLIII].

Only several months later, this letter, dated 10 September 1675, finds its way to Huygens. In this letter Thuret explicitly admits to consider the spiral spring as the exclusive invention by Huygens, although he still does suggest that the displeasure of Huygens somehow may have had its origin in the fact that Thuret recently made some clocks with a pendulum attached to a straight suspension spring instead of a thread[XLIV].
Huygens seems to accept the excuse and grants Thuret the privilege to make clocks using the newly invented spiral spring[XLV].

Also in November, he even sends Oldenburg a watch made by Thuret with the new invention and writes in the accompanying letter: '*It is from Thuret, who until then has made the best and at a good pace. He is the one who did me so wrong, when I thought of it as an invention, but having finally renounced it and apologized by a letter, he was obliged to write to me, I do not make it any more difficult to employ him*'[XLVI].

After November 1675, Huygens never talks about Thuret again.

[17] Charles Honoré d'Albert de Luynes (7 October 1646 – 5 November 1712) was a French nobleman and Duke of Luynes. He is best known as the Duke of Chevreuse till his father's death in 1690. He was a high-ranking French official under King Louis XIV. He also was the son-in-law of Colbert.

The life of Thuret

Isaac Thuret (ca 1630-1706) and his son Jacques Thuret (1669-1738), both became *Horlogers du Roi*. They both signed 'Thuret' or 'I. Thuret' (There is no difference in the 'I' or 'J').
Isaac Thuret was born in Senlis around 1630 as the son of a merchant and shopkeeper in parchment and leather. He was member of the protestant church of Senlis .
Suzanne Thuret (ca 1626 - ?), sister of Isaac married in December 1646 Charles Sarrabat, Maître Horloger (ca. 1615- <1686) and *Marchand-Horloger Privilégié du Roi suivant la Cour* Sarrabat retired in 1678 in favour of Charles Hélot. Isaac may have been apprenticed to Charles Sarrabat.
Isaac Thuret married in April 1663 Madeleine Hélot and lived in a house in the Rue Neuve Saint-Louis (Saint Bartholomew Parish) in Paris. He later moved to the city, *La Cité*, and from 1686 took up lodging at the *Galeries du Louvre*.
Isaac and Madeleine have two children, Jacques III Augustin Thuret, and Suzanne Thuret (1676-1711), wife of Charles-François Silvestre (1667-1738), designer and engraver to the king.

Isaac is appointed *Marchand-Horloger Ordinaire du Roi*[18] before 1663. We do not know when he became master clockmaker, but it has to be before this date. In exchange for fulfilling their obligations, the privileged merchants enjoyed legal and fiscal advantages which were subject to the special jurisdiction of the *Conseil d'Etat du Roi*.
Only the most skilled of the maîtres horlogers were made *Horloger du Roi*, and only a few, were given lodgings at the Louvre.
Before 1672 he was also appointed clockmaker of the *Académie Royale des Sciences*.
In 1686, he restores the clocks of the *Palais de Fontainebleau*. From 1689 until 1694, he also became *Horloger de l' Observatoire de Paris* to maintain the scientific instruments in use here.

In 1688, Isaac Thuret was represented by the most famous portraitist of the reign of Louis XIV, Hyacinthe Rigaud. The painting of which we do not know the whereabouts, nor even the history, was ordered from the artist for the sum of 67 *livres* and 10 *sols*[19], which suggests a representation in bust.

[18] The title, *Marchand Horloger Privilégié du Roi*, indicates that the bearer belonged to an original institution of the French monarchy which assembled various professions into a single body governed by the legal structure, *Les Marchands Privilégiés Suivant La Cour*. It was founded in 1485 during the reign of Charles VIII by the regent, Anne de Beaujeu. Its original purpose was to supply the King's court with food and provisions during its constant moves across the country. The *marchands* were required to set up shop wherever the ruler was, and close down within three days of his departure. Later on, Henri III added two clockmakers to the *marchands*, and in 1672, four was the set limit.
[19] 20 Sol = 1 Livre; 24 Livres = 1 Louis d'Or

Jacques III Augustin Thuret (Isaac had a brother named Jacques (ca. 1625-1680), who had a son also named Jacques (1639-?)) was born in 1669. In December 1703, he marries Louise Bérain, daughter of Jean I Bérain (1637-1711), draughtsman and designer, painter and engraver, *dessinateur de la Chambre et du cabinet du Roi*.
Jacques becomes *Horloger du Roi logé aux Galeries du Louvre* in 1694. Probably then he operationaly takes over the workshop from his father. We do not know when Jacques started working, but most likely he started as an apprentice in his fathers workshop, and kept working here. He continued the workshop on his own after his fathers death in 1706.
Jacques Thuret died in 1739.
His portrait was engraved by his niece Suzanne Silvestre after a pastel by Joseph Vivien.

