The Origins Of Self-Winding Watches 1773 - 1779

Second Edition

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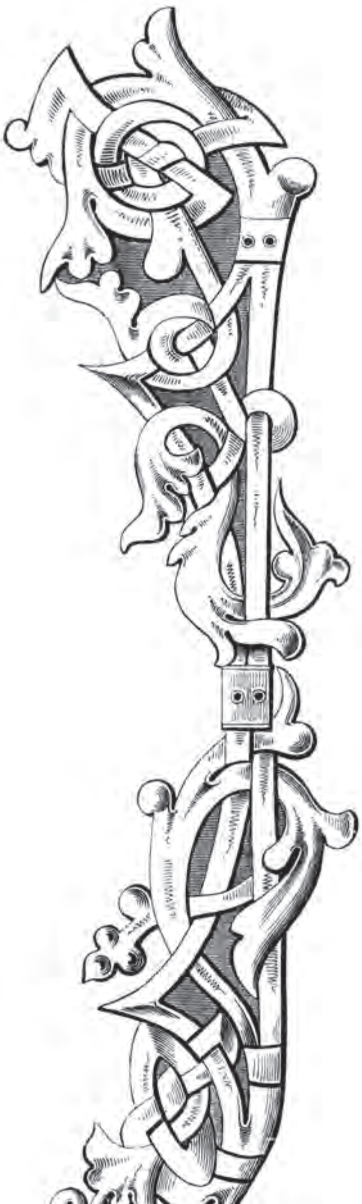


Foreword

The Second Edition

In 1949 Pierre Huguenin wrote the prophetic words:

> *The events relating to "automatic watches" multiply. It is like a detective novel, with successive new ideas, changes of situations, the unexpected, and the passion that surrounds "the affair".*

The first edition of this book was printed in January 2014, and it was distributed in England, Europe and America in February and March 2014. I thought that I had completed a task and I could move on to other work. But that was not to be.

During the following six months a large amount of new information was found, including many documents, an important watch movement and a watch design that had not been described before.

At first I thought that this new material could be included in an addendum to the first edition. Although it needed to be published, it did not alter my conclusions, summarised in the second chapter of "Origins". And so reprinting the whole book with all the additions seemed unnecessary.

That was until Bernard Roobaert politely told me that I had made a serious mistake in the transcript and translation of one fundamental document, the diary of de Saussure. When I corrected this embarrassing error, I found that it had serious implications for the dating and interpretation of other events. Although my conclusions remained the same, it became clear that the changes and the new information could not be presented in an article, and a new edition of "Origins" was needed.

The first edition was pedantic, even obsessive-compulsive. In part this is because I am not the most intelligent person in the world, and sometimes I have difficulty in understanding watch mechanisms. So I decided that if I have problems then some readers might also have problems, and I should include explanations to help them.

Also, I decided that it was essential to ensure that the book was complete and covered all aspects of early self-winding watches. In addition to answering all questions and criticisms put directly to me, I used my imagination to ensure little if anything was omitted. I would fantasise that I was in a conference room where people were asking me questions about anything and everything. And if "Origins" did not have the answer, I knew I had to add the answer to the book. If possible every alternative view should be explained.

Some of the material might have been published in articles, but that would have made the task of the serious reader much more difficult. It was and is necessary to include all relevant material in a single source.

As well as including all the new evidence, producing a new edition that is equally pedantic has enabled me to make other changes. There is much new material that I decided was necessary to fully explain the early history of self-winding watches, and errors in the description of the *Mazzi à Locarno* rotor watch have been corrected with a new appendix devoted to this watch.

Acknowledgements

First, this book could not have been written without the help of Joseph Flores.

Joseph has allowed me to include translations of his work on self-winding mechanisms, and most of the descriptions of mechanisms in Chapters 7, 8, 9 and 12 are based on his articles. And he has provided many of the photographs and diagrams in this book. Also, in our extensive communications Joseph has made penetrating suggestions and asked many important questions. As a result, although not obvious, parts of the book were changed because of the insights he gave me.

It is not an exaggeration to say that without him this book would not have been written. I am deeply indebted to this remarkable person and feel privileged to be his friend.

Five other people have made important contributions to this book.

Heinz Mundschau has contributed substantially to the study of Germanic makers, locating important documents, providing translations of obscure German, and giving insights into the people involved.

In addition to finding the embarrassing error, Bernard Roobaert has supplied important documents and has made many valuable suggestions that have led to changes in the book.

Simon Bull provided the information on the Gschwind movement and he has contributed much to the study of this fascinating watch.

Jean-Michel Piguet, Conservateur adjoint, Musée international d'horlogerie, La Chaux-de-Fonds, Switzerland, provided many photographs and the document describing Vincent's safety locking, and he arranged for Breguet's watch number 28 to be disassembled and photographed.

Finally, in many emails and several telephone conversations, Philip Poniz raised important points about the development of self-winding watches that have influenced me. He has also helped by providing some documents.

Also, I must thank the following people (in alphabetical order) who have provided photographs of watches and other information:

Aurélie Branchini, Restauratrice, Musée international d'horlogerie, La Chaux-de-Fonds; George Daniels; Brandon and Larry Kordower, USA; Gilles Robert, CEO Robert & Fils, Geneve, Switzerland; Marlène Rufenacht, Archiviste-Documentaliste, Musée d'horlogerie, Le Locle, Switzerland; and Marco Stella.

Finally, the decorative illustrations in this book are reproduced from Dubois. *Histoire de l'Horlogerie depuis son Origine jusqu'a nos jours* (1849).

Richard Watkins

March 2016

1: Background

1.1: The History of a History

History is a minefield of unexploded myths

Some early books mention self-winding watches, and these watches have been known for a long time, particularly those made by Breguet. But the examination of their history did not begin until 1949. In that year, Léon Leroy published a description of a very unusual watch that he had just acquired (Leroy, 1949). This unsigned watch, known as the *Leroy watch*, has a rotor mechanism similar to those used in modern wristwatches.

The discovery of the Leroy watch prompted Alfred Chapuis and Eugène Jaquet to study these watches, and in 1952 they published the first, comprehensive history of them: *La Montre Automatique Ancienne, un Siècle et Demi d'Histoire 1770-1931*. Unfortunately Jaquet died in 1951 and did not see the results of their work.

After carefully checking all the information available to them, and examining the Leroy watch, they concluded:

> *Pouvons-nous conclure qu'il s'agit d'une montre perpétuelle dont le mouvement est de A.-L. Perrelet et le boîtier de Abraham-Louis Robert, tous deux au Locle? Cela paraît une quasi certitude, ...* (Chapuis & Jaquet, 1952, page 55.)

That is, based on a 1777 document and other evidence, it is almost certain that Abram Louys Perrelet (to use the old spelling of his name) had made the Leroy watch movement. Further, they suggest that he had made such watches for a long time, certainly before 1777 and perhaps as early as 1770. If so, he is the first inventor of such watches and all other workers in the field followed his lead.

After the book had been typeset and sent to the printer, Chapuis saw a copy of the 1789 document *Description Abrégée de Plusieurs Pièces d'Horlogerie*, written by Hubert Sarton. It includes:

> *Watch with Spontaneous Movement.*
>
> *This watch, which is wound by only the movement that it receives while being carried, was also subjected to the judgment of the Academy of Science of Paris* [in 1778] *which declared that the author had cured very well the disadvantages and variations caused in other watches of this kind by the winding mechanism; and in praising the construction, it considered it to be it worthy of its approval, as being ingeniously arranged to wind itself while being carried.* (Sarton, 1789, page 18; Sarton, 2012, page 5.)

It is clear that Chapuis had not heard of Hubert Sarton in connection with self-winding watches. But, having integrity and realising the importance of this document, he had this information inserted into the book as an "addenda in extremis" on an unnumbered sheet after page 62 and before page 63. Obviously it was impossible for him to comment on it without recalling the book from the printer and rewriting parts of it, and it was too late for that. However, it did not really matter, as whatever Sarton had done was a year or more after Perrelet and did not affect the conclusions regarding the Leroy watch.

In 1956 an English edition of this work, *The History of the Self-winding Watch*, was published. This book is, with one major exception, a translation of the first French edition. However, at some time in the four intervening years, perhaps just before the book was typeset, Chapuis obtained a copy of the report written in 1778 for the Académie des Sciences in Paris (Academy of Sciences, 1778). This report states that Hubert Sarton, of Liège in Belgium, had designed a self-winding watch and goes on to describe that watch in great detail. So a new chapter was added, in which the text of the report is given in translation without any discussion or analysis. Given Chapuis' integrity, shown by his inclusion of the "addenda in extremis" in the first edition, we can assume that the failure to study and discuss the report was again caused by a lack of time. Anyway, 1778 was too late to impact on the conclusions regarding Perrelet, and these were left unchanged:

> *The assumption that the movement of the "Leroy" watch may probably be attributed to Perrelet, and its case to A.-L. Robert, seems to us justified ...* (Chapuis & Jaquet, 1956, page 56.)

But apparently Chapuis did not realise that the report gives a precise description of exactly the same self-winding mechanism as appears in the Leroy watch!

As the majority of interested people were French speakers, many would have only read the first French edition of Chapuis and Jaquet's book, and so they would not have known about the translation of the report. Certainly a quick look at the English edition suggests it is the same as the French edition, and so there would be no point reading both. And it seems that those who did read the second English edition failed to make the connection between the Leroy watch and the report.

For the next thirty-seven years, many writers included remarks on self-winding watches in their books; some are listed in the tertiary sources. These people have just repeated the conclusions of Chapuis and Jaquet (often without acknowledgement), but they have ignored Chapuis and Jaquet's "quasi certitude" and "may probably be attributed", providing illustrations of a self-winding watch (often not the Leroy watch) with the unconditional statement "made by Abraham-Louis Perrelet". As far as everyone was concerned, the origin of these watches had been decided unequivocally.

Until 1993. In that year, forty-one years after Chapuis and Jaquet's book was first published, Joseph Flores rediscovered the 1778 report and realised that it was of great significance, especially because it accurately describes the Leroy watch and suggests this type of mechanism was invented by Sarton and not Perrelet. Because Joseph Flores cannot read English, like many others he did not know that an English translation of the report had been published in 1956. But unlike the few who had read it, he did not ignore it.

Since then Joseph Flores has studied and written extensively on the origins of self-winding watches, including many articles in journals, articles in English and French on the internet, and a book, *Perpétuelles à Roue de Rencontre*, which has appeared in two editions in 2001 and 2009. The core of his work has been the report describing the self-winding watch presented to the academy by Hubert Sarton.

For the next twenty years (to 2013), the reaction to the work of Flores has been mixed. Most people have simply ignored it, sticking to the "fact" that Perrelet had invented the rotor mechanism. And a few have changed their opinions and now believe Sarton was the inventor.

Some people, realising that the report of 1778 cannot be ignored, suggested that Sarton must have lied; he got a watch made by Perrelet and submitted it to the Paris Académie as his own work. But there is no evidence to indicate that Sarton might have been dishonest, and accusing someone of blatant cheating must be done with great care. This has led to a few compromise suggestions, in which Perrelet was the inventor but Sarton modified his design in some way. No matter how, nearly everyone explained the report so that Perrelet retained his position as the original inventor of the self-winding watch, and in particular of the rotor mechanism.

Why?

There were five different designs for self-winding mechanisms, all of which appear to have been developed before 1780. Might not Perrelet have invented one of the other four? We can only assume the obsession with this one mechanism is because it forms the basis of the modern wristwatch and so has a special importance compared to the other mechanisms.

And it was an obsession. In 1952 Chapuis and Jaquet provided photographs of and information about other designs. But, other than an excessive coverage of Breguet's later work, they make no attempt to explain the role of these mechanisms in the history of self-winding watches. They analysed evidence and created an historical context for only one watch, the Leroy rotor watch. And this has continued for the last sixty years. No one has seriously examined the other four designs.

The probable reason is that three of the designs are clearly associated with the names Breguet and Recordon, and it seems everyone is happy to attribute them to these people without any investigation. And no one knows who invented the fourth design, and it seems no one cares. So long as Perrelet invented the rotor watch everyone was happy!

Finally, in 2012, the third book on self-winding watches was released: *The Self-Winding Watch, 18th-21st Century* by Jean-Claude Sabrier.

With regard to the early history, Sabrier presents some, but not all, of the evidence put forward by Chapuis and Jaquet and then dogmatically states that Perrelet invented the rotor mechanism, without any attempt to give reasons. And, like others, he presents photographs of the other four designs without any attempt to integrate them into the history, being satisfied with just Perrelet and the rotor mechanism.

Sabrier resolves the problem of Sarton by two obvious deceptions.

First, he simply ignores the 1778 report to the Paris academy. It is not mentioned in his book, and anyone who has not read other books and articles can be forgiven if they believe it does not exist! This omission is not acceptable.

Second, Sabrier deliberately suggests Sarton was not capable of making the Leroy watch, or any other watches, and he includes a document describing Sarton as a merchant jeweller to support this view. But he ignores Sarton's apprenticeship to a clock *and* watch maker, and a testimonial letter stating that Sarton had designed a watch, which is in a document that Sabrier must have read.

Thus Sarton is erased from history by a blatant distortion of history.

Sabrier's failure to analyse anything comes to a surprising conclusion late in his book. Suddenly, completely out of context, he mentions a previously unknown document which states that Joseph Tlusios invented a self-winding watch in 1775, two years before the earliest mention of Perrelet. And he goes on to mention the invention of a self-winding watch by Joseph Gallmayr in 1777. But apparently these people did not deserve any consideration and Sabrier ignores them.

Unfortunately, it is likely that Sabrier's book will become the "bible" on the subject. It seems many people agree that:

> *The book can be considered as the authoritative successor of the History of the Self-Winding Watch, which was published more than sixty years ago by Eugène Jaquet and Alfred Chapuis.*

Sabrier is an authority, not in the sense of someone who is an accepted source of wisdom, but rather in the sense of someone who expects submission to his views.

Or I should say, submission to the views of Chapuis and Jaquet, because everyone, including Sabrier, has relied on their seminal book.

Which is unfortunate, because that book contains six major flaws:

(a) The book concludes that Perrelet must have made the Leroy watch (and so he must have invented the rotor mechanism) on the basis of what appears to be a lie, the statement that Perrelet's watches can be distinguished from those of all other makers because of technical features. (See Section 15.4, page 179.)

(b) Although the book includes many facsimiles of documents, there is no facsimile of the key evidence, the diary of de Saussure. Instead the book provides a transcript of the diary which is wrong; see Section 20.1, page 224.

(c) The book states that Perrelet tested several designs (Section 15.5, page 185) but there is no evidence to support this claim and a competent watchmaker could not accept it without example watches that could be examined. In addition, this claim is based on a misinterpretation of a biography of Perrelet.

(d) The book states that the case maker of the Leroy watch (the only watch examined) was Abram Louys Robert on the basis of a deliberate or incompetent interpretation of the evidence (Section 15.6, page 186).

(e) Although the text of the book indicates that the authors did not have correct knowledge of Neuchâtel hallmarks (which are used to date the Leroy watch) there is evidence that suggests Chapuis knew the hallmarks were wrong (see Appendix 4, page 311).

(f) In 1953 (or perhaps 1954) Chapuis published an article in *La montre suisse* (Chapuis, 1953?). This article repeats Chapuis' opinions, but it also includes the following:

Mais d'autres horlogers n'avaient pas tardé à entreprendre eux aussi, la confection de ces montres. Delà nous avons cité Hubert Sarton à Liège, horloger de grand mérite, fertile en inventions dans la montre et dans la pendule qui, en 1778 déjà (une année après la communication de H. de Saussure sur la montre de Perrelet) présente à l'Académie des Sciences de Paris «une montre a mouvement spontané» comme il l'appelle ou encore «une montre qui ne se remonte pas». Nous avons retrouvé le rapport approbatif qui s'y rapporte, ce qui nous permet de ranger ce maître parmi les premiers novateurs, sinon parmi les précurseurs. (Chapuis, 1953?, page 77)

But other watchmakers were not slow to also undertake them, the manufacture of these watches. Above we quoted Hubert Sarton in Liege, a horologist of great merit, fertile in inventions in watch and clock work, who already in 1778 (one year after the communication of H. de Saussure on the watch of Perrelet) presented to the Academy of Sciences of Paris "a spontaneous movement watch" as he calls it, or "a watch that does not have to be wound." We found the approving report relating to it, which allows us to include this master among the first innovators, if not one of the precursors.

> That is, Chapuis had seen and presumably read the report describing a rotor watch two or three years before the English translation of his book was published. But even though he had two or three years to study the report, the English translation of his book (*The History of the Self-winding Watch*) makes no attempt to analyse the report and fails to comment on its significance. However, if Chapuis was technically ignorant he might not have realised its importance, although Donald de Carle, his technical advisor, should have but did not (his role was probably limited to checking the technical language).

How could an intelligent, competent person make so many errors?

I do not know, but a likely explanation is that Chapuis reached a point where he had no choice. It seems probable that the discovery of the Leroy watch was the trigger for writing the book. As there is a document stating that Perrelet invented a self-winding watch, and the Leroy watch appears to have been made in Neuchâtel, it was a simple deduction to assume Perrelet made the watch. All that was needed was to explain it.

But when Chapuis wrote the book, he discovered there was nothing in the evidence to link an unsigned watch to Perrelet, and his theory was on the verge of collapse. So he invented the missing links. He made factual statements, even though he probably knew there was no evidence on which to base them, and his "facts" were nothing more than contrived fantasies. In reality there was nothing to show Perrelet had invented the rotor mechanism. And sixty-three years later, in 2015, there is still nothing.

Whether Chapuis acted by himself or was forced against his will can never be known (see Appendix 4, page 299). But he probably thought that a few little distortions of the truth would be accepted. And they were accepted, as it seems no one over the last sixty years has noticed them. But the rediscovery of the 1778 report and the very clear indication that it was Sarton, and not Perrelet, who invented the rotor watch, has changed these little distortions into very serious acts of incompetence or dishonesty.

As a result, the early history of self-winding watches is in a mess. All we have is a myth, that Perrelet invented the rotor mechanism, and a number of very interesting documents, most of which have not been studied seriously.

1.2: The Structure of the Book

During the writing of this book, three things became apparent.

First, it is not possible to examine any individual maker or watch design in isolation. The available evidence covers events over seven years, from 1773 to 1779, during which time it is likely that many interactions took place. And what we know is incomplete, ambiguous and even contradictory.

Second, the six different designs of self-winding mechanism (including one that was discovered in 2014) must be understood, because some conclusions can be drawn from them and the likely order in which they were created. Also, it is too easy to propose explanations for events that turn out to be wrong because they contradict the mechanisms of the known designs. Only understanding these designs will enable us to avoid such traps.

The consequence is that the evidence cannot be successfully analysed and interpreted until *all of it* has been assimilated.

Third, it is essential that the evidence is carefully studied and hypotheses developed to explain it. To some extent other writers have forced this on me. Their presentation of opinions as facts makes it necessary that I examine their views and justify my interpretations by rigorous analysis.

To reflect these points, this book is written in four parts.

The first part, chapter 2, is a summary of the conclusions reached in the third and fourth parts. It is included as a guide to the reader.

The second part, Chapters 3 to 13, presents the available, relevant evidence, without any attempt to analyse it. The evidence, which is in approximately chronological order, has been grouped by the names of the main people referred to in it. This arrangement is the most convenient, but the reader should not assume that this implies any particular interpretation.

The third part, Chapters 14 to 18, begins with a discussion of the methodology used to interpret the evidence. Then, for reasons that will become apparent, the roles of Abram Louys Perrelet and Hubert Sarton are examined, by analysing the hypotheses that have been developed and the conclusions that can be drawn from them.

Finally, the fourth part, Chapters 19 to 22, examines the other evidence chronologically, starting from 1773. This approach is necessary because the documents describe events which occurred in only seven years, 1773 to 1779, and the dates, which may only differ by a few months, are very important.

Although I have been careful to state my view of historical research here, I feel it is necessary to stress that:

> *The following interpretations and conclusions are based on the evidence available to me at the time of writing.*

So the reader must realise that future discoveries of documents and/or watches could significantly alter the way in which events are interpreted.

The interpretation and conclusions in Parts 3 and 4 are, I believe, the most probable explanation of events. They are most certainly not the only possible interpretation, but I believe other interpretations are less likely.

1.3: The Concept of a Self-Winding Mechanism

It is necessary that we clearly distinguish two concepts, those of self-winding and keyless mechanisms. So I define:

> *A keyless mechanism winds a watch when the owner of the watch decides to perform a specific task.*

There are two features of such a mechanism. First, winding only occurs at a particular time, when the owner decides to wind the watch; the owner must make a decision. Second, some particular action must be performed.

There are many different keyless mechanisms and the task to be performed varies: Turning a crown, rotating a bezel, opening and closing a cover, etc. And if the task is not performed regularly the watch will stop.

In contrast:

A self-winding mechanism winds a watch without the owner performing any specific task.

The only requirement for a self-winding watch to work is that it is carried on the person, and carrying a watch is not a task, it is an inherent function; if a watch is not carried it becomes a small clock. And so winding can take place at any time, without the owner being aware. Importantly, the owner does not need to make a decision to wind the watch.

It is also necessary to clearly distinguish which parts of a watch comprise the self-winding mechanism:

A self-winding mechanism consists of all those parts that can be removed from a watch and the watch will still function correctly as a key-wound watch.

1.4: Four General Principles and Some Terms

Compared to other complications, such as repeaters, self-winding mechanisms are quite simple. All the watches that will be considered in this book have three basic features:

First, the self-winding mechanism consists of a pivoted weight, activated by the motion of the wearer of the watch, and a means of converting the movement of that weight into a unidirectional rotation to wind the mainspring.

Second, there must be a mechanism to prevent over-winding, which would necessarily result in the breakage of one or more parts.

And third, the self-winding mechanism cannot interfere with the running of the watch. That is, the watch must run satisfactorily whether it is being wound or not.

The obvious method for classifying self-winding mechanisms is by the weight, and there are four visually distinct forms in the period we are considering:

(a) *Rotor* mechanisms, Figure 1-1. These have a weight, pivoting in the center of the movement, which is capable of turning through 360°. At the time of writing, only five rotor watches have been found and all are technically identical.

(b) *Center-weight* mechanisms, Figure 1-2. These have a weight pivoting in the center of the movement that can only turn through about 120°. The weight is held horizontal by an

Figure 1-1

Figure 1-2

equilibrium spring. At the time of writing, only seven center-weight watches have been found. Six are technically identical and the seventh may be a transitional design.

(c) *Side-weight* mechanisms, Figure 1-3. These have a weight at one end of a horizontal arm which runs across the movement and pivots on the side opposite to the weight. The weight is held horizontally by a small equilibrium spring, and it can only move through an arc of about 40° between banking springs or the sides of the case.

There are many side-weight mechanisms and many variations in their design but, in the period of concern to us, all have the above characteristics.

Figure 1-3

(d) *Transverse weight* mechanism. This has a weight which hangs down, like a pendulum and, instead of swinging from side to side (as do all the other designs), it swings from the front of the watch to the back. There are no known watches with this mechanism.

A subtler, but very important method of classifying self-winding watches is by the escapement:

(a) *Verge escapement*. This escapement was by far the most common at the time. Watches using this escapement were described as *ordinary watches* to distinguish them from watches with other escapements.

It must be remembered that the rate of a verge escapement varies significantly with the motive power from the mainspring, and this creates serious problems in the design of self-winding mechanisms. In particular, a fusee is essential unless there is some special method to equalise power, as in the watches described in Section 9.3, page 110.

(b) *Cylinder and virgule escapements*. To some extent these escapements are self-regulating, and so they can be made with going barrels. The consequence is a significant simplification of the design the self-winding mechanism.

By classifying the designs by both the weight and the escapement, there are six distinct mechanisms to be considered:

(a) *Rotor mechanism*: Rotor weight with fusee and verge escapement (Section 7.3, page 64).

(b) *Center-weight mechanism*: Center-weight with going barrel and either a cylinder or virgule escapement (Section 12.2, page 141).

(c) *Side-weight mechanism with fusee*: Side-weight with fusee and verge escapement (Section 8.2, page 94).

(d) *Side-weight mechanism with going barrel*: Side-weight with going barrel and either a cylinder or virgule escapement (Section 8.2, page 91, and Section 9.4, page 120).

(e) *Side-weight mechanism with barrel remontoir*: Side-weight with barrel remontoir and verge escapement (Section 9.3, page 110).

(f) *Transverse weight mechanism with going barrel* (Section 10.2, page 126).

One error made by Chapuis & Jaquet (1952 and 1956), which has been repeated by most later writers, is that they concluded that a single person, Abraham Louis Perrelet, designed *the* self-winding watch. But as there are six designs there is nothing to preclude six different designers.

1.5: Clockwise and Anti-clockwise Motion

Throughout this book we have to discuss the rotation of wheels and pinions, and it is necessary to use the terms *clockwise* and *anti-clockwise*. But these are *relative* to the view of the watch. For example, when seen from behind, looking through a watch, or looking in a mirror, the hands turn anti-clockwise.

This reversal can be very confusing, especially when a diagram has asymmetrical parts such as clicks. A diagram may appear to be correct when it is not. And an apparently incorrect diagram may be correct, but viewed from the opposite side of the watch. This confusion is common, and diagrams frequently show clicks drawn incorrectly.

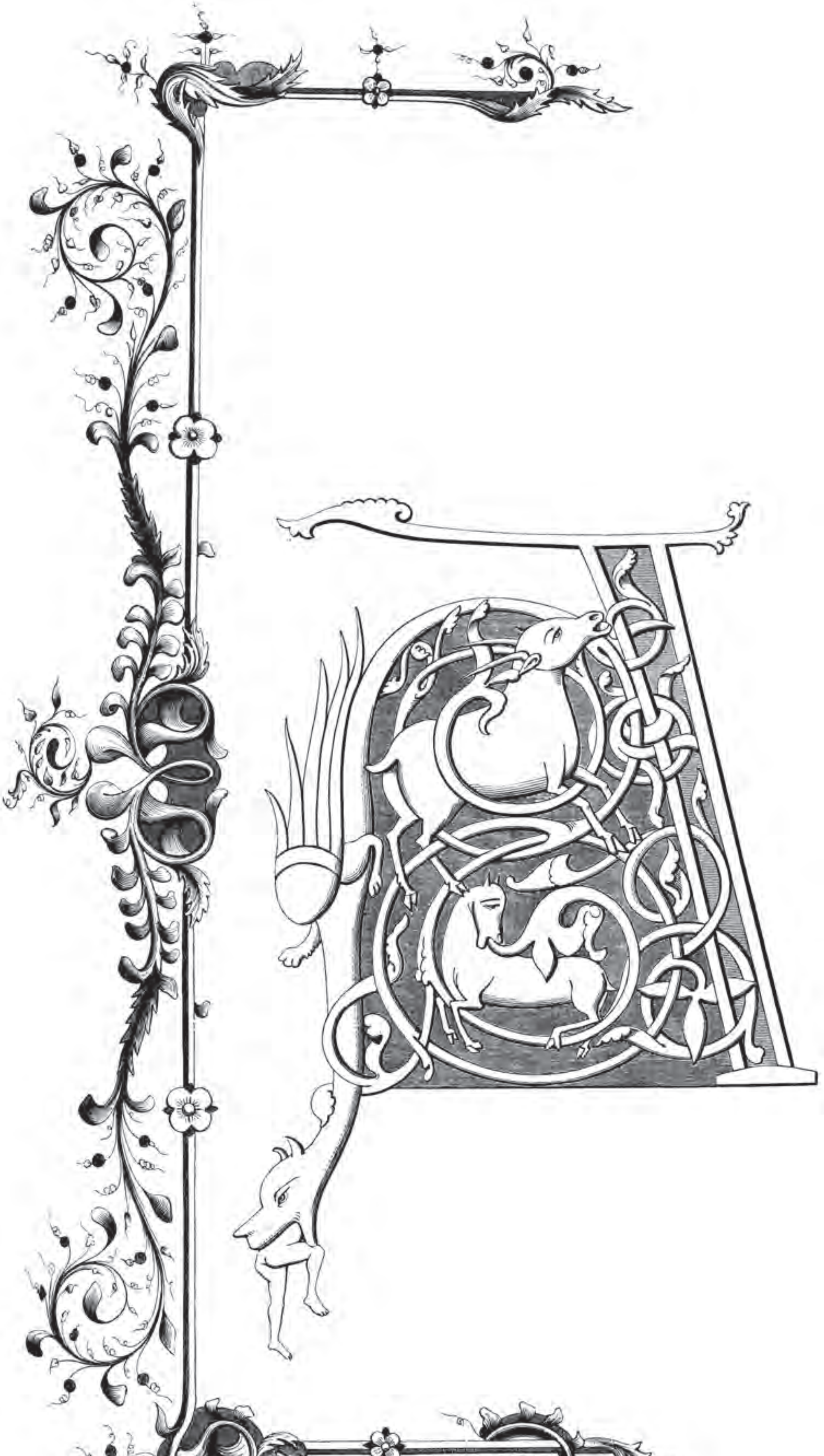
To overcome these problems, unless we *explicitly* state otherwise, *all drawings will be views from the back of the watch*, the top-plate side, as opposed to the front, dial side.

From this perspective, when the watch is running:

(a) The second (center) wheel of the train, with the minute hand, rotates anti-clockwise.

(b) In a fusee watch, when the watch runs the fusee and the first wheel under it rotate clockwise. And when the watch is wound the fusee turns anti-clockwise.

(c) In a going barrel watch, when the watch runs the barrel and attached first wheel rotate clockwise. And when the watch is wound the barrel arbor turns clockwise.



2: A Credible History

This chapter provides a summary of my conclusions in the form of a compact history. To avoid excessive use of words such as "probably" and "it is likely", I have written it as a factual story. But it must be remembered that this is my interpretation of the evidence, based on what I believe to be the most likely explanation of the events spanning only seven years, 1773 to 1779.

Nothing is known with absolute certainty.

It all began near the end of 1773 when a newspaper report stated that Joseph Tlustos had invented a watch that did not need to be wound. Unfortunately his idea was based on the myth of perpetual motion and it was not a practical solution to the problem of self-winding watches.

This claim was ignored until Tlustos repeated it in late 1775.

News of Tlustos reached Abram Louys Perrelet, the church elder, in Le Locle. He became interested in the possibility of such watches and before August 1776 he made the first practical self-winding watches, which used a side-weight with a going barrel, and probably a cylinder escapement.

The Prince de Conti heard of this invention, and he acquired a watch from Perrelet about June 1776. Then, about August 1776, Joseph Gallmayr bought a self-winding watch from Perrelet and claimed to have invented it.

News of Perrelet's work spread throughout Europe and other watchmakers became interested.

In 1777 Abraham-Louis Breguet in Paris heard of Perrelet's side-weight watch. He became fascinated with the idea but, because he lacked experience, his first attempts were to design watches with a verge escapement. This led him to make a self-winding mechanism with a barrel remontoir. Although a successful design, it was too complex and expensive for it to be manufactured and sold. He also designed, but did not make, a side-weight watch with a fusee.

Hubert Sarton in Liège also took up the challenge, and near the end of 1777 he designed the rotor mechanism. Being primarily a clockmaker, he had several watches made for him and started selling them in 1778. Towards the end of 1778, Sarton sent a watch to the Paris Académie Royale des Sciences and a report was written which gave a detailed description of the mechanism.

About the same time Amédée Christin, living in Germany, designed a watch where the weight moved transversely, from front to back, but no watches were made using this poor design.

So, by the end of 1777 five of the six known designs had been created. And a small number of people in Neuchâtel were making side-weight watches based on Perrelet's design.

Towards the end of 1778 the 22 years old Louis Recordon left Geneva to travel to London. To help pay for his journey, he stopped in the Neuchâtel mountains and worked with a watchmaker who was making self-winding watches to Perrelet's design. Seeing the possibility of selling these watches in London, Recordon copied the design and took it with him.

Louis Recordon then stopped in Paris, where he met Abraham-Louis Breguet. He showed Breguet the watch design and talked about his intention to make such watches when he got to London. Breguet immediately realised the importance of a going barrel and struck a deal with Recordon. He would make self-winding watches in Paris and Recordon could make them in London. And, if all went well, Recordon could become Breguet's agent in that city. As part of the arrangement, Breguet gave Recordon his design using a verge escapement with a fusee.

At the beginning of 1779, Breguet studied and improved the side-weight design and began making them. These watches provided him with contacts amongst royalty and the wealthy, which formed the basis for his future work.

When Recordon arrived in London he arranged with Perkins and Spencer to make self-winding watches for him. And he started the process of taking out a patent to protect the designs and, more importantly, to give him exclusive rights to make them.

Finally, and also in 1779, an unknown watchmaker saw watches with Perrelet's side-weight mechanism and Sarton's rotor mechanism. Realising the advantages and disadvantages of each type, he took the best features of both and combined them in the center-weight design.

By the end of 1779 all six known mechanisms had been created. From this point on the emphasis shifted from developing new ideas to manufacture. Of the six designs that had been created, only one survived, the side-weight mechanism with a going barrel. And it was refined and manufactured in Switzerland, France and London.

Although a few self-winding watches were made from then on, and a few patents were taken out, for more than one hundred years these watches were rare, until the advent of the wrist watch.

3: Early Watches Before 1773

3.1: Before 1750

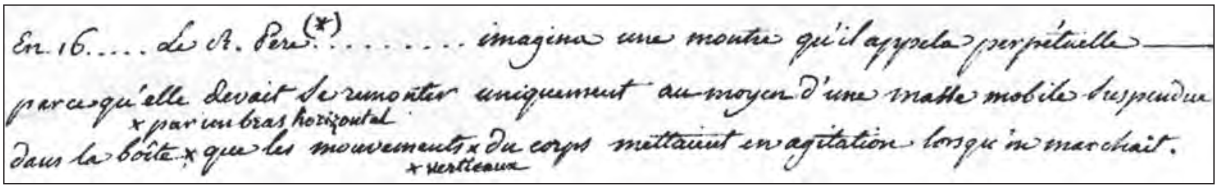
Chapuis & Jaquet (1952 and 1956, Chapter 1) canvas the evidence for self-winding watches being designed prior to 1770.

The earliest concrete proposal, using respiration to wind a watch, appears in the 1651 enlarged second edition of a book by Daniel Schwenter, published after his death in 1636 (Chapuis & Jaquet, 1952, pages 17-20; 1956, pages 19-22). But there is no name of the maker and no details of the mechanism. We think that Chapuis and Jaquet quite rightly dismiss this (1956, page 21):

> *... we can assume that the idea or experiment ... was a novelty, and not a genuine attempt to bring any practical solution to the problem of self-winding.*

Anyway, this description is irrelevant, because we are concerned with watches where the self-winding mechanism is contained completely within the watch.

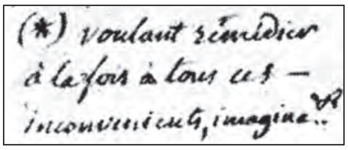
The second early reference appears in Moinet's manuscript of Breguet's notes, Figures 3-1 and 3-2 (Chapuis & Jaquet, 1952, page 22; 1956, page 24).



En 16.... Le R. Pere(*)........ imagina une montre qu'il appela perpetuelle —
parceque'elle devait se remonter uniquement au moyen d'une masse mobile suspendue
× par un bras horizontal
dans la boîte × que les mouvements × du corps mettaient en agitation lorsqu'on marchait.
× verticaux

Figure 3-1

The translation of this (inserting the marginal addition) is:



(*) voulant remédier
à la fois à tous ces —
inconvénients, imagina..

Figure 3-2

> *In 16 ... the Reverend Father .... wanting at the same time to remedy all these disadvantages, imagined a watch which he called perpetual because it was wound up only by means of a mobile weight suspended in the case by a horizontal arm that the vertical movements of the body would put in agitation when one walked.*

However, there are apparently two copies of Moinet's manuscript, the second (reproduced by Sabrier, 2012a, page 13) being different, Figures 3-3 and 3-4.

In the English translation, Sabrier (2012a, page 14) writes:

> *Breguet states: In 16... the Reverend Father ... invented a watch that he called perpetual because it was wound only by means of a mobile weight suspended within the case by a horizontal arm*

But this is a translation of Figures 3-1 and 3-2 and *not* of Figures 3-3 and 3-4! Actually, the text of Figure 3-3 reads:

> *Wanting to try to overcome these difficulties, we imagined in C17....* our watch with weight that we also named perpetual, ...*

So it seems likely that Sabrier took the text from Chapuis and Jaquet without realising the differences between the two original documents.

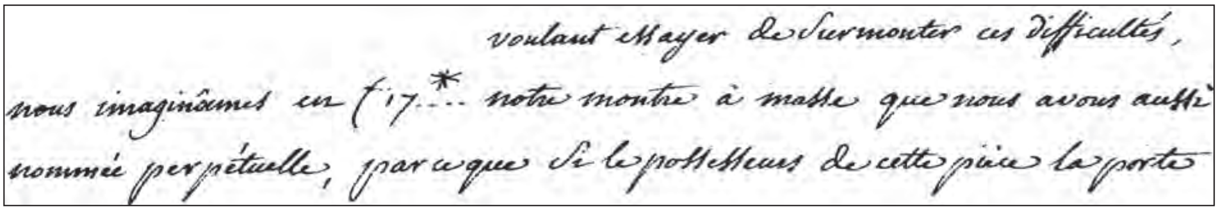
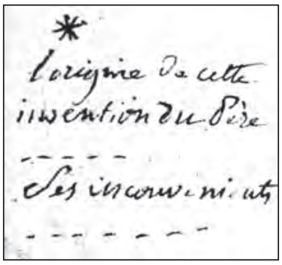

voulant Mayer de surmonter ces difficultés, nous imaginâmes en (17*... notre montre à masse que nous avons aussi nommée perpétuelle, parce que si le possesseur de cette pièce la porte

Figure 3-3


*
l'origine de cette invention du Père

Ses inconvénients

Figure 3-4

The symbol before "17..." is ambiguous and it could be "C" for *circa* or a parenthesis. Unfortunately, inserting the marginal note, *the origin of this invention of Father .... These disadvantages .....*, is problematic.

Neither Chapuis & Jaquet nor Sabrier provide any information that would enable us to determine which document was written first, but we think they have been given here in correct order, the original and the rewriting of it.

Chapuis & Jaquet (1952, pages 16 and 20; 1956, pages 18, 22 and 23) note that Breguet's statement (that a self-winding watch was designed in the 17th century) was repeated later by Dubois (1849, page 343), Saunier and Borsendorff.

Recently Pons (2012a) has stated that a document written by Breguet had been discovered which refers to "P Thuelle" and states that this person is Pierre Thuelle, born 1602 died 1662, a French ecclesiastic *"passionate about horology and inventor of various mechanical devices concerning watches and clocks"* (Pons, 2012b; this entry has been deleted). However this is a fictional character who was created as an April Fool's Day joke.

And so the identity of the Reverend Father, if he ever existed, is unknown.

Somewhat later, the Gentleman's Magazine for March 1748 (Gentleman's Magazine, 1748, pages 108-109; Wood, 1866, page 322) reported on the inventions of the Marquis of Worcester that included:

> *A watch to go constantly, and yet needs no other winding from the first setting on the cord or chain, unless it be broken, requiring no other care from one than to be now and then consulted with, concerning the hour of the day or night; and if it be laid by a week together it will not err much, but the oftener looked upon, the more exact it shows the time of the day or night.*

It is clear that this is an eight-day watch to be wound by opening and closing the cover of a hunter case, and so it is a *keyless mechanism* and not a self-winding mechanism. The remark about rates is curious. It suggests that the watch may have had a going barrel; in which case, as it almost certainly would have had a verge escapement, its accuracy would have been poor. Considering that some of the other "inventions" of the Marquis are fanciful, it is probable that he did not have such a watch made for him and this was most likely an idea rather than a design.

The same magazine for the next year (Gentleman's Magazine, 1749, pages 100-101) included the following letter:

> *Mr Urban.*
>
> *Winding up my watch put me upon thinking how useful it would be, could it be so contrived as to go without wanting to be wound at all, which, I think, might be called perpetual motion. A thought struck into my head, that if the chain, instead of going several times round the wheels, could be made in such a manner as to let it off the barrel to the other wheel, and return again*

(like a jack-chain) to the barrel that holds the spring, it might go perpetually. To effect this, I think, the barrel and the other large wheel might be made with a kind of groove with small holes to receive the chain, which I suppose might be made every link with a sort of spike to go into each small hole of the barrel and other wheel, so as to cast in and let out as it goes round; which spikes I apprehend would hold it fast, and answer the same end of the chain's being fasten'd at one end into the barrel being as they are now; and the force of the spring would keep it going.

If this hint should excite any of your correspondents to try experiments for a thing so much wanted, it may be the means of some improvement, which would be a great pleasure to Your constant reader De. co.

The absurdity of this suggestion is obvious.

In contrast, the Gentleman's Magazine published some good pieces on horology, such as a description of an escapement by Lepaute in 1754 and a discussion of inverted fusees by Le Roy in 1766. So perhaps the two comments on self-winding watches indicate a lack of serious interest in the subject at that time?

Then in 1779 the *Münchner Intelligenzblatt* (Munich, 1779, pages 273-276) published a list of the works of Joseph Gallmayr, apparently written by him, although his name does not appear. The first 14 entries are dated, from 1744 to 1765, but the remaining 15 entries, including mention of a self-winding watch, are not dated.

Although Gallmayr will be discussed later, one entry in this list relates to a design earlier than 1770, Figure 3-5.

In the year 1746, for his highness, the Elector, I made a pair of shoes, in one heel a watch, and in the second a carillon with seven bells. And every 15 steps a melody was played and at the same time the watch in the first heel rewound itself, going for 24 hours.

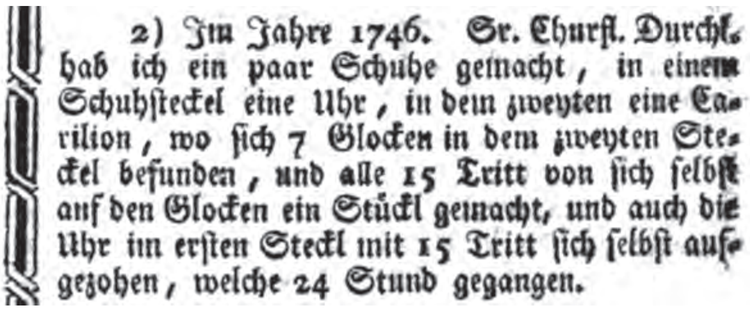

2) Im Jahre 1746. Sr. Churfl. Durchl. hab ich ein paar Schuhe gemacht, in einem Schuhſteckel eine Uhr, in dem zweyten eine Carilion, wo ſich 7 Glocken in dem zweyten Steckel befunden, und alle 15 Tritt von ſich ſelbſt auf den Glocken ein Stückl gemacht, und auch die Uhr im erſten Steckl mit 15 Tritt ſich ſelbſt aufgezohen, welche 24 Stund gegangen.

Figure 3-5

This watch does not fit the definition of a self-winding watch given earlier and, like Marquis of Worcester's watch, it is best described as a keyless mechanism.

Finally, in 1757 Benjamin Franklin (Franklin, 1757) received a letter, from a person whose name is not known, which includes:

I have further invented a Watch or improved one So as to make it wind it Self up as it Goes.

There is no description of the watch. But the writer goes on to say:

... I have invented and try'd a Clock and have made a watch up of the Same Motion as the Clock which I Give this Name too for a Sort of a Description of its moving Power; its a Geometrical Celendrical Concave Triangle Horizontial Watch or Clock. ... Not only this I have Discovird but Have found a Principal or Cause in Nature to make a machine that will Go of its owne Cause for Stop your the wheel take your finger away it goes but When I add more wheels so as to

> *make minutes Hours and Seconds it Stops but am in hopes by the Blessing of Almighty God—to bring it in a Short time to Perfection ... Now Gentlemen Ile Give you as Plaine a Description of my Clock and Watch as I Dare Venture at Present ...* [Figure 3-6]

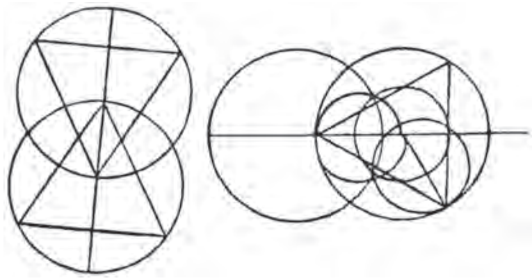


Figure 3-6

It is apparent that the ideas of the writer (who was a Philadelphia clock and watch maker?) are absurd and he was in love with the fantasy of perpetual motion.

Given this dearth of concrete evidence, documents or artefacts, it is reasonable to assume any attempts before 1770 were unsuccessful, and it is likely that Breguet was mistaken. So there is little point considering this early period unless new information comes to light in the future.

Finally, because many pedometers use a weight similar to that used in side-weight self-winding watches, we might expect to find some interesting information in that field.

Chapuis & Jaquet (1952, Chapter 7; 1956, Chapter 8) have studied pedometers, but they fail to provide any satisfactory evidence for them prior to 1780. Live Strong (2009) states that:

> *According to Stephen Inwood's biography, "The Man Who Knew Too Much: The Inventive Life of Robert Hooke, 1635-1703", Hooke invented the pedometer in 1674 as an aid to mapmakers.*

However, this would have used a cord connecting the pedometer to a boot or other clothing to count steps, rather than an internal weight. This is confirmed by the 1778 report examined in Chapter 7, page 59, which states that:

> *This watch goes constantly without being wound, not by an effect similar to that by which an odometer marks the way, that is by the action of the knee when one walks, but only by the effect of a brass weight or a type of clapper ...*

Most Internet sites (probably incorrectly) attribute the invention of the pedometer to Thomas Jefferson circa 1785, which is too late. As is Sarton's invention of an *autograph chronometer* in 1816 (Hognoul, 1822, pages 20-21; 2012, page 11); although the vague description suggests it might have had a fully enclosed mechanism.

Consequently, this area of investigation has yielded nothing useful.

As we will not be revisiting this period, a few comments may be permitted.

Prior to the development of the balance spring, watches were little more than expensive toys, of more use as status symbols than of use for knowing the time. Consequently, hidden complications, which added nothing to the appearance of the watch would not have been popular, and is is unlikely that any serious attempt to develop a self-winding watch occurred that early.

From about 1665 onwards, the radical change brought about by the balance spring led to serious research to improve timekeeping and eventually the creation of new escapements. However, we will see that the design of self-winding watches with verge escapements is very difficult, and was solved by only a few superior makers using complex, sophisticated designs. And so it remains unlikely that anyone would have attempted to add this feature to a watch.

Indeed, what happened in the 1770s can be seen as a consequence of the development of watches with going barrels.

3.2: A 1750 Watch

In addition to repeating Breguet's claim for a 17th century design, Dubois (1849, page 343) also suggests such watches were made in Vienna:

> *To* [Breguet] *we owe the watches with weights, which wind themselves by the effect of the small jerks they experience while carrying them. We know that watches known as perpetual watches were made in the seventeenth century, and a French ecclesiastic and a watchmaker from Vienna disputed this invention, but the mechanism in these machines was so defective and produced so little effect, that the perpetual watches of the early inventors were soon considered at most as toys to satisfy public curiosity.* (See also Chapuis & Jaquet, 1952, page 24; 1956, page 26).

One source, not mentioned by either Chapuis & Jaquet or Sabrier, is Salomons (1921). He wrote (page 14):

> *It has been stated that in the year 1780 Recordon patented a self-winder ... and it is not known whether Breguet made his first one before or after that date, but it is certain that neither of these makers invented the principle, for I possess a watch made in Vienna a great deal older than either ... The watch does not bear the name of the maker.*

And later (page 62) he notes:

> *... the old "perpetuelle" made in Vienna, probably about 1750, ... goes to prove that neither Breguet nor Recordon were the inventors of the pedometer watch.*

He also provided two photographs of the watch, reproduced here in Figures 3-7 and 3-8 (Salomons, 1921 page 209).

Figure 3-7

Figure 3-8

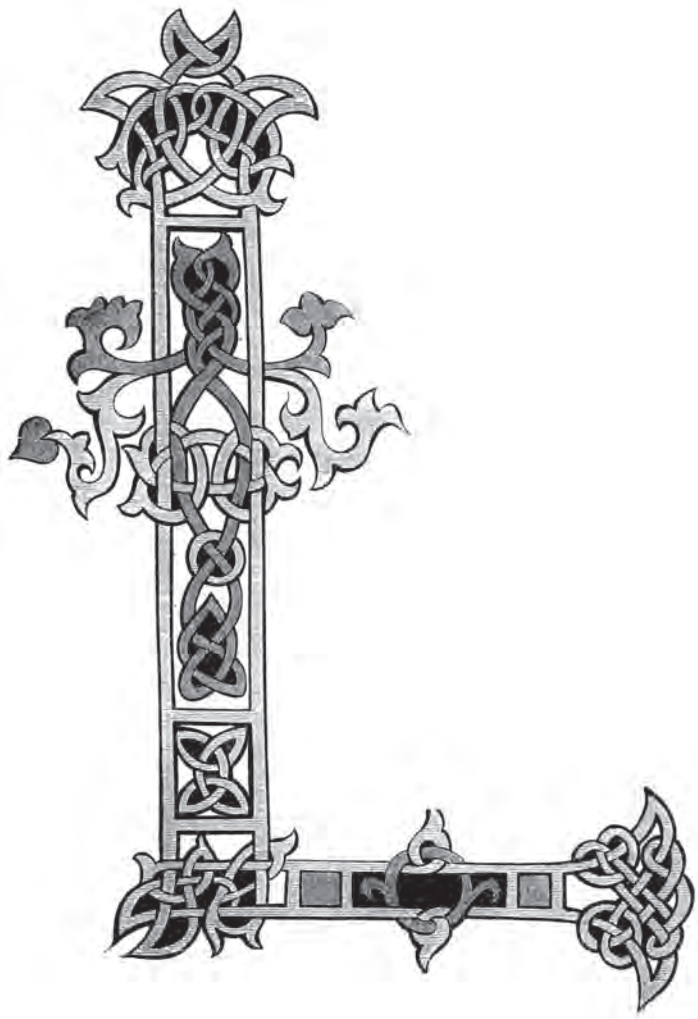
However, it seems that Salomons got his facts wrong. The watch reappeared in an exhibition at the Meyer Memorial Institution, Jerusalem (Daniels and Markarian, 1980, page 116). However, it was then listed as "Switzerland c. 1780"; it had moved many miles across Europe and become 30 years younger!

In addition, Daniels and Markarian provide some information about it:

> *Lever escapement, plain balance with spiral spring and regulator, the movement wound by a circular lead weight constrained by buffer springs and automatically locked when the mainspring is fully wound.*

Assuming the watch is in original condition, the important point is the lever escapement, which cannot have been used in 1750 because it was not invented until about 1759 and was largely ignored until after the 1780s. Even the date "c. 1780" is probably too early. So, sad to say, this watch can no longer be used as evidence for pre 1770s self-winding watches.

However, the move to Switzerland may be misleading. It is probable that Daniels and Markarian based their opinion on the style of the movement and allocated its *manufacture* to Switzerland. But although saying the watch was "made in Vienna", Salomons might be referring to where it came from, and its maker in the sense of retailer. And so it could be evidence for an Austrian "maker".



4: German and Austrian Makers

4.1: A Few Hints

Chapuis and Jaquet were aware of three vague indications that self-winding watches may have been made in Germany. First, Ferdinand Berthoud (1802, volume 2, pages 172-173) wrote:

> *This remontoir watch, invented in Germany, was brought to France around 1780: one saw it in the hands of the late duke of Orleans, and its mechanism was made known. A skilful artist in Paris, Mr Breguet, by adopting this kind of winder, was able to perfect it so that it ensured its effects perfectly. He successfully made a large number of these self-winding watches.*
>
> *The principle that is used as a basis for this winder is the vertical agitation that the watch receives when it is carried. The author of the invention used a weight fixed horizontally at the end of a lever placed on the small plate of the watch: it is this weight that, by its inertia, becomes the secondary engine that winds the mainspring of the watch.*

Second, Moinet (1853, Volume 2, page 507) refers to the perpetual watch as a German invention:

> *For example, there are pieces known as 'perpetuals' or 'with weight', which wind themselves by carrying them, provided that one does not leave them on the hook for more than two and sometimes three days. This German invention, imitated in France, contains a heavy weight of platinum in the shape of a crescent, set at the end of a horizontal lever balanced at its center of movement by a small spring in a special barrel, which enables it to oscillate from top to bottom by the least movement given to the case, and even by only the breathing of the person who carries it; … fifteen minutes of agitation or walking is enough for the driving force to be fully wound. …*

The rest of the description confirms that Moinet is referring to the style of self-winding watch made by Breguet. As Moinet's book extensively quotes the work of Berthoud, this is probably just a repetition of the above information, and so adds nothing to our knowledge.

And finally Chapuis & Jaquet (1952, page 24; 1956, page 26) state that:

> *Towards the middle of the XIXth century, the late Edward Brown, head of the firm of Breguet … mentioned that a Nuremberg watchmaker had been the inventor of a perpetual watch, but added no further particulars to this statement.*

As there are no names and only Berthoud provides a date, it is impossible to place these remarks in context.

4.2: Joseph Tlustos

Sabrier (2012a, page 205) states that in 1775:

> *In the Leipzig newsletters one learns that Joseph Tlusios, watchmaker-mechanic to the Kaiser and the Court, had invented a new type of striking watch that was the same size and shape*

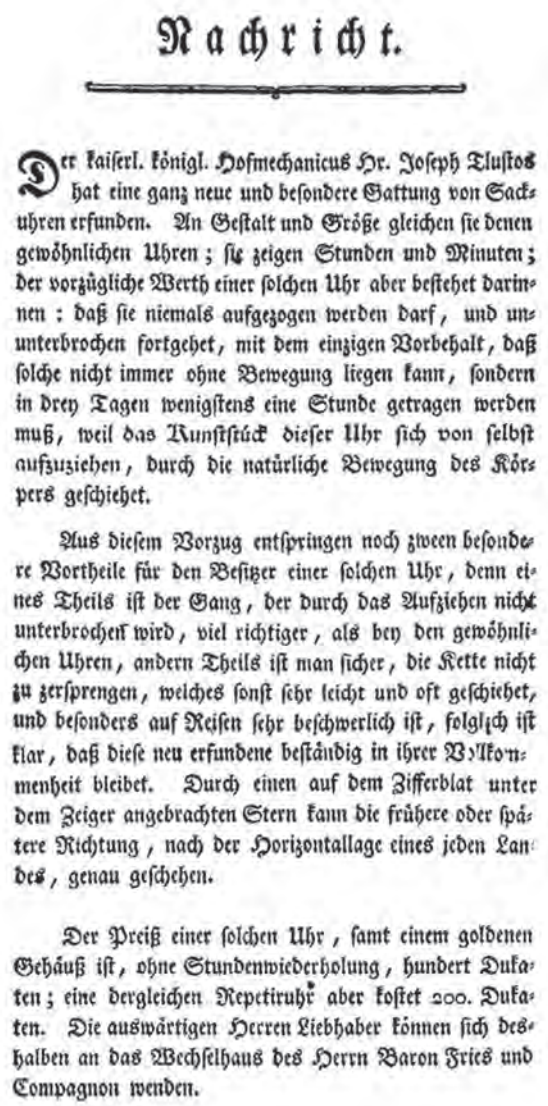
as ordinary watches, and whose principal advantage lay in the fact that it never needed to be wound. The dial indicates the hours and minutes and the watch will continue to run as long as it is not left immobile. It must be worn at least one hour every three days to wind itself through the ordinary bodily motions. The owner of such a watch benefits from two further advantages: the first is it does not stop running during winding and is much more regular than other watches; the second is the elimination of the common problem of the chain breaking. The watch is protected from dust due to the fact that it is very difficult to open.

This report, which is two years earlier than any other documents known at the time, is obviously very important. However, Sabrier fails to provide the name of the source let alone a facsimile of it. It is described as "Leipzig newsletters" in the English edition and "Feuilles de Nouvelles de Leipzig" in the French edition of his book. Despite contacting him several times, Sabrier did not reveal his source.

After some work, I located two possible sources. The first is in the *Wienerisches Diarium*, 8 May 1773 (Vienna, 1773, pages 23-24), Figure 4-1, which was located using ANNO (2013); also see Watkins (2013a, 2013b). This is the earliest document describing self-winding watches that has been found.

Der kaiserl. kön. Hofmechanikus, Hr. Joseph Tlustos, hat eine ganz neue und besondere Gattung von Sackuhren erfunden. An Gestalt und Größe gleichen sie den gewöhnlichen Uhren; sie zeigen Stunden und Minuten. Der vorzügliche Werth einer solchen Uhr aber bestehet darinnen, daß sie niemals aufgezogen werden darf, und ununterbrochen fortgehet, mit dem einzigen Vorbehalte, daß solche nicht immer ohne Bewegung liegen kann, sondern in drey Tagen, wenigstens eine Stunde, getragen werden muß, weil das Kunststück dieser Uhr, sich von selbst aufzuziehen, durch die natürliche Bewegung des Körpers geschiehet.

Aus diesem Vorzuge entspringen noch zween besondere Vortheile für den Besitzer einer solchen Uhr, denn eines theils ist der Gang, der durch das Aufziehen nicht unterbrochen wird, viel richtiger, als bey den gewöhnlichen Uhren, andern theils ist man sicher, die Kette nicht zu zersprengen, welches sonst sehr leicht und oft geschiehet, und besonders auf Reisen sehr beschwerlich ist; folglich ist klar, daß diese neuerfundene beständig in ihrer Vollkommenheit bleibet. Durch einen auf dem Zifferblatte, unter dem Zeiger, angebrachten Stern kann die frühere oder spätere Richtung, nach der Horizontallage eines jeden Landes, genau geschehen.



Nachricht.

Der kaiserl. königl. Hofmechanicus Hr. Joseph Tlustos hat eine ganz neue und besondere Gattung von Sackuhren erfunden. An Gestalt und Größe gleichen sie denen gewöhnlichen Uhren; sie zeigen Stunden und Minuten; der vorzügliche Werth einer solchen Uhr aber bestehet darinnen: daß sie niemals aufgezogen werden darf, und ununterbrochen fortgehet, mit dem einzigen Vorbehalt, daß solche nicht immer ohne Bewegung liegen kann, sondern in drey Tagen wenigstens eine Stunde getragen werden muß, weil das Kunststück dieser Uhr sich von selbst aufzuziehen, durch die natürliche Bewegung des Körpers geschiehet.

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Der Preiß einer solchen Uhr, samt einem goldenen Gehäuß ist, ohne Stundenwiederholung, hundert Dukaten; eine dergleichen Repetiruhr aber kostet 200. Dukaten. Die auswärtigen Herren Liebhaber können sich deshalben an das Wechselhaus des Herrn Baron Fries und Compagnon wenden.

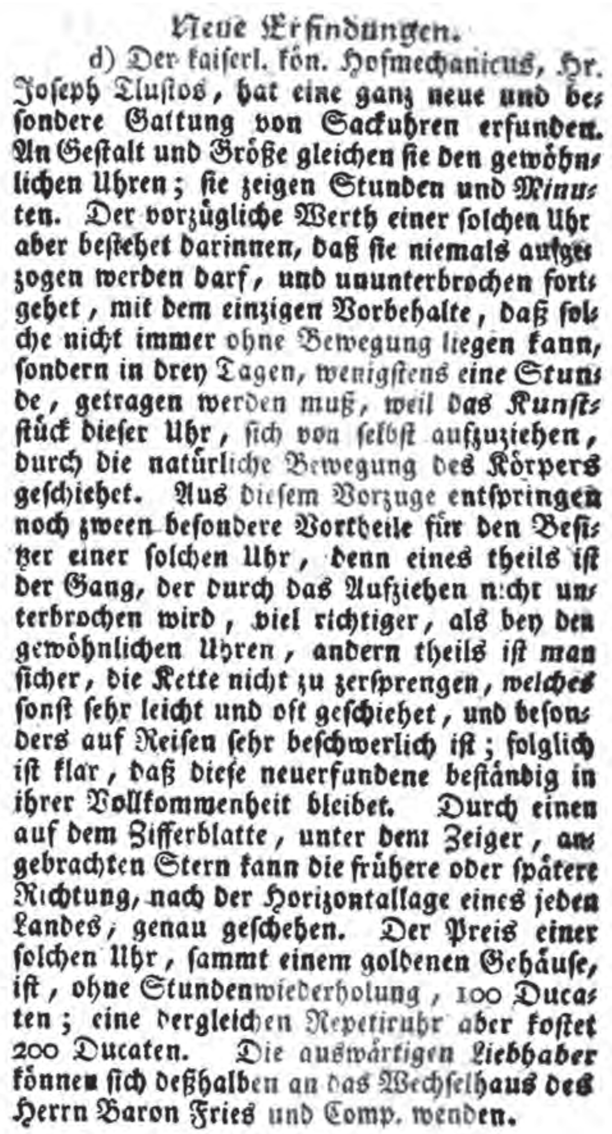
Figure 4-1

> *Der Preis einer solchen Uhr, sammt einem goldenen Gehäuse, ist, ohne Stundenwiederholung, 100 Ducten; eine dergleichen Repetiruhr aber kostet 200 Dukaten. Die auswärtigen Liebhaber können sich deßhalben an das Wechselhaus des Herrn Baron Fries und Comp. wenden. (Transcript by Heinz Mundschau, 2012-2015.)*

The second source, which is identical except for a few very minor changes, is in the *Churbaierische Intelligenzblatt*, September 1775 (Munich, 1775, page 340), Figure 4-2; this was found using Bavarica (2013). But these documents were published in Vienna and Munich, not Leipzig as Sabrier states.

In English, these reports state:

> *The mechanic accredited by the imperial and royal court, Joseph Tlustos has invented a completely new kind of pocket-watch. Concerning their form and dimensions they look like common watches; they indicate hours and minutes. But the great advantage of such a watch consists in the fact that it is not wound, and that it works continuously provided that it does not always lie somewhere but it must be carried for a minimum of one hour during three days, because the speciality of this watch is in fact the self-winding by the corporal movements* [of the owner].
>
> *These advantages have two other agreeable aspects for the owner of such a watch, because firstly the movement is not interrupted by the winding and thus is more correct than common watches, and secondly the chain cannot be broken, a fact which otherwise happens frequently, and which is very unfortunate, especially on journeys. Thus it is clear that this recently invented watch will always be perfect. With a star on the dial under the hand*[s] *you can adjust the advance and retard specially for each country, following the sundial.*
>
> *The cost of such a watch with a gold case, without hour repetition, is 100 ducats; with repetition it costs 200 ducats. Foreign clients can contact the bank of exchange of Baron Fries and Co.* (Translation by Heinz Mundschau, 2012-2015.)



Neue Erfindungen.

d) Der kaiserl. kön. Hofmechanicus, Hr. Joseph Tlustos, hat eine ganz neue und besondere Gattung von Sackuhren erfunden. An Gestalt und Größe gleichen sie den gewöhnlichen Uhren; sie zeigen Stunden und Minuten. Der vorzügliche Werth einer solchen Uhr aber bestehet darinnen, daß sie niemals aufgezogen werden darf, und ununterbrochen fortgehet, mit dem einzigen Vorbehalte, daß solche nicht immer ohne Bewegung liegen kann, sondern in drey Tagen, wenigstens eine Stunde, getragen werden muß, weil das Kunststück dieser Uhr, sich von selbst aufzuziehen, durch die natürliche Bewegung des Körpers geschiehet. Aus diesem Vorzuge entspringen noch zween besondere Vortheile für den Besitzer einer solchen Uhr, denn eines theils ist der Gang, der durch das Aufziehen nicht unterbrochen wird, viel richtiger, als bey den gewöhnlichen Uhren, andern theils ist man sicher, die Kette nicht zu zersprengen, welches sonst sehr leicht und oft geschiehet, und besonders auf Reisen sehr beschwerlich ist; folglich ist klar, daß diese neuerfundene beständig in ihrer Vollkommenheit bleibet. Durch einen auf dem Zifferblatte, unter dem Zeiger, angebrachten Stern kann die frühere oder spätere Richtung, nach der Horizontallage eines jeden Landes, genau geschehen. Der Preis einer solchen Uhr, sammt einem goldenen Gehäuse, ist, ohne Stundenwiederholung, 100 Ducaten; eine dergleichen Repetiruhr aber kostet 200 Ducaten. Die auswärtigen Liebhaber können sich deßhalben an das Wechselhaus des Herrn Baron Fries und Comp. wenden.

Figure 4-2

Both articles differ from Sabrier's text in two respects:

(a) They do not mention that the watch cannot be opened.

(b) They include a sentence on the advance/retard dial that is not in Sabrier's text.

The sentence omitted by Sabrier is not clear:

> *Durch einen auf dem Zifferblatte, unter dem Zeiger, angebrachten Stern kann die frühere oder spätere Richtung, nach der Horizontallage eines jeden Landes, genau geschehen.*

Literally this is:

> *With the help of a star under the hand the earlier or later direction, following the horizontal position of every country can be practised.*

I believe the most likely interpretation for *horizontal* is *horizontal sundial*. Although stating the obvious, it must be remembered that there were no time zones, and every town used its own local time. Although irrelevant today (Watkins, 2007), the equation of time was used to correct mean time, but the very small time differences often made this correction pointless for inaccurate watches.

But this must mean that Tlustos is suggesting that the watch should be adjusted for the equation of time and show solar rather than mean time. Vigniaux (1788, pages 285-287; 2011, pages 114-115) has table for this purpose, Figure 4-3.

TABLE DES ÉQUATIONS.

JOURS DU MOIS	JANVIER.	FÉVRIER.	MARS.	AVRIL.	MAI.	JUIN.	JUILLET.	AOUT.	SEPTEMB.	OCTOBR.	NOVEMB.	DÉCEMB.
	A	A	R	R	R	A	A	R	R	R	R	A
	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
1	28	7	13	18	7	9	12	4	19	19	1	23
2	28	6	13	18	7	9	11	4	19	18	A	24
3	27	5	13	18	6	10	11	5	19	18	1	24
4	27	5	14	18	6	10	11	6	20	18	2	25
5	26	4	14	18	5	10	10	6	20	17	3	25
6	26	3	15	17	5	11	10	7	20	17	4	26
7	25	2	15	17	4	11	9	8	20	17	4	27
8	25	1	16	17	4	11	9	8	20	16	5	27
9	24	R	16	17	3	11	9	9	21	16	6	28
10	24	0	16	16	2	12	8	9	21	15	7	28
11	23	1	17	16	2	12	8	10	21	15	8	28
12	22	2	17	16	1	12	7	10	21	14	9	28
13	22	2	17	16	1	12	7	11	21	14	10	29
14	21	3	17	15	A	13	6	11	21	13	10	29
15	20	4	18	15	1	13	6	12	21	12	11	29
16	20	5	18	14	1	13	5	12	21	12	12	30
17	19	5	18	14	2	13	5	13	21	11	13	30
18	18	6	18	14	2	13	4	13	21	11	14	30
19	18	7	18	13	3	13	4	14	21	10	15	30
20	17	7	18	13	3	13	3	14	21	9	15	30
21	16	8	18	12	4	13	3	14	21	9	16	30
22	15	9	18	12	5	13	2	15	21	8	17	30
23	14	9	19	11	5	13	2	16	20	7	18	30
24	14	10	19	11	6	13	1	16	20	7	18	30
25	13	10	19	10	6	13	R	16	20	6	19	30
26	12	11	19	10	7	13	0	17	20	5	20	30
27	11	12	19	9	7	12	1	17	20	4	20	30
28	10	12	19	9	8	12	1	18	19	4	21	29
29	10		19	8	8	12	2	18	19	3	22	29
30	9		18	8	8	12	3	18	19	2	23	29
31	8		18		9		3	18		1		29

Figure 4-3

For example, if, on January 1, the watch is set about 26 seconds fast, then it will show "sundial time" reasonably accurately for the next 10 days. If this is what is intended, it is probably of little use, because watches of the time would be unlikely to keep time that accurately, and because it would be very difficult to adjust the advance/retard hand with that precision.

Finally, Cassis and Cottrell (2009, page 242) note that Johann Fries (1719-1785) was a Swiss Protestant banker from Mühlhausen who settled in Vienna. So the reference to Baron Fries & Co. suggests that Joseph Tlustos was the court mechanic in Vienna. Abeler (2010, pages 558) lists:

> *Tlustos, Joseph, Wein. Arb.: Louis XVI Carteluhr, ca 1780 (Aukt. Do 589/960), Tischuhr um 1750 (Joanneum Graz)*

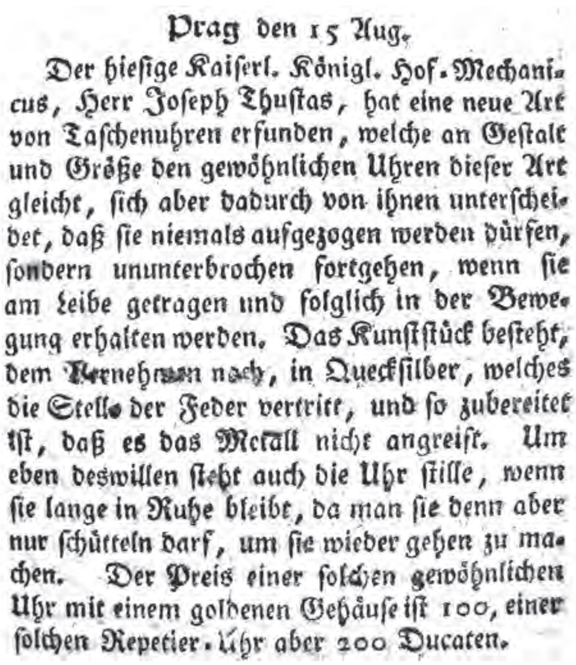
Both Abeler (2010) and Kaltenböck (1993, page 256) list *Tlusios, 1776* in Vienna, but with a different given name, *Peter*. Which is not really relevant, because the original texts in Figures 4-1 and 4-2 clearly reads *Tlustos* and not *Tlusios* as given by Sabrier. But these entries in Abeler and Kaltenböck are probably an error for Tlustos, because Peter Tlustos, uhrmacher, is mentioned in the *Wienerisches Diarium* (Vienna, 1775, page 8).

4.3: Joseph Thustas

At the request of Joseph Flores, addressed to the library of the DGC via his German correspondent Heinz Mundschau, Ralf Weiß (2012) located the following report, Figure 4-4 (Leipzig, 1775, page 795).

Prag den 15 Aug.

> *Der hiesiger Kaiserl. Königl. Hof Mechanicus, Herr Joseph Thustas, hat eine neue Art von Taschenuhren erfunden, welche an Gestalt und Größe den gewöhnlichen Uhren dieser Art gleicht, sich aber dadurch von ihnen unterscheidet, daß sie niemals aufgezogen werden dürfen, sondern ununterbrochen fortgehen, wenn sie am Leibe getragen und folglich in der Bewegung erhalten werden. Das Kunststück besteht, dem Vernehmen nach, in Quecksilber, welches die Stelle der Feder vertritt, und so zubereitet ist, daß es das Metall nicht angreift. Um eben deswillen steht auch die Uhr stille, wenn sie lange in Ruhe bleibt, da man sie denn aber nur schütteln darf, um sie wieder gehen zu machen. Der Preis einer solchen gewöhnlichen Uhr mit einem goldenen Gehäuse ist 100, einer solchen Repetier-Uhr aber 200 Ducaten.*



Prag den 15 Aug.

Der hiesige Kaiserl. Königl. Hof-Mechanicus, Herr Joseph Thustas, hat eine neue Art von Taschenuhren erfunden, welche an Gestalt und Größe den gewöhnlichen Uhren dieser Art gleicht, sich aber dadurch von ihnen unterscheidet, daß sie niemals aufgezogen werden dürfen, sondern ununterbrochen fortgehen, wenn sie am Leibe getragen und folglich in der Bewegung erhalten werden. Das Kunststück besteht, dem Vernehmen nach, in Quecksilber, welches die Stelle der Feder vertritt, und so zubereitet ist, daß es das Metall nicht angreift. Um eben deswillen steht auch die Uhr stille, wenn sie lange in Ruhe bleibt, da man sie denn aber nur schütteln darf, um sie wieder gehen zu machen. Der Preis einer solchen gewöhnlichen Uhr mit einem goldenen Gehäuse ist 100, einer solchen Repetier-Uhr aber 200 Ducaten.

Figure 4-4

Or, in translation:

Prague 15 August

> *The citizen, Imperial and Royal Court Mechanic, Mr Joseph Thustas, has invented a new type of pocket watch, whose shape and size are similar to the ordinary watches of this kind, but they are different, in that they need never be wound, but run continuously when worn on the person and are so kept in motion. The trick is, reportedly, mercury, which takes the place of the spring, and so prepared that it does not attack the metal. For this reason the watch no longer works when it remains still for a long time since it must be shaken to make it run. The price of an ordinary watch with a gold case is 100, and a repeating watch is 200 ducats.*

Although this report comes from a Leipzig "newspaper", it cannot be Sabrier's source, because the name and the text are completely different.

4.4: Joseph Gallmayr (1716-1790)

Lipowsky (1810, pages 226-227) provides a short biography of Gallmayr. A long account of his life is given by König (1982), from which the following summary is derived.

Joseph Gallmayr was born about 1716 in Klein-Essing, the son of a poor cobbler. As a child he was inventive, carving figures out of wood, after which monks at the local monastery educated him.

Following his mother's death, he moved to Munich, taking with him a letter of recommendation to a monastery in that city.

The church had a clock, the Apostle clock, which did not work, despite attempts to repair it. On the hour, the twelve Apostles moved around it in a circle, and then a cock crowed three times. Joseph, after much work, fixed the clock and the automata, which brought him to the attention of the court of the Elector, Maximillian III Joseph. Later he was appointed the court mechanic.

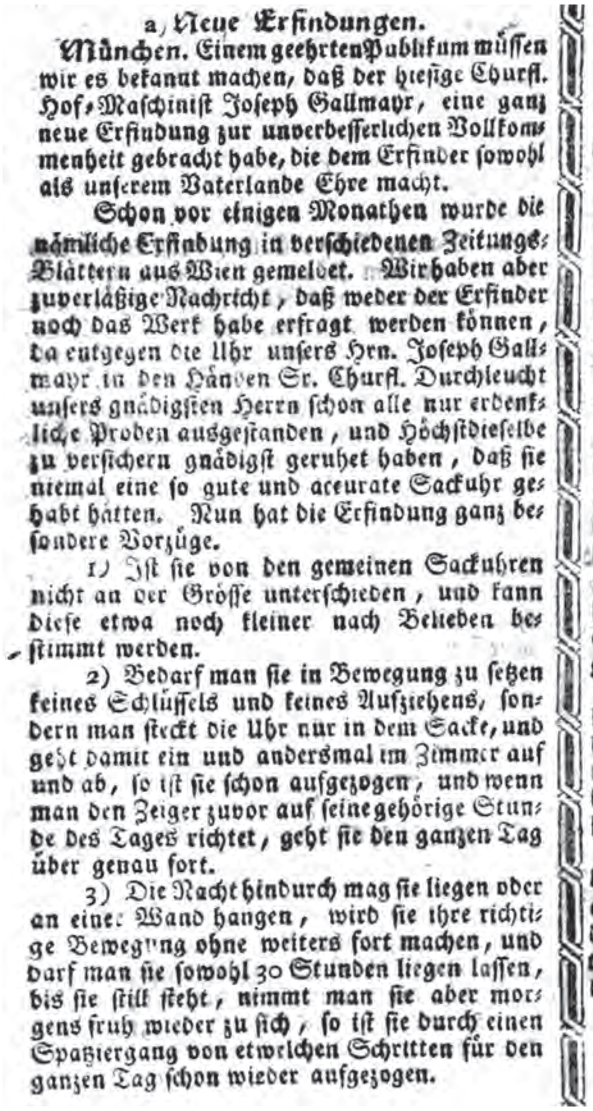
From then on he constructed and repaired automata for the court. He made an artificial leg complete with an articulated knee, and designed drainage and pumping systems.

In 1775 his wife died, and he started loosing his sight and health, later to become completely blind. He remarried in 1777 to provide a mother for his young children.

Unfortunately, König's biography is written as an historical novel and sources are not provided. However, it is clear that Gallmayr was not trained in clock or watch making, although he may have received some training in mechanics.

The earliest report of Joseph Gallmayr making self-winding watches is dated October 1776 (Munich, 1776, pages 352-353; the facsimile in Figure 4-5 has been rearranged):

> *We must inform a honourable public, that Joseph Gallmayr, the current Court mechanic of his Highness the Elector, has just brought a new invention to an unsurpassed perfection, which honours both the inventor and our Fatherland.*
>
> *This invention was announced some months ago in various gazettes in Vienna. However, we have reliable information that neither the invention nor the inventor can be called into question, as the watch of our Mr Joseph Gallmayr has, at the behest of our enlightened and gracious Highness the Elector, been tested in every imaginable way, and with the greatest respect we are able to graciously provide an assurance, that he never had such a good and accurate pocket watch. This invention has the following quite particular advantages.*
>
> *1) Its size is no different from ordinary pocket watches, and it can even be made smaller according to wishes.*
>
> *2) It is not necessary to use a key to wind the watch, rather, to start it working one merely puts it in his pocket and walks the length of a room a few times, and already it is wound up, and when one adjusts the hour hand to the right hour of the day, it continues to keep correct time throughout all the day.*
>
> *3) During the night it can be laid flat or hung on a wall, and it will continue its correct running without fault. Should one leave the watch lying for more than 30 hours until it stops, one picks it up early in the morning, and by going for a walk it will be wound up again for the whole day.*
>
> *4) The mechanism is so strong and reliable that neither a riding a horse nor driving* [in a carriage] *or other jolts will be harmful, as various experiments made by his Highness have confirmed.*
>
> *5) It goes without saying this invention is not a so-called perpetuum mobile, and even those with only an average knowledge of mechanics must admit the great error of those who, in the news announced from Vienna, wanted to explain the movement of the mechanism by mercury or quicksilver being in the machine. These rumour-mongers, said* [our] *inventor, are quite mistaken, and he would wager his head, that nobody will find a grain of mercury in his machine. He has made hundreds of tests and models, for which he can provide evidence, before arriving at his successful idea.*



a, Neue Erfindungen.

München. Einem geehrten Publikum müssen wir es bekannt machen, daß der hiesige Churfl. Hof-Maschinist Joseph Gallmayr, eine ganz neue Erfindung zur unverbesserlichen Vollkommenheit gebracht habe, die dem Erfinder sowohl als unserem Vaterlande Ehre macht.

Schon vor einigen Monathen wurde die nämliche Erfindung in verschiedenen Zeitungs-Blättern aus Wien gemeldet. Wir haben aber zuverläßige Nachricht, daß weder der Erfinder noch das Werk habe erfragt werden können, da entgegen die Uhr unsers Hrn. Joseph Gallmayr in den Händen Sr. Churfl. Durchleucht unsers gnädigsten Herrn schon alle nur erdenkliche Proben ausgestanden, und Höchstdieselbe zu versichern gnädigst geruhet haben, daß sie niemal eine so gute und accurate Sackuhr gehabt hätten. Nun hat die Erfindung ganz besondere Vorzüge.

1) Ist sie von den gemeinen Sackuhren nicht an der Grösse unterschieden, und kann diese etwa noch kleiner nach Belieben bestimmt werden.

2) Bedarf man sie in Bewegung zu setzen keines Schlüssels und keines Aufziehens, sondern man steckt die Uhr nur in dem Sacke, und geht damit ein und andersmal im Zimmer auf und ab, so ist sie schon aufgezogen, und wenn man den Zeiger zuvor auf seine gehörige Stunde des Tages richtet, geht sie den ganzen Tag über genau fort.

3) Die Nacht hindurch mag sie liegen oder an einer Wand hangen, wird sie ihre richtige Bewegung ohne weiters fort machen, und darf man sie sowohl 30 Stunden liegen lassen, bis sie still steht, nimmt man sie aber morgens fruh wieder zu sich, so ist sie durch einen Spaziergang von etwelchen Schritten für den ganzen Tag schon wieder aufgezogen.

4) Ist das Werk so stark und dauerhaft, daß ihm weder reiten noch fahren, weder eine andere Bewegung, auch nur im geringsten schadet, wie dann verschiedene Proben von Sr. Churfürstl. Durchleucht selbst hierüber gemacht worden.

5) Man sieht von sich selbst, daß die Erfindung kein sogenanntes perpetuum mobile sey, und ein in der Mechanik nur mittelmäßig Erfahrner einsehen muß, wie weit sich diejenigen vergangen haben, die in der gemeldten Nachricht von Wien den Grund dieser Bewegung von einem in der Maschine befindlichen Merkurius oder Quecksilber herleiten wollen. Diese Muthmasser, sagte der Erfinder, haben die ganze Scheibe verfehlet, und er verpfändet seinen Kopf, wenn man in seiner Maschine nur einen Gran Quecksilbers findet. Er hat hundert Versuche und Modelle gemacht, die er aufweisen kann, bis er auf den Gedanken gekommen ist, der ihm gelungen.

Nun ist das Werk in seiner Vollkommenheit und zu Stande gebracht, und der Erfinder ist über die Entdeckung des Geheimnisses nicht unzufrieden, sobald er nur den wohlverdienten Lohn seiner mühsamen Arbeit erhalten haben wird.

Er wünschet sich daher nur soviel Liebhaber dieser seiner neu erfundenen Sackuhr auf einmal zu haben, soviel hinlänglich seyn werden, ihn dießfalls zu befriedigen. 60 Dukaten ist der Preis, denn er für eine Sackuhr fodert, wenn sie von Gold seyn soll.

Figure 4-5

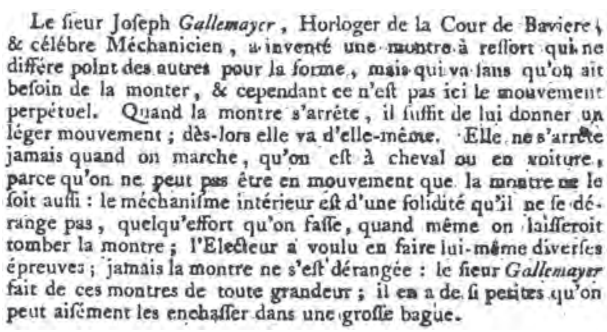
Now the watch is perfected and complete, the inventor will be delighted to disclose his secret, as soon as he receives the richly deserved reward for his troublesome labours.

Thus he wishes only to have as many customers for his newly invented pocket watch as are sufficient to fulfil this wish. The price he asks for the pocket watch is 60 ducats, if it is of gold.

Two brief reports, also dated 1776, followed.

First, in December 1776 the *Courier de l'Europe* (London, 1776, page 79) published the article in Figure 4-6:

M. Joseph Gallemayer, horologist of the Court of Bavaria, and famous Mechanic, has invented a spring watch which does not differ from the others in form, but which does not need to be wound, and yet it is not perpetual motion. When the watch stops, just give it a slight movement; then it will go by itself. It never stops when you walk, when on a horse or in a carriage, because you cannot



Le sieur Joseph *Gallemayer*, Horloger de la Cour de Baviere, & célèbre Méchanicien, a inventé une montre à ressort qui ne diffère point des autres pour la forme, mais qui va sans qu'on ait besoin de la monter, & cependant ce n'est pas ici le mouvement perpétuel. Quand la montre s'arrête, il suffit de lui donner un léger mouvement; dès-lors elle va d'elle-même. Elle ne s'arrête jamais quand on marche, qu'on est à cheval ou en voiture, parce qu'on ne peut pas être en mouvement que la montre ne le soit aussi: le méchanisme intérieur est d'une solidité qu'il ne se dérange pas, quelqu'effort qu'on fasse, quand même on laisseroit tomber la montre; l'Electeur a voulu en faire lui-même diverses épreuves; jamais la montre ne s'est dérangée: le sieur *Gallemayer* fait de ces montres de toute grandeur; il en a de si petites qu'on peut aisément les enchasser dans une grosse bague.

Figure 4-6

move without the watch also moving: the internal mechanism is of a strength it cannot be deranged, whatever we do, even if the watch is dropped; the Elector made various tests himself; the watch was never disturbed: M. Gallemayer makes these watches of all sizes; he has some so small that you can easily put them in a big ring.

Second, Imhof (1782, page 367), in an entry dated 1776 included the short statement in Figure 4-7. This was published in Nürnberg, and is probably the source of Edward Brown's statement (see Section 4.1).

Zu München machte der Hof Mechanikus, Joseph Gallmeyr, eine Sackuhr, die weder eines Schlüssels noch Aufziehens bedarf. Man steckt die Uhr in den Sack, gehet damit einige mal auf und ab so ist sie schon aufgezogen, und läuft dan 30. Stunden lang richtig, sie mag hängen oder liegen.

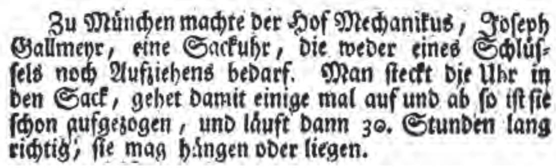
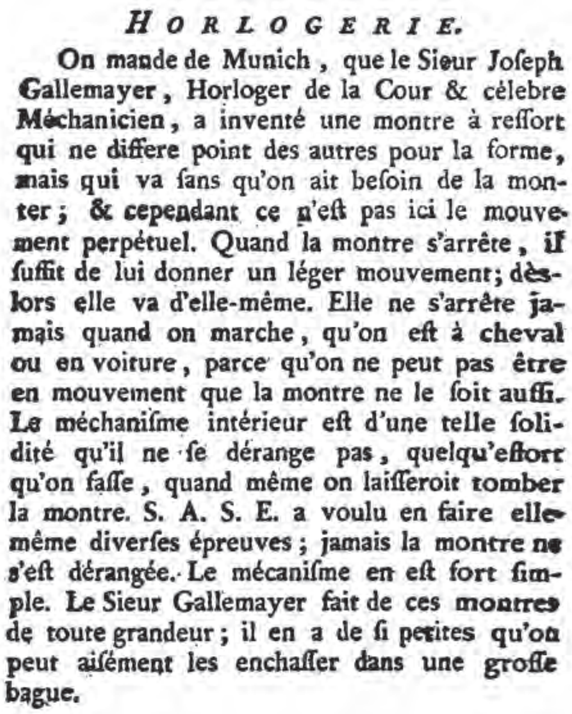

Zu München machte der Hof Mechanikus, Joſeph Gallmeyr, eine Sackuhr, die weder eines Schlüſſels noch Aufziehens bedarf. Man ſteckt die Uhr in den Sack, gehet damit einige mal auf und ab ſo iſt ſie ſchon aufgezogen, und läuft dann 30. Stunden lang richtig, ſie mag hängen oder liegen.

Figure 4-7

In Munich the court mechanic Joseph Gallmeyr made a pocket watch which does not need either a key or winding. One puts the watch in a pocket, one takes some steps and thus it is wound, it then runs for thirty hours, suspended or flat.

Then four reports appeared which are closely related to each other. The first two are identical and appeared in *L'Esprit des Journaux* (Bruxelles and Paris, 1777, pages 347-348), Figure 4-8:

It is communicated from Munich, that Sieur Joseph Gallemayer, clock and watch maker of the Court & celebrated mechanician, invented a spring watch which does not differ from others of the form, but which goes without one needing to wind it; & however it is not perpetual motion. When the watch stops, it is enough to give it a slight movement; then it goes by itself. It never stops when one walks, when one is on a horse or in a carriage, because one cannot be moving without the watch also moving. The interior mechanism is so solid that it does not get out of order, whatever one does, even if one would drop the watch. S.A.S.E. himself did various tests; the watch never got out of order. The mechanism is extremely simple. Sieur Gallemayer makes these watches of any size; he has some so small that one can easily place them in a large ring.


HORLOGERIE.

On mande de Munich, que le Sieur Joſeph Gallemayer, Horloger de la Cour & célebre Méchanicien, a inventé une montre à reſſort qui ne differe point des autres pour la forme, mais qui va ſans qu'on ait beſoin de la monter; & cependant ce n'eſt pas ici le mouvement perpétuel. Quand la montre s'arrête, il ſuffit de lui donner un léger mouvement; dès-lors elle va d'elle-même. Elle ne s'arrête jamais quand on marche, qu'on eſt à cheval ou en voiture, parce qu'on ne peut pas être en mouvement que la montre ne le ſoit auſſi. Le méchaniſme intérieur eſt d'une telle ſolidité qu'il ne ſe dérange pas, quelqu'effort qu'on faſſe, quand même on laiſſeroit tomber la montre. S. A. S. E. a voulu en faire elle-même diverſes épreuves; jamais la montre ne s'eſt dérangée. Le mécaniſme en eſt fort ſimple. Le Sieur Gallemayer fait de ces montres de toute grandeur; il en a de ſi petites qu'on peut aiſément les enchaſſer dans une groſſe bague.

Figure 4-8

The person who tested the watch is His Serene Highness Elector Maximillian III Joseph of Munich.

The third and fourth reports, which are also identical, are in the *Journal Encyclopédique* (Liège, 1777, page 155), Figure 4-9, and *Journaux Politiques* (Bouillon, 1777). These reports are fundamentally the same as the first two and so I do not need to provide a translation.

Finally, a long advertisement was published in 1779 (Munich, 1779, pages 194-195), Figure 4-10:

JANVIER 1777. 155

Le Sr. Joſeph Gallemayer, horloger de la cour de Munich, a imaginé une montre à reſſort, qui ne differe point des autres par la forme, mais qui va ſans qu'on ait beſoin de la monter : il ſuffit de lui donner une légere ſecouſſe, pour la faire aller, quand elle s'arrête, ce qui n'arrive jamais, lorſqu'on marche, qu'on eſt à cheval ou en voiture ; parce qu'on ne peut pas être en mouvement, que la montre ne le ſoit auſſi. Son mécaniſme eſt d'une telle ſolidité, qu'il ne ſe dérange pas, quelqu'effort qu'on faſſe, quand même on la laiſſeroit tomber ; l'électeur de Baviere l'a pluſieurs fois éprouvé. Le Sr. Gallemayer fabrique de pareilles montres de toute grandeur ; il en a de ſi petites, qu'on pourroit aiſément les mettre dans une groſſe bague.

Figure 4-9

Art. VIII. Künste und Wissenschaften. a) Es will Herr Joseph Gallmayr von Weltenburg in Baiern gebürtig, Churfürstl. Hofmaschinist allhier seine schon vor 4 Jahren auf höchsten Befehl und Gutachten durch das Intelligenz-Blatt bekannt gemachte neue Invention, oder wegen seiner besondern Kunst und vortreflichen Nutzen bewunderungswürdige perpetuirliche Sackuhr dem gelehrten, und geehrten Publikum neuerdings zu wissen machen: und eben diese perpetuirliche Sackuhr, welche sowohl von Sr. in Gott ruhenden Churfürstl. Durchl. in Baiern, als Sr. jetzt regierenden herzogl. Durchl. zu Mecklenburg-Schwerin gnädigsten Beyfall erhalten hat, und welche zu zweymal um 60 Dukaten bezahlt worden. (die keiner Aufziehung bedarf, ja nicht aufgezogen kann werden, und doch in der nämlichen Größe, wie die anderen gemeinen Sackuhren, gehen, bisher aber doch allzeit ein Arkanum verblieben) diese will er allen und jeden, besonders aber den Herrn Liebhabern, und gesamten Uhrverständigen dedicieren, also zwar, daß sie nicht nur die neu inventierte Sackuhr, von dem Erfinder selbst haben können, da er selbst noch zwei mit goldenen Gehäußen verfertigter im Vorrathe hat, sondern einen vollständigen und haarklein aufgezeichneten, und zu diesem Ende in einem Kupfer, auf welchem die ganze Uhr samt allen zugehörigen Rädern, Zähnen, Federn, und Spindeln, Stückweise aufgezeichnet ist, also, daß jeder dieser Kunstsverständige auf diesen haarklein entworfenen Abriße, und in dem dabeystehenden schriftl. Unterricht sich ersehen, und sie ohne alle Mühe selbst verfertigen kann. Der nämliche Künstler, ein Mann, welcher vorlängst seine mechanische Wissenschaft der gelehrten Welt genugsam erprobet hat, hat diese feine neue Invention dem geehrten Publicum der Ursachen willen zuerkannt, und zueignen wollen, weil er ja nicht gerecht zu seyn hielt, diese dem gemeinen Weesen so ersprießliche neue Invention mit in das Grab zu nehmen; massen er Alters halber diese neue Kunst nun nicht länger will verbergen. Es ist zwar oben Meldung geschehen, daß diese Uhr schon an zween Höfen bekannt ist; allein eben deßwegen sind diese Uhren nicht publik, aus Ursache, weil der Erfinder noch allzeit den Zugang zu diesen Uhren verschlossen hat, und um nicht das ganze Werk zu ruiniren, von niemand, als von dem Erfinder selbsten, könnten aufgemacht werden. Jetzt aber in seinem neuen in Kupfer aufgezeichneten Unterricht der gänzliche Zugang offenbar wird; also, wenn einer von diesen Uhren was fehlen sollte, ein jeder Uhrverständiger ihr zu helfen weis. Diese Uhren haben keiner solchen Pflege, als wie die andern gemeinen Uhren nöthig. Sie geht beständig, so lang man diese bey sich führet, und wird eben durch ihrem Gebrauche, wenn man auch gleich 3 Täge diesen unterließ, ihre gehörige Dienste machen. Es wird auch die irrige Meynung derjenigen offenbar, welche glaubten, das Werk werde von Merkur, oder Quecksiber regieret, und geleitet: daher allen Kunstreichen, und begierigen Herren Liebhabern gezeiget, und in dem auf dem Kupfer verfertigten Unterrichte dargethan, wie die beständige Bewegung erfolge, und bestehen könne. Zu diesem Ende dann kann sich ein jeder geehrter Liebhaber in Zeit von zwey Monath dieser

Uhr, und dessen ganzen Unterrichtes zu Nutze und eigenthümlich machen. Nur beliebe man auf der Post, oder bey anderer Gelegenheit den Brief Franco samt 2 fl. 24 kr. in des Gallmayrs Behausung zu schicken: und in dieser Zeit wird der Erfinder gewißlich mit dem versprochenen Unterricht (wozu er sich auch verpflichtet) aufwarten. Joseph Gallmayr Hofmachinist, loschirt am Ende der Weinstraße über 3 Stiegen beym Bäcker am Ecke, in München.

Nota: Man ersucht, dieses auch andern Zeitungen zu melden.

Artic. VIII. Künste- und Wissenschaften. a) Es will Herr Joseph Gallmayr von Weltenburg in Baiern gebürtig, Churfürstl. Hofmachinist allhier seine schon vor 4 Jahren auf höchsten Befehl und Gutachten durch das Intelligenz-Blatt bebekannt gemachte neue Invention, oder wegen seiner besondern Kunst und vortreflichen Nutzen bewunderungswürdige perpetuirliche Sackuhr dem gelehrten, und geehrten Publicum neuerdings zu wissen machen: und eben diese perpetuirliche Sackuhr, welche sowohl von Sr. in Gott ruhend Churfürstl. Durchl. in Baiern, als Sr. jetzt regierenden herzogl. Durchl. zu Mecklenburg-Schwerin gnädigsten Beyfall erhalten hat, und welche zu zweymal um 60 Dukaten bezahlt worden. (die keiner Aufziehung bedarf, ja nicht aufgezogen kann werden, und doch in der nämlichen Größe, wie die andern gemeinen Sackuhren, gehen, bisher aber doch allzeit ein Arkanum verblieben) diese will er allen und jeden, besonders aber den Herrn Liebhabern, und gesamten Uhrverständigen dedicieren, also zwar, daß sie nicht nur die neu inventierte Sackuhr, von dem Erfinder selbst haben können, da er selbst noch zwey mit goldenen Gehäußen verfertigter im Vorrathe hat, sondern einen vollständigen und haarklein aufgezeichneten, und zu diesem Ende in einem Kupfer, auf welchem die ganze Uhr samt allen zugehörigen Rädern, Zähnen, Federn, und Spindeln, Stückweise aufgezeichnet ist, also, daß jeder dieser Kunstverständige auf diesen haarklein entworfenen Abriße, und in dem dabeystehenden schriftl. Unterricht sich ersehen, und sie ohne alle Mühe selbst verfertigen kann. Der nämliche Künstler, ein Mann, welcher vorlängst seine mechanische Wissenschaft der gelehrten Welt genugsam erprobet hat, hat diese seine neue Invention dem geehrten Publicum der Ursachen willen zuerkannt, und zueignen wollen, weil er ja nicht gerecht zu seyn hielt, diese dem gemeinen Weesen so ersprießliche neue Invention mit in das Grab zu nehmen; massen er Alters halber diese neue Kunst nun nicht länger will verbergen. Es ist zwar oben Meldung geschehen, daß diese Uhr schon an zween Höfen bekannt ist; allein eben deßwegen sind diese Uhren nicht publik, aus Ursache, weil der Erfinder noch allzeit den Zugang zu diesen Uhren verschlossen hat, und um nicht das ganze Werk zu ruiniren, von niemand, als von dem Erfinder selbsten, könnten aufgemacht werden. Jetzt aber in seinem neuen in Kupfer aufgezeichneten Unterricht der gänzliche Zugang offenbar wird; also, wenn einer von diesen Uhren was fehlen sollte, ein jeder Uhrverständiger ihr zu helfen weis. Diese Uhren haben keiner solchen Pflege, als wie die andern gemeinen Uhren, nöthig. Sie geht beständig, so lang man diese bey sich führet, und wird eben durch ihrem Gebrauche, wenn man auch gleich 3 Täge diesen unterließ, ihre gehörige Dienste machen. Es wird auch die irrige Meynung derjenigen offenbar, welche glaubten, das Werk werde von Merkur, oder Queckfilber regieret, und geleitet: daher allen Kunstreichen, und begierigen Herren Liebhabern gezeiget, und in dem auf dem Kupfer verfertigten Unterrichte dargethan, wie die beständige Bewegung erfolge, und bestehen könne. Zu dem Ende dann kann sich ein jeder geehrter Liebhaber in Zeit von zwey Monath dieser Uhr, und dessen ganzen Unterrichtes zu Nutze und eigenthümlich machen. Nur beliebe man auf der Post, oder bey anderer Gelegenheit den Brief Franco samt 2 fl. 24 kr. in des Gallmayrs Behausung zu schicken: und in dieser Zeit wird der Erfinder gewißlich mit dem versprochenen Unterricht (wozu er sich auch verpflichtet) aufwarten. Joseph Gallmayr Hofmachinist, loschirt am Ende der Weinstraße über 3 Stiegen beym Bäcker am Ecke, in München.