The works of Thuret
If we take the birth date of Isaac Thuret, mentioned in several sources, as 1630, he marries at a quite advanced age of 33, in 1663. We also know in this year he is mentioned as *Marchand-Horloger Ordinaire du Roi* and Constantijn Huygens Sr. mentions clocks made by Thuret already in 1662.

We do not know any still existent 'prototype' box clocks made by Thuret. The first clocks signed *Thuret à Paris* are all of the 'basic type' *religieuse,* with either an ornament or a pediment on top. Of all *Pendules Religieuses* and baroque clocks, made between 1657 and 1715, still known today, almost 10% is made by the workshop of Thuret. Of these early models, six of the 82 with ornament are made by Thuret and of the 77 with pediment even nine are signed *Thuret à Paris*.

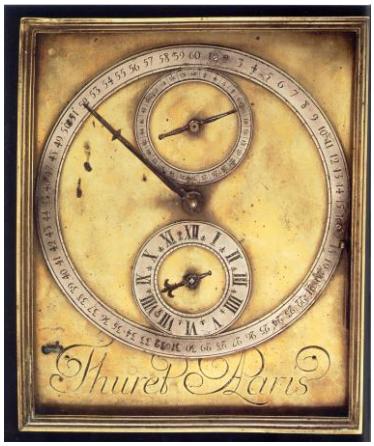
I Thuret AParis (c. 1662)
Basic type 'Pendule Religieuse' with pediment
Former collection dr. R. Plomp

I Thuret AParis (c. 1662)
Basic type 'Pendule Religieuse' with ornament
Collection Science Museum, London

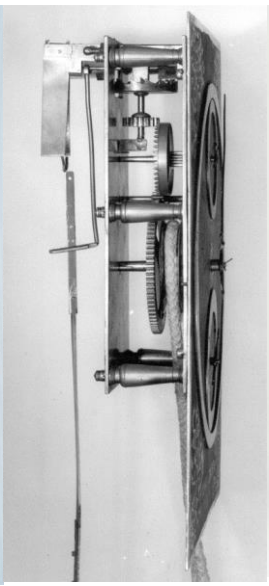
We can follow this 'productive' line throughout the era of the reign of Louis XIV, until 1715, and get an approximate count of 10% of all Paris made religieuses from this era still in existence today made by the Thuret workshop. One striking thing is Thuret was not a fan of Boulle work; it is applied to only very few of his clock cases.

The French did not embrace technical developments, like the anchor escapement, until far into the 18th century. Maybe caused by the fact longcase clocks never caught on in France as they did in England and later in Holland.
We currently do not know any longcase with ancre escapement and 1 second pendulum made by Thuret existing today.

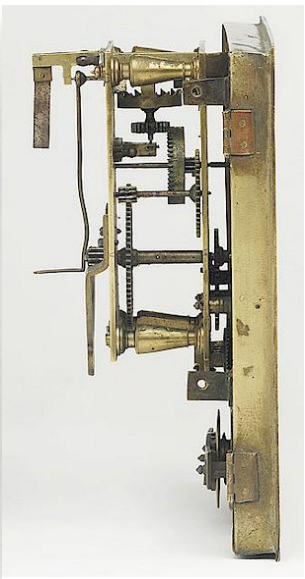
We do still have a few of the scientific clocks, developed in the late 1660's/ early 70's, with a long 3 feet, 2 inches long pendulum and a verge escapement.
The movements are all perfectly in line with the design presented by Huygens in *Horlogium Oscillatorium* (1673).