Nota. Man ersucht, dieses auch in andern Zeitungen zu melden.

Figure 4-10

The English translation is:

> *Mr Joseph Gallmayr born in Weltenburg, Bavaria, mechanic of the Electoral Prince would like by this to present once more to an honoured and intelligent public his latest invention which the "Intelligenz-Blatt" had already published four years ago by special order and appreciation* [of their majesties; it was actually published three years ago in 1776]. *This, because of the special art and use of his wonderful perpetual pocket-watch, which even found the good appreciation of the late Elector as of the now governing Her Highness Mecklenburg-Schwerin, and who has been paid 60 ducats two times. (which need not be wound up, and there is even no possibility to do that, and yet it has the same dimensions as the usual pocket-watches, but so far has always remained a secret). This watch he would dedicate to a larger public, but specially to connoisseurs and specialists in watchmaking firstly that he has still a stock of two watches with golden cases, and then by matter of a copperplate engraving showing the whole construction with all its wheels, teeth, springs and verges. By this way every specialist of this art may see these meticulously designed plans and the textual explanations and so he can construct it himself. The artist, a man who for a long time has largely proved his technical knowledge to the scientific world has dedicated his recent invention to an honoured public because he does not intend that it would be correct to take this invention of public interest with him to the grave. Because of his age he will no longer make a secret of his art. We already said that the watch is already known by two Majesties, but therefore they are publicly unknown and further the inventor has kept the cases hermetically closed to avoid that somebody could ruin the whole mechanism, they can only be opened by the master himself. But now, by matter of his engraved documentation every approach is possible. If there is a missing part, every specialist is capable of replacing it. These watches do not need the same treatment as common watches. It runs as long as you take it with you and even does its duty for three days after putting it away. By studying the case it will be clear that it was an error that some people thought that there was some mercury or quicksilver governing the mechanism. By this way every artist and curious connoisseurs are instructed by the engravings in which manner the perpetual movement is created and maintained. Finally every honoured connoisseur may acquire all the knowledge about this watch. The only condition: one may by the post or otherwise send 2 florins and 24 crowns to the house of Mr Gallmayr: after which the inventor will provide the promised instructions, and therefore he gives his guarantee.*
>
> *Joseph Gallmayr, mechanic to the court, lives on the end of the Weinstrasse on the third floor in the house of the baker on the corner in Munich.*
>
> *Note: You are invited to also put part of this in other journals.* (Translation by Heinz Mundschau, 2012-2015.)

4.5: Forrer

The information in this section has been provided by Heinz Mundschau (2012; 2012-2015).

Nothing is known about Forrer, not even his given name. Kaltenböck (1993, page 241) lists only one person, Jacob Forrer died 1811. But he also lists Johann Forer, died 1780, who is possible.

The earliest reference to Forrer appears in Meusel (1781, page 29), under the heading *Aus Wien. Geschrieben am 9ten August 1780*, Figure 4-11:

> *1) A watchmaker living here, named Forrer, born in Switzerland, is making pocket-watches resulting from a new invention, which need not be wound, because by their mechanism they rewind themselves every 40 hours; this is the reason why the cases cannot be opened, except that you can reach the dial with the advance-retard indicator. If you are walking with this watch in your pocket: it will wind up itself with every step for one little tooth and so it will never unwind completely. To describe the mechanism of this work, I should need to be a watchmaker or another kind of greater mechanic. But I can tell you nevertheless, that here there are watches of this kind which are still working after three years, - that they are a little large, - that the pivots run in drilled diamonds, and that one watch of this kind would cost 70 ducats. Perhaps I shall tell you more about this man after having seen him* [personally].

1) Ein hier angesessener Uhrmacher, Forrer mit Namen, von Geburt ein Schweitzer, verfertigt Sackuhren von einer neuen Erfindung, die gar nicht brauchen aufgezogen zu werden, indem sie sich durch ihren Mechanismus alle 40 Stunden von selbst wieder aufziehen, weswegen auch die Gehäuse gar nicht geöfnet werden können, außer um zum Zifferblatt, und zum Avance- und Retardtäfelgen zu gelangen. Geht man mit der Uhr in der Tasche: so zieht sie sich bey jedem Schritt um 1 Zähnchen auf, und läuft folglich nie gänzlich ab. Den Mechanismus von diesem Werke nun zu beschreiben, müßte ich ein Uhrmacher oder noch ein größerer Mechanicus seyn. So viel soll indeß Ihnen genug seyn, daß sich hier dergleichen Uhren finden, die schon 3 Jahre so gehen, — daß sie etwas groß sind, — daß die Bewegpunkte in unausfeilbaren Diamanten gehen, und daß eine solche Uhr, wozu 25 Ducaten an Gold verwendet werden, auf 70 Ducaten zu stehen komme. Vielleicht, wenn ich den Mann gesehen haben werde, etwas mehrers von Ihm.

Figure 4-11

Chapuis & Jaquet (1956, page 27) give the source incorrectly as Mensel.

Busch (1821, page 103) then repeated this statement, Figure 4-12:

> *The watchmaker Forrer in Vienna, born in Switzerland, has invented pocket-watches, which wind themselves up every 40 hours. If you are walking with this watch in your pocket; it will wind itself with every step you take for one little tooth, and thus it never unwinds completely. The watches are a little large, their pivots run in drilled diamonds; you cannot open them, but via the dial you can reach the advance – retard indicator. One* [watch] *costs 70 ducats.* (Translation by Heinz Mundschau, 2012-2015.)

Der Uhrmacher Forrer in Wien, der aus der Schweiz gebürtig ist, hat Sackuhren erfunden, die sich alle 40 Stunden von selbst aufziehen. Geht man mit der Uhr in der Tasche; so zieht sie sich bey jedem Schritt, den man thut, um ein Zähnchen auf, und läuft folglich nie ganz ab. Die Uhren sind etwas groß, ihre Bewegpunkte laufen in unausfeilbaren Diamanten; sie können aber nicht geöffnet werden, doch kann man zum Zifferblatt, zum Avance- und Retardtäfelchen kommen. Eine kostet 70 Dukaten. [13]

Figure 4-12

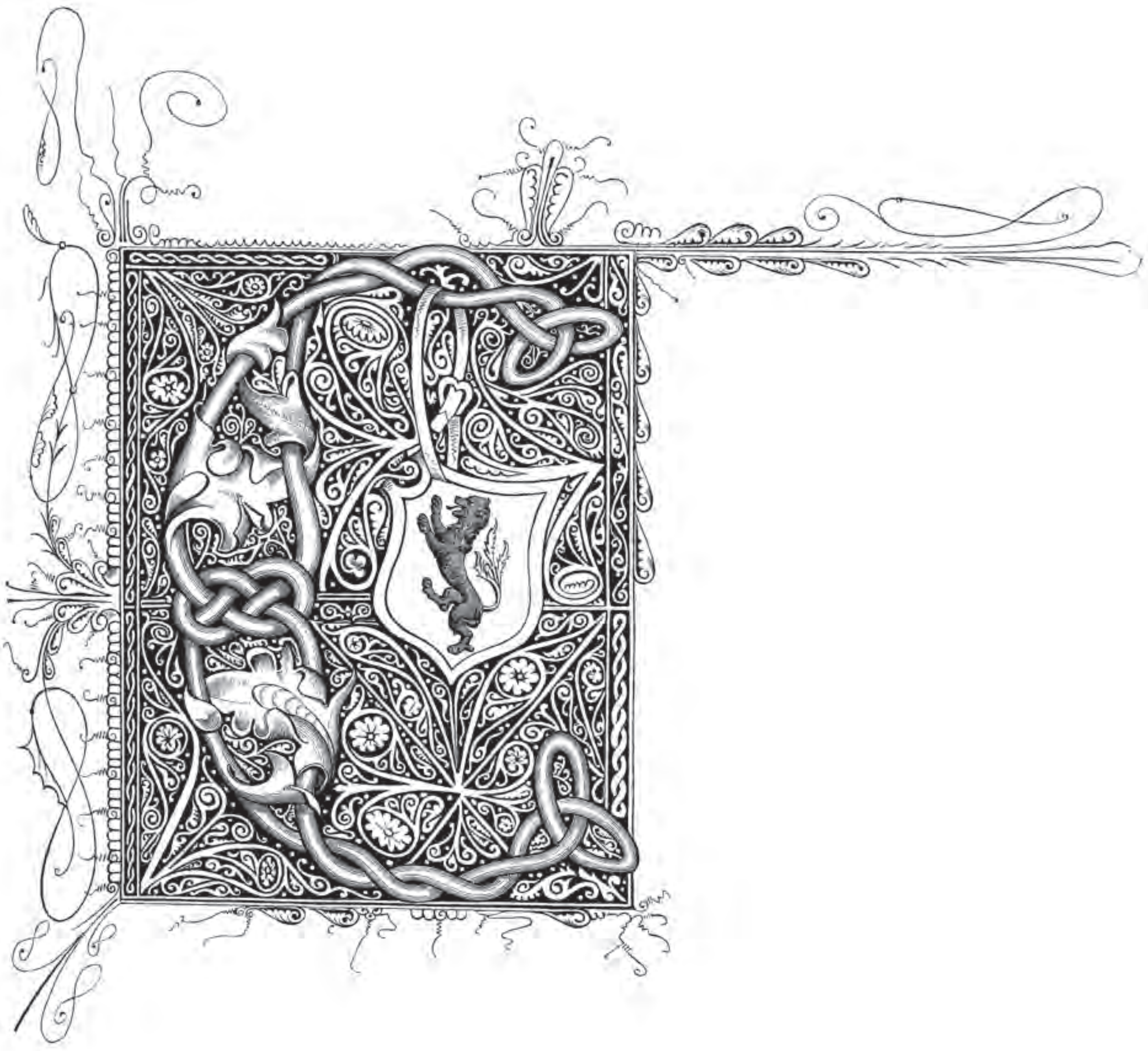
The footnote 13 (on page 104 of that book) notes that the source for this information was Meusel.

It would appear that the writer knew little or nothing about watches and wrote what he thought he had been told. Two parts of these texts support this view:

(a) *alle 40 Stunden von selbst* [wieder] *aufziehen*. Although literally *they rewind themselves every 40 hours*, there can be little doubt that a 40-hour running time is intended.

(b) *um ein Zähnchen auf*. Chapuis & Jaquet (1956, page 27) incorrectly translate this as a small wheel, but *Zähnchen* is a small tooth. Mundschau (2012) suggests that this refers to the click of a click and ratchet.

Although Forrer was born in Switzerland, his name does not appear in Bourdin (2012) or Patrizzi (1998).



5: Perrelet

5.1: Early Documents

The early documents use three different names and do not fully specify the person concerned. For this reason they are examined separately.

The earliest reference appears in the diary of H.B. de Saussure, written when he visited Neuchâtel from 29 May to 8 June 1777. On 5 June he visited Le Locle, Figure 5-1.

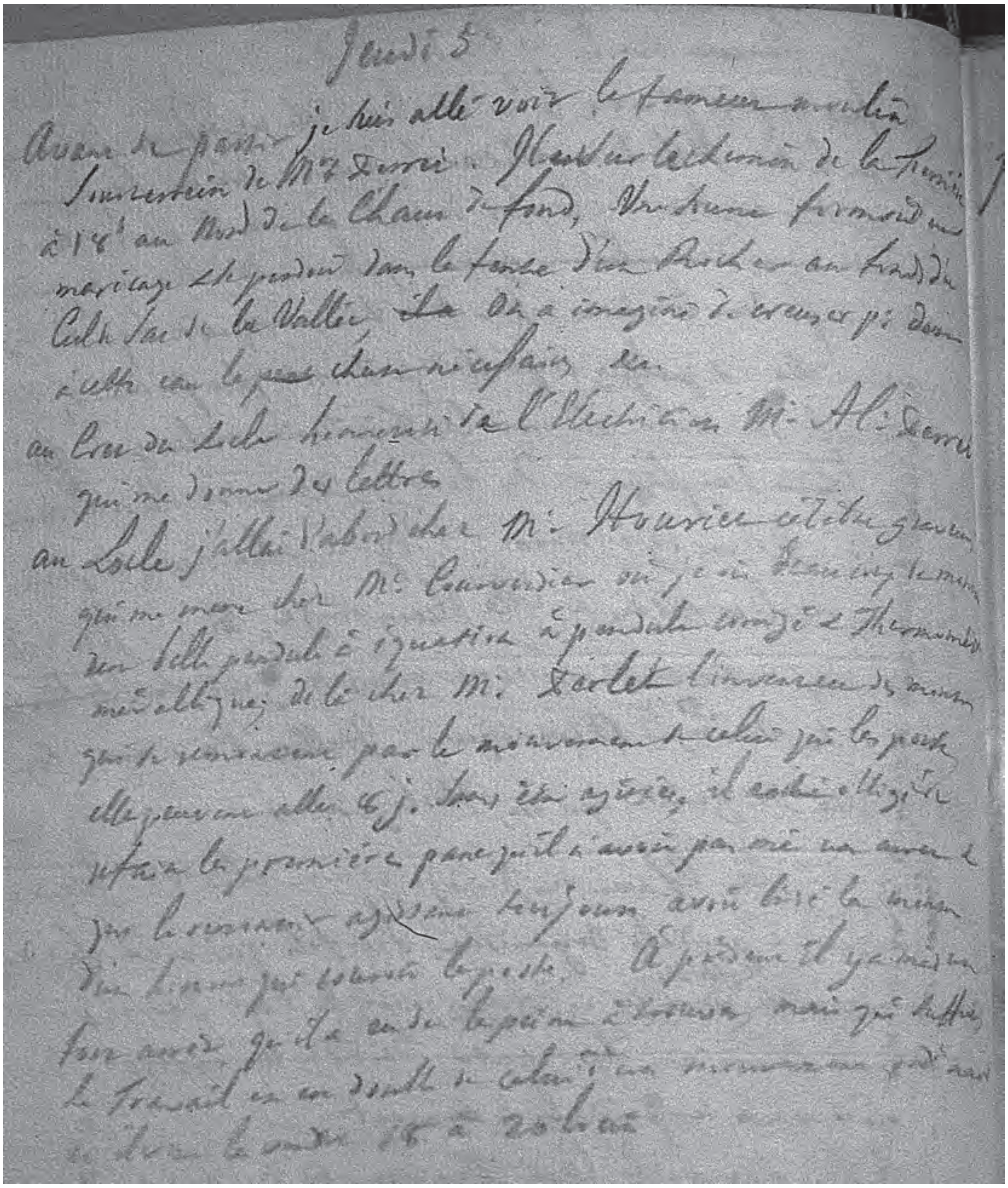


Figure 5-1

5: Perrelet

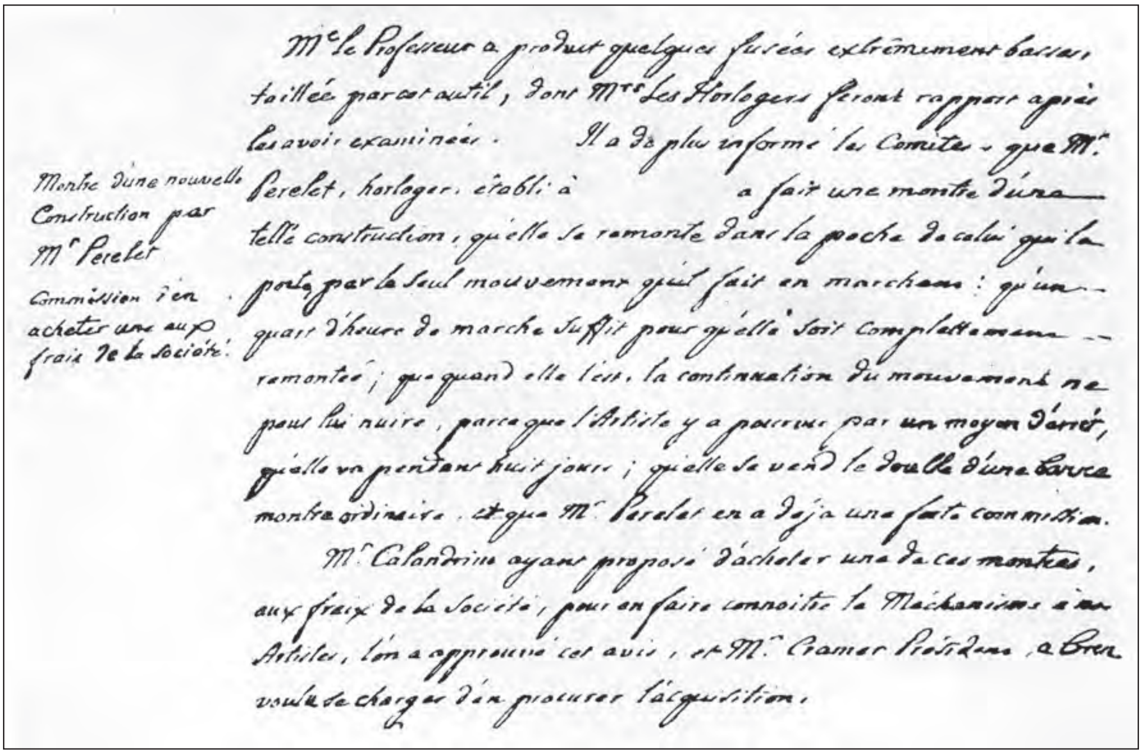
The relevant section is:

> *... de là chez M. Perlet l'inventeur des montres qui se remontent par le mouvement de celui qui les porte, elles peuvent aller huit jours sans être agitées; il a été obligé de refaire la première parce qu'il n'avait pas mis un arrêt et que le remontoir agissant toujours avait brisé la montre d'un homme qui courait à la poste. À présent il a mis un bon arrêt qu'il a eu de la peine à trouver, mais qui suffit. Le travail est en double de celui d'un mécanisme ordinaire et il v... la vendre 18 à 20 louis.*
>
> *... from there to Mr Perlet the inventor of the watches which are wound by the movement of the persons who carry them, they can go eight days without being shaken. He had to remake the first one because he had not put in a stop-work, and the winding always acting had broken the watch of a man who ran to the post office. Now he has put in a good stop-work which he had trouble to design, but which is good enough. The work is double of that of an ordinary mechanism and he ... sell it [for] 18 to 20 louis.*

The missing word, beginning with *v*, is discussed in Section 20.1, page 224.

Six days later, on 11 June, a report appeared in the Registers de l'Assemblée Générale, the minutes of the General Assembly of the Société des Arts in Geneva, Figure 5-2.

> *Mr le Professeur a produit quelques fusées extrêmement basses, taillée par cet outil, dont Mrs les Horlogers feront rapport après les avoir examinées. Il a de plus informé les Comité qui Mr Perelet, horloger, établi à ...... a fait une montre d'une telle construction, qu'elle se remonte dans la poche de celui qui la porte, par le seul mouvement qu'il fait en marchant; qu'un quart d'heure de marche suffit pour qu'elle soit complètement remonter; que quand elle l'est la continuation du mouvement ne pour lui nuire, parce que l'Artiste y a procurer par une moyen l'arrêt, qu'aille en pendant huit jours; qu'elle vend le double d'une bonne montre ordinaire et que Mr Perelet en a déjà une forte commission.*


Monhe d'une nouvelle Construction par Mr Perelet

Commission d'en acheter une aux frais de la Société.

Mr le Professeur a produit quelques fusées extrêmement basses, taillée par cet outil, dont Mrs les Horlogers feront rapport après les avoir examinées. Il a de plus informé les Comité que Mr Perelet, horloger, établi à a fait une montre d'une telle construction, qu'elle se remonte dans la poche de celui qui la porte par le seul mouvement qu'il fait en marchant : qu'un quart d'heure de marche suffit pour qu'elle soit complettement remontée ; que quand elle l'est, la continuation du mouvement ne peut lui nuire, parceque l'Artiste y a pourvu par un moyen d'arrêt, qu'elle va pendant huit jours ; qu'elle se vend le double d'une bonne montre ordinaire, et que Mr Perelet en a déja une forte commission.

Mr Calandrini ayant proposé d'acheter une de ces montres, aux frais de la Société, pour en faire connoitre le Méchanisme à nos Artistes, l'on a approuvé cet avis, et Mr Cramer Président a bien voulu se charger d'en procurer l'acquisition.

Figure 5-2

Mr Calandrini ayant proposé d'acheter une de ces montres, aux frais de la Société, pour en faire connaître le méchanisme a ces Artiste, l'on approuvé cet avis, et Mr Cramer Président, a bien voulu se charger d'en procurer l'acquisition.

The Professor [de Saussure] ... *also informed the Committee that Mr Perelet, watchmaker, established at made a watch of such a construction that it is wound up in the pocket of the person who carries it, by just the movement that he makes while walking; that fifteen minutes of walking are enough for it to be completely wound up and when it is, the continued motion will not harm it, because the Artist has provided for this by means of a stop-work. It runs for eight days. It sells for double that of a good ordinary watch and Mr Perelet already has a large commission.*

Mr Calandrini having proposed to buy one of these watches, at the Society's expense, to make known the mechanism of this Artist, this motion was approved, and Mr Cramer, President, agreed to undertake getting one.

Note that the word *inventeur* in Figure 5-1 does not appear in this report.

As this document is derived from de Saussure's diary, presumably Saussure himself changed the spelling from *Perlet* to *Perelet* when his report was submitted to the Société des Arts in Geneva.

Four later documents are given in facsimile by Chapuis & Jaquet (1952, pages 31, 33, 34 and 36; 1956, pages 33, 35, 36 and 37), but only three are relevant here.

First, Figure 5-3, Jacques-Louis Perrot wrote to F. S. Osterwald on 28 May 1780, stating:

Les pièces Perpétuelles inventées depuis 2 ou 3 ans dans nos montagnes, font l'objet des curieux et n'ont pas laissé que de donner de la renommée en ce lieux; ce sont des montres plus grosses que d'ordinaire qui se remontent d'elles mêmes moyennant qu'on les porte sur soi et qu'on fasse quelques tours de chambre ou quelques mouvements pendant la journée; 8 minutes de marche suffisent pour les remonter pour les 24 heures. Se sont des pièces assez recherchées; et qui se paient chères; mais des contrefacteurs qui ne réussissent pas peuvent les donner à bon compte, l'ouvrage est susceptible pour être bon à une grande délicatesse que chacun ne peut acquérir.

The Perpetual pieces invented 2 or 3 years ago in our mountains, are the subject of curiosity and give fame to this place; these watches, that are larger than the ordinary, wind themselves as one carries them on oneself and one makes some turns of a room or some movements during the day; 8 minutes walking is enough to wind them for 24 hours. They are in some demand and they are expensive; but counterfeiters who do not succeed can supply them cheaply; to be good the work requires great delicacy that not every one can achieve.

Second, Figure 5-4, in a letter to F. S. Osterwald dated 16 March 1781, Abbé Desprades wrote about a self-winding watch:

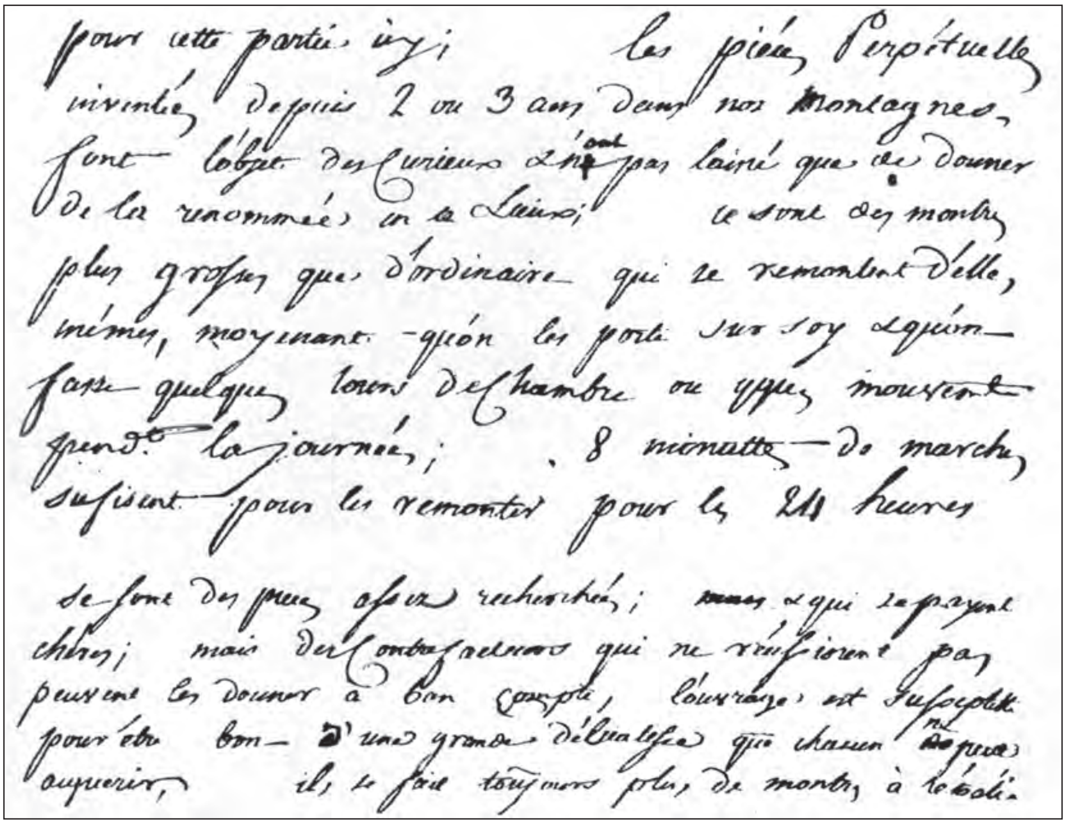
Plusieurs personnes en ont eu envie, mais ils ont été bientôt effrayées du mouvement à sacade qu'éprouve en marchant cette espèce de nouveau balancier ajouté à la montre ...

Several people wanted one, but were soon frightened by the jerky movement felt while walking [with] *this new type of weight added to the watch ...*

Finally, Figure 5-5, in a letter written to Osterwald by Lemulier du Bressy on 7 May 1782, we find:

One Mr Perrelet makes watches that wind themselves in one's pocket.

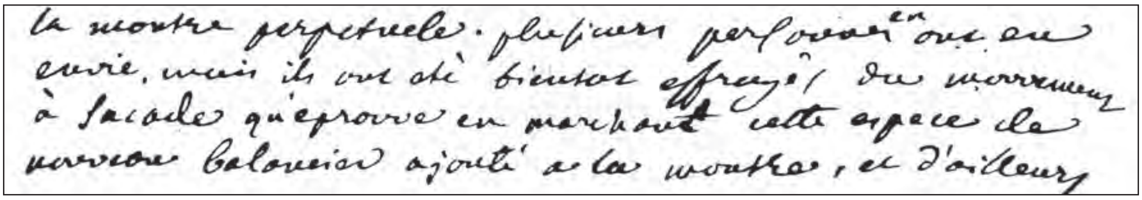
This is apparently the first document that uses the spelling *Perrelet*.



pour cette partie icy; les pièces perpétuelles
inventées depuis 2 ou 3 ans dans nos Montagnes,
sont l'objet des curieux et n'ont pas laissé que de donner
de la renommée en ce Pays; ce sont des montres
plus grosses que d'ordinaire qui se remontent d'elles
mêmes, moyennant qu'on les porte sur soy et qu'on
fasse quelques tours de chambre ou quelques mouvements
pendant la journée; 8 minuttes de marche
suffisent pour les remonter pour les 24 heures

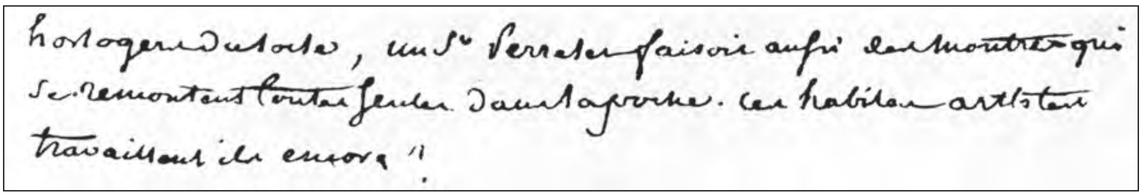
ce sont des pièces assez recherchées; mais ce qui les rend
chères; mais des contrefacteurs qui ne réussiront pas
peuvent les donner à bon compte, l'ouvrage est susceptible
pour être bon d'une grande délicatesse que chacun ne peut
acquérir, il se fait toujours plus de montres à ...

Figure 5-3



la montre perpétuelle. plusieurs personnes en ont eu
envie, mais ils ont été bientot effrayés du mouvement
à saccade qu'éprouve en marchant cette espece de
marteau balancier ajouté à la montre, et d'ailleurs

Figure 5-4

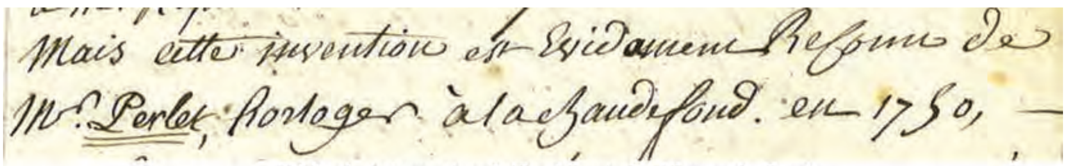


horlogers du Locle, un Sr Perrelet faisoit aussi des montres qui
se remontoient toutes seules dans la poche. ces habiles artistes
travaillent-ils encore ?

Figure 5-5

Finally, Figure 5-6, in 1791 a report to the *Société nationale des inventions et découvertes* refers to Perlet at La Chaux-de-Fonds as the inventor of a self-winding watch (Paris, 1791):

But this invention is clearly acknowledged to Mr Perlet, watchmaker at Chaudefond, in 1750



Mais cette invention est évidemment reconnue de
Mr. Perlet, horloger à la Chaudefond. en 1750, —

Figure 5-6

5.2: One, Three or Eight Days?

One technical point needs to be made here. The number of hours that a watch will run depends on the gear ratio between the first wheel, mounted on the going barrel or on the fusee, and the center pinion carrying the minute hand. If the center pinion rotates Tc times (a running time of Tc hours) and the first wheel rotates Tf times then the gear ratio between the pinion mounted on the center wheel and the first wheel is Tc/Tf, where Tf is limited by the number of turns made by the mainspring. But this ratio must be small to ensure that the teeth counts of the center pinion and the first wheel are practical, and it is normally limited to values of about 8 to 12. Also, the teeth count of the first wheel is limited by the need for the teeth to be large enough to withstand the force of the mainspring.

In the case of a going barrel, the number of turns of the barrel $Tb = Tf$. But to ensure the first and last parts of the mainspring are not used, because they provide torque which is too high and too low respectively, the mainspring should make about $Tf + 1\frac{1}{2}$ turns. Stop-work (see Appendix 7) prevents these turns being used.

The three interesting cases are:

(a) A "one-day" watch usually runs for about 32 hours. This is easy to achieve by using an 8:1 gear ratio with a mainspring that makes 5½ turns of which 4 are used.

(b) A "three-day" watch (running for 3½ days or 84 hours) is possible by using a gear ratio of 12:1 with a mainspring that makes 8½ turns of which 7 are used. But this is difficult because the barrel must be much larger.

(c) An "eight day" watch (running for 8½ days or 204 hours) is impossible without a special design. With a gear ratio of 12:1 it requires a mainspring with 18½ turns of which 17 turns are used. Although only a rough guide, using the formulae such as those in Reymondin et al (1999, pages 47-48) with approximate figures suggests that the barrel for an 8-day watch would have a diameter of about 40 mm and so the watch would have an absurd diameter of about 80 mm.

If the watch has a fusee then the number of turns of the fusee Tf (the running time) is greater than the number of turns of the barrel. An acceptable approximation is to assume that the fusee is a regular cone with Tf separate steps. (In reality the chain groove is a spiral and this approximation gives values that are a little too high. But we are interested in the number of turns of the barrel and the difference is small.)

When the watch is fully unwound, the first turn of the fusee will turn the barrel Tl times, depending on the diameter of the largest step on the fusee. The second turn of the fusee will turn the barrel less by the amount x that the second step is small that the first. And so on, until the last turn of the fusee that will turn the barrel Ts times.

With these assumptions the number of turns of the barrel Tb is:

$$Tl + (Tl - x) + (Tl - 2x) + \dots (Tl - nx) + \dots$$

That is:

$$Tb = Tl\,Tf - \sum nx, \text{ where } n = 1, 2, \dots (Tf - 1)$$

$$= Tl\,Tf - x\,([(Tf - 1)\,Tf] / 2)$$

Because the last turn of the fusee turns the barrel Ts times $Ts = Tl - (Tf - 1)\,x$, we have:

$x = (Tl - Ts) / (Tf - 1)$.

Often the largest diameter of the fusee is about the same as the diameter of the barrel and $Tl = 1$, and the smallest diameter of the fusee is about ½ the diameter of the barrel and $Ts = 0.5$. With such a fusee the three cases above are now:

(a) One-day watch: A gear ratio of 8:1 and a fusee with $Tf = 4$ steps requires about 4½ turns of the mainspring of which 3 are used. An example is given in Figure 7-11, page 65.

(b) Three-day watch: A gear ratio of 8:1 requires a fusee with $Tf = 10½$ steps, and about 9½ turns of the mainspring of which nearly 8 are used. Or with a 12:1 ratio the fusee has 7 steps and the mainspring has about 6¾ turns of which 5¼ are used. The former is difficult because the fusee steps will be narrow and the chain weak. The latter is used by rotor watches.

(c) Eight-day watch: A gear ratio of 8:1 requires a fusee with Tf = 25½, and about 20½ turns of the mainspring of which 19 are used. Or with a 12:1 ratio the fusee has 17 turns and the mainspring has about 14¼ turns of which 12¾ are used. Both are obviously impractical.

Changing the shape of the fusee changes the number of mainspring turns. Table 5-1 gives some results for $Tl = 0.9$ and $Ts = 0.55$.

Running time	Gear ratio	Tf	Tb	Mainspring turns
32.00	8.00	4.00	2.90	4.40
56.00	8.00	7.00	5.08	6.58
80.00	8.00	10.00	7.25	8.75
80.00	12.00	6.67	4.83	6.33
200.00	8.00	25.00	18.13	19.63
200.00	12.00	16.67	12.08	13.58

Table 5-1

Provided there is enough space in the frame for a fusee with 7 steps, two and three day watches are practical.

But eight day watches with going barrels are not possible. There are four options for making them:

(a) Use a very long, thin mainspring. The going barrel example was calculated using a spring with a thickness (strength) of 0.17 mm. Reducing this to 0.085 mm reduces the barrel diameter to about 19.5 mm, but such a spring would not have enough power to run the watch.

(b) Use a short, thick mainspring. Such a spring could be used by adding an extra wheel and pinion to the train. But this solution, as Aaron Dennison found out (Watkins, 2009, pages 21-22), creates serious problems with the rate of the watch and is not practical.

(c) Use two barrels and two thin mainsprings equivalent to the required strength.

(d) Use a much larger barrel by moving the train.

When de Saussure visited Perlet he stated that the watch he saw had a running time of 8 days, at least 192 hours. But it is very unlikely (even impossible) that the watch described by de Saussure could have run for 8 days. In addition, such a long running time is pointless in a self-winding watch.

5.3: A Question of Names

As shown above, none of the contemporary documents specify who the inventor was, other than to variously call him *Perlet* or *Perelet* or *Perrelet*. The only definite information about him is that he lived in Le Locle.

However, no one with the names *Perlet*, *Perelet* or *Perrlet* is listed in Bourdin (2012) as working in or around Le Locle. Patrizzi (1998) lists P. E. Perlet (enamel painter, 1764-1774) and Wikipedia (2012b) notes that Charles Frédéric Perlet (1758-1828) was a watchmaker in Geneva, but both are clearly irrelevant.

The most likely explanation for the name *Perlet* in Figures 5-1 and 5-6 is that the people had not seen the name written down but had only heard the name *Perrelet* spoken with the first and third syllables run together. Such errors are not uncommon. In a letter written in November 1843, Edward John Dent discussed the shape of the teeth of wheels and he noted that:

> *I believe I am pretty well acquainted with Comer's book ...* [Mercer, 1977, page 238.]

However, no one with the name *Comer* has written on the subject. Unless Mercer made a transcription error (which is unlikely) we can be confident that Dent was referring to *Camus*, and in particular to Camus and Hawkins (1837). That is, he had not read the book but had heard someone speaking about it.

Saussure's change from *Perlet* to *Perelet* only six days later supports this "oral history" view. So we can be confident that *Perrelet* was intended.

But which Perrelet?

Bourdin (2012) lists four possible watchmakers living in Le Locle at that time:

Abraham Louis: Master watchmaker and the person to whom a self-winding watch is attributed.

Isaac: Master watchmaker mentioned in 1769 and "Formal identity impossible." But he is probably the Isaac Perrelet mentioned in Figure 5-14, page 48. Family Search (2014) states that he was born in 1733.

Jean Jacques: Master watchmaker mentioned between 1758 and 1777.

Pierre Henri: Master watchmaker mentioned between 1765 and 1773.

The above list omits people who had the same family name but worked in other trades, such as cadraturier (repeater-work maker) and monteur de boîtes (case maker).

In addition, Chapuis (1957, page 25) states:

> *In 1760 in Locle there are mentioned two Abram-Louis Perrelet, watchmakers, plus a third, a case assembler, ...*

The two watchmakers were, according to Chapuis & Jaquet (1952, page 42; 1956, page 43), the son of Abram and Suzanne (née Huguenin), and the son of Daniel and Jeanne-Marie (née Robert). And so there are five possible people.

Philipe DuBois (1758-1824) had dealings with all these people and mentions:

Isaac Pierre. (1771, no occupation, at Entre deux Monts; see *Inventory Book 1*, page 169.)

Jeanjaques, son of Isaac. (1769 as *horloger*, and entries to 1778 probably for the same person; see *Inventory Book 1*, including pages 57, 80, 112, 114, 165 and 208.) However, DuBois also had dealings with another Jeanjaques Perrelet who was a glazier, and some entries may refer to this person.)

Pierre Henry. (1769 to 1776; see *Inventory book 1*, pages 82, 207 and 248, and *Book 2*, page 199.)

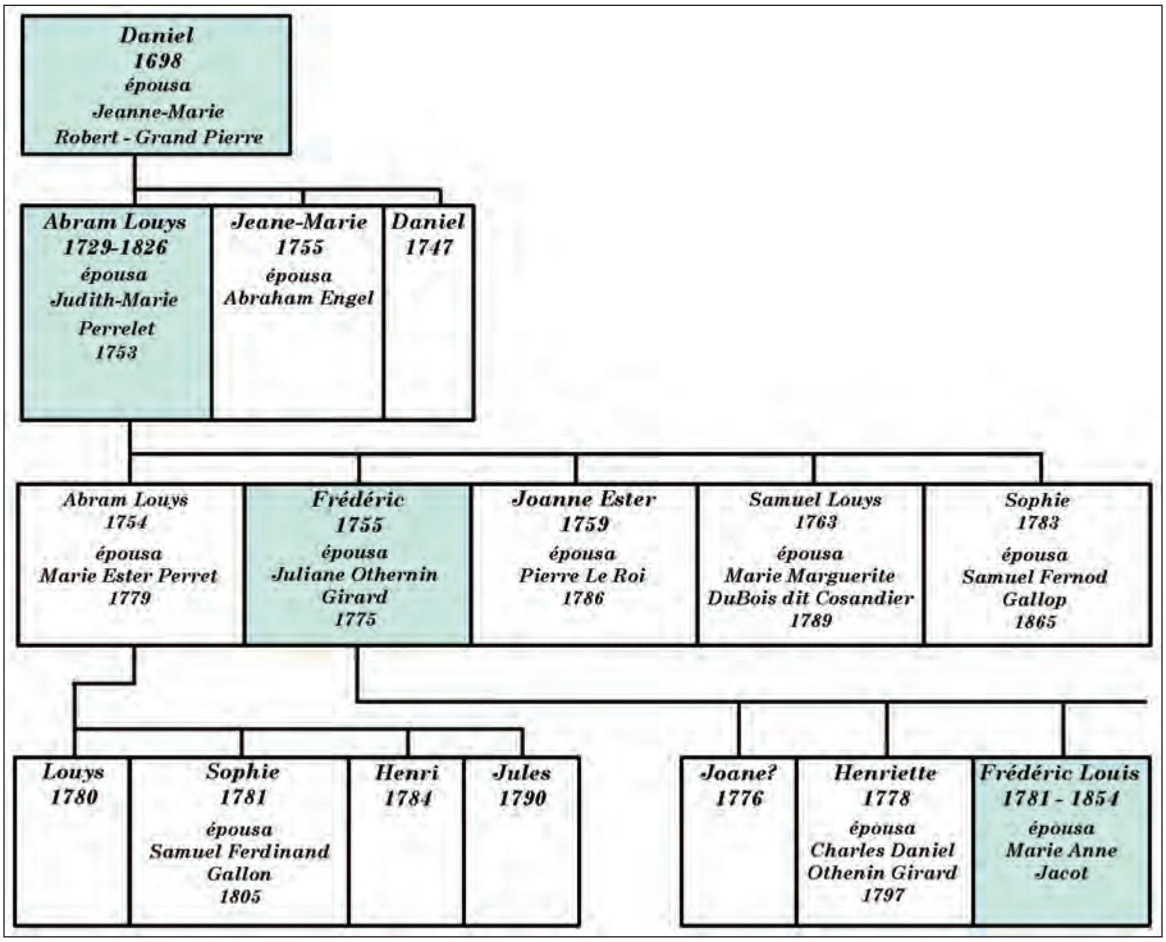


Figure 5-7

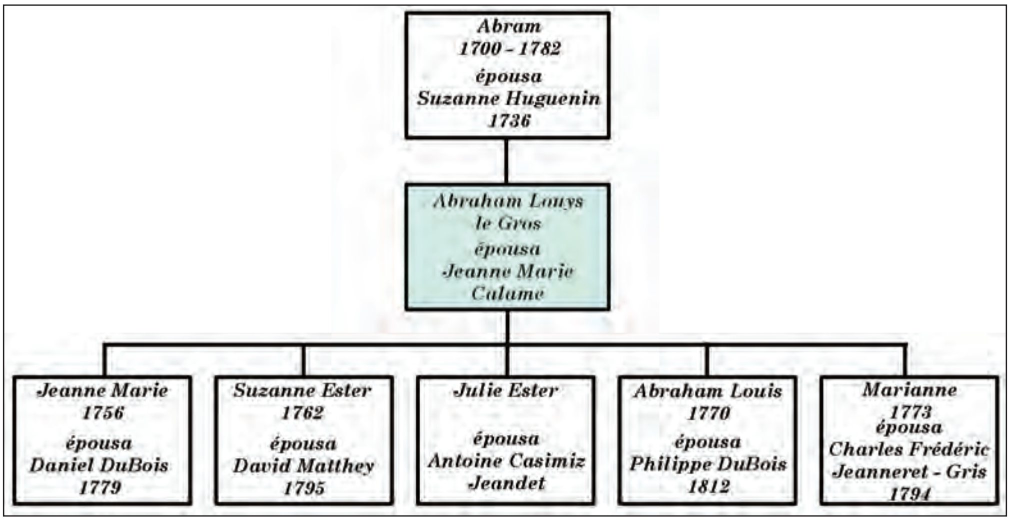


Figure 5-8

He also lists *Abram Louys* as a cadraturier (repeater work maker), adding to the statement of Chapuis above.

Of these people, a family tree (Perrelet, 2012) includes *Abram Louys Perrelet,* son of Daniel and Jeanne-Marie, Figure 5-7.

And, on a different branch, *Abram Louys Perrelet, le Gros*, son of Abram and Suzanne, Figure 5-8.

Although the information is inconsistent, Family Search (2014) states that *Abram Louys Perrelet le Gros* was christened on 7 July 1737, and so he was eight years younger than the other Abram Louys Perrelet. This is the person referred to by Chapuis & Jaquet; the French edition (Chapuis & Jaquet, 1952, page 42) specifically mentions *dit le Gros*, but the English edition omits this information.

In 1774, 1778 and 1782 Philipe DuBois refers to *Abram Louys Perrelet, le Gros*, but the address and occupation are not mentioned (DuBois, 1758-1824, *Inventory Book 1*, pages 249, 326 and 401). We do not know the significance of the qualification *le Gros*.

Finally, in a report on the 1823 Paris exhibition, Thury and Migneron (1824, pages 341-342) note that Mugnier of Paris received an honourable mention for four exhibits including:

> 3.° Une montre qui se remonte d'elle-même quand on la porte, à l'aide d'un artifice fort simple, imaginé, il y a une quarantaine d'années, par un horloger de Neufchâtel, nommé *Perrelet*;

Figure 5-9

> *A watch that winds itself when carried using a very simple trick, devised forty years ago by a Neufchâtel watchmaker named Perrelet;* [Figure 5-9]

At this point, if we rely solely on contemporary documents and the above report, it is impossible to decide which one of these five different people were referred to by de Saussure, Perrot, the Abbé Desprades and du Bressy. Assuming, of course, that they were all referring to the same person.

The earliest document that defines a particular person is Meissner and Caumont (1838, page 266). In a list of celebrated horologers they include:

> *another Perrelet, qualified by the title elder, is said to have discovered the mechanism of the watches that wind themselves, an invention Louis Breguet, as we have seen above, took to a degree of perfection that leaves nothing to be desired.* [Figure 5-10]

> un autre Perrelet, qualifié du titre d'ancien, passe pour avoir découvert le mécanisme des montres qui se remontent d'elles-mêmes, invention que Louis Breguet, comme nous l'avons vu plus haut, amena à un degré de perfection qui ne laisse rien à désirer.

Figure 5-10

The title *d'ancien* could simply mean *old*. But, as confirmed later (Figure 5-11), it has the specific meaning of *church elder*. And only one of the five people named Perrelet had this title, Abram Louys Perrelet l'Ancien, as distinct from Abram Louys Perrelet le Gros. Although the given names are not specified, the title *l'ancien* leaves little doubt that Meissner is referring to Abram Louys Perrelet. As this book was published only 12 years after Perrelet's death, it can be considered to be very strong evidence for the name of the person mentioned in de Saussure's diary

In this context, a letter Breguet wrote in July 1793 makes sense:

> *... we have both forgotten to visit or mention that fine man, Mr Perlet the Elder, I believe that is his name. But he is the man who had such a wicked wife that she is now mad. He is a good and very gifted man, to whom my sister owes a great deal.* [Chapuis & Jaquet, 1952, pages 78-79; 1956, pages 83-84]

It is a little strange that Breguet does not use the name *Perrelet* if this person was so gifted and so notable, especially as many believe Breguet bought self-winding watches from him. It may indicate that Breguet had only a little contact with him, although surely an association with self-winding watches would have been important enough for his name to be remembered? However, the addition of *the Elder* leaves little room for doubt that he is referring to Abram Louys Perrelet l'Ancien.