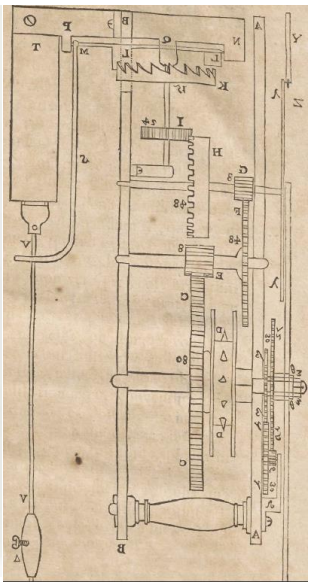
Thuret
(Private collection)



Thuret
(Museum Boerhaave)



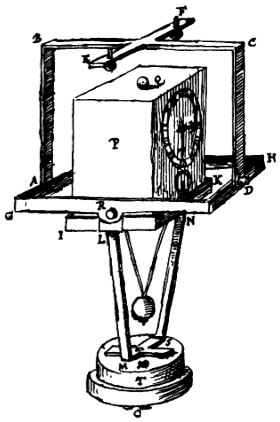
Thuret
(AH, December 2008, pp. 201-222)



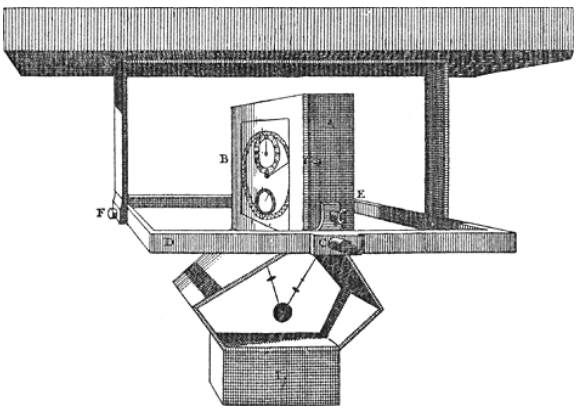
Horologium Oscillatorium

We see however a discrepancy in the dial layout, if we compare the existing Scientific Clocks with the design presented in *Horlogium Oscillatorium*. The design presented in *Horologium* in 1658 does not fit either.
We need to take a closer look at the evolution in dial layout, both in several descriptions in Huygens correspondence from his *Oeuvres Complètes*, and by observing the designs made from the invention till that finally presented in *Horologium Oscillatorium*.

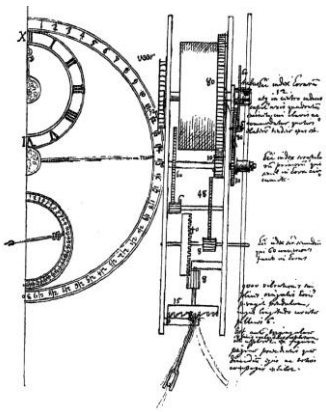
The evolution of this 'scientific dial'-layout can be followed by the development of the sea clocks.



Type 1 Sea clock (1665)



Type 2 sea clock (1672)



Dail layout of type 2 sea clock

In all clocks mentioned until 1667, from the invention in 1656 and Horologium in 1658, up till the sea clocks and scientific clocks with long pendulum during the 1660's, we see one similar dail plate layout, the one presented in *Horologium*.
Only towards the publication of *Horologium Oscillatorium* (1673) we see a different dial layout. Interestingly the layout of the dial of the clock presented in *Horologium Oscillatorium* is different again. Even more interesting is the fact we do not know any clock still existing with either the dial layout of *Horologium* or *Horologium Oscillatorium*. We do have three examples left of the scientific type, all made by Thuret[20]. These are the only ones, currently known and verified, with verge escapement and 1 second-pendulum.

[20] There is one other clock, not signed, but owned by the Danish astronomer Ole Rømer, made after an example made by Thuret; Antiquarian Horology 30/5 (March 2008), pp. 624-628.
Recently another 'regulator' was discovered, signed *Langlois Paris*, Antiquarian Horology 38/3 (September 2017), pp. 365-384.

From the correspondence of Christiaan Huygens we know Thuret was involved in these developments from 1665, and even became the exclusive 'privileged' clockmaker of the sea and scientific clocks with long pendulum in France.
Before 1672 Thuret was also appointed as official clockmaker of the *Académie Royale des Sciences*, the clockmaker responsible for the maintenance of the *machines* of the Academy.

The French academy of sciences, *l'Académie Royale des Sciences*, met for the first time on 22 December 1666 in the King's library in the Louvre in Paris. In contrast to its British counterpart, the Academy was founded as an institution of government.
The British Royal Society was founded, some years earlier, on 28 November 1660. Christiaan Huygens was a member of both institutions.

The foundation of the observatory of Paris originates in the ambitions of Jean-Baptiste Colbert to extend France's maritime power and international trade in the 17th century. Louis XIV promoted its construction, which was started in 1667 and completed in 1671. It thus predates by a few years the Royal Greenwich Observatory, which was founded in 1675. Later on Isaac Thuret also became the official *Horloger de l'Observatoire de Paris*.

His involvement with the Academy of Sciences and the observatory allowed him to get in touch with foreign scholars such as Christiaan Huygens and Ole Christensen Rømer to make and maintain their scientific instruments and clocks.

Two astronomical machines

During two sessions of the Academy of Sciences, August 17 and 31, 1680, Ole Rømer informed his colleagues of two projects: the construction of a *machine for planets* and a *machine for eclipses* which he had invented; one showing the movements of Jupiter and its satellites, the other, the movements of Saturn and its rings (1678)[XLVII]. At the end of the year 1680, the last demonstrations completed, it was therefore decided to have the two new *machines* built by 'a clever watchmaker', in charge of the maintenance of the Academy clocks, Isaac Thuret. In January 1681, just before his final departure for Denmark, Rømer showed his machine for the new moons and eclipses to the academicians. In spite of significant progress due to the observation of the rotation of the satellites of Jupiter, with the more accurate and more frequent results, in 1690 one still resorted to the observation of the eclipses of moon and sun, when determining the longitude. This interest of academicians in astronomical observations was undeniably linked to the desire to produce precise geographical maps, and a member such as Jean-Dominique Cassini (1625-1712) could only approve Rømer's guidelines for applied research.

The new *machines eclipses* were manufactured by Isaac Thuret and allowed to anticipate and predict the lunar cycle over two centuries, until 1881, with a mistake of one day. The *machine* of the planets presented the movements of the stars of the solar system[XLVIII].

Notes

[I] R. Plomp, "Spring-driven Dutch pendulum clocks 1657-1710", Interbook (Schiedam), 1979, pp. 15
[II] Mercurius Politicus, issue number 439, October 21-28, 1658; as reproduced in Penney, op.cit., 619-620. In this article I made use of the work and the article of David Penney, "The Earliest Pendulum Clocks: A Re-Evaluation", Antiquarian Horology, Volume 31 No 5, (September 2009), pp. 614-620.
[III] Oeuvres Complètes de Christiaan Huygens, Tome Deuxième, correspondance 1657-1659, Martinus Nijhoff, 1889, No. 605, pp. 382; No. 670, pp. 486
[IV] Oeuvres Complètes de Christiaan Huygens, Tome Troisième, correspondance 1660-1661, Martinus Nijhoff, 1889, No. 815, pp. 192
[V] Oeuvres Complètes de Christiaan Huygens, Tome Dix-Septième, L'horloge à pendule 1656-1666, Martinus Nijhoff, 1932, Horloges marines (et sympathie des horloges) IV, pp. 171-179
[VI] Oeuvres Complètes de Christiaan Huygens, Tome Quatrième, correspondance 1662-1663, Martinus Nijhoff, 1891, No 955, pp. 11
[VII] Oeuvres Complètes de Christiaan Huygens, Tome Quatrième, correspondance 1662-1663, Martinus Nijhoff, 1891, No 983, pp. 63-65
[VIII] Oeuvres Complètes de Christiaan Huygens, Tome Quatrième, correspondance 1662-1663, Martinus Nijhoff, 1891, No 1004, pp. 110
[IX] Oeuvres Complètes de Christiaan Huygens, Tome Quatrième, correspondance 1662-1663, Martinus Nijhoff, 1891, No 1078, pp. 270
[X] Oeuvres Complètes de Christiaan Huygens, Tome Quatrième, correspondance 1662-1663, Martinus Nijhoff, 1891, No 1189, pp. 477
[XI] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, No 1207, pp. 18-19
[XII] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, No 1227, pp. 58
[XIII] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, No 1228, pp. 59
[XIV] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, No 1228, pp. 60
[XV] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, No 1352, pp. 268
[XVI] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, No 1356, pp. 277
[XVII] Oeuvres Complètes de Christiaan Huygens, Tome Dix-Septième, L'horloge à pendule 1656-1666, Martinus Nijhoff, 1932, Horloges marines (et sympathie des horloges) IV, pp. 173
[XVIII] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, No 1358, pp. 278
[XIX] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, No 1361, pp. 281
[XX] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, No 1370, pp. 301
[XXI] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, No 1408, pp. 358
[XXII] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, No 1409, pp. 358-359
[XXIII] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, No 1417, pp. 371
[XXIV] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, No 1430, pp. 398