This interpretation is reinforced by Andrié (1859, page 156) who gives the full title *l'ancien d'église*; see Figure 5-11:

> *Our country has produced famous clock and watch makers. Ferdinand Berthoud took watchmaking to a high degree of perfection and especially chronometers, also called garde-temps and marine watches. His various writings on horology are reputed to be the best. After him I must name Abram-Louis Breguet, who improved and simplified almost all the branches of his art; Frederic Houriet, inventor of the isochronal, spherical balance spring; the church elder Abram-Louis Perrelet, who invented watches which wind themselves by the little walking of the men who carry them; they are called shaking watches. I pass over our famous clock and watch makers who are still alive.*

Notre pays a produit des horlogers célèbres. Ferdinand Berthoud a porté à un haut degré de perfection l'horlogerie et surtout les chronomètres, nommés aussi garde-temps et montres marines. Ses divers écrits sur l'horlogerie sont réputés les meilleurs. Après lui je dois nommer Abram-Louis Breguet, qui a perfectionné et simplifié presque toutes les branches de son art; Frédéric Houriet, inventeur du spiral sphérique isochrone; l'ancien d'église Abram-Louis Perrelet, lequel inventa des montres qui se montent d'elles-mêmes pour peu que marche l'homme qui les porte; on les nomme montres à secousses. Je passe sous silence nos horlogers célèbres encore vivants.

Figure 5-11

5.4: Abram Louys Perrelet, Church Elder

Abram-Louis Perrelet (1729-1826) is certainly him who would live almost a century as one of the most famous watchmakers of the Mountains, also known by the portrait of him that Charles-Samuel Girardet engraved [Figure 5-12]. *... The biographical details show clearly that there can be no question that it is he whom one still knows today as "the Elder Perrelet."* [Chapuis (1957, page 25)]

But if it was not for the biography in Jeanneret and Bonhôte (see below) it is likely that *Abram Louys Perrelet l'Ancien* would have been forgotten, simply recorded in lists such as Bourdin (2012) together with the hundreds of other watchmakers who did little that was noteworthy. Indeed, if it was not for his association with self-winding watches, his name probably would not appear in any modern books.

Abram Louys Perrelet is briefly mentioned by Osterwald (1766, pages 72-73; 2008, page 20):

> *So many of those in Le Locle and La Chaux-de-Fond are involved with the perfection of this art that only the names of the most distinguished are included in this description, such as we know them. Those whom we omit because of pure ignorance would have no less the right to form part of an enumeration. But considering their great number, we could not make it exact, by including all the rest, without necessarily making it excessively long. Seigneurs Abraham Robert, and Daniel Perrelet, are the principal workmen of Le Locle for the construction of tools. The first is a skilful horologist, who invented the machine for the gearing of watches* [the rounding-up tool?]. *The second is an excellent dial-work maker, and the tool to plant parts perpendicularly owes its discovery to him. His son Abraham Louis makes watches with ratchet and with cylinder.*

The Seigneur Abraham Robert was the first to think of the escapement at rest. The Seigneur Jonas Pierre Du Common is one of the most skilful clock makers, as the Seigneur Jonas Perret Jeanneret is for watches.

Figure 5-12

From the family tree, Figure 5-7, this clearly refers to Perrelet the Elder.

The original French reads: *Son fils Abraham Louis fait des montres à rochet et à cylindre*, and this statement is repeated by Bachelin (1888, page 151). Gros (1913, page 19) notes that the early clock escapements, which replaced crown wheel (verge) escapements, used escape wheels called ratchet wheels because they resembled the ratchet wheels in click work. Although Gros does not refer to this term in the context of watches, we can assume that Osterwald used the word in this manner. It appears that Jeanneret and Bonhôte (below) have interpreted this as the duplex escapement, but it could also refer to the virgule escapement.

It appears that the only important biography of Abram Louys Perrelet is that in Jeanneret and Bonhôte (1863, volume 2, pages 193-195). This was repeated by Bachelin (1888, pages 49-52). The following is a full translation:

Abraham-Louis Perrelet was born in Le Locle in January 1729, his father, David [sic] *Perrelet, was a carpenter and a farmer and not very well off. As soon as the young man was in a position to do some favours, he helped his parents on the farm, and during the winter worked at joinery, filed saws, manufactured small elegant bellows, and when he had finished a dozen of them, sold them in Neuchâtel by going there on foot. At the age of twenty to twenty one years, seeing watchmaking taking root in our Mountains, he gave up his modest work to launch out into this new industry. After an apprenticeship of fifteen days at one named Prince, in Le Locle, who worked little and very badly, and where he learnt absolutely nothing, he started to work independently and so became his own master. Endowed with a great intelligence and a remarkable sagacity, he not only knew in a very short time all that was known then, but by his discoveries, which he communicated to his fellows with great satisfaction, he gave a very strong impulse to the manufacturing of watches. At this time it was especially the tools that were lacking for our watchmakers, and Perrelet strove to fill this gap: he invented the uprighting tool, the rounding-up tool and those that are necessary to make cylinder escapements. After discovering new tools, he modified the mechanism of the watch by using new combinations to make it run; he is the first who, in Le Locle, worked with the cylinder and duplex watch escapements, calendars, equation to time, etc. It was he who invented perpetual or jerking* [à secousse] *watches, which wind themselves by the movement that one gives to them while carrying them. The first that he built were bought by Breguet and one named Recordon who lived London; they were convenient (except the size) and he adapted a device to them which made it possible to wind them with a key when they were not carried.*

A continual researcher, he tried a variety of systems and also endeavoured to discover perpetual motion; he occasionally made twelve watches each one having a different escapement, and when his many friends congratulated him on his discoveries, he told them, while smiling with modesty: "there are a few which are not worth much." He manufactured every part of the interior of the watch, starting by forging a piece of rough brass for the plate, then making the ébauche, finishing, the pinions, the teeth, the escapement, the winding, in a word all of the mechanism. For these watches, which he sold in Le Locle and La Chaux-de-Fonds, he was paid on average a louis (23.17 francs) each. For many years he was, so to speak, master of all the watchmakers of Le Locle, because when the workmen were held up by some difficulty, which often happened, they said in their good old dialect "it is necessary to go to the Elder Perrelet", and he enjoyed doing them a favour by showing them the flaws which he saw without difficulty. He had adroitness and an extraordinarily steady hand, which did not decline as he advanced in age. His descendants have a watch with lever escapement that he finished at the age of ninety-five years.

Abraham-Louis Perrelet had many pupils all of whom gave him the greatest honour; we will mention among them only famous Breguet, Raguet, Lépine, and his grandson, F-L. Perrelet, about whom we will speak below. The magistrates of Neuchâtel, undoubtedly wishing to bring part of the manufacture of watches to the city, offered the bourgeoisie to him provided that he moved there; he refused and lived all his life in the house of his father, at the bottom of Crêt-Vaillant in Locle, where he died on 4 February 1826, ninety-seven years old.

The whole population of Le Locle accompanied his funeral convoy, each had in their heart to pay homage to this respectable old man, and the pastor Grellet made a remarkable speech at his tomb from which we extract the following fragment: "For a long time this man, just and God fearing, had become the object of our veneration. For a long time the echo of our mountains in the distance was fond of repeating the works of his creative genius, his rare qualities, his beautiful virtues. For a long time, for more than fifty years a member of the worthy consistory of this church, you saw him perform his duties with the regularity of old and boundless devotion. In the last years of his life, you still saw him come, covered with grey hair and his legs weakened like those of a tired traveller, to take his place in the congregation and to receive from his trembling hands the sums of money for the poor. His voice weakened by the years edified all those around him and who came to visit… Yes, once again, my dear brothers, come to bid your farewell to the patriarch of our Mountains, to one of the examples to the flock, and one of the founders of our industry and our prosperity; and for the last time casting glances down on the tomb which will receive his mortal remains, let us say with submission to the will of God: peace be in his soul, blessing on his ashes."

Sources. This note is from information collected by Mr Henri-Ernest Sandoz, in Locle.

The watchmaker who trained Perrelet might be Charles Frédrich Prince who worked around 1745-1760 (Bourdin. 2012).

The reliability of this biography is examined by Chapuis & Jaquet (1952, pages 27-28; 1956, pages 29-30). They state that Henri-Ernest Sandoz:

... was very intimate with Louis Frederick, Perrelet's grandson, and himself a watchmaker to three kings of France and later to the Emperor Napoleon III ... and we can quite well assume that it was from this source that he obtained inter alia his information about the perpetual watches.

Louis Frédéric Perrelet (Jeanneret and Bonhôte, 1863, volume 2, pages 196-200) was trained by his grandfather Abram Louys Perrelet and, although established in Paris, he was in Le Locle from 1807 to 1810. Thus we can be sure that, if his grandfather had designed self-winding watches he would have known about it. Consequently, although written almost 90 years after the events, this biography should be reliable.

Even so, Jeanneret and Bonhôte's biography creates two problems. First, Osterwald, cited above, states clearly that Abraham Robert invented the rounding-up tool and Daniel Perrelet, Abram Louys' father, invented the uprighting tool. As he was present at the time, his testimony must be considered more reliable. And second, although it might be the result of misinterpreting poor handwriting, the father of Abram Louys is incorrectly said to be David, when he was Daniel.

Although the documents we have examined are consistent in pointing to a person named Perrelet as the designer of a self-winding watch, another source contradicts this attribution. Writing only one year earlier, Jeanneret (1862, pages 20-21) provided a short biography of Abram Louys Perrelet that does not mention self-winding watches, although it repeats the error regarding the uprighting tool:

> *The old one of the church Abram-Louis Perrelet, who died in 1827 almost 100 years old (he was born in January 1729), is the first who made a repeating watch in our Mountains. One saw him leave the modest tools of the craftsman to dedicate himself to the art of watchmaking, which he honoured by his application, his studies, his discoveries and his respectable conduct. He is the inventor of the uprighting tool, had good students, and improved many of the instruments used by watch makers. He had a singular sagacity to seize and carry out without models what he heard of discoveries that were mysteries, and communicated with great satisfaction, and with no professional jealousy, his own discoveries to those who could benefit in competition with him. … A remarkable truth is that, like Ferdinand Berthoud, old Perrelet could execute, when very old, the most difficult parts of the escapement.*

And, when writing about Breguet's work (Jeanneret, 1862, pages 40-41) states:

> *They include his perpetual watches, which wind themselves by the movement that one gives to them while carrying them. If Mr Houriet of Locle was the inventor, it is to Breguet that one owes the convenient and practical use of them.*

There is, to our knowledge, no other source that attributes the design of self-winding watches to Houriet, and Sabrier (2012a) does not mention them. However, in 1777 Houriet described a pedometer with a partly external mechanism (Sabrier, 2006, pages 142-143) and Jeanneret was probably confusing this with a self-winding watch.

Another, more picturesque account of Abram Louys Perrelet is given by Ephrem Jobin (Matthay, ca 1979, pages 17-20). Although this clearly derives from the above, it is also worth quoting:

> *All sleep. The clock of the old man Moutier has already struck the twelve strokes of midnight for more than twenty minutes. The watchman makes his busy round from one district to another of the Mother Commune of the Neuchâtel Mountains. It is not a short walk, because like rosary beads they spread themselves along the valley, each one with its name forming as many urban areas with their personal character. It is a hot night. Summer lightning creates a heavy and threatening atmosphere.*
>
> *Do all sleep? Let us look. The watchman arriving at the bottom of Crêt-Vaillant observes an open window that lets out the light of an argand lamp. Who can still be staying up? But yes, it is the "Elder", Abraham-Louis Perrelet. Nothing astonishing for this seeker after illusions! Besides,*

is it not his wife Judith you hear grumbling, rudely asking him to allow the household to sleep and take some rest himself.

Because indeed, to test the operation of the mechanism of his invention, to which he has just made a last improvement, he paces around his work room, checking the number of steps necessary to complete the winding of his oignon; moreover, it is necessary to go further to check if the device is activated when the spring is fully wound.

This is only how we can imagine our inventor, since the documents on this subject are missing. Yes, the Neuchâtelois rarely left us hard copies of their work. Fortunately, Alfred Chapuis had the patience to bring together all that he could find, to recall the evolution of an industry that made the wealth of our area, thanks to the inventive spirit and the skill of this population isolated at the top of the Jura.

At the time of the birth of Abraham-Louis Perrelet in 1729 in Le Locle, this area had been Prussian since 1707. His father David [sic] *Perrelet was a carpenter and a peasant and very early his son was to assist him. Nothing astonishing in that in spite of this youthful initiation to hard work requiring much effort, our young man developed a critical mind, open to all the problems of movements. A curious and imaginative spirit, he was subject to the good influence of pioneers in the area who had made names for themselves. Indeed, eight years before the birth of Abraham-Louis, Pierre Jaquet-Droz was born at La Chaux-de-Fonds.*

In 1727, Josué Robert received the warrant of watchmaker to the King and Ferdinand Berthoud uttered his first cries. While Pierre Brand-dit-Grieurin the oldest manufacturer of tower clocks died at Pélard, close to La Chaux-de-Fonds, Jean-Jacques Vaucher, student of Daniel JeanRichard, is said to have introduced the manufacturing of watches to Fleurier in 1730, whereas Jean-Jacques Rousseau appeared in the Mountains for the first time, going to visit Gagnebin of La Ferrère.

Abraham-Louis was 12 years old when Daniel JeanRichard died. All the population who crowded his burial felt the death of the master watchmaker of the Mountains painfully. He was buried near the temple. Abraham-Louis Perrelet certainly wanted to celebrate the praises of the father of the watch industry in Le Locle. Didn't he dream to be a watchmaker in his turn, or rather, like JeanRichard, to combine this profession with that of a peasant? That undoubtedly appealed to him more than being a farmer and a carpenter.

Besides, did not the long winters with their endless evenings invite one to break inaction by being variously occupied? He began a manufacture very near to the business he learned with his father. Initially wood utensils: spoons, bellows to enliven fires; then in iron, such as rotisseries, weapons. The skill of his fingers improving, he tried watch making. But to learn well, it is necessary to take an apprenticeship and to work with a good master. It was unfortunately not the case for our young man who had to fall back on himself, being instructed only by his thoughts. Each difficulty was solved thanks to his inventive spirit doubled with that of manufacturer. Thus he created for himself (as did Daniel JeanRichard) the tools that would facilitate his work: the uprighting tool, the machine for shaping teeth, etc. On the lookout for anything new, he wanted to master the merits of these innovations and to apply them while seeking to improve them, removing the weak points that his critical spirit had discovered. Thus one owes to him the introduction into our mountains of the manufacturing of watches with calendars, the equation of time, the cylinder or duplex escapements. He became a veritable watch-making encyclopaedia so that when problems arose with our watchmakers, there was only one recourse: "it is necessary to go and find elder Perrelet" said one. He had specialized in

> *the sample set of twelve watches, each one having its characteristic and his modesty made him say "Oh there are some which are not worth much".*
>
> *Consequently one readily understands that at a time when the idea of perpetual motion was very fashionable and worried many researchers, and the automatists such as Vaucanson and Jaquet-Droz were reaping beautiful successes, Perrelet directed his research to a useful application to compensate for the lapse of memory that many users had to wind their watches.*
>
> *Just as later Edison used the unconscious effort of the people coming to visit to him to be supplied with drinking water; passing the turnstile gate at the bottom of his property, the visitor was much surprised to note that this gate offered some resistance. And when they pointed it out to Edison, expressing their surprise that his inventive genius has not yet been able to find how to loosen this mechanism, the inventor smiled and said: "I know, but with each passage, the turnstile raises ten litres of water for me!"*
>
> *Let us say, to close these anecdotes, that Perrelet had two notable pupils: J.-F. Houriet who spent two years with his master before working with Julien Roy in Paris. The second was his grandson, Louis Perrelet, born in 1781 in Calame near Le Locle, and who became watchmaker at the Polytechnic in Paris, watchmaker to the king and chevalier of the Legion d'Honneur.*
>
> *At 95 years old, Perrelet still worked at the bench, familiarising himself with the execution of a watch with the new lever escapement. This booklet illustrates the way he traversed, starting from the first realization of a watch with automatic winding, then called a perpetual watch, this being the conclusion of the work of Abraham-Louis Perrelet, known as "the Elder of Le Locle", around 1774, as has been established with certainty by Alfred Chapuis.*

Although there is a little more in Chapuis & Jaquet (1952, pages 41-44; 1956, pages 43-45), other than these accounts there is not much information, and the Internet appears to be devoid of anything useful. (It is interesting to note that the Internet site *Dictionnaire historique de la Suisse* does not have an entry for Abram Louys Perrelet.)

These biographies are strange because they provide no genealogical information, and all we know is the strange remark made by Breguet that his wife was mad. And although the biography of his grandson Louis Frédéric (Jeanneret and Bonhôte, 1863, volume 2, pages 196-200) was based on "documents provided by the Perrelet family", it does not name his father and mother, and it dates his birth to 1784, whereas Bourdin (2012) gives it as 1781. However, another source (DHS, 2012) states that Louis Frédéric's parents were Frédéric, carpenter and farmer, and Julianne Othenin Girard, agreeing with the genealogical trees in Figures 5-7 and 5-8 that fill in the gaps.

Confusion exists with regard to Perrelet's apprentices. Various claims have been made, which include that he taught:

(a) Abraham Louis Breguet (above biography; Landes, 1983, page 260; Landes, 2000, page 279): Not true. This is obviously incorrect as Breguet received his training in Les Verriers and Versailles.

(b) Frédéric Houriet (above biography; Bachelin, 1888, page 54; Sabrier, 2006, page 7): Not true. Flores (2012a) provides a facsimile of the apprenticeship papers showing that he was apprenticed to Abraham Louis Perret-Jeanneret, "horloger du Locle"; see Figure 5-13.

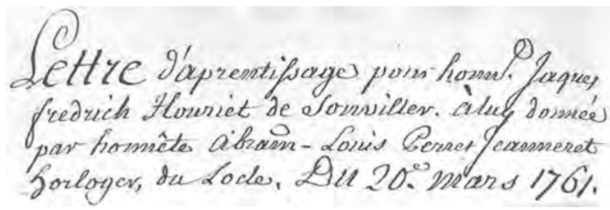

Lettre d'aprentissage pour honn.l Jaques fredrich Houriet de Sonviller. à luy donnée par honnête Abram-Louis Perret Jeanneret horloger du Locle. Du 20e mars 1761.

Figure 5-13

(c) Frédéric Japy (Bachelin, 1888, page 20; Nicolet, 2006, page 132): Not true. Flores (2012a) provides a facsimile of the apprenticeship papers showing that he was apprenticed to Jean Jaques Perrelet, son of Isaac Perrelet "maitre horloger du Locle"; see Figure 5-14. A Perrelet, but the wrong one.

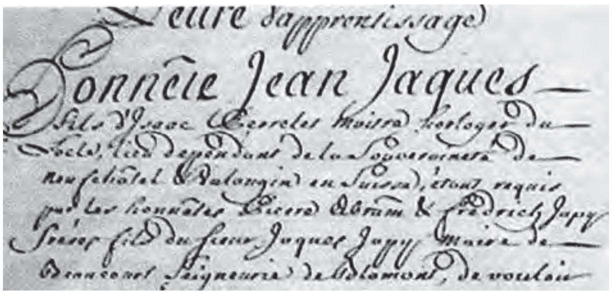


Figure 5-14

(d) Jean Antoine Lépine (above biography): Not true. Lépine was apprenticed to Decrose in Saccinnex-en-Genevois, probably about 1736 when Perrelet was only 7 years old (Antiquorum, 1993b, page 168; Thompson, 2008, page 100).

(e) Raguet (above biography): Unlikely. Jeanneret and Bonhôte are vague, but presumably they are referring to Claude-Pierre Raguet (dit Lépine) who worked for Lépine, married his daughter Pauline in 1782, and later became his partner (Antiquorum, 1993b, page 168).

(f) Louis Frédéric Perrelet, his grandson. Jeanneret and Bonhôte (1863, volume 2, pages 196-200) is the only source for this information. But they state that their biography was derived from "documents provided by the Perrelet family". In addition, it would be cheaper and more convenient to indenture a child to a family member.

In these circumstances it is likely that Abram Louys Perrelet had only one apprentice, his grandson.

Finally, there is a second portrait, Figure 5-15 (Wikipedia, 2012a) that has been used as a portrait of Abram Louys Perrelet. However, the information provided states that the artist is unknown and the portrait is circa 1820. As Abram Louys was 91 in 1820 it is obviously not his portrait. But Haute Horlogerie (2012) uses an engraving from the same portrait for his grandson Louis Frédéric Perrelet (1781-1854). He would have been 39 years old at the time and this attribution is much more likely to be correct.

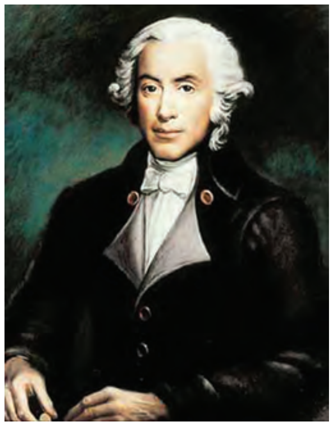


Figure 5-15

In addition Chapuis (1942) states that:

> *Everyone knows the engraving by Girardet representing which represents him stooping over the workbench. M Robert has, in addition, a plaster portrait of the same person executed much earlier.*

Unfortunately the plaster portrait has not been found.

5.5: Watches

As Chapuis & Jaquet (1952, pages 44-45; 1956, page 46) note, watchmakers in the Principality of Neuchâtel were not organised into guilds and "there was therefore no compulsion for them to sign their products." And Sabrier (2012a, pages 23-24) adds that

> *... nearly all historians ... agree that the watches made by most of the artisans of Le Locle and its region - Perrelet in particular - are not signed or bear only the signature of the merchant who ordered and eventually sold them.*

This situation is to be expected. The vast majority of watches made in Neuchâtel were exported, and the vast majority of the artisans were ordinary watchmakers who were producing ordinary watches for établisseurs who were, in effect, wholesalers. Under these circumstances it is not surprising that signatures of original makers are rare.

However, signed watches are not unknown. For example, Sabrier (2012a, pages 187-188) illustrates two watches signed by DuBois & Fils, and a number of other examples exist.

We know of two watches that may have been made by Perrelet.

The first, Figures 5-16 and 5-17, is signed *Abram Louis Perrelet*.

It is a simple movement with a cylinder escapement (with steel escape wheel) and going barrel. It has been put into a wood case that is inscribed:

> *Dernier mouvement fait par Abm Ls Perrelet en 1825 à l'age de 96 ans. Conserveé par Cs Ate Grandjean Perrenoud lequel a fait la boite pr sf usage en souvenir de l'artiste. HGP 1873*
>
> *Last movement made by Abm Ls Perrelet in 1825 at the age of 96 years. Preserved by Cs Ate Grandjean Perrenoud who made the case for use in memory of the artist.*

The second watch is mentioned by Chapuis and Jaquet:

> *The magnificent Maurice Robert collection at Fontainemelon contains a watch with lever escapement which Perrelet finished at the age of ninety-five* [sic]. (Chapuis & Jaquet, 1952, page 43; 1956, page 44)

Initially, the only information about this watch that we could discover appears in Chapuis (1941) and Chapuis (1942, pages 66-67), from which Figure 5-18 is reproduced. His description of this watch is very short:

> *... as an inscription on the movement indicates, it was made by the Elder Perrelet, that is by Abram-Louis Perrelet of Locle at the age of 94 years. It is indeed truly the "last watch" of the worthy watchmaker, to the exclusion of others that one sees, because this piece comes directly from the descendants of Perrelet.*

Figure 5-16

Figure 5-17

The inscription on the barrel bridge reads:

Fait pr l'ancien Perrelet à l'âge de 94 ans

Although the provenance is vague, it is confirmed by Jeanneret and Bonhôte (1863, volume 2, pages 194):

> *His descendants have a watch with lever escapement that he finished at the age of ninety-five years.*

With the help of Gilles Robert, CEO of *Robert & Fils 1630* and grandson of Maurice Robert, I located the watch and obtained the photographs in Figures 5-19 and 5-20, together with the following description:

> *Watch made by old Perrelet at the age of 94 years, ca 1820* [actually it must be 1823]. *Watch in plain, silver, Louis XVI style case. Enamel dial with Roman numerals and small seconds at six hours. Gilded movement with cylindrical pillars, fusee and chain, side* [right angle] *rack lever escapement of the Litherland type, polished steel balance, inscription on the plate.*

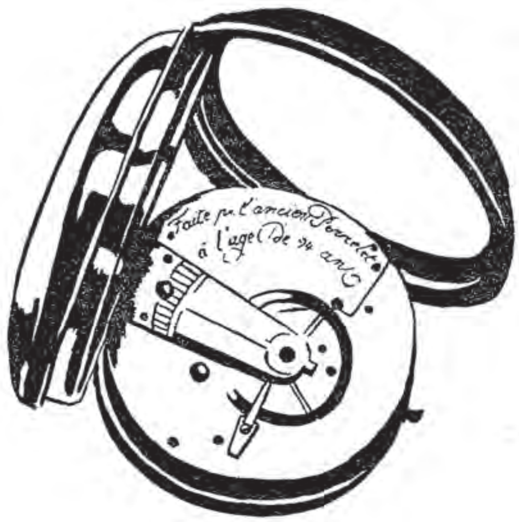


Figure 5-18

Figure 5-19

Figure 5-20

In addition, one other unsigned watch must be mentioned; it is illustrated in Figures 5-21 to 5-23 (NAWCC, 2011. Reproduced with the permission of the owner, Larry Kordower).

As noted by Philip Poniz (NAWCC, 2011):

> *These watches were marketed by DuBois & Fils of Le Locle from 1780s through 1790s and sold to all kinds of retailers from Perrin Freres of Neuchâtel to Markwick Markham and Barwise, both of London. The movements most likely were made not by DuBois but by one of the local ébauche makers such as C.R. & D.,Courvoisiers or Meuron. They have a very characteristic layout with a slot through the weight.*

Figure 5-21

Figure 5-22

Figure 5-23

The slot through the weight allows the mainspring to be wound with a key; we know of no other self-winding watches that can be key wound.

Several of these watches are illustrated by Sabrier (2012a, pages 187-191). Also, because Philipe DuBois did not adopt the name DuBois & Fils until 19 December 1785, that is the earliest date for this watch; DuBois (1758-1824, *Inventory Book 2*) contains inventories for 1785-1794 and begins with a signed document for the formation of the new company.

The importance, if any, of this watch lies in the inscription on the case dome, *Systeme Abram-Louis Perrelet au Locle*. If the inscription is contemporary with the movement, it suggests that Perrelet designed a side-weight mechanism.

5.6: The Mysterious ALP Dials

In addition to these three watches, there are three others with interesting signatures on the reverse of the dial.

The first (Matthey, ca 1979, page 19; Sabrier, 2012a, pages 182-184) is a side-weight self-winding watch that is described as "Signée sous le cadran A. L. Perrelet" (Matthey, ca 1979, page 19) and "Signed under the dial A. L. Perrelet" (Sabrier, 2012a, page 184). This watch is illustrated on the cover of this book.

However, Figure 5-24 shows that the signature, *AL Perelet* (or *LA Perelet*) is on *the reverse of the dial* and not *under the dial.*

Because dial making was an entirely separate trade from watchmaking, it is possible that this signature is not that of Abram Louys Perrelet the watchmaker, but of A. L. Perelet or L. A. Perelet a dial maker. However, we have found no evidence for a dial maker with this name. Bourdin (2012) lists Jean Pierre Perrelet as a dial maker, but he was probably too early (circa 1750) and there is no way the dial signature could be interpreted to be his; the initials would be *IPP*.

© Musée d'horlogerie du Locle, Château des Monts

Figure 5-24

The second related signature, is on the reverse of the dial for a watch signed *Hubt Sarton à Liège*; this watch has center seconds, calendar and quarter repeater, Figures 5-25 and 5-26.

In addition to this dial signature, enlarged in Figure 5-27, the same signature appears twice on the back of the rosette, Figure 5-28.

The signature on the rosette creates a serious problem. If it is genuine, then the signature cannot be that of a dial maker, who would never sign a movement. Therefore, it is likely that this mysterious person was a movement maker or a watchmaker.

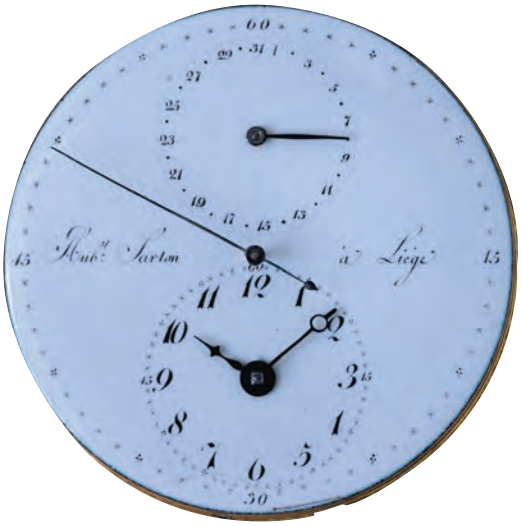


Figure 5-25

Figure 5-26

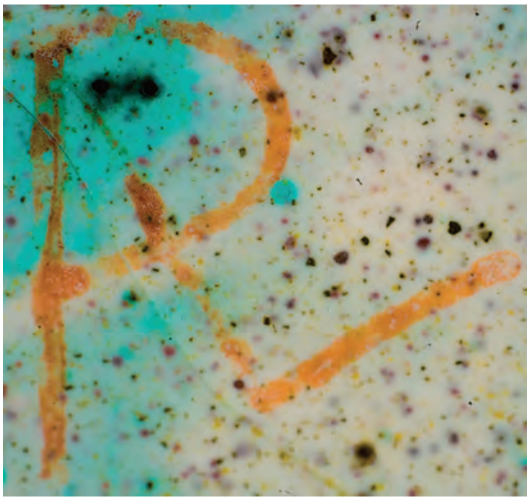


Figure 5-27

Figure 5-28

The third related dial signature is shown in Figure 5-29. It is on the reverse of the dial of a watch in the style of a Breguet souscription watch. However, Piguet (2008, page 156) notes that the case has French hallmarks in use from 9 May 1838 and so it was made after that date. Further, Piguet (2012-2016) is confident that the movement has not been re-cased.

If this is correct, then the movement was made after the death of Abram Louys Perrelet, and the signatures on the dials of these watches must be of some other person. However, limiting ourselves to the initials, we have found no other person listed in Bourdin (2012), or elsewhere, who might have used them.

Figure 5-29

5.7: Watch Making

Other than taking one or two apprentices, it seems that Perrelet worked alone. And Jeanneret and Bonhôte (cited above) state:

> *... he manufactured every part of the interior of the watch, starting by forging a piece of rough brass for the plate, then making the ébauche, finishing, the pinions, the teeth, the escapement, the winding, in a word all of the mechanism ...*

Auch (1827), Berthoud (1786, volume 2), Berthoud & Auch (2007) and Vigniaux (1802; 2011) describe the 18th and early 19th century process of making a watch by hand. All three use the same order of operations:

(a) The movement is designed and a brass calibre plate is made with all necessary holes drilled in it. With a one-off movement, the positions of the holes might be marked on the plates instead of using a separate calibre plate.

(b) The pillar and top pillar plates are made from hammer hardened brass plates and the large holes and recesses made.

(c) The pillars are made but not attached to the pillar plate.

(d) The calibre is used to drill the pivot and screw holes in the pillar plate.

(e) The calibre is used to drill the pivot and screw holes in the top plate.

(f) The pillars are riveted to the pillar plate. Vigniaux (2011) suggests an alternative method where the pillars are riveted after step (d) and then an uprighting tool is used to drill the top plate.

(g) The wheels and pinions are made.

(h) The movement is *finished*. Finishing is a complex process, because the teeth and leaves of the wheels and pinions are filed by hand. Peep holes are made to see the depthing, and then the pivot holes are enlarged, plugged and new pivot holes drilled in the correct center-to-center positions. Vigniaux uses a depthing tool to determine the center-to-center distances.

(i) The dial feet holes are drilled in the pillar plate. This is the last step and is done after everything else. The positions of the holes are taken from the actual dial.

(j) The movement is gilded, after which the movement is cleaned, assembled and tested.

It is generally accepted that making a movement by hand would take about a month, 25 days of work.

In 1833 there were 6,000 watchmakers in the Canton of Neuchâtel producing about 120,000 watches (Bowring, 1836, pages 30-34). This suggests a production rate of 15 man-days per watch, but the statistics do not include workers who were not watchmakers (such as parts makers, gilders, case makers and dial makers) and give an estimate that is probably too low. One watch per month (25 man-days) is more realistic.

Landes (1983, page 254; 2000, page 274) suggests that Geneva produced about 85,000 watches per year during 1781-1786, which indicates that there were about 7000 workers.

If Perrelet made complete movements by himself, then he would probably have produced about 12 watches per year. The consequence is that in the 30 years from when he was 21 years old (and apprenticed to Prince) to 1780 he probably only made about 360 watches.

Although the number of days of work involved may have been only about a month, the *elapsed* time from start to finish could be considerably longer. This is because gilding, dial and hand making, and case making were separate trades, so there could be significant delays while the watchmaker waits for these tasks to be done. And it is important to remember that, after gilding, the watchmaker has to clean out all holes, re-assemble the movement, and check and adjust it.

Of course, if the movement was based on a standardised ébauche, then the supply of dials, hands and cases would probably be done in less time. Even so, the elapsed time, from forging the rough brass to having a finished movement ready for sale, would be much greater than a month. And if Perrelet made watches in batches of 12, then it would take about a year to complete the batch.

There is no evidence to suggest that Perrelet marketed these movements himself, and he probably depended on établisseurs like Philipe DuBois to sell his watches in Europe. As, naturally, most of the foreign retailers would prefer watches that were unsigned or signed with their names, it is not surprising that only one watch signed *Abram Louis Perrelet* is known to us.

One statement made by Jeanneret and Bonhôte needs comment:

> *... he occasionally made twelve watches each one having a different escapement, ...*

It is difficult to accept this statement. Perrelet would have used the verge, cylinder, virgule and duplex escapements, but I cannot think of another eight different escapements that he might have used.

More importantly, we must remember that Perrelet's main aim would have been to put food on the table. And so, to provide a living for his family, he would have made watches to sell, most likely ordinary verge watches. And only after that would he have considered experimenting with designs that might be difficult to make and which might not have a market. Certainly, experimenting with a self-winding watch would have been a risk, because it might lead to a waste of time and materials without any benefits.

6: Other Swiss Makers

6.1: Jonas Perret-Jeanneret

Jonas Perret-Jeanneret is mentioned by Osterwald (1766, page 73; 2008, page 20):

> *The Seigneur Jonas Pierre Du Common is one of the most skilful clock makers, as the Seigneur Jonas Perret Jeanneret is for watches.*

And he is mentioned in 1776 (Berne, 1776, page 6) with regard to a repeater mechanism.

In a letter from Pierre Jacquet-Droz to Osterwald dated 31 January 1781 (Chapuis & Jaquet, 1952, page 144; 1956, page 156) we read:

> *I shall very soon start work on the small clock the Abbé* [Desprades] *is asking for. As for the perpetual watch he received from Mr Jonas Perret-Jeanneret, it is as resistant to running as to walking."*

In a second letter, dated 4 February 1781, Pierre Jacquet-Droz writes:

> *As for the perpetual watch, he asked me to have it given back to Mr Perret, ...*

The second letter is important because this same person is referred to as Perret and not Perret-Jeanneret.

Bourdin (2012) notes that Jonas Perret-Jeanneret was born in 1726, in Le Locle. The Internet site Sngenealogie (2012) states that Jonas Perret-Jeanneret was baptised on 3 March 1726, in Le Locle, and died between 1778 and 1781 (age 51). From the above letters, he must have died in 1781 aged 55, or later. Philipe DuBois mentions him in an inventory dated 9 December 1782 (DuBois, 1758-1824, *Inventory Book 1*, page 403), indicating that he was alive in that year.

Perret-Jeanneret is associated with the invention of self-winding watches by Frêne (1993-94). In 1784 he wrote:

> *I forgot to put in its place 11 April [1784] Easter Day, Sr Justice Boillat showed me a beautiful pocket watch that the Prince gave him to clean; it was acquired by the late Prince Frederic, who put it among the jewels of the Principality in the Castle Porrentruy. It goes without saying that it is gold and also very beautiful. But what was remarkable and why I mention it here is that it is one of these new watches that wind themselves by carrying, but you have to walk with it. Left to itself, it is 3 times twenty four hours. It is a skilful watchmaker from Le Locle, Mr. Perret, who is the inventor of these watches; it seems only a few years ago. As I hinted, they wind themselves as long as the person is wearing and walking with it. Put down and at rest, they will go for some time and, like ordinary watches, they finally stop. Then taken up and carried, they recover without issue and resume without winding in another way.*

6.2: Moÿse Gevril

Moÿse Gevril was born in 1749, in Le Locle, and lived at Crêt Vaillant in Le Locle (DuBois, 1758-1824, *Book 5*, page 140). He also made self-winding watches, but unfortunately, with one exception, Chapuis & Jaquet (1952; 1956) and Sabrier (2012a) do not provide dates for his watches. The exception, which is illustrated by Chapuis & Jaquet (1952, pages 179-180; 1956, pages 188-190) is dated 1781 by its mainspring. (The signature, *D. L. 9 c 14 janvier 1781*, may be that of Daniel Henry Lequeureux, living *sur le Cret* in Le Locle, and who was a spring maker used by Philipe DuBois between 1782 and 1797.) Three watches attributed to Gevril are illustrated by Sabrier (2012a, page 167).

Chapuis & Jaquet (1956, page 188) state:

> *Gevril is the only watchmaker in the Neuchâtel Jura region, apart from Perret-Jeanneret, whom we have so far been able to trace as a maker of the "imitations" (contre-façons) mentioned in Perrot's letter to Osterwald.* [See Figure 5-3, page 36]

But as the known work of Gevril cannot be described as worthless counterfeits, this suggestion is not sensible.

The importance of these two makers is that they worked at the same time as Abram Louys Perrelet. However, there is no concrete evidence that they made self-winding watches before 1780. More importantly, there is no evidence to suggest that they *designed* self-winding watches, and it is likely that they produced watches to the designs of other people, which were not worthless.

6.3: Meuron

The role of the Meuron family is hard to assess.

We have found mentions of only two particular persons. The first is the signature *Guglielmo Meuron* on a center-weight watch (illustrated in Chapter 12, page 139). The second is Henri François Meuron, who was born in 1736 and is listed in Bourdin (2012); the Gazette de Berne (Berne, 1792, page 4) states he was a watchmaker in Le Locle.

Chapuis & Jaquet (1952, pages 151-152; 1956, pages 162-163) note that the company Meuron & Cie had branches in Neuchâtel, La Chaux-de-Fonds, Geneva and Paris, and there are some self-winding watches signed by Meuron; one is illustrated by Sabrier (2012a, page 167). Sabrier (2012a, page 127) notes the close relationship between Meuron & Cie, who were établisseurs, and Jaquet Droz.

DuBois (1758-1824) had transactions with Lardy & Meuron in Neuchâtel (from 1782 to 1799), Meuron & Bovet in Neuchâtel (from 1791 to 1808), Meuron & Cie in Chaux-de-Fonds (from 1759 to 1791) and Meuron & Silliman (from 1775 to 1780). DuBois also had transactions with Silliman Wavre in Neuchâtel from 1814 to 1821. Berne (1789, page 4) mentions the company Meuron & Wavre in Neuchâtel.

One interesting watch is that illustrated on the cover of this book. As shown on the cover, the weight appears to be signed with the three initials *DHF*, Figure 6-1. However, turned upside-down, Figure 6-2, it is clear that there are, in fact, only two initials *M.C.*, raising the possibility that it was made by Meuron & Cie.

Figure 6-1

Figure 6-2

7: Hubert Sarton

7.1: Biography

The following biography is an amalgamation of information from several sources.

Hubert Sarton (1748-1828) was Belgium's greatest clockmaker and is renowned for his fine multi-dial skeleton clocks. He was born in Liège and baptised on 3 November 1748. From his early childhood he showed an aptitude for science and mechanics.

Figure 7-1

In 1762 he was apprenticed to his uncle, Dieudonné Sarton (1730-1782) and taught clock and watch making. On 1 March 1769 the 'Gazette of Liège' announced that "Dieudonné Sarton has just completed a clock on which he worked several years, he completed it with his nephew and godson Hubert Sarton". Dieudonné also made an exceptional 8-day watch with reversed fusee around 1770-1780 (Flores, 2000a). Very few watches have been built in this way. The inventor would have been Jean-Baptiste Leroy, the son of Julien Leroy. [Gentleman's Magazine, 1766, pages 369-370; first published in 1763 in the Memoires de l'Academie Royale des Sciences.] *The advantage of this arrangement with reversed fusee is to be able to place the meshing of wheels closer to the center of their axes, in order to prevent premature wear. In 1774 before leaving (in 1778 he moved to near Lyon) Dieudonné Sarton considered giving his business to his nephew and godson Hubert Sarton.* [Fraiture, 2009, page 565.]

According to Delvenne (1829, pages 372-373), in 1768 Hubert Sarton went to Paris to work at the house of Julien Leroy, horologer to the King of France, where he was accepted with pleasure because of his ability. [Julien had died in 1759 and so he probably worked with Pierre Leroy, the eldest son of Julien.]

He returned to Liège when he was 24 years old and in 1772 Sarton was appointed Court Mechanic to Duke Charles Alexander, Prince of Lorraine. He was commissioned to make several clocks for the Duke, including a superb example with a moving dial.

He married Marie-Joséphe Lhoest and had eight children.

Sarton also enjoyed the patronage of the Prince Archbishop François Charles Alexander de Velbrock, whose court contacts no doubt helped Sarton a good deal, and who asked him to start a Science Society (the Société d'Emulation). By 1783 he had been appointed City Councillor and Treasurer.

The subsequent invasion of Belgium by the French Revolutionary armies in 1794 undoubtedly led to a downturn in Sarton's business but this must have improved in the early 1800s as a *number of clocks date from this period. (Although it is also said that in 1812, political events and reverses of fortune completely ruined him.)*

On 9 December 1810 he placed an advertisement in the 'Gazette of Liège', where he offered for sale all his inventory of clocks, as well as pocket watches, regulators, travel clocks and clocks with multiple dials.

In 1817 Sarton was made a Brother in the Order of the Lion of Belgium.

Sarton was also an outstanding engineer, and he left many submissions, reports and scientific documents containing draft machinery he had designed for diverse activities, including a machine to extract coal, a windmill with rotating propellers, and a hydraulic machine to drain water and dry the Dutch polders. He is supposed to have invented the escalator.

He retired in 1820 and died at Liège on 18 October 1828 at the age of 80 years.

Some information on his work can be found in Sarton (1789, 2012) and Hognoul (1822, 2012), and a good study of his clocks is in Aghib (1972).

7.2: Documents

On Friday 3 July 1778, the *Avertissements de Liège* carried the following advertisement, Figure 7-2:

H. Sarton, Horloger & Mécanicien to the S.A.C., has the honour to give public notice that he has just completed several watches that, by a mechanism of the simplest kind, wind themselves, needing for continual running only that one makes some use of them. He sells them at a very fair price & with guarantee. He also has made a number of other Horological pieces, & among others a Carillon with several airs, whose delicacy, harmony & precision make it the admiration of Connoisseurs. If some Amateurs are amused by other extraordinary Horological pieces, he will be flattered to make them to their complete satisfaction.

NUM. LXXIX.

AVERTISSEMENTS DE LIEGE,

DU VENDREDI 3 JUILLET 1778.

H. SARTON, Horloger & Méchanicien de S. A. C., a l'honneur de donner avis au Public qu'il vient d'achever pluſieurs Montres qui, par un méchaniſme des plus ſimples, ſe remontent d'elles-mêmes, ayant pour moteur continuel le ſeul uſage que l'on en fait. Il les vend à très-juſte prix & les garantit. Il a auſſi fini quantité d'autres Pieces d'Horlogerie, & entr'autres un Carrillon à différents airs, dont la délicateſſe, l'harmonie & la préciſion font l'admiration des Connoiſſeurs. Si quelques Amateurs deſiroient d'autres Pieces extraordinaires en Horlogerie, il ſe flatte de les exécuter à leur entiere ſatisfaction.

Figure 7-2

At some time early in December 1778, Sarton submitted a self-winding watch to the Paris Académie Royale des Sciences, Figure 7-3 (Academy of Sciences, 1778, title from page 328 left and text from page 330 left):

> *Wednesday 16 December 1778 ... M. Sarton, horologist at Liège, has presented a watch that winds itself by the agitation while it is carried; Messers Leroy and Defouchy are nominated commissioners to examine it and give an account of it.*

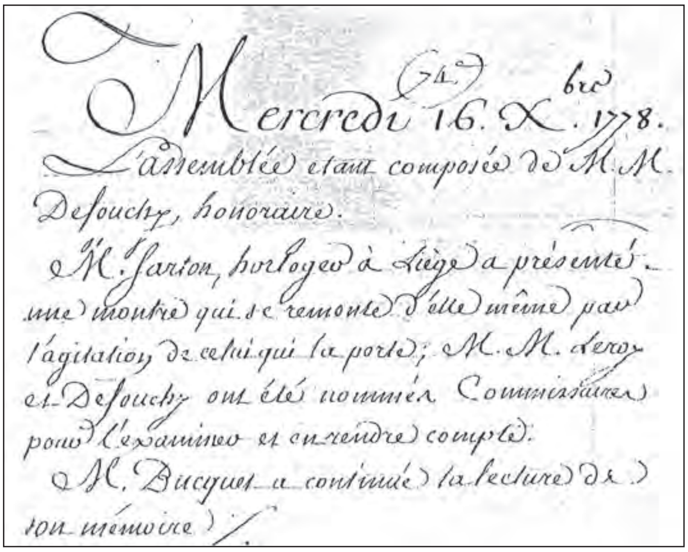

(74)
Mercredi 16. X.bre 1778.
L'assemblée étoit composée de M.M.
Defouchy, honoraire.
M. Sarton, horloger à Liège a présenté
une montre qui se remonte d'elle même par
l'agitation de celui qui la porte; M.M. Leroy
et Defouchy ont été nommés Commissaires
pour l'examiner et en rendre compte.
M. Bucquet a continué la lecture de
son mémoire /.

Figure 7-3

Then on Wednesday 23 December 1778, Leroy & Defouchy presented their report on the watch to the Paris Academy of Sciences. There are two copies of this report. The first (Flores 1993; Flores, 1995 pages 216-224; and Flores, 2009, pages 13-21) is the original report, hand-written by Leroy. The second (Academy of Sciences, 1778, pages 332 right to 335 left) is the clean transcript in the minutes of the Académie Royale des Sciences. The latter is presented here in full, Figures 7-4 to 7-6, interleaved with a complete translation; a few minor transcription errors have been corrected.

> *Messers Leroy and Defouchy submitted the following report.*
>
> *We examined a watch presented to the Academy by Mr Sarton, watchmaker of Liège. This watch goes constantly without being wound, not by an effect similar to that by which an odometer marks the way, that is by the action of the knee when one walks, but only by the effect of a brass weight or a type of clapper, agitated by the movement which one has while walking. We will make known to the Academy the mechanics by which this effect is achieved, without speaking about the other parts of this watch, they being built about the same as others.*
>
> *Two things are necessary so that a watch of this type fills its purpose well. It is necessary not only that it is wound up by the effect of the weight of which we will speak, but that while winding the watch still continues to go, without which there would be too many delays in its running. Here is how the things are laid out to meet these two conditions. But before speaking about it, it is necessary to remember that we said that this watch is built like ordinary watches, and there is a fusee and a barrel as in these watches.*
>
> *This fusee turns on its arbor instead of forming a unit with it as usual, and it has below at its base a pinion of 10, placed so that it gears in a pinion of the same number carried by this arbor By this, when the arbor turns, it makes this pinion turn, and the large wheel which carries this fusee, instead of having a click in its recess, carries a small wheel of which the 30 teeth have their points directed toward the center. The fusee being placed on the large wheel, its pinion gears into this small interior wheel. By this provision the arbor of the fusee cannot turn without its pinion making the pinion of this fusee turn at same time, which being carried in the same direction pushes the large wheel in contrary direction. By this, if one supposes that one turns the arbor of the fusee in the direction that it is turned to wind the watch, one will make this fusee turn and in consequence one will wind the chain or the watch, and at the same time the large*

wheel will be pushed in the contrary direction to make the watch run as when it is drawn by the chain. This effect is, of course, produced by the movement of the weight about which we spoke.