[xxv] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, No 1429, pp. 396-397
[xxvi] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, No 1444, pp. 438
[xxvii] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, No 1454, pp. 476-477
[xxviii] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, No 1485, pp. 511
[xxix] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, No 1491, pp. 525
[xxx] Oeuvres Complètes de Christiaan Huygens, Tome Dix-Huitième, Avertissement, Martinus Nijhoff, 1934, pp. 505, note 9, 'les Comptes des Bâtiments du Roi', sous le règne de Louis XIV (1664-1687), published by J. Guiffrey (Paris, 1881). Here is also mentioned a planetarium in 1680, a 'machine for measuring the eclipses' in 1682 and a 'parallax machine for observations' in 1687, all made by Thuret.
[xxxi] Oeuvres Complètes de Christiaan Huygens, Tome Septième, correspondance 1670-1675, Martinus Nijhoff, 1897, No 1853, pp. 117, note 12. The source is 'Observations astronomique et physique faites en l'isle de Caïenne' published in the Mémoires de l'Académie Royale des Sciences depuis 1666 jusqu'à 1699, II, part 1 (Paris, 1729).
[xxxii] William Derham, The Artificial Clockmaker, London, 1696, pp. 99
[xxxiii] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, No 1435, pp. 427
[xxxiv] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, Appendix to No 1465, pp. 486
[xxxv] Oeuvres Complètes de Christiaan Huygens, Tome Cinquième, correspondance 1664-1665, Martinus Nijhoff, 1893, No 1435, pp. 427
[xxxvi] Oeuvres Complètes de Christiaan Huygens, Tome Troisième, correspondance 1660-1661, Martinus Nijhoff, 1889, No. 920, pp. 389
[xxxvii] Oeuvres Complètes de Christiaan Huygens, Tome Septième, correspondance 1670-1675, Martinus Nijhoff, 1897, No 2027, pp. 458
[xxxviii] Oeuvres Complètes de Christiaan Huygens, Tome Septième, correspondance 1670-1675, Martinus Nijhoff, 1897, No 2011, pp. 419
[xxxix] Oeuvres Complètes de Christiaan Huygens, Tome Septième, correspondance 1670-1675, Martinus Nijhoff, 1897, No 2060, pp. 507-508
[xl] Oeuvres Complètes de Christiaan Huygens, Tome Septième, correspondance 1670-1675, Martinus Nijhoff, 1897, No 2023, pp. 453 note 23
[xli] Oeuvres Complètes de Christiaan Huygens, Tome Septième, correspondance 1670-1675, Martinus Nijhoff, 1897, No 2008, pp. 408-416
[xlii] Oeuvres Complètes de Christiaan Huygens, Tome Septième, correspondance 1670-1675, Martinus Nijhoff, 1897, No 2014, pp. 524-425
[xliii] Oeuvres Complètes de Christiaan Huygens, Tome Septième, correspondance 1670-1675, Martinus Nijhoff, 1897, No 2021, pp. 434
[xliv] Oeuvres Complètes de Christiaan Huygens, Tome Septième, correspondance 1670-1675, Martinus Nijhoff, 1897, No 2055, pp. 498
[xlv] Oeuvres Complètes de Christiaan Huygens, Tome Huitième, correspondance 1676-1684, Martinus Nijhoff, 1899, No 2055a, pp. 561
[xlvi] Oeuvres Complètes de Christiaan Huygens, Tome Septième, correspondance 1670-1675, Martinus Nijhoff, 1897, No 2078, pp. 542.
[xlvii] The Emperor's New Mathematics, Catherine Jami, Oxford University Press, Oxford, 2012, pp. 105-106
[xlviii] History of Astronomy: An Encyclopedia, edited by John Lankford, Routledge New York/London, 1997, pp. 272-273