This weight, located on top of the plate and mobile like a pendulum, carries under it a pinion and a small wheel with click-and-ratchet work, the purpose of which we will explain in a moment. The pinion gears in a wheel carried on the same plate which has a pinion under it, so that it is inside the frame. Finally this last pinion gears in a wheel placed on the top of the fusee and which forms a unit with its arbor instead of the square of ordinary watches. It is now very easy to conceive the action of these various parts. One sees that the weight, receiving a rocking movement, for example in the direction that the watch is wound, will make the wheel in which its pinion gears turn and it then turns, by means of its pinion, that which is carried by the arbor of the fusee, making it turn at the same time in the same direction and thereby the chain will wind up as we said, etc., etc. Because one will well imagine, though we did not specify it, that the momentum of this weight is large enough to overcome the action of the spring on the fusee, and consequently to make it turn. We supposed that this weight went in one direction, but it could go in the contrary direction, which would produce a precisely opposite effect, which would disturb everything. To make all these various movements profitable, the author has placed a second small wheel with a pinion and click-and-ratchet work, very similar to that which forms a unit with the weight, so that it gears with that one, and that its pinion gears with the wheel

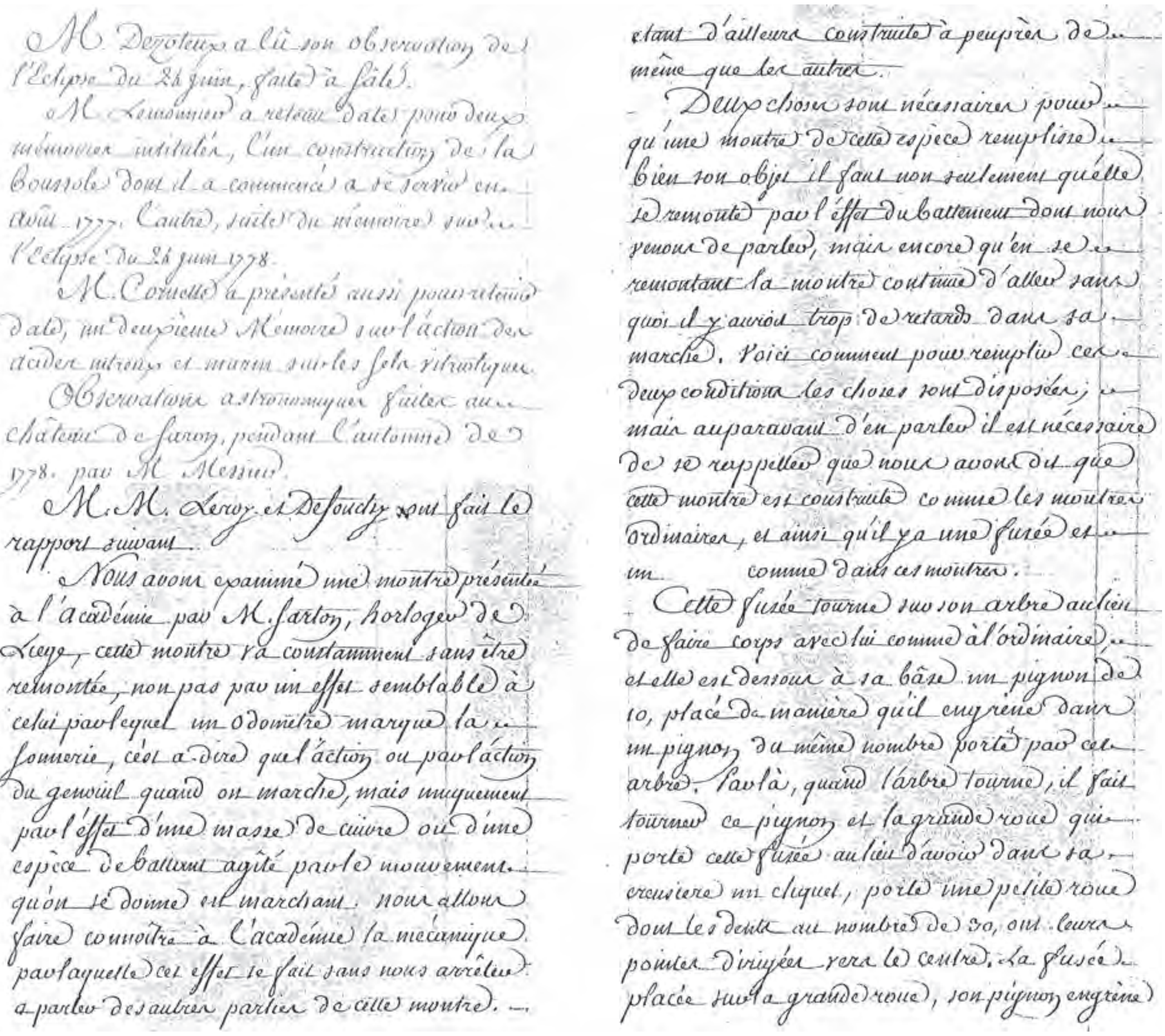
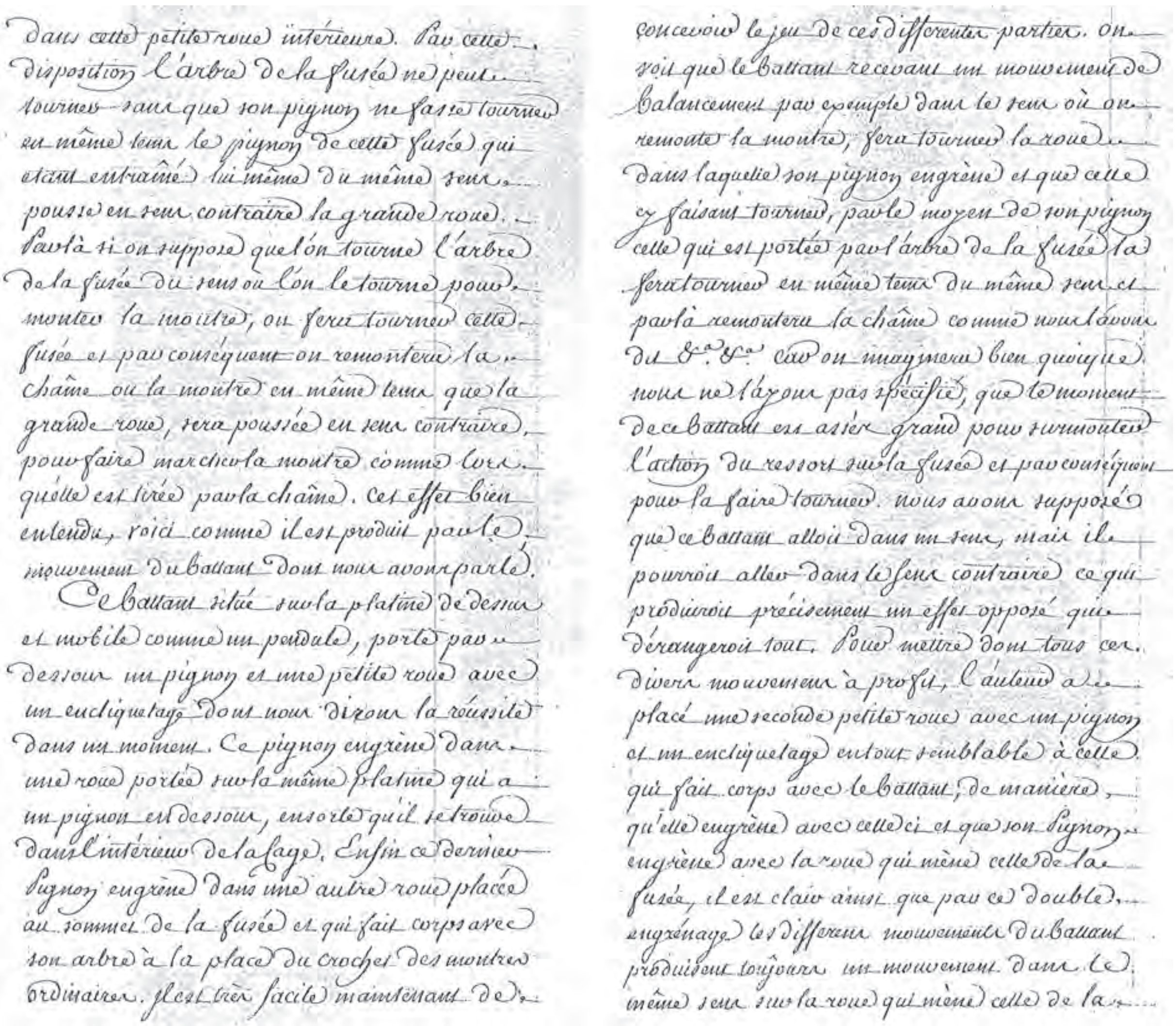

M. Dezoteux a lû son observation de l'Eclipse du 24 juin, faite à Sâle.
M. Lemonnier a retenu date pour deux mémoires intitulés, l'un construction de la Boussole dont il a commencé à se servir en avril 1777. l'autre, suite du mémoire sur l'Eclipse du 24 juin 1778.
M. Cornette a présenté aussi pour retenir date, un deuxième Mémoire sur l'action des acides nitreux et marin sur les sels vitrioliques.
Observations astronomiques faites au chateau de Saron, pendant l'automne de 1778. par M. Messier.
M.M. Leroy et Defouchy ont fait le rapport suivant.
Nous avons examiné une montre présentée à l'académie par M. Sarton, horloger de Liege, cette montre va constamment sans être remontée, non pas par un effet semblable à celui par lequel un odomêtre marque la sommerie, c'est à dire que l'action ou par l'action du genouil quand on marche, mais uniquement par l'effet d'une masse de cuivre ou d'une espèce de battant agité par le mouvement qu'on se donne en marchant. nous allons faire connoître à l'académie la mécanique par laquelle cet effet se fait sans nous arrêter à parler des autres parties de cette montre. —
etant d'ailleurs construite à peuprès de même que les autres.
Deux choses sont nécessaires pour qu'une montre de cette espèce remplisse bien son objet il faut non seulement qu'elle se remonte par l'effet du battement dont nous venons de parler, mais encore qu'en se remontant la montre continue d'aller sans quoi il y auroit trop de retards dans sa marche. Voici comment pour remplir ces deux conditions les choses sont disposées; mais auparavant d'en parler il est nécessaire de se rappeller que nous avons dit que cette montre est construite comme les montres ordinaires, et ainsi qu'il y a une fusée et un comme dans ces montres.
Cette fusée tourne sur son arbre au lieu de faire corps avec lui comme à l'ordinaire, et elle est dessous à sa bâse un pignon de 10, placé de manière qu'il engrene dans un pignon du même nombre porté par cet arbre. Par là, quand l'arbre tourne, il fait tourner ce pignon et la grande roue qui porte cette fusée au lieu d'avoir dans sa croisiere un cliquet, porte une petite roue dont les dents au nombre de 30, ont leurs pointes dirigées vers le centre. La fusée placée sur la grande roue, son pignon engrène

Figure 7-4

which moves that of the fusee. Thus it is clear that by these double gears, the various movements of the weight always produce a movement in the same direction on the wheel that moves that of the fusee. It is good to note that the click-and-ratchet work are only necessary here, so that the pinions can turn independently of the wheels, and vice versa. Lastly, so that, when the watch is completely wound, it cannot be wound more, the chain guard carries a pin which goes through the plate and will engage in the notches of a plate which is under the weight, so that it is stopped by this pin, remains motionless and the chain is no longer wound.

To make an experiment with this watch one of us had it carried by his servant for the space of two thousand steps or there about, it was run down before, and the chain was wound up two turns.

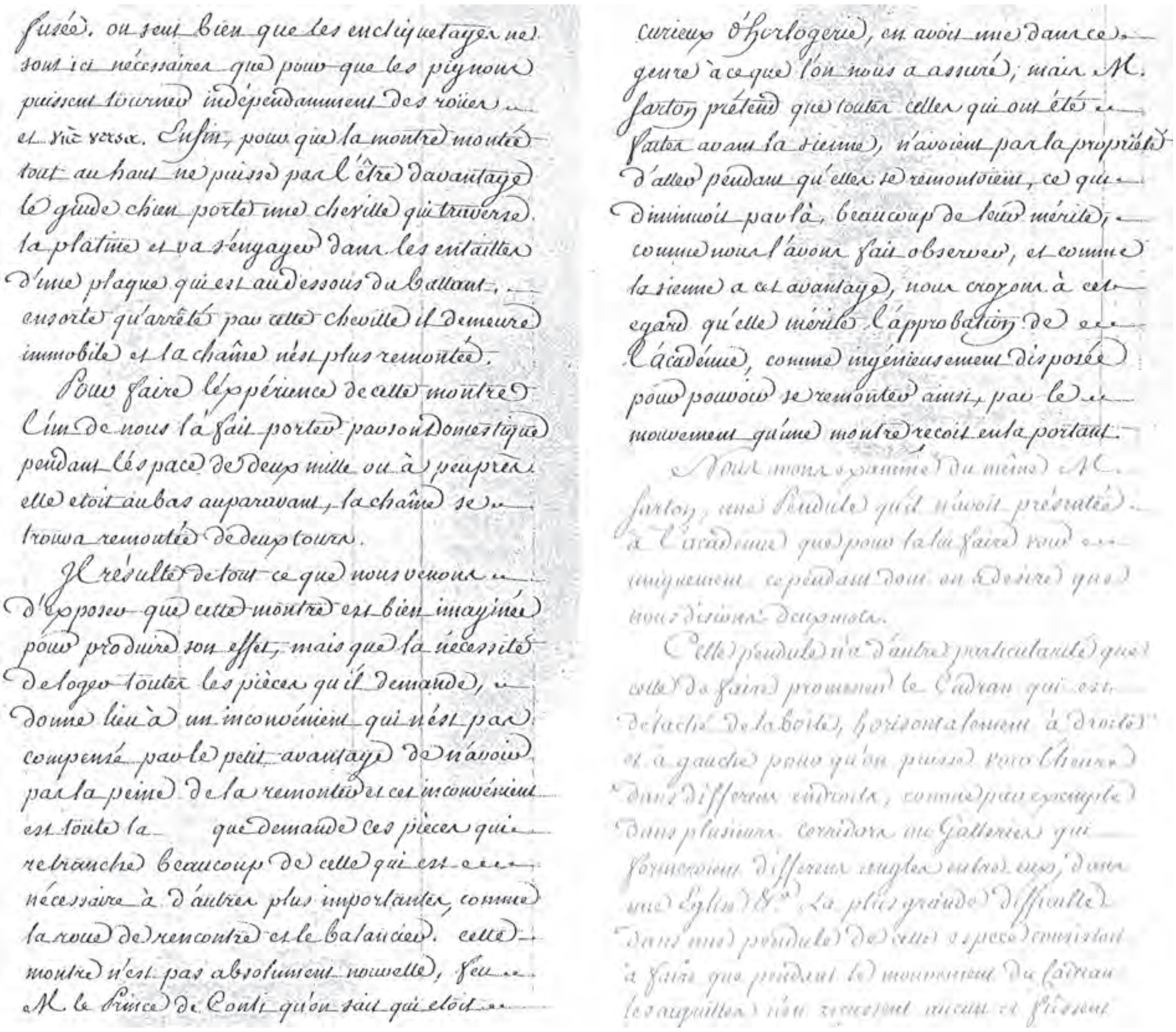
It results from all this, that we state that this watch is well designed to produce its effect, but the need to have all the parts that it demands, causes a disadvantage which is not compensated by the small advantage of not having to wind it, and this disadvantage is all the space that these parts require, which deducts much from that which is necessary for others more important, like the verge escape wheel and balance. This watch is not absolutely new. The late Prince de Conti whom one knows was interested in watchmaking, had one of this kind, so we have been assured. But Mr Sarton claims that all those that were made before his did not have the property of running while being wound up, which much decreased their merit. As we remarked, and


dans cette petite roue intérieure. Par cette disposition l'arbre de la fusée ne peut tourner sans que son pignon ne fasse tourner en même tems le pignon de cette fusée qui étant entraîné lui même du même sens pousse en sens contraire la grande roue. Par là si on suppose que l'on tourne l'arbre de la fusée du sens où l'on le tourne pour monter la montre, on fera tourner cette fusée et par conséquent on remontera la chaîne ou la montre en même tems que la grande roue, sera poussée en sens contraire, pour faire marcher la montre comme lors qu'elle est tirée par la chaîne. Cet effet bien entendu, voici comme il est produit par le mouvement du battant dont nous avons parlé.

Ce battant situé sur la platine de dessus et mobile comme un pendule, porte par dessous un pignon et une petite roue avec un encliquetage dont nous dirons la réussite dans un moment. Ce pignon engrène dans une roue portée sur la même platine qui a un pignon en dessous, ensorte qu'il se trouve dans l'intérieur de la cage. Enfin ce dernier pignon engrène dans une autre roue placée au sommet de la fusée et qui fait corps avec son arbre à la place du crochet des montres ordinaires. Il est très facile maintenant de concevoir le jeu de ces differentes parties. On voit que le battant recevant un mouvement de balancement par exemple dans le sens où on remonte la montre, fera tourner la roue dans laquelle son pignon engrène et que celle ci faisant tourner, par le moyen de son pignon celle qui est portée par l'arbre de la fusée la fera tourner en même tems du même sens et par là remontera la chaîne comme nous l'avons dit &c. &c. car on imaginera bien quoique nous ne l'ayons pas spécifié, que le moment de ce battant est assez grand pour surmonter l'action du ressort sur la fusée et par conséquent pour la faire tourner. Nous avons supposé que ce battant alloit dans un sens, mais il pourroit aller dans le sens contraire ce qui produiroit précisement un effet opposé qui dérangeroit tout. Pour mettre donc tous ces divers mouvemens à profit, l'auteur a placé une seconde petite roue avec un pignon et un encliquetage en tout semblable à celle qui fait corps avec le battant, de manière qu'elle engrène avec celle ci et que son pignon engrène avec la roue qui mène celle de la fusée, il est clair ainsi que par ce double engrénage les differens mouvemens du battant produisent toujours un mouvement dans le même sens sur la roue qui mène celle de la...

Figure 7-5

as his has this advantage, we believe in this respect it deserves the approval of the Academy, as ingeniously laid out to be able to also wind itself by the movement which a watch receives while carrying it.



fusée. or seul bien que les encliquetages ne sont ici nécessaires que pour que les pignons puissent tourner indépendamment des roües, et vice versa. Enfin, pour que la montre montée tout au haut ne puisse pas l'être davantage le guide chien porte une cheville qui traverse la platine et va s'engager dans les entailles d'une plaque qui est au dessous du battant, ensorte qu'arrêté par cette cheville il demeure immobile et la chaîne n'est plus remontée.

Pour faire l'expérience de cette montre l'un de nous l'a fait porter par son Domestique pendant l'espace de deux mille ou à peu près elle étoit au bas auparavant, la chaîne se trouva remontée de deux tours.

Il résulte de tout ce que nous venons d'exposer que cette montre est bien imaginée pour produire son effet, mais que la nécessité de loger toutes les pièces qu'il demande, donne lieu à un inconvénient qui n'est pas compensé par le petit avantage de n'avoir pas la peine de la remonter et cet inconvénient est toute la que demande ces pièces qui retranche beaucoup de celle qui est nécessaire à d'autres plus importantes, comme la roue de rencontre et le balancier. cette montre n'est pas absolument nouvelle, feu M. le Prince de Conti qu'on sait qui étoit curieux d'horlogerie, en avoit une dans ce genre à ce que l'on nous a assuré; mais M. Sarton prétend que toutes celles qui ont été faites avant la sienne, n'avoient pas la propriété d'aller pendant qu'elles se remontoient, ce qui diminuoit par là, beaucoup de leur mérite; comme nous l'avons fait observer, et comme la sienne a cet avantage, nous croyons à cet égard qu'elle mérite l'approbation de l'académie, comme ingénieusement disposée pour pouvoir se remonter aussi par le mouvement qu'une montre reçoit en la portant.

Nous avons examiné du même M. Sarton, une Pendule qu'il n'avoit présentée à l'académie que pour la lui faire voir uniquement cependant dont on a desiré que nous disions deux mots.

Cette pendule n'a d'autre particularité que celle de faire promener le cadran qui est détaché de la boîte, horizontalement à droite et à gauche pour qu'on puisse voir l'heure dans differens endroits, comme par exemple dans plusieurs corridors ou Galleries qui formeroient differens angles entre eux, dans une Eglise &c. La plus grande difficulté dans une pendule de cette espèce consistoit à faire que pendant le mouvement du cadran les aiguilles n'en reçussent aucun et fissent

Figure 7-6

The Prince de Conti mentioned above is Louis François de Bourbon, born 13 August 1717, died 2 August 1776.

In addition, there is a drawing, Figure 7-7.

This drawing, about 30 x 30 cm, was not found until September 2009, some 53 years after the first publication of the report (Chapuis & Jaquet, 1956, pages 66-68). It may be one of the drawings mentioned in Hognoul (1822, page 29; 2012, page 15) in which Sarton wrote:

> *It was around the same time* [1778] *that I found myself, in connection with the mechanical arts, in contact with this erudite Academy, and particularly with my compatriot Mr Morand, intimate adviser to S.A.C. the Prince of Liège, and librarian of the Royal Academy of Sciences in Paris. It was, I say, around this time that he wrote to me: I request from you urgently, Sir, to agree to give me, for the Academy, the drawings that I promised that you would supply.*

Unfortunately Figure 7-7 is not signed. Also, this quote suggests that Sarton may not have gone to Paris and delivered the watch to the academy himself, but got Morand to do so on his behalf.

Figure 7-8 is a diagram based on the 1778 drawing in Figure 7-7 together with translations of the text on the original:

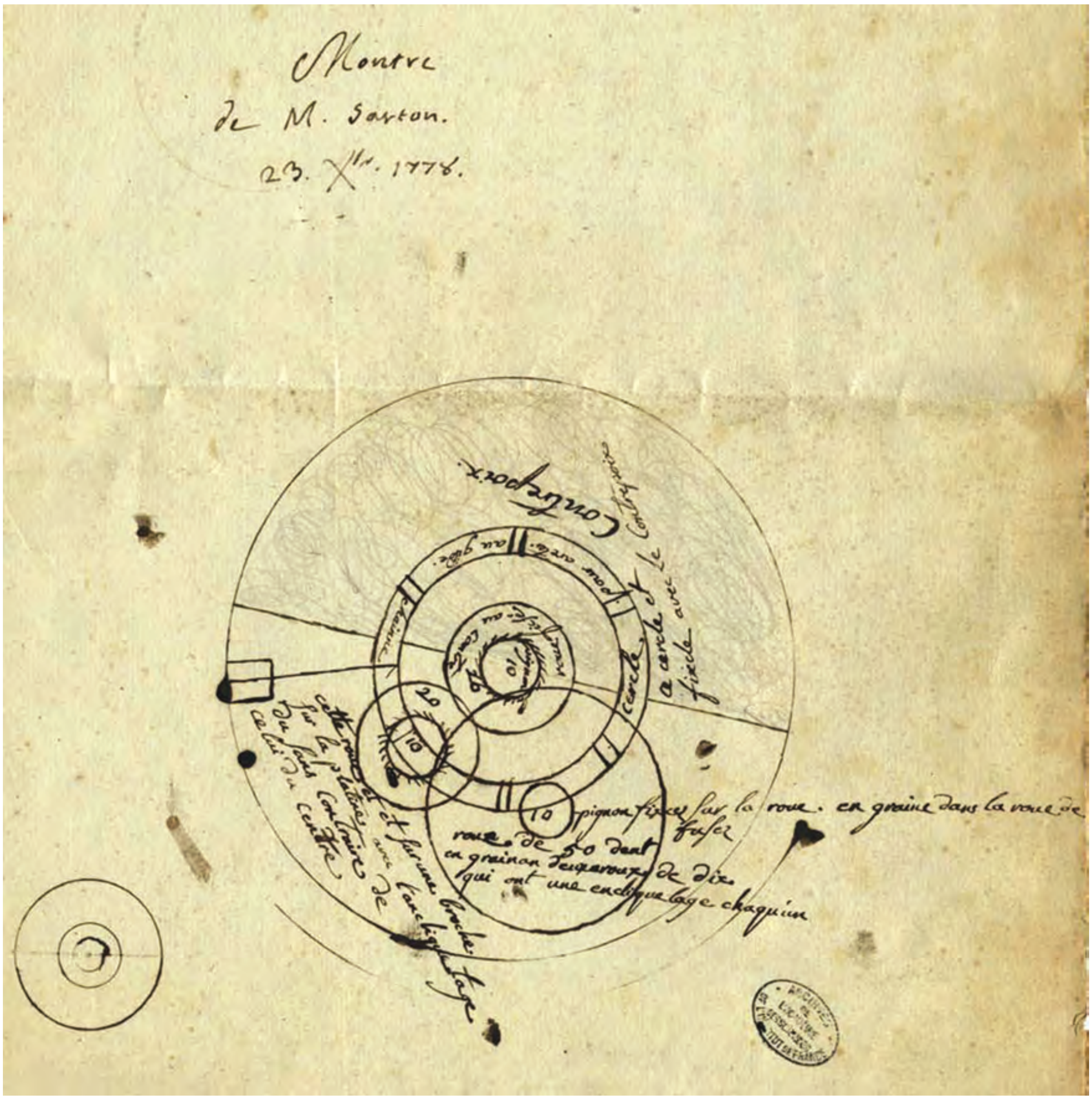


Figure 7-7

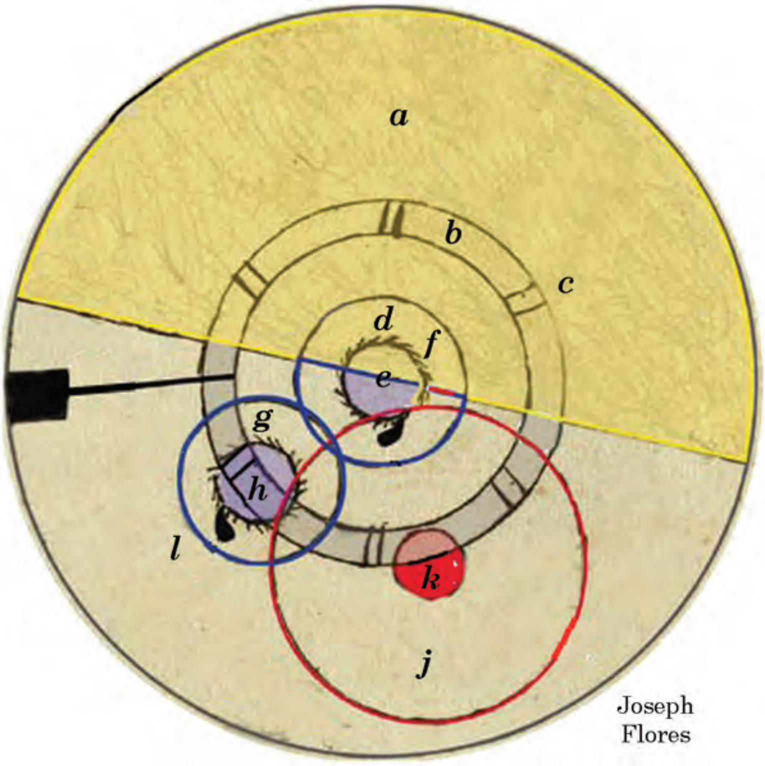


Figure 7-8

a	*Counterweight.*
b	*Notched ring to stop winding by means of the chain guard.*
c	*The notched ring is fixed to the counterweight.*
d	*Wheel fixed to the counterweight.*
e	*Pinion of 10 leaves.*
f	*Wheel with 20 teeth.*
g	*Wheel with 20 teeth.*
h	*Pinion of 10 leaves.*
j	*Wheel of 50 teeth gearing with the two wheels of ten teeth which each have click-and-ratchet work.*
k	*Pinion of 10 leaves fixed to the wheel gearing with the wheel of the fusee.*
l	*This wheel is on a post on the plate with click-and-ratchet work in the opposite direction to that of the wheel in the center.*

As we will see, the description at ***l*** and the clicks on the drawing are incorrect; the clicks must act in the same direction.

7.3: Explanation of the Rotor Mechanism

We will now explain the mechanism of the watch described in the 1778 report. To do this:

(a) The parts of the 1778 report by Jean-Baptiste Leroy and Defouchy will be examined in order.

(b) The automatic movement which is in the Patek Philippe Museum, Figures 7-9 and 7-10, will used to illustrate the explanation, showing, at the same time, that it is technically identical to the watch supplied by Sarton to the Royal Academy of Sciences at Paris. This watch is known as the *Leroy watch*, after the person who found it, Léon Leroy (1949), and it is the watch studied by Chapuis & Jaquet (1952 and 1956). It is one of five currently known movements which are all technically identical. (Indeed, for all we know the *Leroy watch* may have been the watch submitted by Sarton.)

Figure 7-9

Figure 7-10

All photographs of the *Leroy watch* were taken by Joseph Flores in the workshop of the Patek Philippe Museum, on 20 January 2007.

> *Two things are necessary so that a watch of this type fills its purpose well. It is necessary not only that it is wound up by the effect of the weight of which we will speak, but that while winding the watch still continues to run, without which there would be too many delays in its running. ... But before speaking about it, it is necessary to remember that we said that this watch is built like ordinary watches, and there is a fusee and a barrel as in these watches.*

Before looking at the watch, it will be useful to make some things clear. Although this may repeat the obvious, it is necessary in order to make some observations.

An *ordinary* watch of the time used the verge escapement. Unfortunately, this escapement has a serious defect: Its rate, and hence the rate of the watch, varies significantly according to the power provided by the mainspring through the train. This is so serious that the escapement has to have a mechanism to even out the power from the mainspring; without it the performance, not particularly good at the best of times, would be unacceptable.

As a result, other than a few, very rare exceptions, all verge escapement watches have fusees, as in Figure 7-11.

Figure 7-11

The first consequence of using a fusee is its main drawback; it has to be able to rotate both clockwise and anti-clockwise. From the perspective of Figure 7-11, to wind the watch the fusee must be turned anti-clockwise to draw the chain off the barrel. But during this time, the first wheel of the train, mounted under the fusee, cannot turn with it, or it would drive the train backwards. Then, when the watch runs, the fusee must turn clockwise to drive the first wheel and the train.

This is easy to achieve. Essential to the operation of a fusee is the click and ratchet connecting the body of the fusee to the first wheel of the train under it. In Figure 7-12 the ratchet ***1*** in the base of the fusee meshes with the click ***2*** (activated by the spring ***3***) on the loose first wheel. During winding, the ratchet teeth slide over the click, allowing the chain to be wound without the first wheel moving. Then, during running, the click meshes with the ratchet and the first wheel is driven by the chain and mainspring.

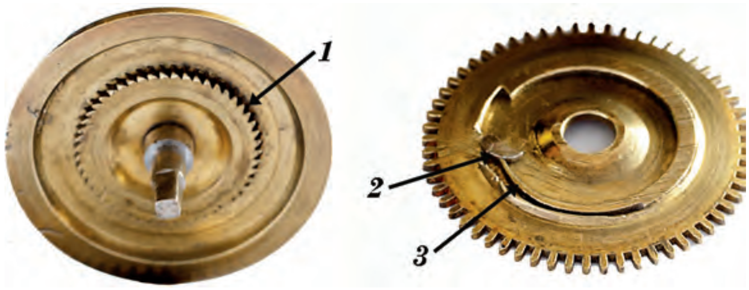


Figure 7-12

The second important consequence of the fusee is that *during winding no power from the mainspring reaches the train*, because the first wheel is not being driven by the click and ratchet.

This was not a problem with ordinary watches of the time. Their inaccuracy could be measured in minutes, not seconds, and the short, intermittent time that the train looses power, because the key is being turned, was insignificant. And so these watches did not have *maintaining power*. The problem only became serious when much more accurate watches, in particular chronometers, were developed and when fractions of a second mattered. The common maintaining power developed by John Harrison then became standard in watches with fusees, even in ordinary watches that did not really need it. But it could only supply a very small amount of power, sufficient for the time when a key was being turned but not much more. Which is presumably why even modern chronometers with fusees are wound with a key and not a crank; continuous winding for several seconds could stop the watch.

Although these two features of fusees, the need for them to turn both ways and the lack of maintaining power, did not matter in ordinary watches, they become major problems in the context of self-winding watches. It is clear from the above quote that the design intended to remove the disadvantage of ordinary fusees, and therefore to enable the watch wind and run simultaneously.

> *This fusee turns on its arbor instead of forming a unit with it as normal, and it has in its base a pinion of 10, placed so that it gears into a pinion of the same number carried by this arbor. By this, when the arbor turns, it makes this pinion turn.*

Thus the arbor and body of the fusee are separate and, looking up into the base of the fusee, there is a pinion of 10, as in Figures 7-13 to 7-15.

In Figure 7-16 the arbor of fusee is placed on the body of the fusee, under which the pinion turns on a stud. It is specified that the pinion on this arbor also has 10 leaves.

> *The large wheel that carries this fusee, instead of having a click in its recess, carries a small wheel of which the 30 teeth have their points directed toward the center.*

Figure 7-13

Figure 7-14

Figure 7-15

Figure 7-16

Figure 7-17

Figure 7-17 shows this first wheel. The comparison is obvious, and up to now the fusee of the automatic movement in the Patek Philippe Museum agrees perfectly with the fusee of the movement deposited by Sarton and described by the two reporters Leroy and Defouchy.

> *The fusee being placed on the large wheel, its pinion gears into this small interior wheel. By this provision the arbor of the fusee cannot turn without its pinion making the pinion of the fusee turn at same time, which, being carried in the same direction, pushes the large wheel in the contrary direction. By this, if one supposes that one turns the arbor of the fusee in the direction that it is turned to wind the watch, one will make the fusee turn and, in consequence, one will wind the chain or the watch. And at the same time the great wheel will be pushed in the contrary direction to make the watch run, the same as when it is drawn by the chain.*

Figure 7-18

Figure 7-18 shows the positions of the pinion and the arbor when placed in the first wheel.

The diagram in Figure 7-19 shows the various movements of the wheels.

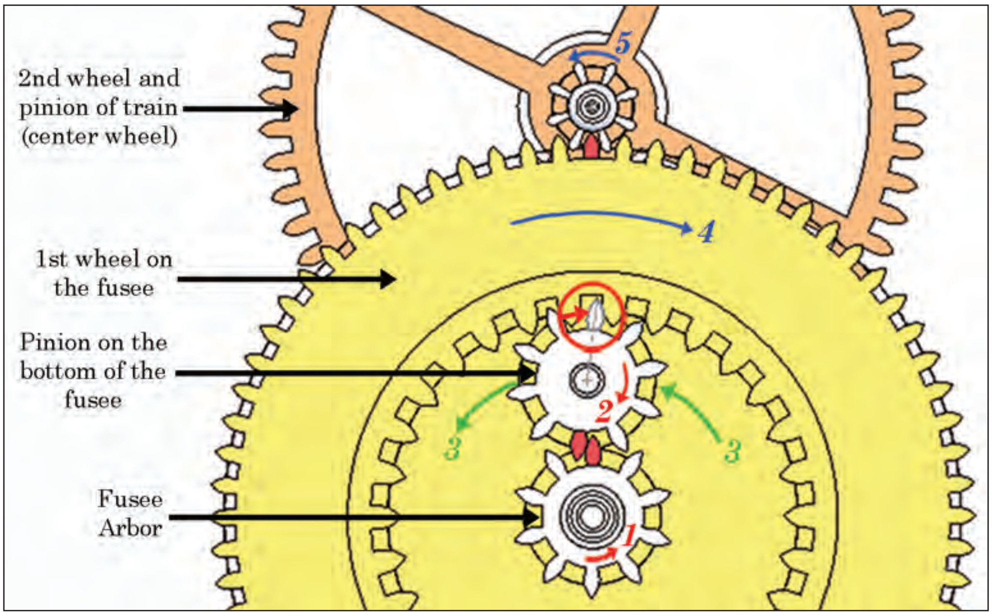


Figure 7-19

When the fusee arbor turns anti-clockwise (in the direction of the red arrow ***1***), it turns the satellite pinion that is attached to the fusee base. This pinion has two simultaneous motions:

(1) The pinion turns on itself clockwise (in the direction of the red arrow ***2***). This produces a reactive effect of its teeth at the point of contact with the internal teeth of the first wheel, indicated by the red circle and the direction of the red arrow inside it. This effect pushes the first wheel on the fusee clockwise in the direction of the blue arrow ***4***, which makes the first wheel of the train turn anti-clockwise ***5***, in order to make the watch run. Thus the mechanism provides maintaining power.

(2) Simultaneously, the pinion moves anti-clockwise in the direction of the green arrows ***3***, orbiting around the pinion on the fusee arbor. This causes the cone of the fusee, to which it is attached, to turn in the same direction, and thus to wind up the chain and wind the watch.

It must be remembered that these wheels are not turning loosely, but under the opposing forces produced by the mainspring and the self-winding mechanism. Further, because the fusee has no click-work, without the winding mechanism the mainspring would always draw the chain off the fusee and onto the barrel, and the watch could not be wound. Clearly the force of the winding mechanism must be greater than the counteracting force of the mainspring.

In contrast, when the self-winding mechanism is not active (because the watch is not moving, or it is fully wound) the behaviour of the fusee is that in Figure 7-20.

As the mainspring pulls the chain off it, the fusee cone with its satellite pinion is rotating clockwise (green arrows ***3***). Because the fusee arbor is not turning, the satellite pinion has to turn clockwise (red arrow ***2***) and it drives the first wheel clockwise as before.

Figure 7-21 is a diagram of the complete fusee.

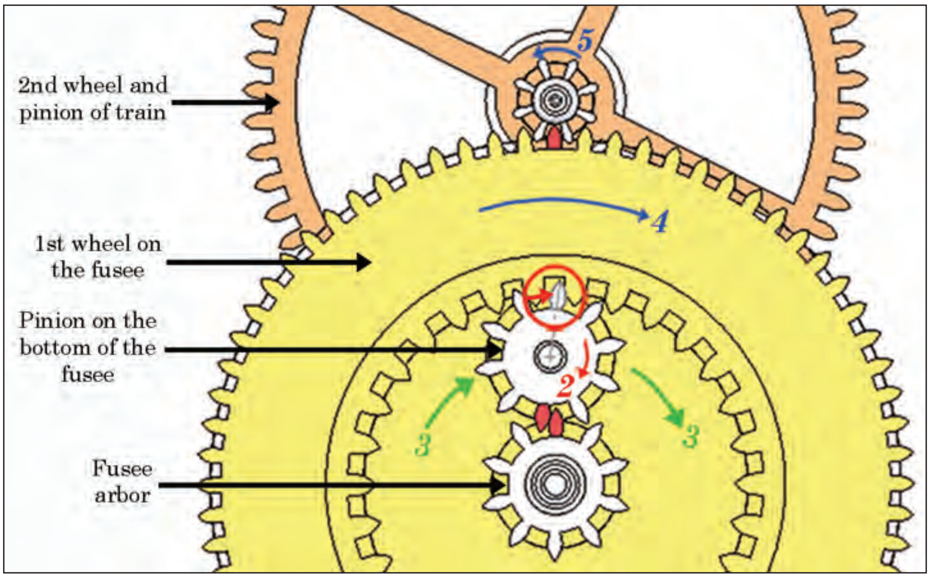


Figure 7-20

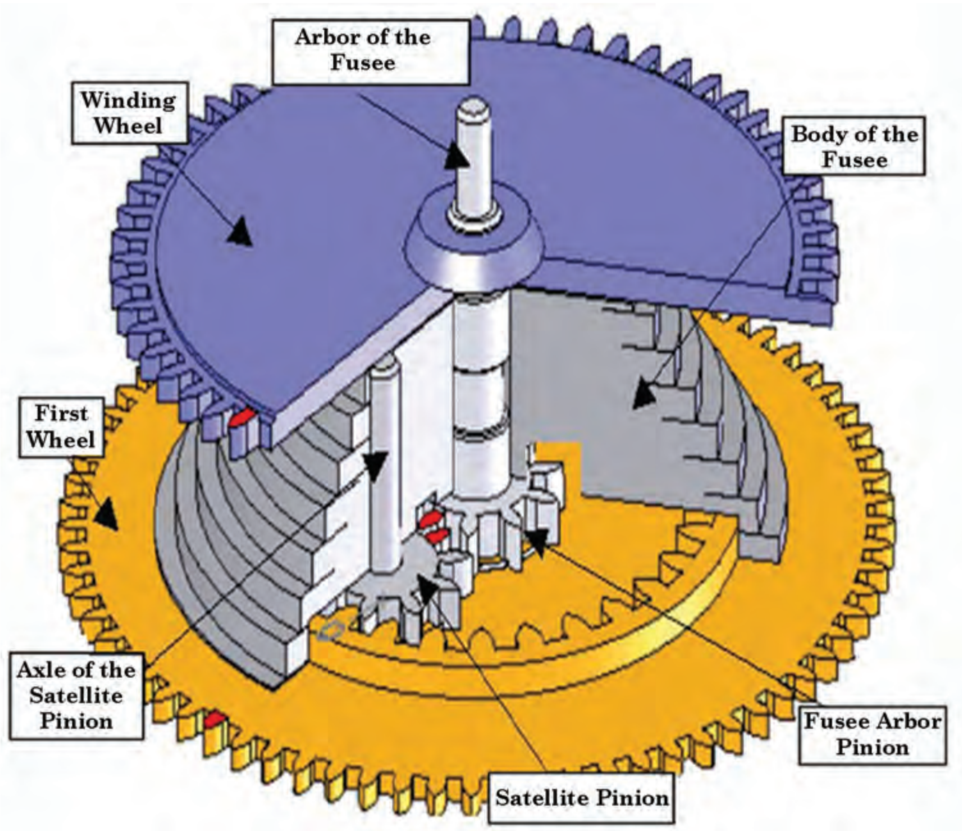


Figure 7-21

We have described how the fusee functions, and now we need to understand the mechanism that makes the arbor of the fusee turn, so that all the actions are done automatically.

This effect, of course, is produced by the movement of the weight about which we spoke. This weight, located on top of the plate and mobile like a pendulum, carries under it a pinion and a small wheel with click-work, the purpose of which we will explain in a moment.

Figure 7-22 is an *underneath* view of part of the weight; that is, from the front of the watch. The small *driving wheel* is screwed to the weight and carries the click that acts in the ratchet on the loose driving pinion. (This loose pinion with its integral ratchet is shown separately.)

> *The pinion gears with a wheel carried on the same plate that has a pinion under it, so that it is inside the frame. Finally, this last pinion gears in a wheel placed on the top of the fusee and which forms a unit with its arbor instead of the square of ordinary watches.*

Figure 7-22

In Figure 7-23 the driving pinion under the weight has been put by itself on the pivot shank for the weight, and it gears with the *intermediate wheel* placed on the plate. That wheel has a pinion under it, so that it is inside the frame. Figure 7-24 shows this intermediate wheel and Figure 7-25 shows the pivot shank on which it turns. In the hole for the pinion we see 3 teeth, which are part of the *winding wheel* placed on the fusee, as shown in Figures 7-10 and 7-21.

Figure 7-23

> *It is now very easy to understand the action of these various parts. One sees that the weight, receiving a rocking movement, for example in the direction that the watch is wound, will make the wheel in which its pinion gears turn, and it then turns, by means of its pinion, that which is carried by the arbor of the fusee, making it turn at the same time and in the same direction, and thereby the chain will wind up as we said, etc., etc. Because one will understand, though we did not specify it, that the momentum of this weight is large enough to overcome the action of the spring on the fusee, and consequently to make it turn.*
> *We supposed that this weight went in one direction, but it could go in the contrary direction, which would produce precisely the opposite effect and which would disturb everything. To make all these various movements profitable, the author has placed a second small wheel with a*

Figure 7-24

Figure 7-25

pinion and click-work, very similar to that which forms a unit with the weight, so that it gears with that one, and that its pinion gears with the wheel which moves that of the fusee.

In Figure 7-26 the 2 small driving wheels gear together, and in Figure 7-27 their respective pinions gear with the intermediate wheel.

It is clear that, by these double gears, the various contrary movements of the weight always move the intermediate wheel and the winding wheel mounted on the fusee in the same direction.

Figure 7-26

Figure 7-27

There are two possibilities, Figure 7-28:

(a) The weight turns anti-clockwise: Wheel ***A***, which is fixed to the weight, turns anti-clockwise and its click ***d*** turns the ratchet ***C*** and its attached pinion ***B***, which then turns the intermediate wheel clockwise. The intermediate wheel turns the winding wheel on the fusee arbor anti-clockwise, which winds the watch. While this is happening, the wheel ***A′*** is turned clockwise by wheel ***A*** and its click ***d′*** rides over the ratchet ***C′*** freely. Also, the intermediate wheel is turning the pinion ***B′*** anti-clockwise.

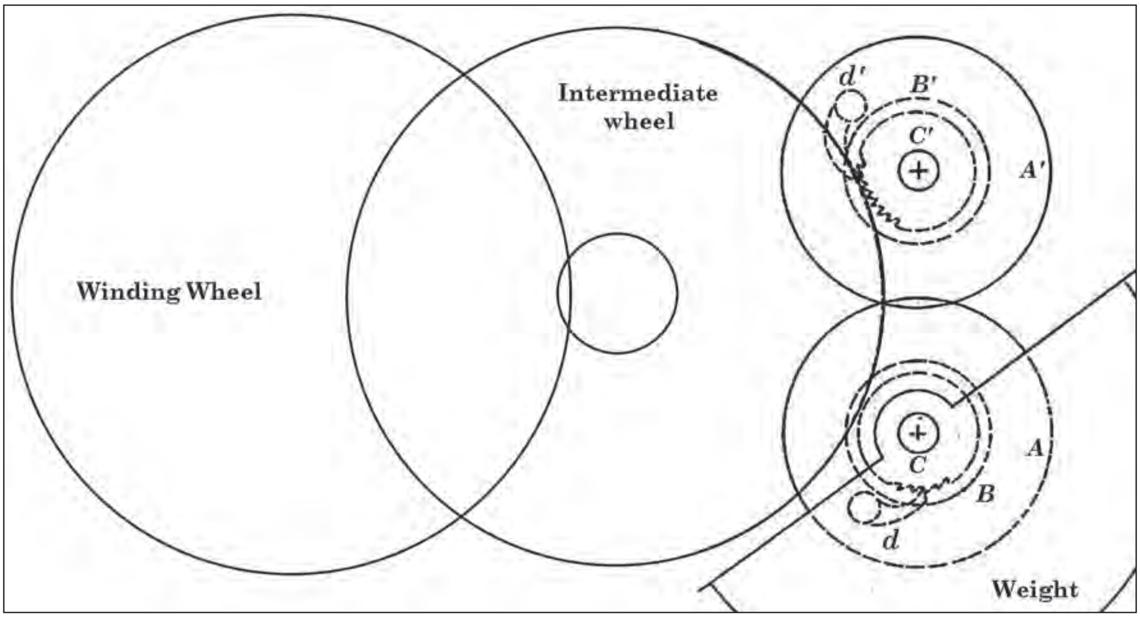


Figure 7-28

(b) The weight turns clockwise: Wheel ***A*** turns clockwise and its click rides over the pinion ***C*** freely. But at the same time wheel ***A*** turns wheel ***A′*** anti-clockwise, and its click ***d′*** turns the ratchet ***C′*** anti-clockwise so that its pinion ***B′*** makes the intermediate wheel turn clockwise, winding the watch. As this happens, the intermediate wheel is turning the pinion ***B*** anti-clockwise.

Thus the intermediate wheel always turns clockwise and winds the watch.

It is essential that we distinguish two different ways in which loose ratchets can function:

(a) *Driven*: The ratchet is driven by the click attached to the wheel. This is the situation described above.

(b) *Driving*. The ratchet drives the click and hence the wheel. Because the fusee does not contain a ratchet and click, the mainspring is continually trying to turn the fusee arbor clockwise, and consequently trying to turn the intermediate wheel anti-clockwise and *both ratchets* clockwise. But this is impossible, because it means both wheels ***A*** and ***A'*** would have to turn clockwise which, as they mesh, cannot occur.

That is, the ratchets are simultaneously driving and being driven.

It should be noted that the wheel ***A′*** and pinion ***C′*** are essential. Consider Figure 7-29. As in (b) above, the mainspring is trying to turn the ratchet ***B*** clockwise. So when the weight rotates clockwise, which it must, the intermediate wheel will be free turn anti-clockwise, being driven by the mainspring pulling the chain *off* the fusee, and drive the pinion ***C*** clockwise. This clockwise motion is limited by the click ***d***, but it will be enough to unwind the chain off the fusee by about the same amount that it had been wound on (unless the weight turns a full circle). So it will be impossible to wind the watch.

This problem can be easily solved by adding a second click acting in the ratchet ***C*** and facing in the same direction, but mounted on the plate. This click will prevent the pinion rotating anti-clockwise. Obviously such a system is less efficient because the weight only winds the watch when turning one way.

It remains to explain the stop-work.

In any watch with self-winding it is necessary to stop the winding operation when the main spring is completely wound, in order to prevent the mainspring or some other part breaking (see Appendix

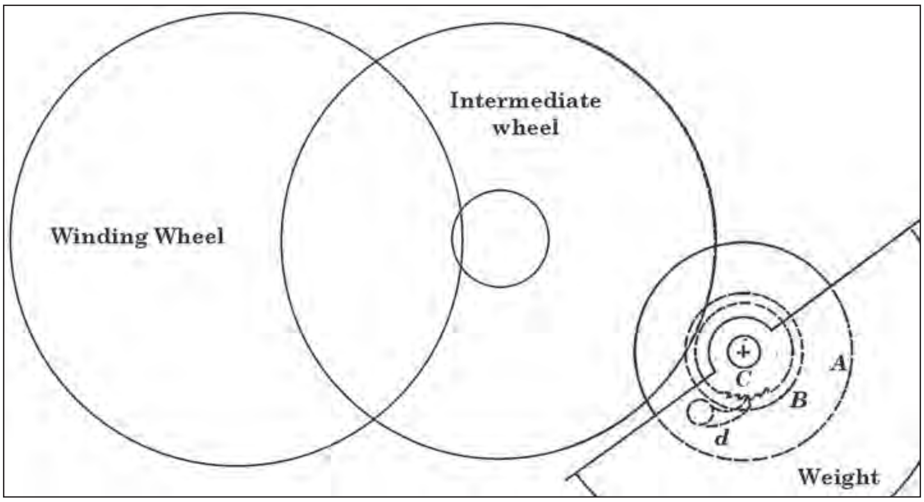


Figure 7-29

7, page 375). This is still true for modern self-winding watches, however this effect is usually produced by a sliding brace on the end of the mainspring, which allows the main spring to slide inside its barrel when it is fully wound. This design dates from the middle of the 19th century.

Ordinary fusee watches also need to stop the winding operation when the main spring is completely wound, and they do this by means of a *chain guard*. The top of the fusee has a beak ***b***, Figure 7-30. The chain guard ***c***, Figure 7-31, is a small lever mounted on the inside of the top plate, with a spring ***s*** which holds it away from the plate; this is an underneath view of the plate.

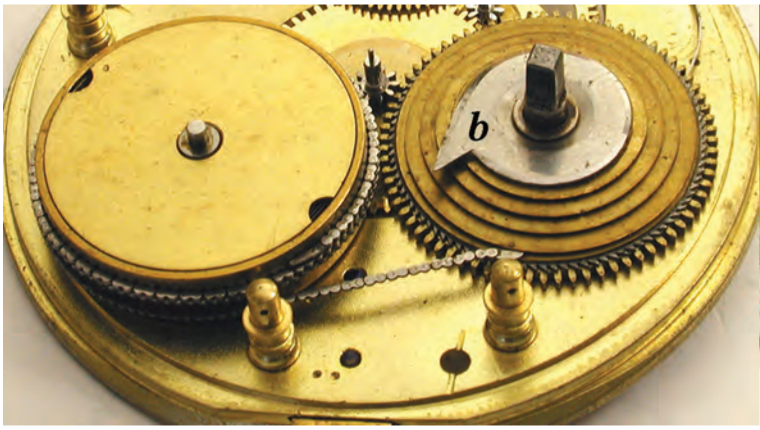


Figure 7-30

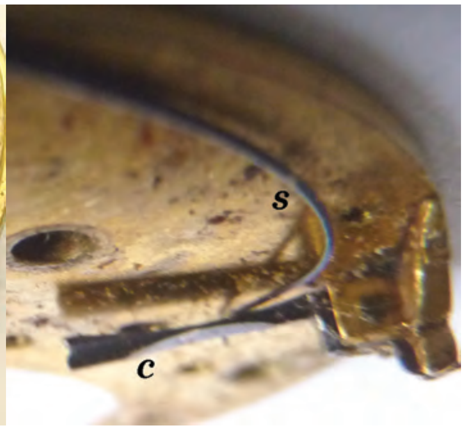


Figure 7-31

Normally, as the fusee rotates during winding and running, the beak of the fusee passes freely between the chain guard and the plate. But as the watch is wound the chain progresses up the fusee until, at the last turn, the chain presses the chain guard up towards the plate and it then obstructs the fusee beak, preventing the fusee turning further. As the watch runs, the chain moves down the fusee, releasing the chain guard, and the beak again passes freely.

The watch described in the report modified this design so that the chain guard locks the rotating weight instead of the fusee. As the report says:

> *Finally, to prevent the main spring being wound up any more, because it is already at its maximum, the chain guard carries a small pin which protrudes through the plate, inside the slots of a ring attached below the rotating weight.*

Therefore, when the mainspring is completely wound, the rotating weight is locked and can no longer move. This system is shown in Figure 7-32. Its action is obvious.

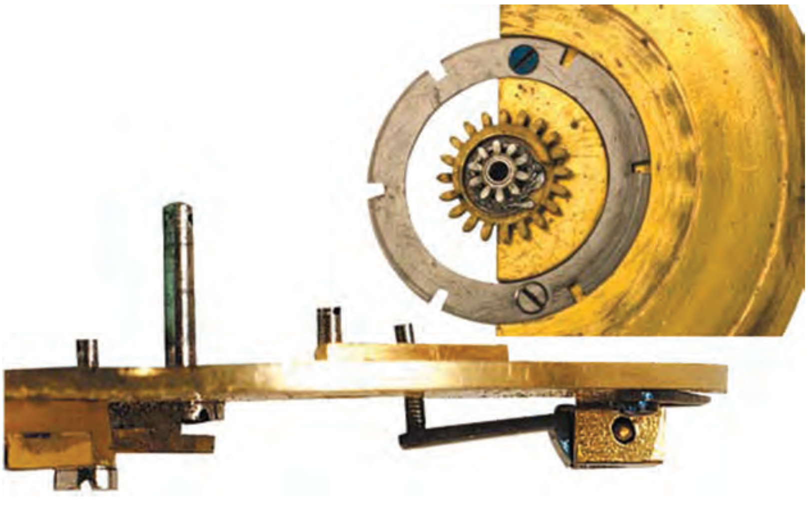


Figure 7-32

Finally, the reporters noted that:

> *It results from all this, that we state that this watch is well designed to produce its effect, but the need to have all the parts that it demands, causes a disadvantage which is not compensated by the small advantage of not having to wind it, and this disadvantage is all the space that these parts require, which deducts much from that which is necessary for others more important, like the verge escape wheel and balance.*

Figures 7-9 and 7-10 illustrate this disadvantage, where the balance and escapement have been moved to a limited area on the edge of the plate.

7.4: Planetary Gears

The design of the fusee, which uses *planetary gears*, deserves special attention. In general, a planetary gear system has the form shown in Figure 7-33, where:

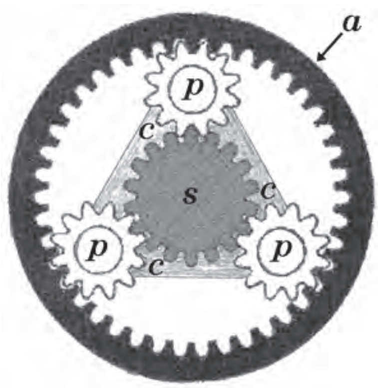


Figure 7-33

> ***s***: The *sun* gear with ***Ns*** teeth, mounted on the central arbor.
>
> ***p***: The *planet* gears with ***Np*** teeth, mounted on the *carrier* ***c***.
>
> ***a***: The *annular* gear (shown in black) with ***Na*** *internal* teeth.

Thus there can be three concentric axles, which are attached to the sun gear, the planet gear carrier and the annular gear. Attaching axles to the planet gears is very difficult; as well as turning on their centers, they pirouette around the center of the system, the center of the sun gear.

Normally the formula relating these gears is expressed in speeds, turns per second. But in the context of horology the speeds are not important and it is more useful to consider the relative number of turns.

To derive the formula for the motion of the sun, carrier and annulus, first note that the number of turns of each component, although related, is arbitrary. If we make one component rotate a fixed number of turns, the other two can rotate varying, related numbers of turns. So instead of looking at absolute values we will examine the relative numbers of turns with respect to the carrier.

If ***Ts***, ***Tc*** and ***Ta*** are the number of turns of the sun gear, the carrier and the annular wheel, then we want to find the ratio of the turns of the sun gear and the annular wheel *with respect to the carrier*; that is:

$$(Ta - Tc) / (Ts - Tc)$$

As the motion of the carrier is irrelevant, this ratio is determined by the number of teeth of the wheels and is:

$$- NsNp / NpNa = - Ns / Na$$

This is is negative because the sun and the annulus rotate in opposite directions. That is:

$$(Ta - Tc) / (Ts - Tc) = - Ns / Na$$

Re-arranging, we have:

$$Na\,(Ta - Tc) = -\,Ns\,(Ts - Tc)$$

And so:

$$NaTa + NsTs = (Na + Ns)\,Tc$$

All gears must, of course, have identical teeth in order to mesh correctly. This leads to an important constraint.

Let ***Rs***, ***Rp*** and ***Ra***, Figure 7-34, be the radii of the pitch circles of ***s***, ***p*** and ***a***. As these pitch circles touch it is necessary that $Ra = Rs + 2Rp$ and consequently their circumferences are related by

$$2\pi Ra = 2\pi Rs + 2\pi 2Rp$$

Now if ***D*** is the common tooth and space distance, then the circumferences of the gears are ***DNs***, ***DNp*** and ***DNa*** respectively, so $DNa = DNs + 2DNp$ or $Na = Ns + 2Np$, and the planetary gear formula can be rewritten as:

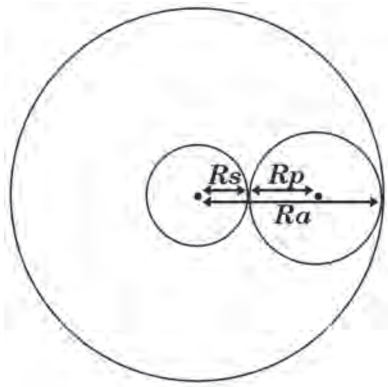


Figure 7-34

$$(2Np + Ns)\,Ta + NsTs = (2Np + 2Ns)\,Tc$$

In practice, one of the three axles is locked and the turns ***T*** for that axle are zero. Then one axle provides the input and another the output. There are three possibilities:

(a) $Ts = 0$, the sun gear is locked: Then $(2Np + Ns)\,Ta = (2Np + 2Ns)\,Tc$. Note that ***Ta*** and ***Tc*** are either both positive or both negative. This means that the annular gear and the carrier rotate in the same direction.

(b) $Ta = 0$, the annular gear is locked: Then $NsTs = (2Np + 2Ns)\,Tc$. Again, the sun gear and the carrier rotate in the same direction.

(c) $Tc = 0$, the carrier is locked: Then $(2Np + Ns)\,Ta = -\,NsTs$. In this case the sun gear and the annular gear rotate in *opposite* directions.

In the case of the rotor watch fusee described in Section 7.3 above: ***s***, the sun gear, is on the fusee arbor; ***p***, the planet gear, is mounted on the fusee cone ***c*** (the carrier); and ***a***, the annular gear, is part of the first wheel of the watch train mounted under the fusee. As we have $Ns = Np = 10$ the constraint means it is necessary that $Na = 30$, which is the case. Then:

(a) *Winding*: The input is ***s*** from the fusee arbor and the output is ***c*** to the fusee cone. The first wheel, attached to ***a***, is locked by the rest of the watch train. (It is of course rotating, but very slowing relative to the other gears and so is effectively stationary during winding.) In this case $Ta = 0$ and for one turn of the fusee cone, $Tc = 1$, we have $NsTs = (2Np + 2Ns)$. As $Ns = Np = 10$, $Ts = 40/10 = 4$. That is the fusee arbor must turn four times anti-clockwise to turn the cone once anti-clockwise.

(b) *Running*: The input is from ***c***, the fusee cone and the output is to ***a***, the first wheel. The fusee arbor ***s*** must be locked; if it was not, the fusee cone would turn the arbor and no power would go to the train. So $Ts = 0$ and

$$(2Np + Ns)\,Ta = (2Np + 2Ns)\,Tc.$$

Thus, for one clockwise turn of the fusee cone, $Ta = 40/30 = 4/3$ turns clockwise. This ratio means that the mainspring needs to be stronger to provide the same power to the train as would occur with a normal fusee.

This situation can only occur when the self-winding mechanism is inactive and stops the fusee arbor from turning; that is, the watch is stationary or the mainspring is fully wound. Otherwise case (a) applies.

(c) *Maintaining power*: First, if the planet gear carrier is locked and $Tc = 0$, then

$$(2Np + Ns)\ Ta = -\ NsTs$$

and the annular gear rotates in the opposite direction to the sun. While the watch is being wound and the annular gear is locked, the torque created by the self-winding mechanism (or by turning a key) acts on the first wheel of the train in the opposite direction, that which is required to run the watch.

Although planetary gears are very old, the earliest relevant design for a fusee is that described by Huygens in 1683 (Huygens, 1934); see Figure 7-35 (this figure has new labels to be consistent with the planetary gear terminology above).

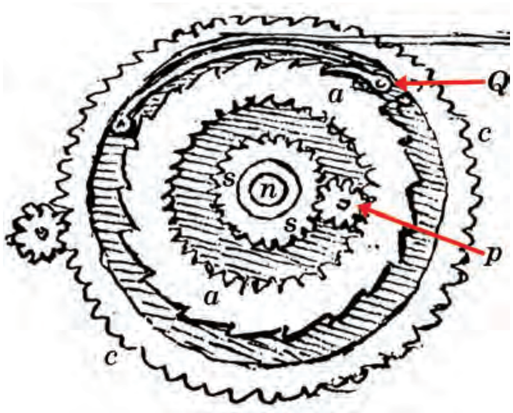


Figure 7-35

This mechanism, designed to provide maintaining power, differs from the rotor watch in two ways. First, it has a ratchet and click ***Q*** linking the fusee cone and the first wheel, as in ordinary fusees. And second, compared to the rotor watch fusee, the roles of the fusee cone and the first wheel are reversed, the fusee cone becoming the annular gear ***a*** and the first wheel becoming the planet gear carrier ***c***. That is, the combined annular gear and ratchet ***a*** is fixed to the cone, and the planet gear ***p*** is fixed to the first wheel. Which means, when the watch is wound by turning the sun, the carrier is fixed ($Tc = 0$) and

$$(2Np + Ns)\ Ta = -\ NsTs$$

Consequently:

(a) *Winding*: The fusee arbor ***s*** is turned *clockwise* and the output is to the fusee cone ***a***, which turns *anti-clockwise*. The first wheel ***c*** is locked by the train (see above) and the carrier cannot move. As the cone rotates, the click ***Q***, attached to the first wheel, slides over the ratchet, attached to the fusee cone, and has no effect. So, for the planet gear ***p*** to turn, it necessarily creates a clockwise force on the carrier, providing maintaining power.

Note that this design is inferior, when compared with the rotor watch, because the key has to be turned in the counter intuitive direction to wind the watch.

(b) *Running*: The input is from the fusee cone and the anular gear ***a***, and the output is to the carrier ***c***, the first wheel. This is achieved by the ratchet and click; as the ratchet rotates with the fusee cone, the click forces the first wheel to rotate with it, and both turn as a single unit. So in the formula given above, $Tc = Ta$ and:

$$NsTs = (2Np + 2Ns)\ Ta - (2Np + Ns)\ Ta = NsTa$$

That is $Tc = Ta = Ts$ and all three parts rotate together as in an ordinary fusee.

In fact, if any two components of a planetary system are locked together then all three components move together and the gears are locked.

Huygens suggests using a 2:1 ratio so that the key is turned twice to turn the fusee cone once; that is, $\boldsymbol{Na} = 2\boldsymbol{Ns}$. As the constraint requires $\boldsymbol{Na} = \boldsymbol{Ns} + 2\boldsymbol{Np}$, then $\boldsymbol{Ns} = 2\boldsymbol{Np}$. For example, $\boldsymbol{Np} = 8$, $\boldsymbol{Ns} = 16$ and $\boldsymbol{Na} = 32$.

Later, Thiout (1741, volume 2, page 383 and Plate 38) described a clever, if pointless mechanism to enable a fusee to be wound while turning the key in either direction, aptly named a *drunken fusee*; see Figure 7-36.

The problem here is to devise a mechanism so that, during winding, the fusee cone always rotates anti-clockwise irrespective of the direction in which the arbor rotates.

Fusee of a Watch that winds to the right & to the left, by Mr Vergo.

> ***AB** is the mounted fusee; one then sees it separated from its wheel in Fig. **A B**. **BB** is the wheel upside down which represents Mechanism. **C** is a ratchet; it carries a pinion **D** of 6 that gears in a pinion of 8 that is fixed onto the arbor. **E, F** are two clicks, the click **E** retains the ratchet **C**, & the click **F** retains the second ratchet **G** placed in the base of the fusee. This ratchet is made of a circle toothed internally at the place **I** to gear in the pinion of 6, so that when one normally winds the Watch the two ratchets act together, but when one winds it the wrong way, the ratchet **C** remains fixed, & the fusee acts by the means of an intermediate pinion & the second ratchet **G**, in this case the fusee goes much more slowly; the convenience which is in this fusee made him give it the name of the drunken fusee. Indeed, one can by its Mechanism do nothing to force in the Watch, because which ever way you turn it, it always winds the movement. Mr Vergo does not claim to be the first who made these fusees, since he based this only on what he had heard of the first ones that are very old.*

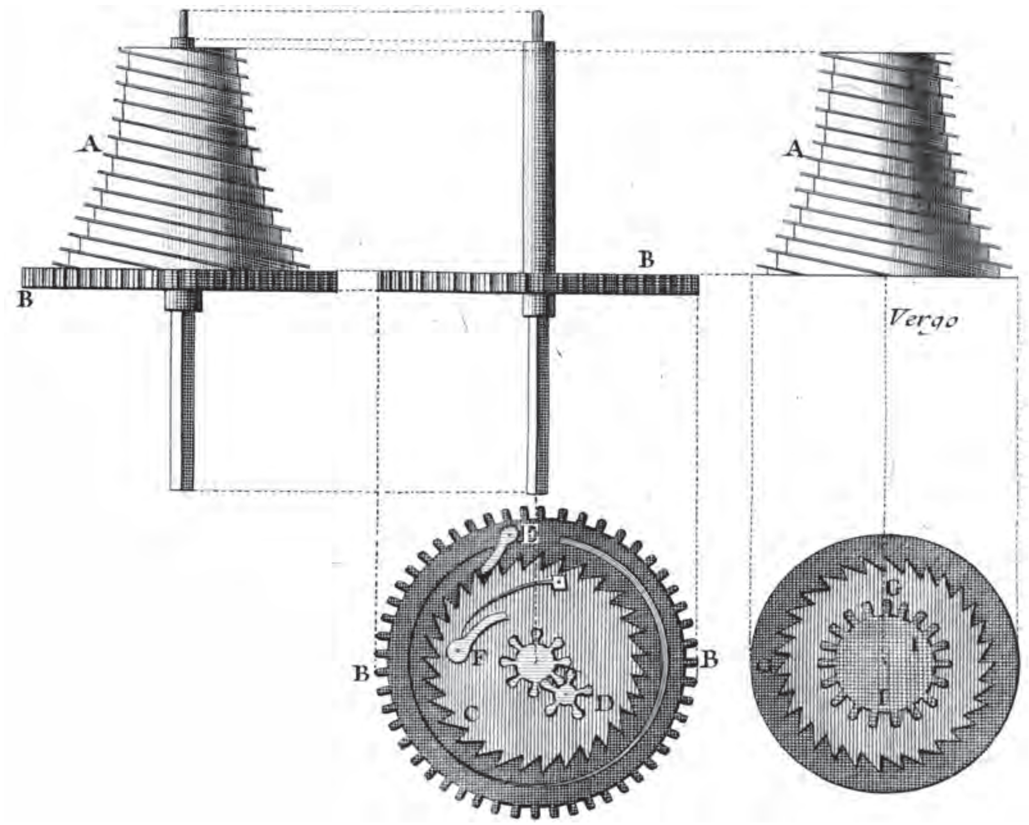


Figure 7-36

The original drawing in Figure 7-36 is both wrong and confusing. To understand the mechanism, Figure 7-37 corrects an error in the position of the click ***F***, and it also changes the view of the bottom of the fusee so that both it and the first wheel are viewed from above; that is, the former is a "transparent" view through the fusee cone. The figure has some different labels to match the terms we are using.

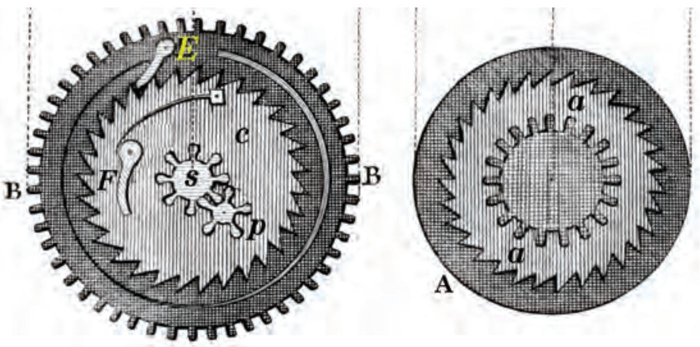


Figure 7-37

Another problem is that Thiout's drawing shows the different parts at the wrong size. First, as in Huygens's fusee, ***a*** is a (steel) ring with the annular gear teeth on the inside and a ratchet on the outside. Obviously the annular gear must be large enough to fit around the planet gear ***p***, which it is not. Second, the carrier ***c***, a (steel) disk with ratchet teeth on the outside, must be much larger than ***a*** so that its click ***F*** can mesh with the ratchet on the outside of ***a***. The two steel pieces are, of course, on different levels, the carrier ***c*** being under the annular gear ***a***.

To achieve the desired effect, the planet gear carrier ***c*** is loose, linked to the rest of the mechanism by the two clicks ***E*** and ***F***, and the annular gear ***a*** is rigidly attached to the fusee cone. Then:

(a) *Running*: When the watch runs the fusee cone, with ***a*** attached, rotates clockwise. The ratchet on ***a*** meshes with the click ***F*** and forces the loose planet carrier ***c*** to rotate clockwise. In turn, its ratchet meshes with the click ***E*** mounted on the first wheel ***B*** and so forces the first wheel to turn clockwise. In this situation, the annular gear ***a*** and the planet carrier ***c*** are locked and rotate together, $Ta = Tc$; so the fusee arbor ***s*** rotates with them.

(b) *Anti-clockwise (normal) winding*: This is the same as running but in reverse. When the fusee arbor ***s*** is rotated anti-clockwise, it causes the planet gear ***p*** to rotate clockwise and simultaneously attempt to turn the planet carrier anti-clockwise. But the click ***F*** locks the carrier to the annular gear ***a*** through its ratchet and so $Tc = Ta$. As the planetary gears are locked, $Ts = Ta$ and winding is the same as in an ordinary fusee.

(c) *Clockwise winding*: When the fusee arbor ***s*** is rotated clockwise, it causes the planet gear ***p*** to rotate anti-clockwise and simultaneously attempt to turn the planet carrier ***c*** clockwise. But the click ***E*** locks the carrier and so $Tc = 0$ and

$$(2Np + Ns)\ Ta = -\ Ns\,Ts$$

That is, the annular gear and the fusee cone rotate anti-clockwise.

Using Thiout's tooth counts, $18\,Ta = -\ 8\,Ts$ and so for $Ts = 1$, $Ta = -\ \frac{4}{9}$. Thus it takes about 2 turns of the key to turn the fusee once. Note that in the illustration $Na = 19$ which is incorrect; it should be 18.

(d) *Maintaining power*: Maintaining power can only be provided to the first wheel ***B*** when the carrier ***c*** is turning clockwise and power is provided through the click ***E***. As the carrier rotates anti-clockwise in (b) there is no maintaining power when the fusee is wound in the normal direction.

In 1742, Massotéau de Saint Vincent claimed he was the inventor of this design (Paris, 1742, pages 1667-1671), and his fusee is shown in Figure 7-38.

The drawing is confusing because the action of the click ***P*** is not clear. However it prevents the sun gear from turning anti-clockwise relative to the planet carrier ***N***. (Also note that a fold in the paper has hidden part of the fusee cone.) So:

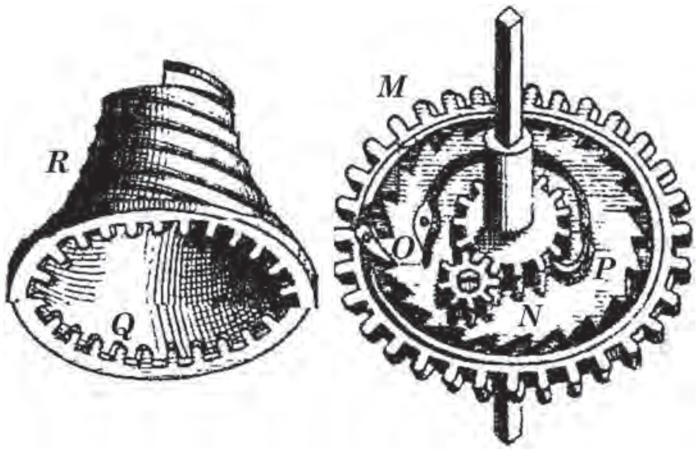


Figure 7-38

(a) *Running*: When the watch runs the chain rotates the fusee cone ***R*** clockwise. In turn, the annular gear ***Q*** tries to turns the planetary gear clockwise and the sun gear anti-clockwise. However, the click ***P*** prevents this movement and locks the sun and the planetary carrier ***N*** together. So, as above, the fusee cone, carrier and fusee arbor rotate clockwise together. And, because of the click ***O***, the first wheel ***M*** rotates with them, running the watch.

(b) *Anti-clockwise (normal) winding*: This is the same as running but in reverse. When the fusee arbor is rotated anti-clockwise, the click ***P*** locks the sun and the planet carrier ***N*** together. As before, this causes the planet gear to turn the annular gear anti-clockwise and the watch is wound.

(c) *Clockwise winding*: When the fusee arbor is rotated clockwise, the click ***P*** is no longer active and the sun and the carrier ***N*** can turn separately. So the planet gear rotates anti-clockwise and simultaneously attempts to turn the planet carrier clockwise. But the click ***O*** locks the carrier and so $Tc = 0$ and therefore we have $(2Np + Ns)\,Ta = -NsTs$, and the annular gear and the fusee cone rotate anti-clockwise.

Using Massotéau's tooth counts, $Ns = 12$ and $Np = 8$, $28Ta = -12Ts$ and so when $Ts = 1$, $Ta = -3/7$.

(d) *Maintaining power*: Massotéau states his design always provides maintaining power, whether the key is turned clockwise or anti-clockwise. But as with Vergo's fusee, maintaining power can only be provided to the first wheel ***M*** when the carrier ***N*** is turning clockwise and power is provided through the click ***O***. As the carrier rotates anti-clockwise during normal winding (b) there is no maintaining power in this case.

Massotéau states that Thiout's fusee "in the manner that he shows it, cannot run, nor work." As we have seen, because the click is placed incorrectly, this is true. But Massotéau is not above criticism. In the same article he illustrates and describes a ship's capstan that he invented in 1719 which uses planetary gears. But in both he has omitted an essential wheel. We pity the sailors using it, for they would walk around endlessly without achieving anything! (See Appendix 7, page 375)

Finally, about 1771 John Arnold used planetary gears in at least three chronometer fusees, and Mercer (1972, pages 31 and 35, plates 29, 30, 41 and 42) illustrates two different fusees. These are the same as the rotor mechanism fusee described above, except they include a ratchet and clicks. So the planet gear is mounted on the fusee cone, the carrier, and the annular gear is part of the first wheel.

The first fusee, Figures 7-39 and 7-40, has a ratchet mounted on the fusee arbor and two clicks mounted underneath the first wheel. Figure 7-39 is a composite of two photographs showing the view from the top through a transparent fusee; when the watch runs the fusee and first wheel rotate clockwise. Figure 7-40 is also a transparent view looking down on the first wheel so that the direction of motion is the same in both illustrations; the ratchet and clicks are under this wheel.

Winding is the same as in the rotor watch. The sun gear, and its attached ratchet, turn anti-clockwise. The ratchet has no effect, because it is turning anti-clockwise and slides under the clicks. So the annular gear is locked by the train and $NsTs = (2Np + 2Ns)\ Tc$, the fusee cone turns anti-clockwise. When running, the fusee cone is turning clockwise and driving the system. So the planet gear tries to rotate the sun gear clockwise. However, now the clicks stop the ratchet from turning, locking the sun gear and the annular gears together, and the fusee behaves like an ordinary fusee. Specifically, $Ts = Ta$ and so:

$$(2Np + Ns)\ Ta + NsTa = (2Np + 2Ns)\ Ta = (2Np + 2Ns)\ Tc$$

And so $Ta = Tc$.

Figure 7-39

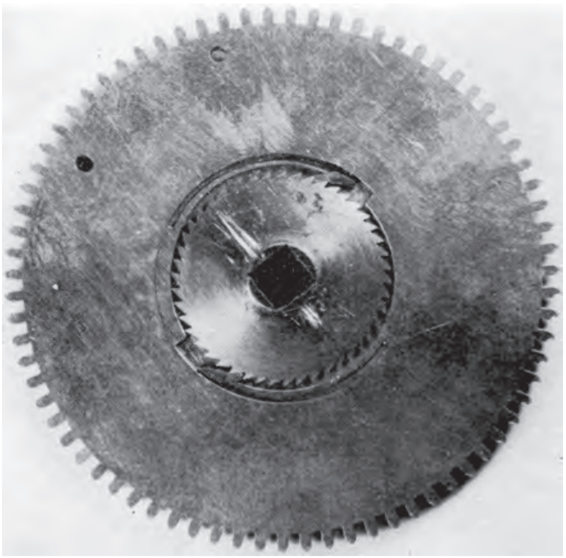


Figure 7-40

The second fusee, Figures 7-41 and 7-42, differs in that the ratchet is a part of the fusee cone, the carrier, and the clicks, as before, are mounted on the first wheel, the annular gear. Figure 7-41 is a transparent view through fusee, so the rotations are the same as in Figure 7-42, which is a normal view of the first wheel.

During winding, the fusee cone turns anti-clockwise and the ratchet has no effect, sliding under the clicks. During running, and clicks now operate between the first wheel and the fusee cone, the carrier, so $Ta = Tc$ and the fusee behaves as a normal fusee.

Mercer (1972, page 31) notes:

> *This* [planetary maintaining power] *involves a large amount of friction and would be liable to jam with constant use; which probably explains why No. 3 "refused to be wound up" when on the voyage with Captain Cook.*

Figure 7-41

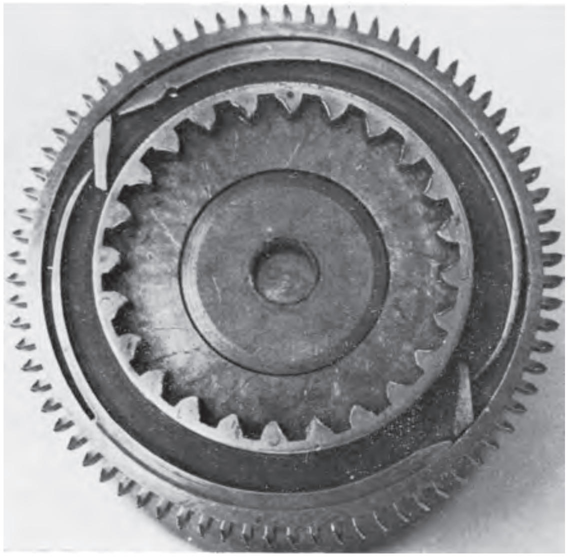


Figure 7-42

Certainly there is evidence of serious wear on the annular teeth.

However the problem has much more to do with Arnold's apparent incompetence than with inherent faults with the concept:

(a) In Figure 7-39 $\boldsymbol{Ns}$ = 12, $\boldsymbol{Np}$ = 7 and $\boldsymbol{Na}$ = 24. However, the constraint given above means it is necessary that $\boldsymbol{Na} = \boldsymbol{Ns} + 2\boldsymbol{Np}$ which is 26!

(b) And in Figures 7-41 and 7-42 $\boldsymbol{Ns}$ = 12, $\boldsymbol{Np}$ = 8 and $\boldsymbol{Na}$ = 24 when it should be 28!

That is, the annular teeth of the first wheel are the wrong size and there must be significant friction. It is interesting to note that the latter, worse case, shows more damage to the teeth, as we would expect.

From this it is clear that Arnold did not understand planetary gears. Where he got the idea from is unknown, but he must have learnt of the general principles and did not know of the constraint or did not realise its significance.

In addition, Arnold used very low tooth counts that were bound to cause problems, especially as the shapes of the teeth appear to be far from ideal. It seems that these wheels owe more to the *thumb and bay leaf* approach of hand-filing teeth than to epicycloid gearing, and we might suspect that he knew little or nothing of the advantages of high tooth counts.

This is not surprising. About 1837 John Hawkins visited a number of workshops to find out the practical methods used to form the teeth of wheels, including "Dent and Arnold, chronometer Makers" (Camus & Hawkins, 1837, pages 175-178). To quote part of his findings relating to the horology industry:

> *... the answers to the inquiries, were, by some, "we have no rule but the eye in the formation of the teeth of our wheels;" ... "in Lancashire they make their teeth of watch-wheels of what is called the bay leaf pattern; they are formed altogether by the eye of the workman; and they would stare at you for a simpleton, to hear you talk about the epicycloidal curve." ... The Lancashire workmen are called bay-leaf fanciers, because they cannot be bay-leaf copiers; since it is notorious that there are not two bay-leaves of the same figure.*

Hawkins goes on to describe a tool for cutting epicycloidal watch teeth, but adds:

> *One of our most eminent watch makers, however, says, that the prices at which, even first rate watches are sold, will not warrant the care that must be bestowed on them, to insure perfect accuracy in the figure of the teeth of all the wheels of a watch.*

The only watchmaker that we know of, who used epicycloid gear cutters, was American, probably the Waltham Watch Company (David, 1992, pages 68-70; 2003, pages 51-53). Indeed, such cutters are so difficult to make that they were replaced by circular cutters. In the Russian watch industry Tarasov (1962, page 160) notes:

> *The reason for the replacement of the epicycloids by circular arcs in gear-wheel teeth lies in the difficulty of producing milling cutters of epicycloid contour.*

Finally, although it is obvious from the above, there *must* be a ratchet and click in the mechanism somewhere. Otherwise the mainspring will unwind by the path of least resistance, which is the fusee arbor, and the watch could not run, ever.

7.5: The Problem of Decoupling

The focus of the above explanation has been on the provision of maintaining power, this being the main point raised by Leroy and Defouchy. But there is another, more serious problem that has been glossed over, probably because the rotor watch design solves it.

Ignoring the problem of maintaining power for the moment, imagine that an ordinary fusee, as in Figure 7-30, is used with the same self-winding mechanism, Figure 7-28; that is, a fusee in which the arbor and cone are a single piece (actually two pieces soldered together). Now, when the watch runs, the fusee cone and the winding wheel turn clockwise, and the intermediate wheel turns anti-clockwise, which *drives both ratchets* clockwise. As a result, the two clicks are active and try to turn the two driving wheels (***A*** and ***A'*** in Figure 7-28) clockwise. But they are geared together and cannot rotate in the same direction! So the winding system is locked and *none* of the wheels, including the winding wheel on the fusee arbor, can turn. Maintaining power is quite irrelevant because no power can *ever* be delivered to the train.

The consequence of this is simple:

> *Any self-winding mechanism used with a fusee must be able to be decoupled from the fusee cone for the watch to run.*

Seen in this light, the fusee design in Figure 7-21 is simply essential and the fact that it also provides maintaining power is secondary.

The fusee with planetary gears is not the only way to decouple the self-winding mechanism.

First, Recordon used a completely different method that enables an ordinary fusee to be used; as we will see in Chapter 8, page 95, decoupling is achieved by disconnecting the self-winding mechanism from the fusee arbor.

Second, decoupling, if that term can be used, is inherent in going barrels and is achieved by the mainspring. The inner end of the mainspring is used to wind the watch, via the barrel arbor, and the outer end to run it, via the barrel and its integrated first wheel. What is important is that both actions occur in the *same direction*, and the mainspring provides power to the train irrespective of whether the barrel arbor is turning or is stationary. And so the going barrel watches described in Chapters 8, 9, 10 and 11 need no special provision to achieve decoupling.

7.6: Performance of the Rotor Mechanism

The *Leroy watch* was tested by Mr P. Huguenin, who stated:

> *This self-winding system works well. When tested* [with the watch completely run down], *the chain coiled on the fusee and filled the first five spirals during the first twelve hours of wear in the pocket. Twelve hours later, the watch having been left at rest, the chain still covered four spirals. The motive power obtained during the first twelve hours sufficed to keep the watch running for a total of seventy-two hours.* (Chapuis & Jaquet, 1952, page 59; 1956, page 51.)
>
> *However, the greatest care was observed … and the wearer certainly moderated all his movements throughout the day he carried* [the] *watch in his pocket.* (Chapuis & Jaquet, 1952, page 50; 1956, page 59.)

Despite this test, Sabrier & Imbert (1974) state that the mechanism:

> *… did not ensure a sufficient winding; indeed, the weight swivelling in the center of the movement, when carried in the pocket, the "rotor", in the absence of energetic movements, remained hopelessly in the low position.*

These contradictory views are examined in Appendix 6.5, page 352.

We will be more precise and examine the behaviour of the mechanism in detail.

To do so, we must know the relevant gear ratios. Flores (2009, page 155) lists the number of teeth on the wheels and pinions of the rotor watch signed *Berthoud a Paris* and the *Leroy watch* has the same gearing. They are (see Figure 7-43):

Driving wheels ***A***, ***A′***	20		
Driving pinions ***B***, ***B′***	10	Driving ratchets ***C***, ***C′***	28
Intermediate wheel	50	Intermediate pinion	8
Winding wheel	60		
First wheel	72	Center-wheel pinion	8

In addition, the fusee holds 7 coils of the chain.

We will assume that the weight rotates y° and there is negligible play in the gears.

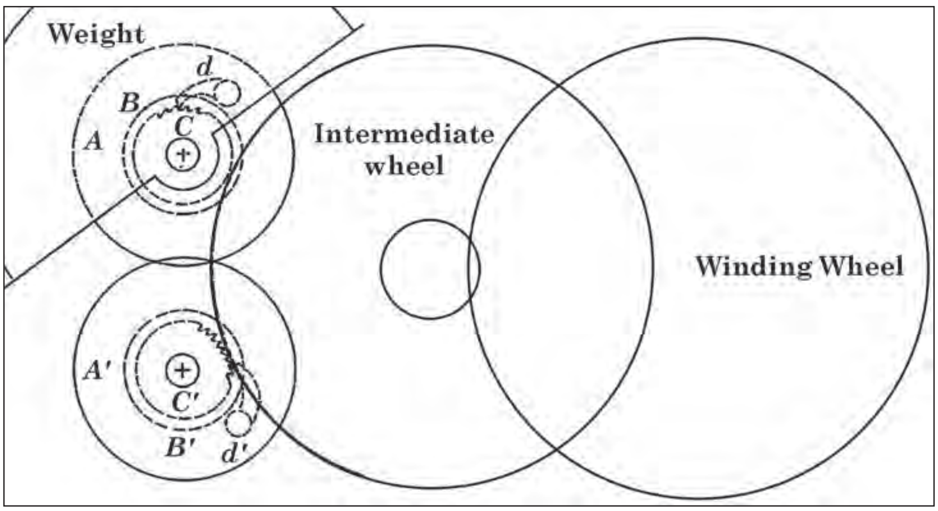


Figure 7-43

Also note that the force of the mainspring is always attempting to rotate the intermediate wheel anti-clockwise and this is prevented by one or both of the clicks $\boldsymbol{d}$ and $\boldsymbol{d'}$ being fully engaged with ratchet teeth. Obviously, to wind the watch the force provided by the moving weight must be greater than that of the mainspring.

When the weight rotates $\boldsymbol{y}^\circ$ anti-clockwise, the pinion $\boldsymbol{B}$ will rotate the intermediate wheel $(10/50)\,\boldsymbol{y}^\circ$ clockwise. At the same time, the intermediate wheel will turn the pinion $\boldsymbol{B'}\,\boldsymbol{y}^\circ$ anti-clockwise, and the wheel $\boldsymbol{A}$ will turn the wheel $\boldsymbol{A'}\,\boldsymbol{y}^\circ$ clockwise. That is, the *relative* motion of ratchet $\boldsymbol{C'}$ and the click $\boldsymbol{d'}$ is $2\boldsymbol{y}^\circ$. (The same will occur when the weight turns clockwise, the roles of the components being reversed.)

Now, the ratchets $\boldsymbol{C}$ and $\boldsymbol{C'}$ have 28 teeth which cover $360/28^\circ = 12.86^\circ$; for convenience we will round this to 13°. For the weight to wind the watch, it must rotate far enough to advance one of the ratchets by at least one tooth, so that a click can fall into this next tooth. This happens when the relative motion of $\boldsymbol{C'}$ and $\boldsymbol{d'}$ is 13° and so $\boldsymbol{y} = 6.5^\circ$. This is the minimum rotation needed to wind the watch.

When the weight rotates $\boldsymbol{y}^\circ$ it turns the fusee arbor $(10/50)(8/60)\,\boldsymbol{y}^\circ = (2/75)\,\boldsymbol{y}^\circ$. However, there is a 4:1 reduction between the fusee arbor and the cone (Section 7.4, page 75), and so the fusee cone turns $(1/150)\,\boldsymbol{y}^\circ$.

When the watch runs, 1 turn of the first wheel rotates the center wheel $72/8 = 9$ times; that is, for nine hours. But the fusee cone rotates the first wheel 4⁄3 turns and one 360° turn of the cone equates to 12 hours. Huguenin's statement is correct. For the Berthoud watch, Flores (2009, pages 87 and 154) gives the barrel diameter as 15 mm and the largest step on the fusee as 15 mm. Using the method in Section 5.2 (page 37) and the shape of the fusee in Figure 7-13, the mainspring would have about 7 turns of which 5½ are used.

If the cone turns $\boldsymbol{z}^\circ$ the watch will run for $(12/360)\boldsymbol{z}$ hours or $2\boldsymbol{z}$ minutes. The total reserve with 7 turns of the fusee is 84 hours or 3½ days.

Combining the two results, if the weight rotates $\boldsymbol{y}^\circ$ then the watch runs for $(2/150)\boldsymbol{y}$ minutes, and advancing one of the ratchets by a single tooth provides 5.2 seconds of running time.

More interesting is the amount of activity needed to fully wind the watch 7 turns of the fusee cone. If the fusee cone is to make seven 360° rotations, the weight must make 1,050 rotations.

Assume the watch is carried while constantly walking, and that the weight rotates 60° twice a second (30° on either side of vertical); that is, one oscillation per second. Because winding is bidirectional, all movements of the weight will cause winding, that is 120°, and it will take 3 seconds to turn the weight through 360°. So the total time to fully wind the watch is 3,150 seconds or 52½ minutes.

If a watch is carried regularly, 48 hours, or perhaps only 24 hours of running reserve is needed. These can be obtained after 30 and 15 minutes of walking respectively.

One oscillation per second is very slow, and it is possible to halve these times.

These estimates are approximate, but it is clear that the mechanism is very efficient and Huguenin's test must have involved many periods of rest.

Another useful measure of performance is the time taken to wind a watch by shaking it. If a rotor watch is shaken we can reasonably expect the weight to turn through at least 270°, and with four oscillations per second the weight will make the equivalent of 6 full rotations per second. As 600 rotations are required to wind the watch so that it will run for 48 hours, it would take about 100 seconds. To fully wind the watch would take 175 seconds, about three minutes.

7.7: Rotor Watches

As noted above, there are five known examples of rotor watches, but none are signed by Sarton. All five movements are technically identical. They are:

Figure 7-9, page 65, and Figure 7-48: Unsigned, cased movement, Patek Philippe Museum, Geneva. With serial numbers 22 and 3616. This is the *Leroy watch*.

Figures 7-44 and 7-49: Unsigned movement, Goud'Zilver Klokkenmuseum, Shoonhoven, Holland. With serial numbers 13 and 3483. I will call this the *Klokken* movement.

Figures 7-45 and 7-50: Cased movement signed *Berthoud à Paris*, Goud'Zilver Klokkenmuseum, Shoonhoven, Holland. With serial number 3246. As shown, this watch also has the number 4782 on the weight. Note that the engraving on the weight of this watch appears to be identical to that on the watch in Figure 1-3, page 8. This suggests the same engraver may have worked on both watches.

Figures 7-46 and 7-51: Cased movement signed on the dial *Mazzi à Locarno*, private collection. No serial number. (This watch is discussed in Appendix 6, page 339.)

Figures 7-47 and 7-52: Movement signed on the edge of the plate *Egidius Link, Augsburg*, Byer Collection, Zurich. The serial number, if any, is not known.

Figure 7-44

Figure 7-45

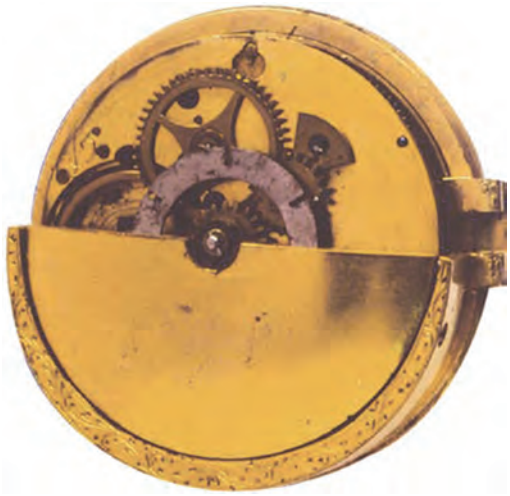


Figure 7-46

Figure 7-47

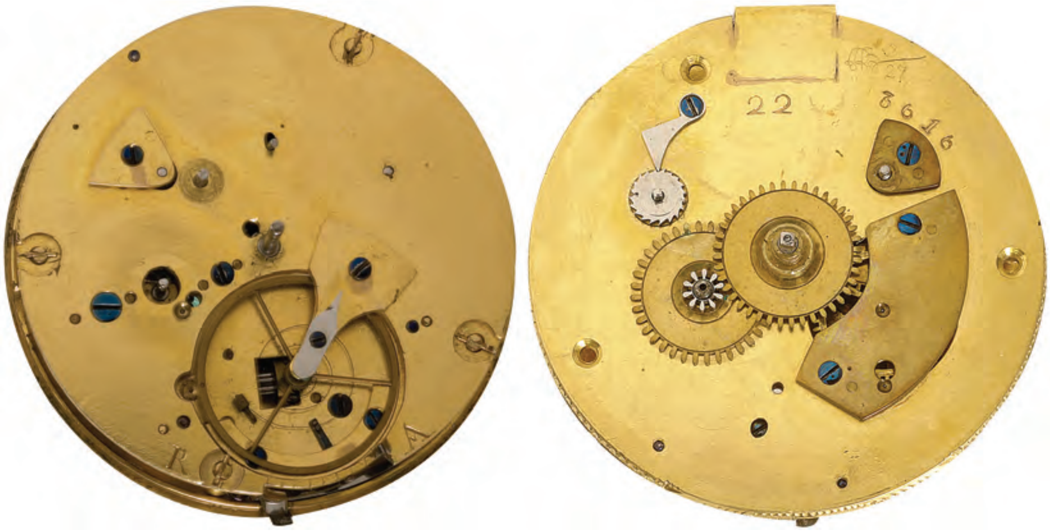


Figure 7-48

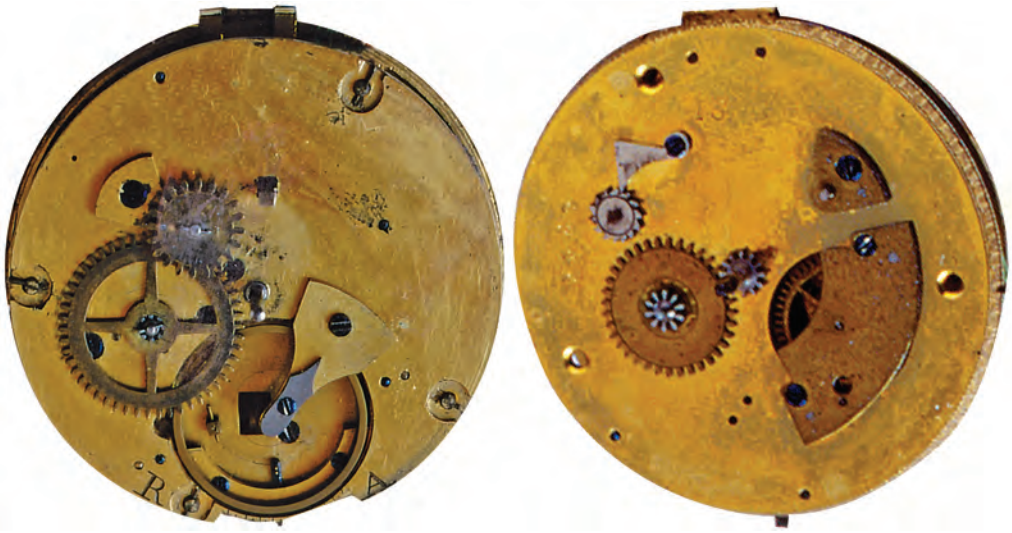


Figure 7-49

Figure 7-50

Figure 7-51

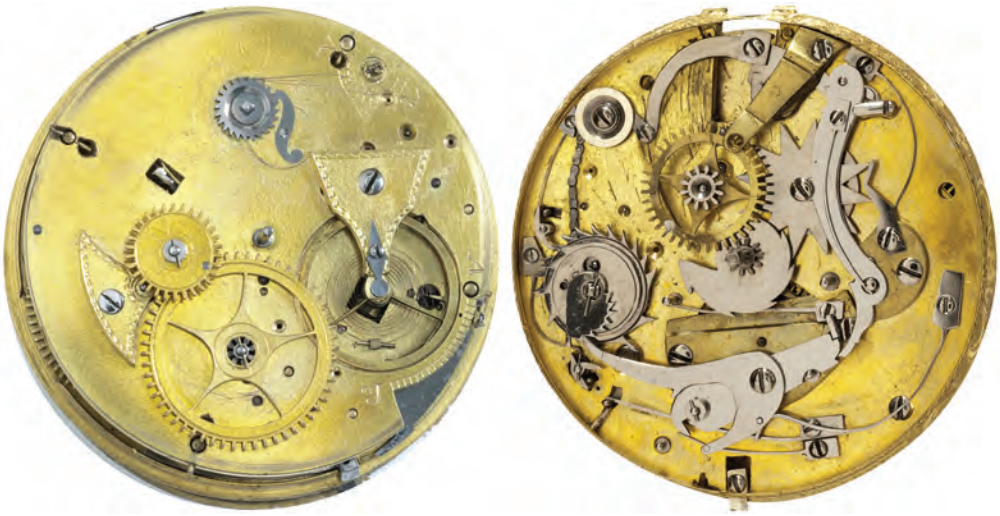


Figure 7-52

Finally, there is a sixth watch that probably has a rotor movement, Figure 7-53. The only information we have is that it was sold at auction in 1996: *Automatic pocket watch 18th century, signed Berthoud à Paris, No 4563, very interesting movement giving its value to the watch, very recent case. Estimate: 10,000 - 15,000 francs only for the movement!*

This watch is not the *Berthoud à Paris* watch in Figures 7-45 and 7-50. In addition to having a different serial number, the case, dial and hands of that watch are different, Figure 7-54 (from Flores, 2009, page 94).

© Montres Passion, 1996

Figure 7-53

Figure 7-54

It has been suggested that the serial numbers indicate établissage production, and the small numbers (13 and 22) may be those of the actual maker. In which case, it is possible that a series of 22 or more rotor watches were made. The large numbers (3246, 3483 and 3616) may be the serial numbers used by the établisseur who ordered the watches.

However, the different shapes of bridges and other variations show that these watches were not made in a batch. If they had been we would expect much greater similarity because the maker would have produced parts for several movements at the same time.

These movements are compared in Appendix 5, page 320.

7.8: Watches Signed Sarton

Although a number of watches signed by Sarton exist none are self-winding watches. The following illustrations are a small selection:

(a) Figures 7-55 and 7-56: Louis XVI watch movement. Cylinder escapement. Signed *H Sarton à Liège*.

(b) Figures 7-57 and 7-58: Watch in gold. Quarter repeater à toc, calendar. Verge escapement. Signed *Sarton à Liège*.

(c) Figures 7-59 and 7-60: Calendar movement. Verge escapement. Signed *Sarton à Liège*.

(d) Figures 7-61 and 7-62: Watch in silver. Direct center seconds with and Rigot stop seconds. Signed *Sarton à Liège*.

Figure 7-55

Figure 7-56

Figure 7-57

Figure 7-58

Figure 7-59

Figure 7-60

Figure 7-61

Figure 7-62

8: Louis Recordon (1756-1826)

8.1: Biography

It seems very little is known of Louis Recordon's early years. To summarise Chapuis & Jaquet (1952, pages 123-128; 1956, pages 131-136), he came from a family that was established at Ste. Croix in the Canton of Vaud, some members of which moved to Geneva and were watchmakers. Patrizzi (1998, page 337) adds that he completed his apprenticeship in Geneva.

In 1778 "he set up a second establishment in London" and later he was in partnership with Charles Dupont.

Although there is concrete evidence that Recordon had a significant business association with Breguet dating from the 1790s, Chapuis & Jaquet state:

> *It appears that, quite early in his career, in about 1775, Abraham-Louis Breguet established business relations with Louis Recordon at about the same time as with the elder Decombaz at Geneva. These three men formed a kind of association ... Recordon served as liaison officer, as it were, between Geneva, Paris and London.*

This is based on unpublished letters written by Decombaz and Recordon, but Chapuis & Jaquet do not provide any details or significant quotes. But as Recordon was only 19 years old in 1775 he is unlikely to have been in business.

In addition, Chapuis & Jaquet (1952, pages 130; 1956, page 139) cite a manuscript written by Edward Brown (head of Breguet) in 1895:

> *L. Recordon and A. Breguet were fellow countrymen and knew each other and I have strong reason to presume that Breguet was the maker of the watches patented by Recordon; I find on the books of Breguet many self-winding watches ... inscribed 'envoyées à Recordon à Londres' between 1780 and 1790.*

8.2: Recordon's 1780 Patent

Chapuis & Jaquet (1956, pages 141-151) provide the complete specification for Recordon's patent, followed by a five page analysis, which is not very good. (The French edition, Chapuis & Jaquet, 1952, pages 133-139, does not give the full specification.)

This patent, taken out on 18 March 1780, describes three mechanisms:

(a) Self-winding mechanisms. Two are presented, the first for use with a going barrel and the second for a watch with a fusee. Three variants of the second are described.

(b) A mechanism to convert a seconds display to jump seconds.

(c) An escapement.

The following considers only the first part of the specification that describes self-winding watches. The other two mechanisms are described by Flores (2003).

In order to make it intelligible, the text of the patent is interspersed with explanations. In addition:

(a) The figures have been renumbered to suit the format of this book, and the labels on the figures have been replaced to improve legibility.

(b) The text has been modified to improve readability, primarily by altering the spelling, but also a few errors have been corrected.

A.D. 1780 *MARCH 18* *No, 1249*

RECORDON'S SPECIFICATION

A description of the watches that renew their maintaining power without the use of a key or other manual operation and referred to in the annexed Deed.

This first part of the patent and its diagrams (Figures 8-1 to 8-3) describes a self-winding mechanism to be used with a going barrel. The original diagrams, Figures 8-1a and 8-2a, which must be views from the back (top plate side) of the watch, are wrong. From that perspective the center-wheel pinion must rotate anti-clockwise so that the hands rotate clockwise when viewed from the front of the watch. In Recordon's diagrams and description, the mainspring is wound when the weight drops, turning anti-clockwise. And then the intermediate wheel ***B*** rotates clockwise and the barrel arbor rotates anti-clockwise. That means the center pinion ***D*** rotates clockwise and, from the front of the watch, the hands rotate anti-clockwise. The diagrams given in Figures 8-1b and 8-2b correct that error by flipping the drawings so that they are mirror images of the originals.

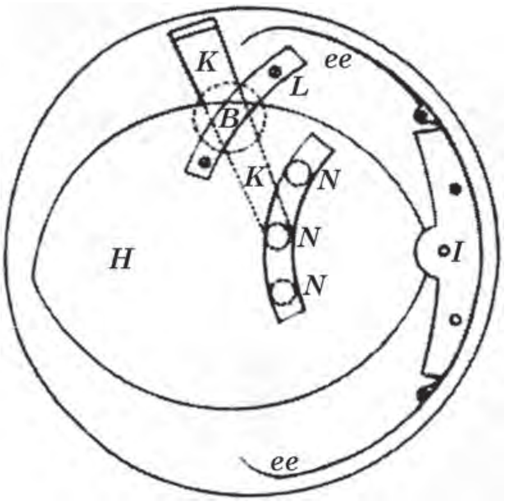


Figure 8-1a

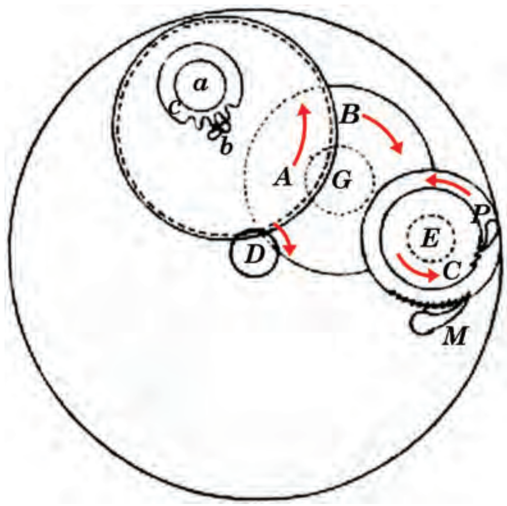


Figure 8-2a

*Letter **H** represents a weight of silver or other metal which is in equilibrium in the position it is viewed, being sustained so by a spiral spring fixed to its arbor as described by Fig. 8-3. In wearing the watch or by any external motion that lifts the watch up, it loses its state of rest and by its vis-inertia, the matter overcoming the strength of the spring, it yields to the laws of gravity and falls upon the lower spring marked **ee**. When the watch, by the motion of the body descends, the spring **ee** and the aforesaid spiral spring are left at liberty to exert themselves and return the weight upwards till it touches the other spring **ee**. ...*

Other than the old-fashioned language, the above description is clear.

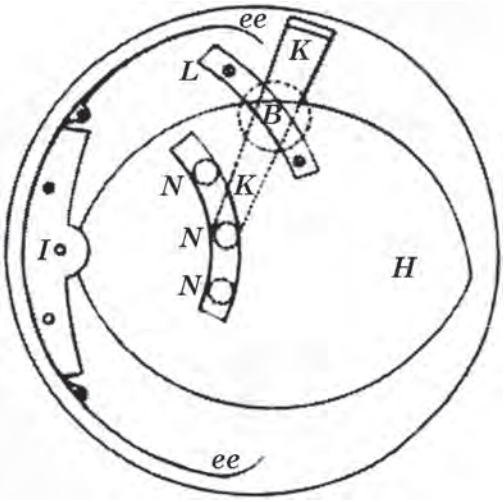


Figure 8-1b

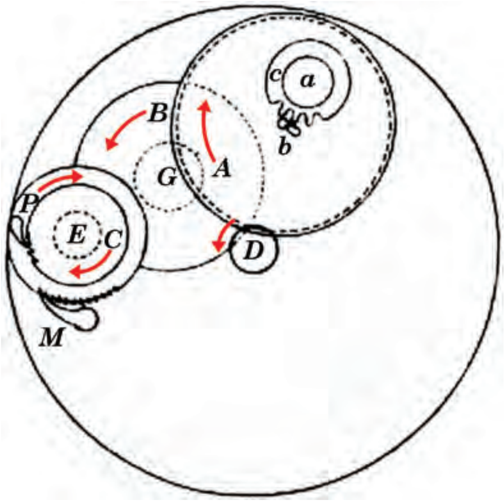


Figure 8-2b

Figure 8-3

*... and thus by the motion of the body is this weight alternatively thrown up and down, which, turning the ratchet wheel marked **C** in Fig. 8-2, which is fixed on the arbor of the weight just below the spiral spring, gathers a few teeth every motion in the wheel **P**, and being prevented from returning by the click **M**, carries forward the wheel with a pinion of 10 marked **E**, ...*

This system winds in one direction only. There is a click mounted on the ratchet ***P***, which is not mentioned in the text. This click meshes with the smaller ratchet ***C*** that is fixed to the weight. When the weight drops, moving clockwise, ratchet ***C*** turns ***P*** clockwise via the click. When the weight moves anti-clockwise, the teeth on ***C*** slide past the click and ***P*** does not rotate clockwise because the second click ***M***, mounted on the plate, prevents it from turning.

*... which turns the wheel **B*** [anti-clockwise]*, which having a pinion of 12 at **G** takes into and turns a wheel under the barrel **A*** [clockwise] *which is fixed on the barrel arbor and by that means is the spring wound up.*

Recordon has described the winding mechanism used by Breguet (see Figure 9-27, page 120) and the original Figure 8-2a in the patent has the same orientation. That is, it is correct for use with two barrels rotating anti-clockwise, but not for one barrel rotating clockwise.

*The upper part of the barrel arbor marked **b** has a tooth which gains a tooth in the wheel **a** at every revolution and that brings the pin **c** nearer to the center which, when it arrives in a certain position, it raises the piece **KK** Fig. 8-1 of which the center **B** is conical in order that when the said pin **c** comes nearer it, it raises it with ease and forces it into the holes marked **N N N** in the weight marked **H** Fig. 8-1 which effectually stops its motion and prevents the ill consequences of over winding.*

Except for the pin ***c***, the stop-work on the barrel arbor is the normal Geneva stop-work (see Appendix 7, page 360, for details of this mechanism). The pin ***c*** moves in a number of concentric circles around the arbor, repeatedly passing under the lever ***KK*** which is hinged at the edge of the plate.

The part of the lever ***KK*** that passes over the barrel arbor has a raised, conical section ***B***. When the watch is fully wound, the pin ***c*** meets this conical section and lifts up ***KK***. This raises the end of ***KK***, which has a pin that enters one of the three holes ***N N N*** in the weight, locking it.

***L** is a Cock that carries the pivot of the Barrel's Axis. **I** is a Cock that carries the pivot of the weight **H**. **A** is the barrel which carries a wheel that catches the pinion **D** which carries the minute hand.*

The second part of the patent (Figures 8-4 to 8-12) describes a self-winding mechanism to be used with a fusee.

> *Fig. 8-4 shews the plan of the upper plate with the weight and train of wheels marked **A B C** which are small and that marked **C** has a pinion which takes into the large wheel marked **D**.*
>
> *The weight marked **E** turns on the pivot at **F** and, by being partly suspended by a spiral spring in a box which may be seen in **G** Fig. 8-5 and at **G** Fig. 8-6, is enabled to play up and down by any external motion the watch may receive.*
>
> *Every motion carries the ratchet wheel **H** Fig. 8-7 some small way. It is prevented from returning by a click at **I** in Fig. 8-8 and on the return of the weight the click at **K** Fig. 8-7 gaining some few teeth carries the ratchet wheel still further and thus by the alternate motion of the weight up and down is the train of small wheels marked **A B C** in Fig. 8-4 carried round which taking by its pinion at **C** Fig. 8-8 into the wheel **D** which being fixed on the square of the fusee the chain is wound up off the barrel marked **L** in Fig. 8-8 and Fig. 8-9 ...*

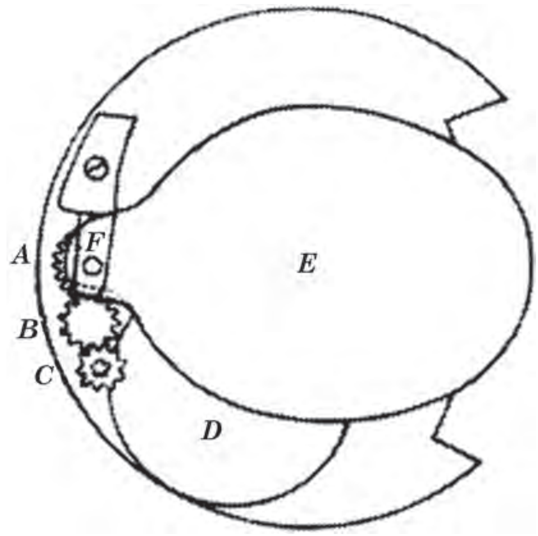


Figure 8-4

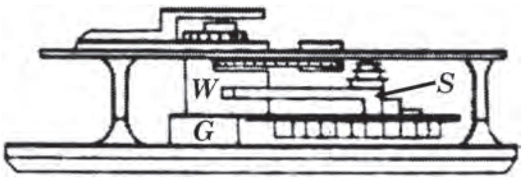


Figure 8-5

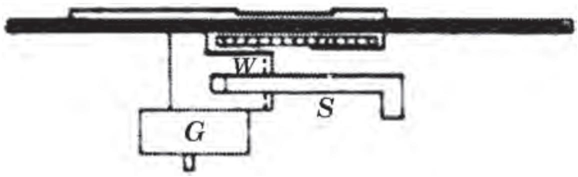


Figure 8-6

So far this mechanism is basically the same as that in the going barrel watch above. As Figure 8-7 is a view of the underneath of the weight, the weight only winds the watch when it drops, turning clockwise.

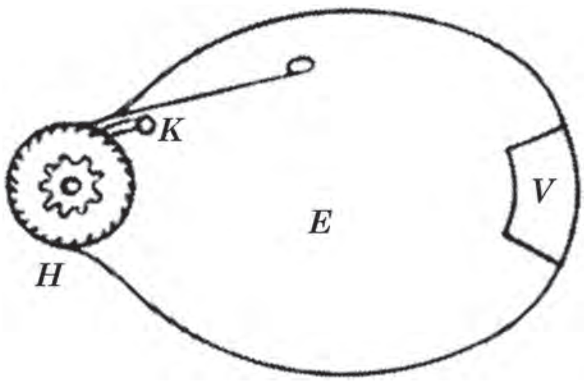


Figure 8-7

Under ***D*** there is a normal fusee with a ratchet and click connecting it to the first wheel, so that when the fusee turns clockwise it drives the train of the watch. The click ***I*** is mounted on the plate ***W*** (see below) and stops the wheel ***A*** from turning clockwise. But ***A*** must turn clockwise to wind the watch and the click must be reversed (as shown in red) so that it stops ***A*** from turning anti-clockwise and unwinding the mainspring. But the fusee and ***D*** must be able to turn clockwise to run the watch, and without some other mechanism the click now prevents the fusee turning to run the watch!

> *... and thus while the external motion is continued does the watch continue winding up till the chain is nearly wound off the barrel, and then the chain being on the top of the fusee winds against a piece of steel marked **M** Fig. 8-9 which being pinned to another piece of steel marked*

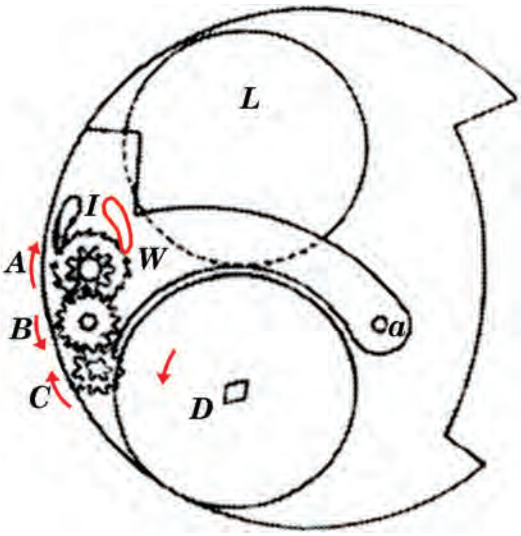


Figure 8-8

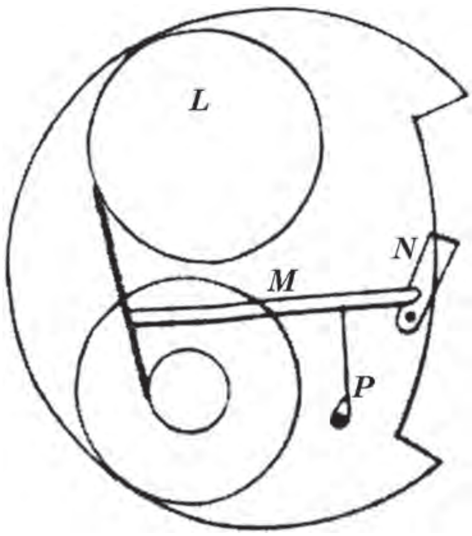


Figure 8-9

> ***N*** *Fig. 8-9 is by that means thrown outwards and fixes against the part of the weight marked* ***V*** *in Fig. 8-7 and Fig. 8-10 which stops all motion in the weight till the watch by going down a small way suffers the steel* ***M*** *to return to its former situation which is caused by the spring marked* ***P*** *which draws in the steel marked* ***N*** *and the weight is then suffered to go on again.*

> *Fig. 8-10 is a side view of the weight. The arbor marked* ***Z****, the pivot at the upper end works in the Cock* ***F*** *Fig. 8-4. The pivot at the lower end works in the barrel cover at* ***G****, Fig. 8-6.*

Figure 8-10

This is obscure. Figure 8-9 is a view of the inside of the top plate. Because of the action of the chain, the lever ***M*** cannot turn sideways and must rock up and down with its pivot point somewhere near the center. So the left end of ***M*** at the chain is normally held away from the plate by the spring ***P*** and, when the chain reaches the top of the fusee, it is pushed up towards the plate. That is, when this stop-work is activated, the end of ***M*** at ***N*** moves away from the plate and so moves ***N*** into the path of ***V***. Note that ***N*** cannot be given a rotational movement by ***M***. So for this to work, ***N*** must have vertical movement, and the statement that ***N*** is *"by that means thrown outwards"* must mean to move away from the plate.

> *A provision is likewise made to throw off the operation of the renovating part that when the watch hangs up at rest it may not impede the performance of that part which relates to the measuring time and is effected in this manner.*

Not surprisingly, at this point the analysis in Chapuis & Jaquet (1956, page 150) becomes very short and very vague!

Recordon is noting a serious problem, the need for *decoupling*; see Section 7-5, page 82. The fusee is an ordinary fusee in that the arbor and the cone are rigidly joined together and click-work in the base of the fusee links the cone to the first wheel under it. So when the watch is running it is essential that the fusee can turn to activate the first wheel. But the weight and the train ***A B C*** only allow the fusee to turn anti-clockwise to wind the watch and the fusee cannot turn clockwise to run the watch.

Figure 8-4 is only a partial view of the mechanism and Figure 8-8 includes nearly all the additional features required to resolve this issue.

> *The piece marked **W** Fig. 8-8 turns on a screw at **a** which is so fixed that it is the centre of gravity to the weight being so poised, that the train of small wheels **A B C** the bridge **F** and spring box **G** and all the work at the small end of the weight, is but a counter balance to the large end and the whole turns freely on the screw at **a** Fig. 8-8 which it is suffered to do about ⅛th of an inch so that the pinion of the small wheel **C** in Fig. 8-4 may be of a proper depth in the large wheel **D** when the renovating part operates, but when the watch is hung up the wheel **D** by turning towards the train of small wheels throws the pinion out of its teeth and then is entirely disengaged from them by the piece marked **W,** slipping ⅛th of an inch towards the barrel ...*

With the exception of the winding wheel ***D***, fixed to the fusee arbor, the entire self-winding mechanism, including the weight, is attached to the plate ***W*** pivoting at ***a***. This assembly is poised so that its center of gravity is at ***a***, or near enough. Consequently we can view the mechanism as a balanced see-saw whose motion is limited, in one direction by the pinion of wheel ***C*** meeting ***D***, and in the other direction by a slot and pin (not shown).

The mechanism as described is satisfactory for the watch when it is as rest.

When it is hung on a hook, for example, the winding wheel, Figure 8-8 ***D***, attached to the fusee arbor, rotates clockwise as the watch runs. Because ***W*** is poised, the pressure of the teeth of ***D*** on the wheel ***C*** is sufficient to push ***C*** away from ***D***, rotating ***W*** clockwise around its pivot ***A*** and moving ***C*** out of mesh with ***D***. A slot and a pin limit this movement. Now the fusee is free to turn clockwise (under the force of the mainspring) to run the watch. Obviously the teeth of ***C*** and ***D*** must be carefully shaped so they cannot lock together.

But the mechanism cannot work when the watch is being wound by the weight. Because the system is poised, when the weight drops, rotating clockwise, this movement must rotate ***W*** (the other end of the lever) taking ***C*** out of mesh with ***D***. This is made worse by the fact that the pressure applied by wheel ***C*** on ***D*** will also force the assembly ***W*** to rotate clockwise and throw ***C*** out of mesh with ***D***. So the fusee will not rotate. When the weight rises, it moves ***W*** so that ***C*** and ***D*** are in mesh and the watch can run provided the train ***A B C*** can rotate. Which is true, provided the click ***I*** does not exist, because the click ***K*** is not active.

Finally, Recordon describes the two missing pieces:

> *... but in order to convey the same power to the balance at all times there is a ratchet something larger than the great wheel teeth fixed to the great wheel as marked **Q** Fig. 8-11 and 8-12 which the piece marked **S** in Fig. 8-5 and 8-6 and turns upon a pin where the dots are near **W** in Fig. 8-6 by which means all the power which is used in forcing up the wheel **D** is applied to the ratchet of the great wheel and consequently the same power carried to the balance, but this is only in use while the renovating part is in action for at other times the ratchet of the great wheel passes it freely.*

Figure 8-11

Figure 8-12

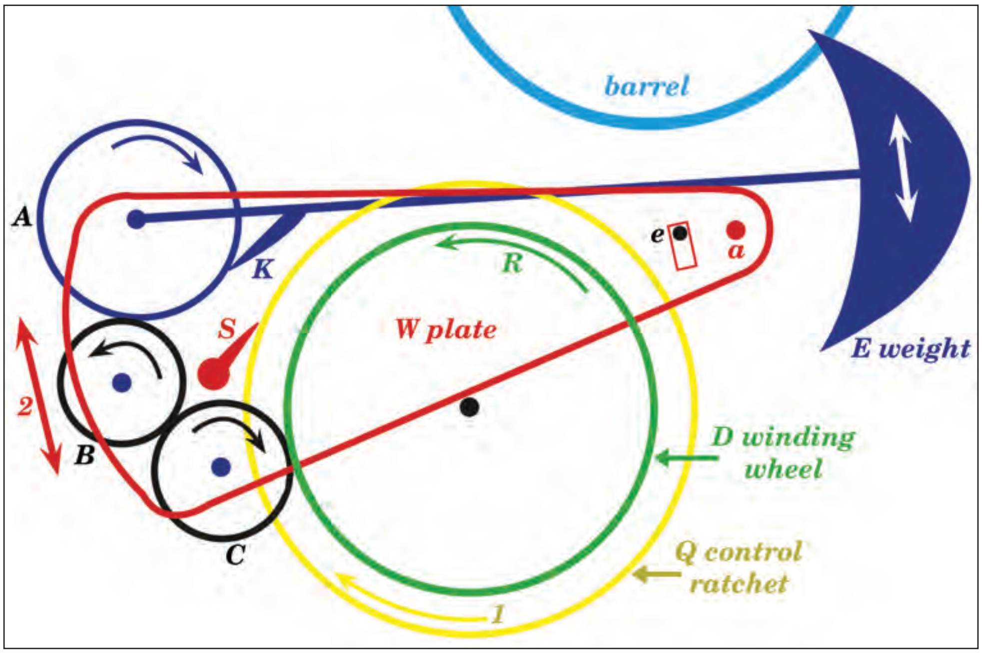


Figure 8-13

Figure 8-13 shows the purpose of ***S***. It does not show the first (great) wheel or the center-wheel's pinion, and it omits the incorrect click ***I***.

The ratchet ***Q*** is rigidly fixed to the first wheel and Figure 8-11 shows it as a wheel with a square in the middle. To work, the fusee must have the normal click-work consisting of a ratchet fixed to the inside of the base of the cone and a click and spring attached to the first wheel. These must work together and nothing can be placed between them. So presumably the click and spring are mounted on ***Q***, which is squared onto a boss on the first wheel with the fusee arbor passing inside it.

S is a click mounted on the plate ***W***. It is rather long so that it can mesh with ***Q*** no matter the position of ***W***. The effect of these two parts is:

(a) When the weight ***E*** drops (Figure 8-13): The click ***K*** activates the train ***A B C*** (in the direction of the arrows). The click ***S*** locks into ***Q***, stopping the plate ***W*** from turning clockwise and ensuring that the wheel ***C*** remains in mesh with the winding wheel ***D***. So the fusee cone turns anti-clockwise in the direction of the green arrow ***R*** and the mechanism winds the watch.

At the same time, the force produced by the weight dropping, which tries to rotate ***W***, is transferred by the click ***S*** to the ratchet ***Q*** which attempts to turn the ratchet and the first wheel clockwise in the direction of the arrow ***1***. This provides maintaining power to the first wheel and the watch runs.

(b) When the weight ***E*** rises: The click ***K*** slides over the teeth of ***A*** and the train ***A B C*** is free. At the same time the movement of the weight rotates ***W*** to keep ***C*** in mesh with ***D***.

The fusee rotates clockwise to run the watch train in the direction of the arrow ***1***. The train ***A B C*** does not impede this. At the same time the click ***S*** slides over the teeth of ***Q***. The watch runs. (In fact, the time periods are so short that ***D*** and ***Q*** will barely move.)

Note that Recordon specifies that the ratchet ***Q*** should have a larger diameter than the first wheel. This creates a problem, because the center wheel pinion, which meshes with the first wheel, must go under (and possibly contact) ***Q***. However the alternative, when ***Q*** is smaller, means the click ***S*** must be thin, and any play might result in it missing its action.

Also note that the cock ***F*** supports the top pivot for the weight, Figure 8-4, and this cock must be mounted on ***W***. So ***W***, the train ***A B C*** and the winding wheel ***D*** are above the top plate. Because the click ***S*** and the equilibrium spring ***G***, Figure 8-5, are between the plates, there must be a large cut-out in the top plate for these parts hanging below ***W***. And the whole, very heavy mechanism is supported by a single pivot at ***a***, Figure 8-8, which would probably cause serious problems.

Recordon also suggests two variations on this design.

> *Another method of applying the renovating part is by using the piece marked* ***W*** *in Fig. 8-8 with the spring and barrel to balance the weight and the piece marked* ***S*** *in Fig. 8-5 and 8-6 with the ratchet to the great wheel and every part as described before except the train of small wheels marked* ***A B C*** *in the room of which a double crank as in Fig. 8-14 is used as described at* ***N*** *from which two levers are guided at* ***O*** *and* ***P*** *into the ratchet wheel* ***D*** *the motion of the weight up and down works the levers* ***O*** *and* ***P*** *up and down alternately and by that means force the ratchet wheel* ***D*** *forwards which being fixed on the fusee square as in the before described method winds the chain off the barrel and consequently raises the spring which it continues doing till it is stopped by the work* ***M N P*** *before described in Fig. 8-9. The piece marked* ***W*** *Fig. 8-8 is as in the other method used in this, which when the watch is at rest by sliding ⅛th of an inch disengages the levers from the ratchet and the watch is left to go entirely free of the renovating work.*

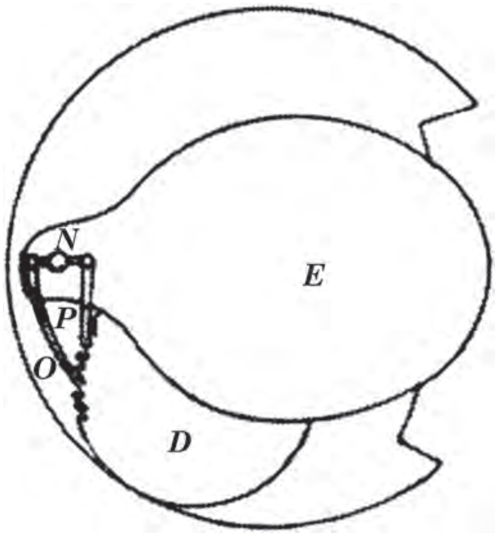


Figure 8-14

Recordon is vague, but except for the levers ***O*** and ***P*** replacing the train ***A B C*** this is the same as the previous design. It is potentially superior to the original because it winds the watch with the weight moving in both directions.

However, this mechanism cannot work. The purpose of the crank ***N*** is not explained and it is not clear how the levers are fixed to it. There are two possibilities:

(a) Fixed levers: the crank ***N*** cannot move and the levers ***O*** and ***P*** are rigidly attached to it. Then, as the weight rotates, the levers move as shown in Figure 8-15. This diagram illustrates, in red, the positions of the lever ***P*** and the crank ***N*** for the middle position of the weight, as in Figure 8-15 and, in black, the two extreme positions of ***P*** when the weight has rotated as far as possible. The tips of ***P*** move in an arc. It is obvious that the weight cannot rotate anti-clockwise because ***P*** cannot enter the space occupied by the winding wheel ***D***. And, as the weight rotates clockwise, ***P*** will only move ***D*** a very small distance, insufficient to wind the watch.

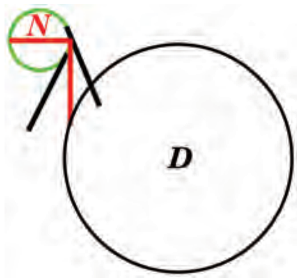


Figure 8-15

(b) Spring-loaded clicks: The levers ***O*** and ***P*** are loose clicks, held against the wheel ***D*** by springs. But when the watch is at rest, or the weight is locked because the watch is fully wound, they always remain in contact with ***D*** irrespective of the position of ***W***. That is, the mechanism cannot be decoupled from the fusee, and the fusee cannot rotate clockwise to run the watch. This can be overcome by shaping the tips of ***O*** and ***P*** and the teeth of ***D*** so that as ***D*** rotates clockwise the clicks will be pushed away from the teeth. But during winding, when the weight pushes the clicks against the teeth, they will rise up and slide over them without turning ***D***. Either the watch will not run when the weight is not moving or the watch cannot be wound.

The problems of decoupling and maintaining power, which make this design useless, do not occur with going barrels, and in the 1920s Léon Leroy made pocket and wrist watches using the same idea of two cranked clicks; see Chapuis & Jaquet (1952, pages 210-213 and 216-217; 1956, pages 220-223 and 226-227) and Sabrier (2012a, pages 244-245).

*Another way of applying the renovating part is in every respect as the last only instead of a crank to make use of an endless screw as in Fig. 8-16 at **F** which works into the toothed wheel **D** and disengages itself in the same manner by sliding of the piece **W** Fig. 8-6 ⅛th of an inch and the piece **F** Fig. 8-16 having a curve which working against a pin at **K** Fig. 8-16 by that sliding throws the endless screw out of the teeth of the Wheel **D**.*

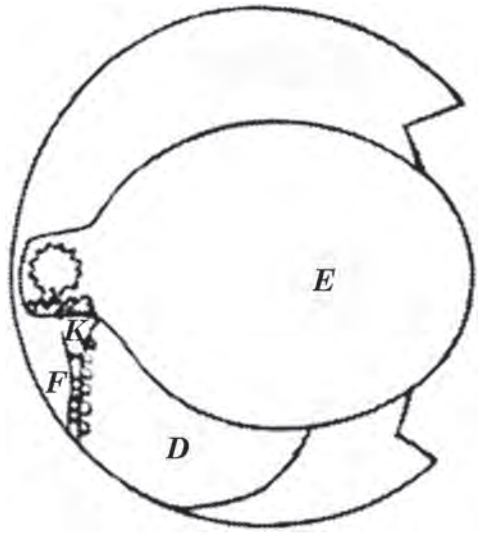


Figure 8-16

This is obscure. Presumably the unlabelled wheels in Figure 8-16 are the ratchet ***H***, Figure 8-7, meshing, at a right angle, with a wheel attached to the endless screw. If this design is *"in every respect"* the same then the pin ***K*** is a mystery, especially as we are not told where it is mounted. The movement of the plate ***W*** should disengage ***F*** from ***D***, but Recordon may have decided that this is not the case, because the plate ***W*** swivels and the end of ***F*** nearest the weight may stay engaged with ***D***. Then we could suppose that the pin ***K*** is attached to ***W*** so that, as ***W*** swivels, ***K*** moves along the curved end of ***F*** and pushes ***F*** away from ***D***. But for this to happen, ***F*** must move independently of ***W***, so how is it attached?

It is reasonable to conclude that these two designs have been added to the patent to include other forms and so prevent copying of them. But, unlike the first design, it seems Recordon did not seriously examine them and did not understand them.

8.3: Patent Renewal

Chapuis & Jaquet (1952, pages 140-141; 1956, pages 152-153) state that Recordon's patent was renewed in 1856:

Renewal and registration of Recordon's Specification was granted to Peter Des Granges in 1856, the official publication being still deposited at the Patent Office in London ...

And the French edition adds:

Imprimé par Georges-Edouard Eyre, imprimeur de la reine notre excellente Majesté, 1856.

They then reproduce part of the 1780 specification.

Three points should be noted:

(a) Patents cannot be renewed. Recordon's patent would have been for about 20 years and, after about 1800, the specification entered the public domain and anyone could use it.

(b) Patents for Inventions (1979, Volume 1) does not mention this renewal.

(c) An online request to the Business & IP Centre of the British Library received the following response:

... once a patent had served its lifespan or term a patent can not be renewed ... I have been unable to find the patent which you believe exists ...

Thus it is clear that Chapuis and Jaquet were wrong, and we do not know what led them to this absurd suggestion.

Chapuis and Jaquet also state:

> *Peter Des Granges produced a certain number of "pedometer" watches signed Louis Recordon, but it is difficult to establish exactly in what year this manufacture was abandoned.*

Although information on Recordon and Peter Des Granges is limited, they should have been aware (Britten, 1922, pages 677 and 764) that Peter Des Granges succeeded Recordon in 1816 and retired in 1842. From which we can conclude that the self-winding watches he produced were probably old, unsold stock.

8.4: Watches

Several self-winding watches signed Recordon exist and are illustrated in books. For example, in addition to Figure 8-17 see Chapuis & Jaquet (1956, page 151), Camerer Cuss (2009, page 272) and Sabrier (2012a, pages 52, 58-63). With one exception, these watches are signed *Recordon Spencer & Perkins London*. None are dated, but one (Camerer Cuss, 2009, page 272) has a mainspring signed *27 May 1780*. They use the going barrel mechanism described above.

The most likely explanation for the signature on these watches is that they were made by Spencer & Perkins, using Recordon's patent and probably under licence from Recordon.

Figure 8-17

8.5: Documents

The following documents do not mention Louis Recordon directly.

The earliest reference is in a booklet by J.H. Magellan (1779, page 158), Figure 8-18. (The pagination of this booklet is 87 to 164 and it forms part of a compilation). After describing a self-winding clock working by barometric pressure, Magellan goes on:

> *But modern mechanics has lately taken another similar step, with regard to pocket watches, of which there are already those that never need to be wound to run continuously; because they wind themselves by the simple movement that they receive being carried in the pocket; and that without their form or their volume being different from ordinary watches. I tested two of them recently, made by Messrs Spencer & Perkins, for 28 days, and I could not be more satisfied.*

In July of the following year, Rozier (1780, pages 60-61) published part of a letter written by Magellan, Figure 8-19.

> *It is very true, Sir, that the new watches which do not need to be wound are currently made in London. However, they are as exact as others, of which they still join together the size, the external form and the same advantages. I saw two made of gold, very well done, smart even; their price is fixed at £50 sterling; some are made for £40, but not below. This price will prevent them being common. But for those who will be in a position to spend this, nothing will be so convenient; one will enjoy all the advantages of an excellent watch without having to wind it every 24 hours. However, we must not imagine this to be perpetual motion; a small weight skilfully arranged in the interior of the watch, supported by a rather elastic spring, winds the mainspring which puts all the train in motion, with each jolt of the movement of the person while walking. This communicated movement can last 30, 40 and even 50 hours, so that this watch can remain suspended and motionless this long amount of time; by detaching it and taking it again, it continues to be wound constantly. If at the end it comes to stop by resting too long, it is enough to immediately set the hour and minute hands, to give some shakes to the watch and at once it continues to go regularly, as before.*

The same extract was also printed in the *Nouveau Journal Helvétique* (Neuchâtel, 1780a, pages 105-106).

The third report of interest, Figure 8-20, is a letter to the editors of the *Nouveau Journal Helvétique* dated 1 September 1780 (Neuchâtel, 1780b, pages 98-100).

> *We saw, Sirs, in your Journal of last July, article VIII, the extract of a letter by Mr Magellan, of the Royal Society of London, on the new watches that do not need to be wound. The author gives only a faint outline of the mechanism of these kinds of watch; neither will we go into this detail. But we think ourselves invited to show to the public that it is more than three years since pieces of this kind have been manufactured in our mountains, which have already spread into Russia, Germany, Spain and France. It appears that the English have known of this invention for only two years. We could more properly allot this discovery to us. Here at least is what is very certain. It has been nearly two years since a young man, working in watchmaking with one of our best Masters, who, according to the idea that one had given to him, arrived through research at the mechanism which makes the merit of this work. This young man, rather skilful on his part I say, apparently tempted by the charms of the profit which a similar discovery could get him, found the means to remove the secret and withdrew himself to London, where he currently works. When he left our mountains the invention was still in its cradle; he consequently improved it so much that these new watches, which indeed are a little larger than ordinary watches, were found so exact (on all who have the care to give them action by movement) that after one month of testing, one noticed only four minutes variation with a clock with a long pendulum. Still the price is very different from that for which they are sold in London; it is within reach of an amateur, if he was well off, since they are given away for thirty new Louis. Repeaters of this kind are also made, but it is seen that the price is higher.*

372. L'horloge perpetuel, qu'on a fait à Londres, il y a quelques années, & qui reuſſit parfaitement bien, étoit conſtruit ſur le même principe du Barometre Statique. Deux grands vaiſſeaux de criſtal, dont l'un faiſoit l'office du tube *b d* (fig. 53.), & l'autre celui du reſervoir *a c f*, étoient ſuſpendus par des chaines qui paſſoient ſur des poulies ; & qui, avec leur mouvement, faiſoient remonter, par des rochets & encliquetages à propos, la force motrice de la pendule. Cette idée eſt fort heureuſe & très commode dans un inſtrument, ſi généralement neceſſaire, & ſi communement employé dans la vie civile, pour connoître les différentes portions de la méſure ſucceſſive du tems. **Mais la méchanique moderne vient encore de faire, dernièrement, un autre pas ſemblable, à l'égard des montres de poche, dont il y en a dejà, qui n'ont pas beſoin d'être montées jamais, pour marcher continuellement ; car elles les ſe remontent d'elles-mêmes par le ſimple mouvement, qu'elles reçoivent, étant portées dans la poche : & celà, ſans que leur forme, ni leur volume ſoient différentes des montres ordinaires. J'en ai eſſayé deux depuis peu, faites par Meſſrs. Spencer & Perkins pendant 28 jours : & j'en fus on ne peut plus ſatisfait. En raportant ces Idées aux obſervations météorologiques, je me trouve entrainé à communiquer celles, qui me ſont venues ſur cette matière, & qui font l'objet des articles ſuivans.**

Figure 8-18

De M. MAGELLAN, *de la Société Royale de Londres, ſur les Montres nouvelles qui n'ont pas beſoin d'être montées, ſur celles de M.* MUDGE *& ſur l'ouvrage de M.* CRAWFORD.

IL eſt très-vrai, Monſieur, qu'on fait actuellement à Londres des montres nouvelles qui n'ont pas beſoin d'être montées ; elles ont cependant la même exactitude que les autres, dont elles réuniſſent encore la grandeur, la forme extérieure & les mêmes avantages. J'en ai vu deux en or très-bien faites, élégantes même ; leur prix eſt fixé à 50 liv. ſterl. ; on en fait auſſi pour 40, mais pas au-deſſous. Cette cherté empêchera qu'elles ne ſoient communes. Mais pour ceux qui

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ſeront en état de faire cette dépenſe, rien ne ſera ſi commode, on jouira de tous les avantages d'une montre excellente, ſans être obligé de la remonter toutes les 24 heures. Il ne faut pas cependant s'imaginer qu'il s'agit ici d'un *mouvement perpétuel ;* un petit poids artiſtement diſpoſé dans l'intérieur de la montre, appuyé ſur un reſſort aſſez élaſtique fait remonter le grand reſſort qui met en mouvement tout le rouage, à chaque ſecouſſe du mouvement de la perſonne qui marche & ſe promène. Ce mouvement communiqué peut durer 30, 40 & même 50 heures de ſuite, de ſorte que cette montre peut reſter ſuſpendue & immobile ce long eſpace de tems : en la détachant & la reprenant elle continue à ſe remonter continuellement. Si à la fin elle vient à s'arrêter par un repos trop prolongé, il ſuffit de placer les aiguilles ſur l'heure & la minute, donner quelques ſecouſſes à la montre & ſur le champ elle continue à marcher régulièrement, comme auparavant.

Figure 8-19

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commerce des beſtiaux fait partie de ſes richeſſes, & ſouvent la principale.

II. *Lettre aux Éditeurs. Premier ſeptembre 1780.*

NOUS avons vu, meſſieurs, dans votre Journal de juillet dernier, article VIII, l'extrait d'une lettre de M. Magellan, de la ſociété royale de Londres, ſur les montres nouvelles, qui n'ont pas beſoin d'être remontées. L'auteur ne donne qu'une faible eſquiſſe du méchaniſme de ces ſortes de pieces; nous n'entrerons pas non plus dans ce détail, mais nous nous croyons appellés à manifeſter au public qu'il y a plus de trois ans que l'on fabrique dans nos montagnes des pieces de ce genre, qui ſe ſont déja répandues en Ruſſie, en Allemagne, en Eſpagne & en France; il paraît que ce n'eſt que depuis deux ans que cette invention eſt connue aux Anglais. Nous pourrions à plus juſte titre nous attribuer cette découverte. Voici du moins ce qui eſt très-certain. Il y a près de deux ans qu'un jeune homme, travaillant en horlogerie chez un de nos meilleurs maîtres, qui d'après l'idée qu'on lui en avait donnée eſt parvenu, à force de recherches, à trouver le méchaniſme qui fait le mérite de cet ouvrage: ce jeune homme, dis-je, aſſez habile dans ſa partie, tenté apparemment par l'appas du gain que pourrait lui procurer une ſemblable découverte, trouva moyen d'enlever le ſecret & ſe retira à Londres, où il travaille actuellement. Lorſqu'il quitta nos montagnes, l'invention était encore dans ſon berceau; elle s'eſt dès-lors perfectionnée au point que ces nouvelles montres, qui en effet ſont un peu plus groſſes que les montres ordinaires, ont été trouvées ſi exactes (ſur-tout lorſqu'on a ſoin de les remettre en mouvement par l'action) qu'après un mois d'eſſai, l'on n'a remarqué qu'une variation de quatre minutes d'avec une pendule à longue ligne. Le prix en eſt au reſte bien différent de celui auquel elles ſe vendent à Londres; il eſt à la portée d'un amateur, pour peu qu'il ſoit aiſé, puiſqu'on les cede à trente louis neufs. On fait auſſi des répétitions dans ce genre; mais on conçoit que le prix en eſt plus haut.

Voilà, meſſieurs, ce que nous avons cru devoir vous communiquer pour l'honneur de nos montagnes: nous eſpérons que vous ne déſapprouverez pas la liberté que nous avons priſe de vous écrire à ce ſujet. Zélés patriotes comme vous l'êtes, meſſieurs, & intéreſſés à tout ce qui peut contribuer à

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donner quelque crédit à nos arts & fabriques, vous ne vous refuſerez pas d'inſérer cette réponſe dans votre Journal.

Figure 8-20

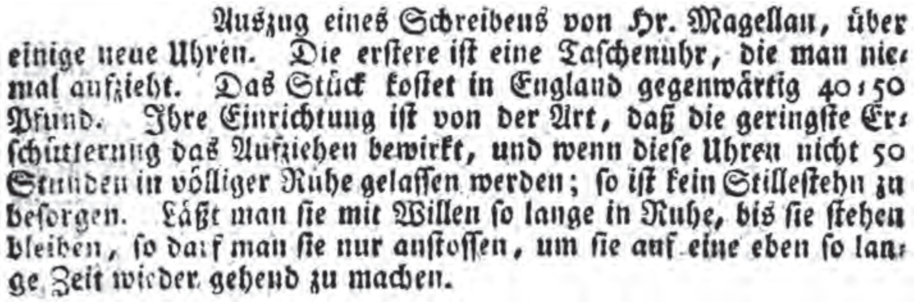
Here is, Sirs, what we believe we have to communicate to you for the honour of our mountains. We hope that you will not disapprove of the freedom that we have taken to write to you on this subject. Zealous patriots as you are, Sirs, and interested in all that can contribute to give some credit to our arts and factories, you will not refuse to insert this answer in your Journal.

There can be very little doubt that these three reports refer to Louis Recordon.

First, the watches signed *Recordon Spencer & Perkins* show the close relationship between Spencer & Perkins and Recordon. In the first extract Magellan states that the watches he tested were *made by Messrs Spencer & Perkins* which does not preclude them being signed *Recordon Spencer & Perkins*.

Second, at the time of the second extract, July 1780, Recordon held a patent on self-winding watches and Magellan's letter must refer to him.

Third, "This young man … withdrew himself to London, where he currently works" again must refer to Recordon, he being the only person who is Swiss, young (he was about 22 years old in 1778), moved to London, and made self-winding watches.



Auszug eines Schreibens von Hr. Magellan, über einige neue Uhren. Die erstere ist eine Taschenuhr, die man niemal aufzieht. Das Stück kostet in England gegenwärtig 40:50 Pfund. Ihre Einrichtung ist von der Art, daß die geringste Erschütterung das Aufziehen bewirkt, und wenn diese Uhren nicht 50 Stunden in völliger Ruhe gelassen werden; so ist kein Stillestehn zu besorgen. Läßt man sie mit Willen so lange in Ruhe, bis sie stehen bleiben, so darf man sie nur anstossen, um sie auf eine eben so lange Zeit wieder gehend zu machen.

Figure 8-21

Magellan's report was repeated in Vienna (Vienna, 1780, page 5), Figure 8-21; this was found using ANNO (2013):

> *Auszug eines Schreibens von Hr. Magellan, über einige neue Uhren. Die erstere ist eine Taschenuhr, die man niemals aufzieht. Das Stück kostet in England gegenwärtig 40:50 Pfund. Ihre Einrichtung ist von der Art, dass die geringste Erschütterung das Aufziehen bewirkt, und wenn diese Uhren nicht 50 Stunden in völliger Ruhe gelassen werden; so ist kein Stillestehen zu besorgen. Lässt man sie mit Willen so lange in Ruhe, bis sie stehen bleiben, so darf man sie nur anstossen, um sie auf eine eben so lange Zeit wieder gehend zu machen.*

A free translation, with the help of Heinz Mundschau (2012-2015), is:

> *Extract of a letter from Mr Magellan, regarding some new watches. The first is a pocket watch that you never wind. The piece currently costs 40 to 50 pounds in England. Their advantage is that the slightest vibration causes winding and you need not worry about the mechanism stopping, provided these watches are not be left completely still for 50 hours. If you leave them so long at rest until they stop, then one only needs to shake them in order to make them go an equally long time again.*

This report adds nothing to what we already know.

Finally, in 1783 Johan Bernoulli published a 494-page guide book about Neuchâtel and Vallengin. This book includes the following (Bernoulli, 1783, pages 144-146), Figure 8-22. Heinz Mundschau (2012-2015) noted that this is a bad translation into German from another language, and it is clear that it is mainly derived from Neuchâtel (1780a, pages 105-106), Figure 8-19, with a little taken from Neuchâtel (1780b, pages 98-100), Figure 8-20.

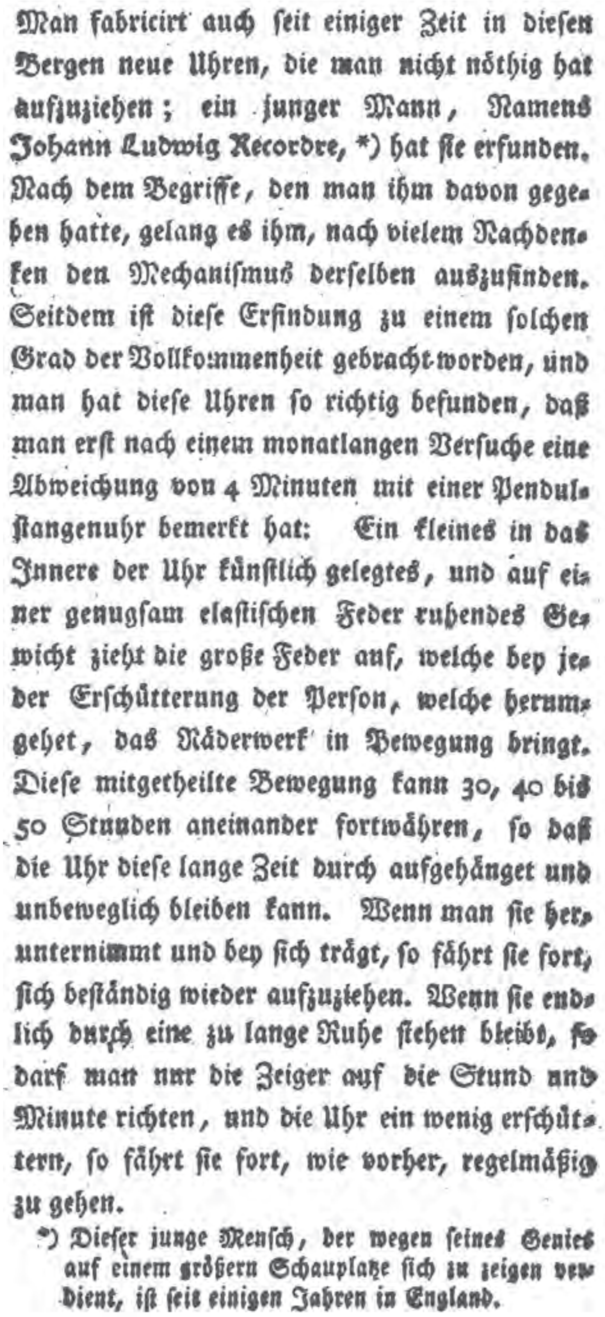
Our translation of Figure 8-22 is:

> *For some time in these mountains people fabricate new watches that you do not have to wind, A young man named Johann Ludwig Recordre *) invented them. In accordance with the ideas given to him, he succeeded (after much reflection) to find out this mechanism. Since then, this invention has been brought to such a perfection, and one found these watches so good that one noticed, after tests during several months, only a difference of 4 minutes compared with a pendulum clock: A small weight in the interior of the watch, and resting on a sufficiently elastic spring rewinds the large spring which puts the wheels in motion with every movement of the walking person. This motion imparted can last 30, 40 to 50 hours so that the watch can hang this long somewhere without being moved. When you take it off and put it in your pocket, it will continue with the self-winding. When it finally stops because of not being moved, you only have to adjust the big and the little hand and shake the watch a little bit, and it continues to go regularly as before.*

**) This young man, who deserves great respect on a larger theatre because of his genius, has since lived for several years in England.*

We do not know the source of the name *Johann Ludwig Recordre.* However, it confirms that the previous documents all refer to Recordon.

Man fabricirt auch seit einiger Zeit in diesen Bergen neue Uhren, die man nicht nöthig hat aufzuziehen; ein junger Mann, Namens Johann Ludwig Recordre, hat sie erfunden. (Dieser junge Mensch, der wegen seines Genies auf einem größern Schauplatze sich zu zeigen verdient, ist seit einigen Jahren in England.) Nach dem Begriffe, den man ihm davon gegeben hatte, gelang es ihm, nach vielem Nachdenken den Mechanismus derselben auszufinden. Seitdem ist diese Erfindung zu einem solchen Grad der Vollkommenheit gebracht worden, und man hat diese Uhren so richtig befunden, daß man erst nach einem monatlangen Versuche eine Abweichung von 4 Minuten mit einer Pendulstangenuhr bemerkt hat: Ein kleines in das Innere der Uhr künstlich gelegtes, und auf einer genugsam elastischen Feder ruhendes Gewicht zieht die große Feder auf, welche bey jeder Erschütterung der Person, welche herumgehet, das Räderwerk in Bewegung bringt. Diese mitgetheilte Bewegung kann 30, 40 bis 50 Stunden aneinander fortwähren, so daß die Uhr diese lange Zeit durch aufgehänget und unbeweglich bleiben kann. Wenn man sie her, unternimmt und bey sich trägt, so fährt sie fort, sich beständig wieder aufzuziehen. Wenn sie endlich durch eine zu lange Ruhe stehen bleibt, so darf man nur die Zeiger auf die Stund und Minute richten, und die Uhr ein wenig erschüttern, so fährt sie fort, wie vorher, regelmäßig zu gehen.



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*) Dieser junge Mensch, der wegen seines Genies auf einem größern Schauplatze sich zu zeigen verdient, ist seit einigen Jahren in England.

Figure 8-22

9: Abraham-Louis Breguet

9.1: Biography

There are, of course, several biographies of Abraham-Louis Breguet (1747-1823), and we will not repeat them here. However, as our concern is with his early years, a summary of the relevant information is necessary. The following is derived from Antiquorum (1991), C. Breguet (1964), E. Breguet (1997), Chapuis & Jaquet (1956), Daniels (1975) and Salomons (1921). Unfortunately, these writers rarely provide sources for their statements, and it is unclear how reliable they are.

Abraham-Louis Breguet was born in Neuchâtel and spent his early childhood in Les Verrières. After his father died, his mother married a skilled watchmaker by the name of Tattet. Osterwald (1766, page 40; 2008, page 14) notes that the "Tatet brothers are distinguished in this art and have a big business, having a house in Paris for this purpose."

In 1762, at the age of fifteen, he was sent on probation to work with a watchmaker in Les Verrières and then he left Switzerland and was apprenticed to an unnamed watchmaker in Versailles where he stayed for at most two years. He must have finished his apprenticeship about 1768, when his family immigrated to France.

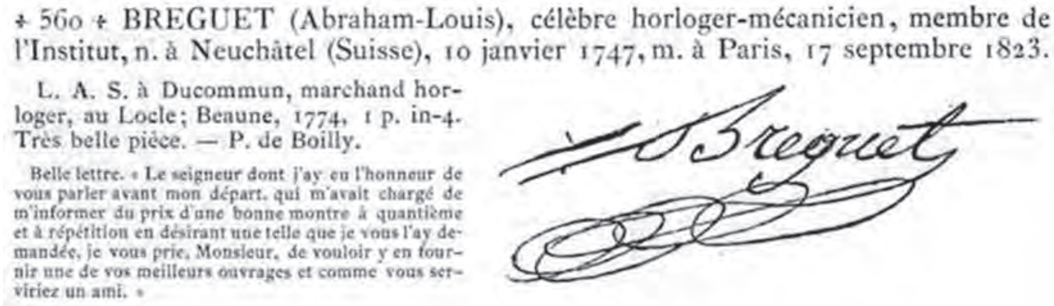
After (or some say during) his apprenticeship he studied mathematics with the Abbé Marie and through him gained recognition in Court circles, and an introduction to the King and Queen.

Jeanneret & Bonhôte (1863, volume 1, pages 104 and 106) add a little to this summary:

> *Breguet had lost his father early, and his mother having remarried to a watchmaker, he, on the recommendation of the regents that the child was not suited to study, withdrew him from the school and wanted to teach him his trade of watchmaker. But it appears that in the workshop our indolent young man did not display any happier attitudes than on the benches of the school. They despaired of him, when they decided to place him in Versailles with a skilful Master; he was then in his fifteenth year.*
>
> *Little by little his love for the art developed, he tasted study, felt the need to learn, and his loathing ceased. But necessity, this violent schoolmistress, contributed perhaps more than anything else to make his genius flower. Hardly he had finished his apprenticeship when he lost, one after another, his mother and his stepfather, and an older sister fell into his charge. How was he, at the beginning of his career, to provide for the upkeep of two people?*
>
> *In the presence of the new duties that were imposed to him, sacred duties that raise and strengthen the soul, far from bringing him down, Breguet understood that to face his obligations of brother and guardian, there was only one way, which was to redouble his zeal and activity. He did it, and success crowned his efforts. Prolonged work made him capable of providing not only for his needs, but also to take a course of mathematics; because already he felt that knowledge of the exact sciences was an essential preliminary for him. His professor was the abbot Marie, who could appreciate his genius and his character.*
>
> *It is from this time that the name of Breguet started to emerge from the crowd.* [This presumably refers to the 1780s.]

> *It is to him that we owe the convenient use of perpetual watches, which wind themselves by the movement that one gives them while carrying them, and which had been invented by his compatriot, old Perrelet of Locle. The watches of this kind were baubles suitable to satisfy curiosity rather than useful instruments. Not only were they wound only by a long and even painful walk, but also they would get out of order at any moment. Breguet, by redesigning them on better principles, made the least trace of this double disadvantage disappear.*

Nothing is known of what he did between finishing his apprenticeship and when he set up in business in 1775. He may have worked for Ferdinand Berthoud or Jean-Antoine Lépine and he may have spent some time in London. However, one interesting letter exists, Figure 9-1 (Charavay (1887, page 204):



+ 560 + BREGUET (Abraham-Louis), célèbre horloger-mécanicien, membre de l'Institut, n. à Neuchâtel (Suisse), 10 janvier 1747, m. à Paris, 17 septembre 1823.

L. A. S. à Ducommun, marchand horloger, au Locle; Beaune, 1774, 1 p. in-4. Très belle pièce. — P. de Boilly.

Belle lettre. « Le seigneur dont j'ay eu l'honneur de vous parler avant mon départ, qui m'avait chargé de m'informer du prix d'une bonne montre à quantième et à répétition en désirant une telle que je vous l'ay demandée, je vous prie, Monsieur, de vouloir y en fournir une de vos meilleurs ouvrages et comme vous serviriez un ami. »

Figure 9-1

> *L. A. S. à Ducommun, marchand horloger, au Locle; Beaune, 1774, 1 p. in-4. Très belle pièce. P. de Boilly.*
>
> *Le Seigneur dont j'ay en l'honneur de vous parler avant mon départ, qui m'avait chargé de m'informer du prix d'une bonne montre à quantième et à répétition en désirant une telle que je vous l'ay demandée, je vous prie, Monsieur, de vouloir y en fournir une de vos meilleurs ouvrages et comme vous serviriez un ami.*
>
> *To Ducommun, merchant watchmaker, at Locle; Beaune, 1774.*
>
> *The Lord of whom I had the honour to tell you before I left, who had instructed me to inform me* [sic] *of the price of a good calendar and repeating watch as I have requested, I pray you, sir, to provide me with one of your best works and as you would serve a friend.*

It is clear that Breguet, in the year before he set up his business, visited Le Locle. And, during his return trip to Paris, he stopped in Beaune (on the road from Le Locle to Paris) where he wrote the letter to order a watch with a calendar and repetition. Of the people listed in Bourdin (2012) with the name Ducommun only four seem possible: Jonas Pierre Ducommun (maker in 1757, but clock maker in 1779, negotiant 1780), Frédéric Ducommun dit Boudry (maker about 1770), Jean Pierre Ducommun dit Boudry (master maker in 1757) and Isaac Pierre Ducommun dit Verron (master maker in 1767). Unfortunately we do not know who else Breguet visited in Le Locle.

At the time it was the custom for a craftsman to set up in business at the same time as he set up a home, using the dowry from his wife. Abraham-Louis was 28 years old when, in 1775, he married. Breguet (1997, page 35) states that "As he was not yet a master watchmaker (and is not mentioned as such until 1784) Breguet had to obtain a special dispensation to set up his own business."

It appears that Breguet worked on his own until 1787. Very few complicated watches survive from the period, but there are no records of watches manufactured before 1787.

9.2: Documents

There is very little information regarding Breguet's early work on self-winding watches. The most important appears to come from Jeanneret & Bonhôte (1863, volume 2, page 194):

> *It was* [Perrelet] *who invented perpetual or jerking* [à secousse] *watches, which wind themselves by the movement that one gives to them while carrying them. The first that he built were bought by Breguet and one named Recordon who lived London.*

The relationship between Perrelet, Breguet and Recordon is clearly very important, but we defer discussing this until later (Section 21.3, page 250).

Breguet himself made a few statements on his early involvement with self-winding watches.

Chapuis & Jaquet (1952, page 67; 1956, pages 72-73) cite an "unpublished exposé of his inventions":

> *Furthermore, I would mention the perpetual watches, the perfecting of which ... This watch was made by me in 1780 for the Duke of Orleans ..."*

And later, Chapuis & Jaquet (1952, page 75; 1956, page 82) give a statement from "Breguet's notes, apparently recopied by Moinet":

> *These first works were improvements on the 'perpétuelle' watches he made in about 1780 for the Duchess de l'Infantado, the Duke of Orleans and Her Majesty Queen Marie Antoinette.*

The most significant document is the description of Breguet's "improved" mechanism, which is given in full, with explanations, by Chapuis & Jaquet (1952, pages 82-106; 1956, pages 85-111); it also appears in Sabrier (2012a, pages 68-89), but without any explanatory text.

Most of this concerns Breguet's post 1780 design and so is directly not relevant here. However a summary of the self-winding part of the mechanism is given in Section 9.4.

9.3: Watches with Barrel Remontoirs

The following explanation is based on a translation of Flores (2009, pages 124-148).

There are two known watches which use the verge escapement coupled with a barrel remontoir, Figures 9-2 and 9-3. These are signed on the weights *Breguet à Paris* and *Papillion à Paris n° 1069*. Both are bare movements without cases or dials, and the Breguet movement is incomplete.

Figure 9-2

Figure 9-3

There are no known makers with the name Papillion. Three makers with the name *Papillon* are recorded by Patrizzi (1998, page 301) and Tardy (1972, page 500):

> Papillon, Jean-François, master watchmaker, 1770-1791.
>
> Papillon, Jean-Pierre, son of Pierre, Paris (France), watchmaker, recorded living in 1762.
>
> Papillon, Philippe. Abbeville. Sur une montre Louis XIV (but he is too early).

With two exceptions, one being different gear ratios and the other most likely the result of a repair, the movements are technically identical. Indeed, they are so similar that it is very likely that they were made by the same person.

This is the third known method of coupling a self-winding mechanism to the verge escapement. The previous two, tentatively attributed to Sarton and Recordon, use a fusee to ensure the escapement performs satisfactorily. But in contrast this method dispenses with the fusee and uses a going barrel. There are two advantages from doing this. First, the mechanism linking the weight to the actual winding mechanism is greatly simplified, because there is no need to decouple it during the running of the watch. And second, no maintaining power is required. However, a going barrel *cannot* be used with the verge escapement unless some other method is adopted to even out the power to the train, to replace the function of the fusee. The barrel remontoir in this design achieves that.

Figure 9-4 is a diagram of the system, with the input from the self-winding weight at the bottom left, and the output to the watch train at the bottom right. It consists of two, linked going barrels. An overview of the action is:

(a) The self-winding weight, through its train, winds the spring in barrel ***A*** by the wheel attached to its arbor (blue). When the spring is fully wound, the inclined boss of the stop-work on barrel ***A*** locks the weight.

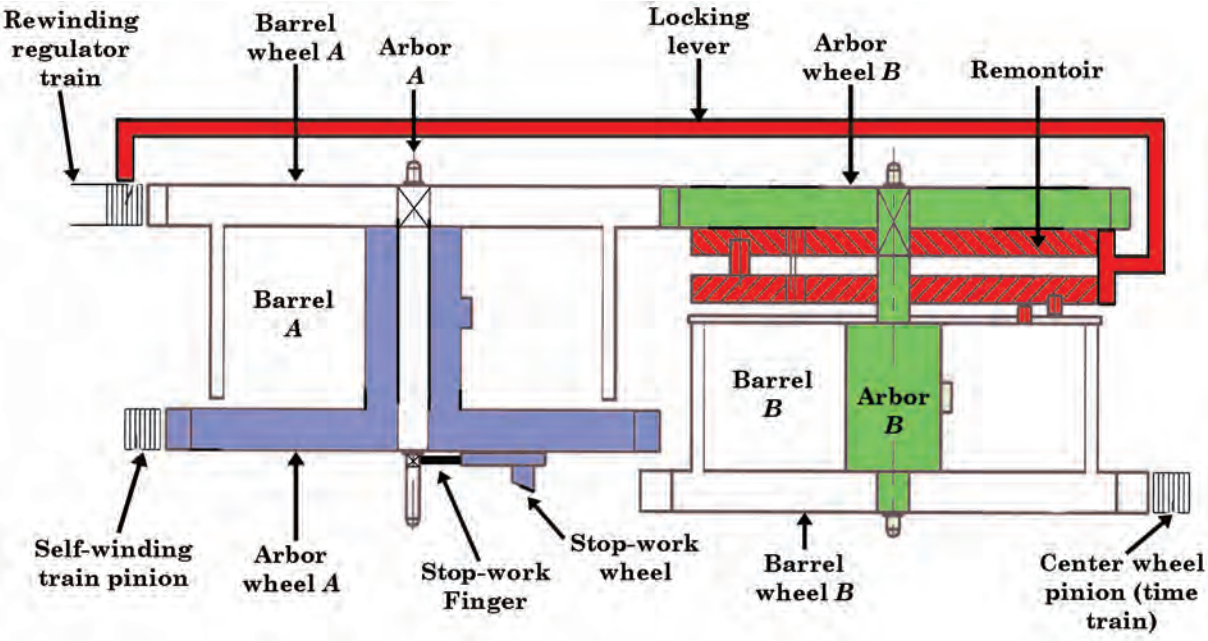


Figure 9-4

(b) Barrel ***A*** (white), through its integral wheel, winds the spring in barrel ***B*** by the wheel attached to its arbor (green). A small train of wheels, the rewinding regulator train, moderates the speed of winding.

(c) Barrel ***B*** (white), through its integral wheel, drives the going train of the watch.

(d) Normally, the remontoir mechanism (red), mounted on the arbor of barrel ***B***, prevents barrel ***A*** from rotating, because its locking lever locks the rewinding regulator train. In this situation, the spring in barrel ***A*** can be wound by the weight, and the spring in barrel ***B*** can drive the train, but barrel ***A***, and consequently the arbor of barrel ***B***, cannot rotate, and so the spring in barrel ***B*** is not wound.

(e) Every time barrel ***B*** rotates ½ turn, it triggers the remontoir mechanism, which moves the locking lever and unlocks the rewinding regulator train on barrel ***A***. Barrel ***A*** then rotates and rewinds the spring in barrel ***B*** via its arbor. After winding the spring ½ turn, the remontoir again locks the rewinding regulator train on barrel ***A*** and winding stops.

The result is that only one half turn of the spring in barrel ***B*** is used to drive the watch train, and this small segment of the spring provides nearly constant power to the escapement.

Because the movements are technically identical, only the Papillion movement will be described here, but the Breguet movement will be illustrated when the differences are considered.

The weight, Figure 9-5, is squared onto an arbor that passes through the movement to the dial side.

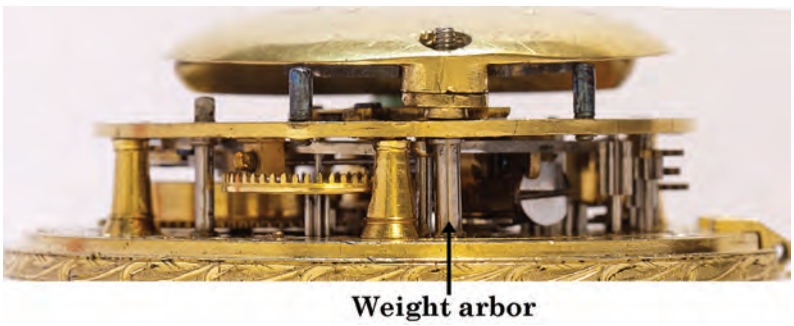


Figure 9-5

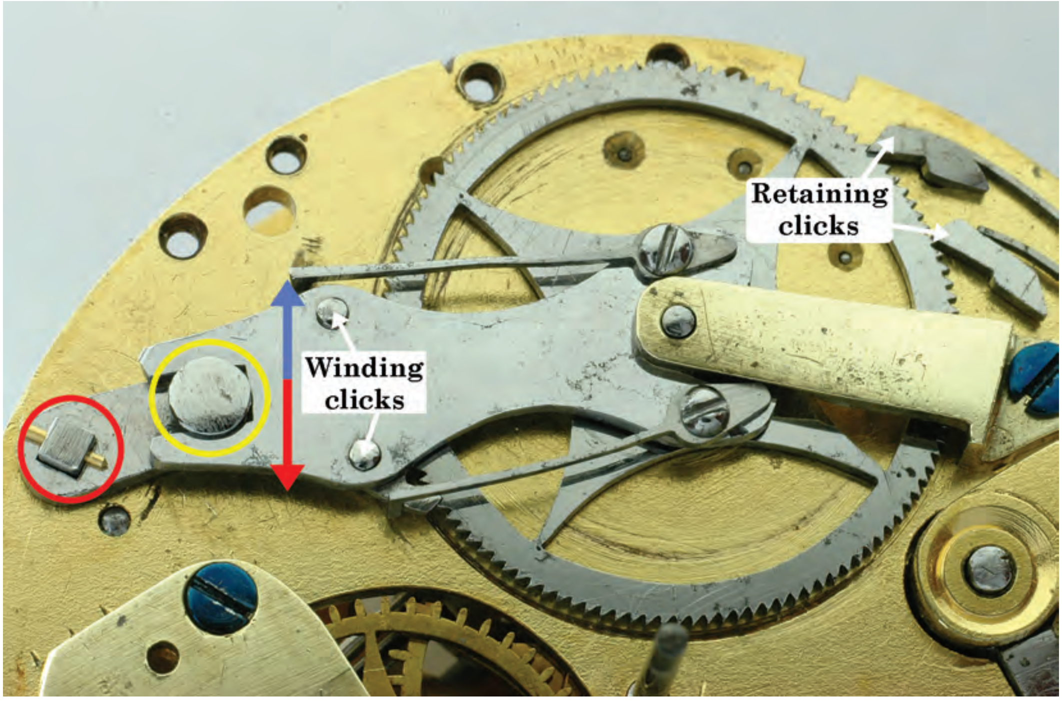


Figure 9-6

On that side, Figure 9-6, the arbor is squared onto the end of a two-piece articulated lever (red circle). As the weight oscillates it causes the main part of the lever, pivoted under the cock, to oscillate (red and blue arrows).

Beneath the articulated lever is a large ratchet wheel with 120 teeth. There are four clicks that act in this ratchet, two winding clicks attached to the articulated lever and two retaining clicks attached to the plate.

Figure 9-7 shows the action. When the weight descends (the red arrow) the small end of the articulated lever also goes down, and the 2 red clicks make the ratchet wheel turn anti-clockwise. The retaining clicks (blue) slide over the teeth.

Conversely, when the weight goes up (blue arrow) the winding clicks (red) pass over the teeth, while the retaining clicks mounted on the plate ensure that the position of the wheel does not change.

Thus the oscillatory motion of the weight is converted into the anti-clockwise motion of the ratchet.

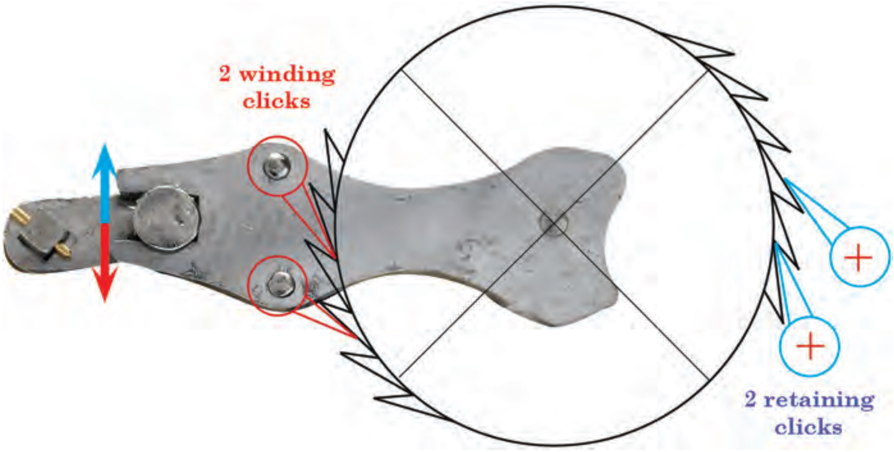


Figure 9-7

Pairs of clicks are used which are displaced by half a tooth, Figure 9-8. This means the ratchet has effectively twice the number of teeth, 240, and correspondingly smaller movements of the weight will turn the ratchet.

The Breguet movement has a different arrangement for the clicks, but the action is the same; see Figure 9-9.

On this movement the ratchet has 150 teeth, but the pairs of clicks mean it effectively has 300 teeth.

Figure 9-8

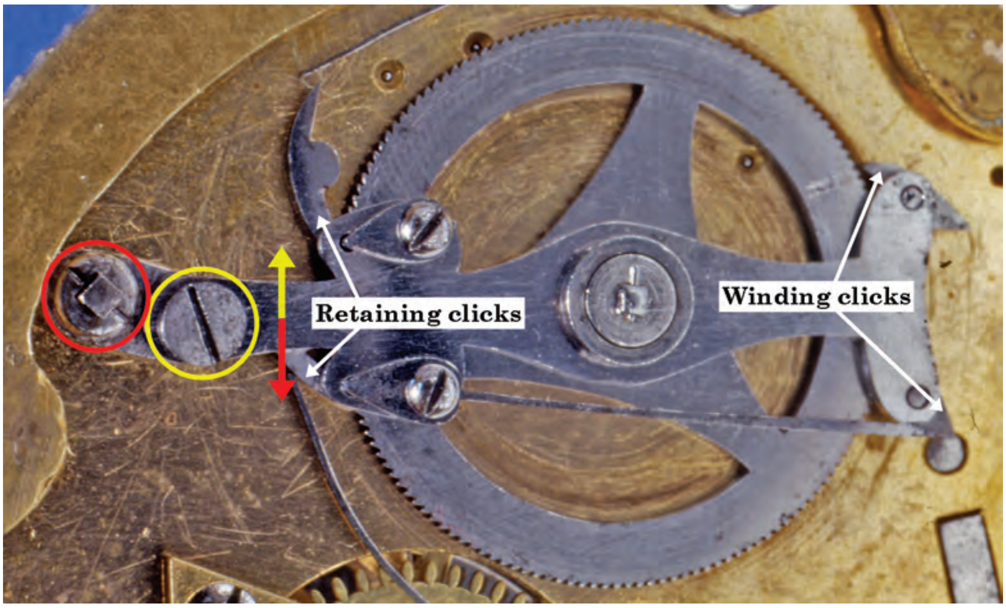


Figure 9-9

The pinion of the ratchet passes through a hole in the plate and meshes with the arbor wheel of barrel ***A***; Figures 9-10 and 9-4.

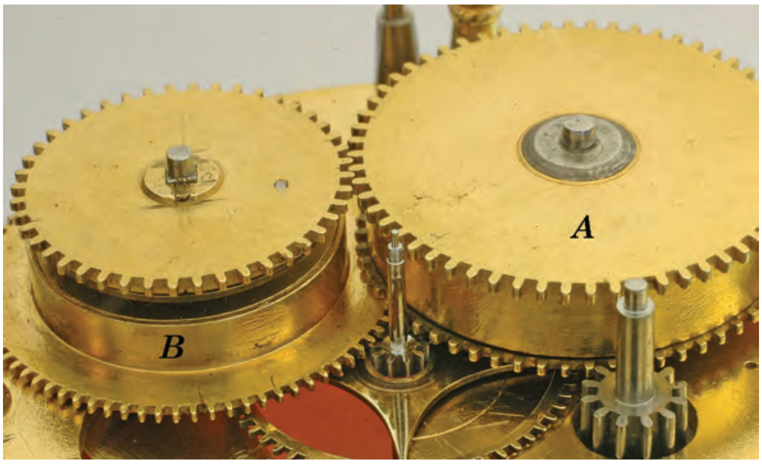


Figure 9-10

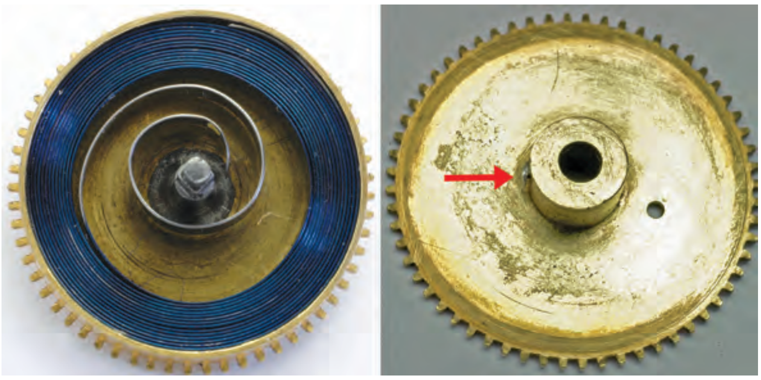


Figure 9-11

This wheel, Figure 9-11, forms the lid of the barrel, and the inner end of the spring is attached to it by a hook on its boss; the arbor itself is only used to align the barrel and the arbor wheel.

The mechanism used to lock the weight is similar to Geneva stop-work (see Appendix 7, page 360, for details). In Geneva stop-work, the barrel arbor is separate from the barrel and holds the inner end of the mainspring. In that case, the stop-work consists of a finger attached to the barrel arbor which meshes with the stop-work wheel that is usually mounted on the barrel lid. This is the arrangement used by Recordon (Section 8.2, Figures 8-1 and 8-2, page 93).

However, in the barrel remontoir design (Figure 9-4) the arbor ***A*** (white) is rigidly attached to the barrel ***A***, and the inner end of the spring is held by the sleeve of the arbor wheel ***A*** (blue), which is loose on the arbor ***A***. So the stop-work is reversed, with the finger mounted on the barrel (via the attached arbor ***A***) and the stop-work wheel mounted on the true arbor, which is part of the arbor wheel ***A***.

So Barrel ***A*** has a stop-work with a boss on the arbor wheel ***A***, Figure 9-12. Note that on this watch, the Papillion, the spring in barrel has 5 used turns. In the Breguet movement, the stop-work allows 6 turns.

The boss acts on the locking lever, Figure 9-13. This lever pivots in the thickness of the plate (dotted red line). Its left end has a raised annulus surrounding the arbor of barrel ***A***, and its right end has a raised section, the end of which fits into a vertical pin ***p***. This lever is shown upside down with respect to the stop-work.

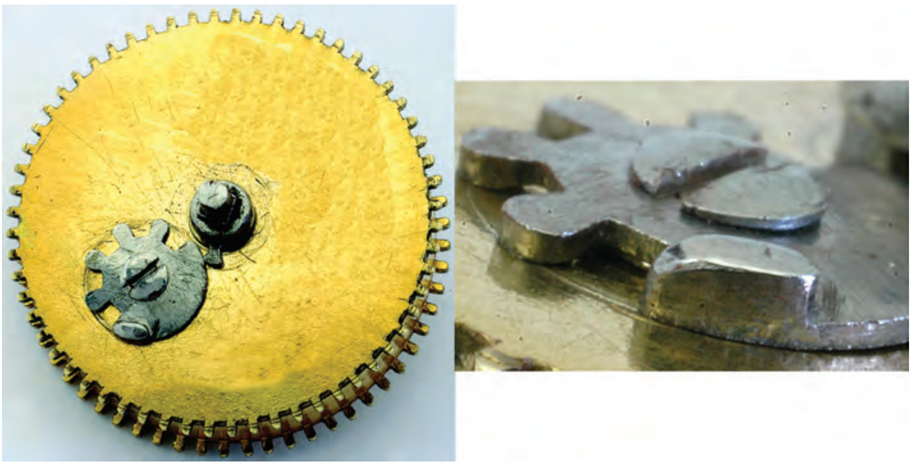


Figure 9-12

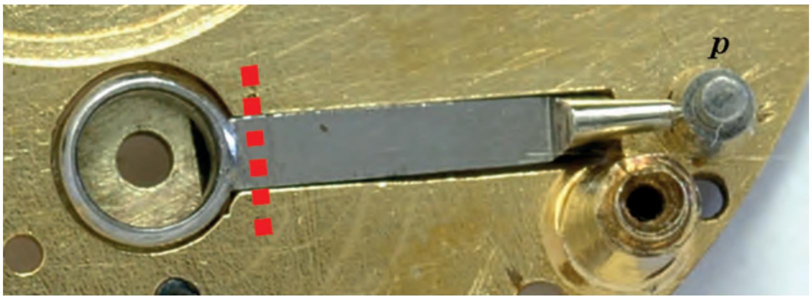


Figure 9-13

When the spring in barrel ***A*** is fully wound, the boss on the stop-work wheel depresses the left end of the locking lever, raising the right end and so lifting the pin. As shown in Figure 9-14, this pin is normally held down by its spring. When it is lifted (Figure 9-15), its end enters a hole in the weight and locks it.

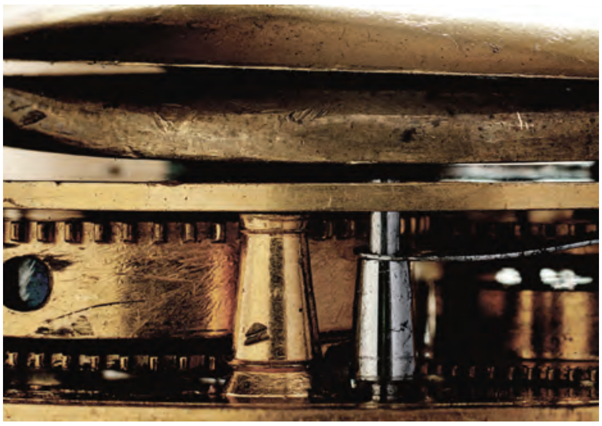


Figure 9-14

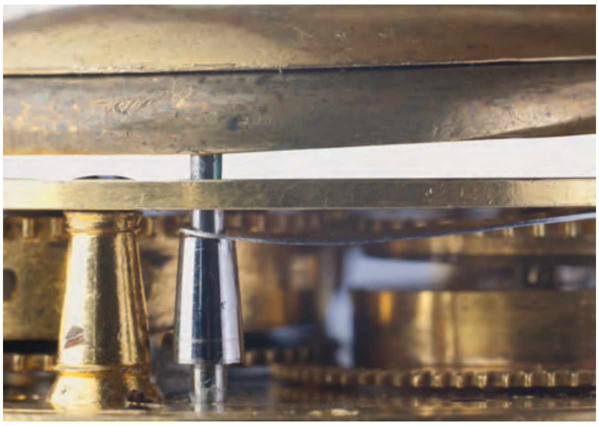


Figure 9-15

The point of locking can be adjusted. The back of the weight, Figure 9-16, has a separate piece ***a*** held by two screws (yellow arrows). The end of the third screw beside the locking hole (white arrow) rests on the surface of the weight. The two fixing screws are loosened and then the third screw can be used to move the piece ***a*** away from or towards the body of the weight.

Figure 9-16

The remontoir has three components.

First, the rewinding regulator train, Figure 9-17. It regulates the speed at which barrel ***A*** rotates when it rewinds the spring in barrel ***B***; it is similar to the small train in a repeater.

Second, the remontoir locking lever, Figures 9-18 and 9-19. Normally, the end ***1*** of this lever enters the leaves of the last pinion of the rewinding regulator train, locking this train so that barrel ***A*** cannot rotate. The position of the other end ***2*** of the lever is controlled by the remontoir mounted on barrel ***B***. When the remontoir is activated, it turns the locking lever anti-clockwise, freeing the rewinding regulator train, and barrel ***A*** rewinds the spring in barrel ***B***.

Figure 9-17

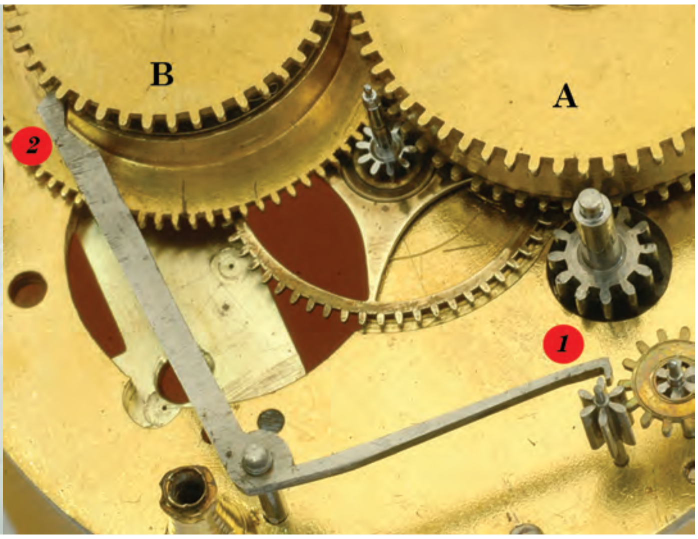


Figure 9-18

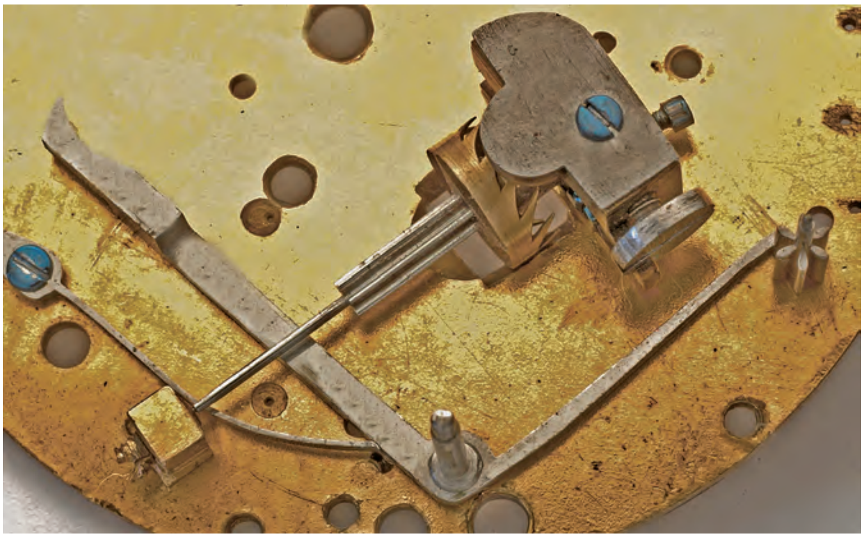


Figure 9-19

Finally, the remontoir itself. Mounted on the arbor of barrel ***B*** are the arbor wheel ***B*** and the remontoir disk, Figure 9-20.

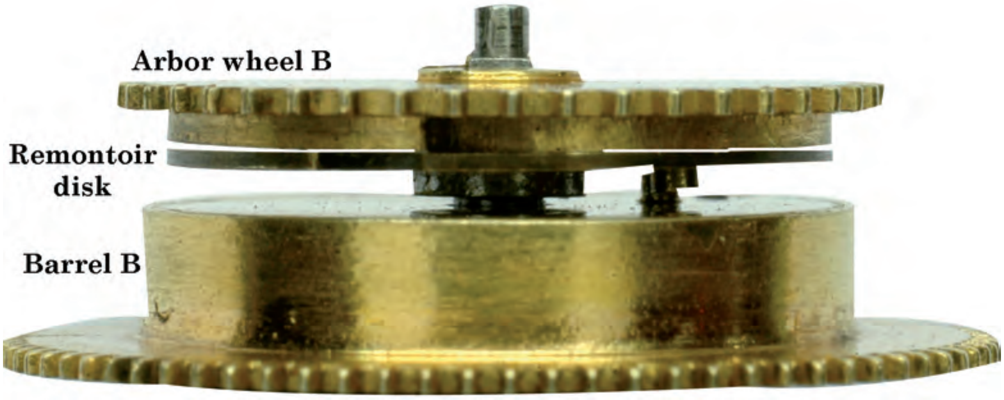


Figure 9-20

The arbor wheel, Figure 9-21, which is squared onto the arbor, has two inclined notches ***a*** beneath the teeth. The center is recessed and holds a spring whose end fits into the slot ***b*** that is the same width as the inclined notches.

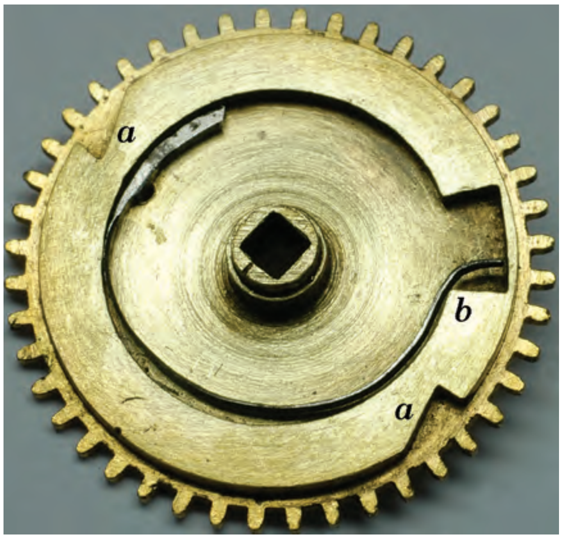


Figure 9-21

The remontoir disk, Figure 9-22, is loose on the arbor and it is free to rotate. It also has two inclined notches, and, in addition, it has two pins, one on each side. The pin on the side that faces the arbor wheel, Figure 9-22 left, fits into the slot in the recess, so the length of the slot limits the rotation of the remontoir disk. The spring, acting on the pin, keeps the inclined notches of the remontoir disk aligned with the notches in the arbor wheel. The disk can turn so that the inclined notches are out of alignment, but the spring will always bring them back into alignment.

The pin on the other side of the remontoir disk is the same distance from the center as a pin on the lid of barrel ***B*** and so the barrel cannot rotate without these two pins meeting.

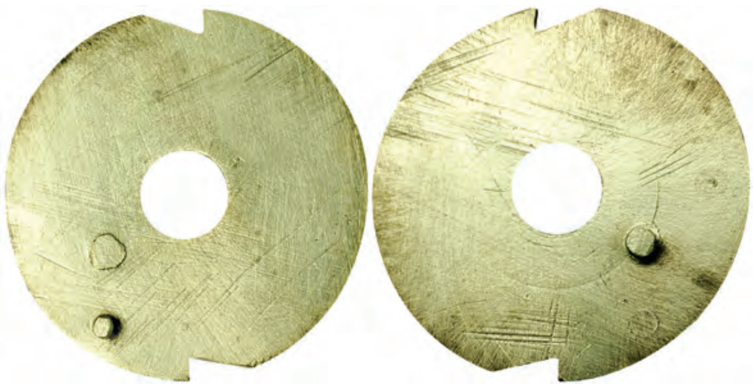


Figure 9-22

The action of the remontoir is as follows:

(a) Figure 9-23: During normal running, the end ***2*** of the locking lever (Figure 9-18) fits into one of the inclined notches in the arbor wheel and the remontoir disk. End ***1*** of the lever locks the rewinding regulator train, and so barrel ***A*** and the arbor wheel ***B*** cannot rotate. Barrel ***B*** rotates, driving the watch train through the center pinion. The pin on the lid of barrel ***B*** rotates, as shown by the red arrow and red dot in Figure 9-23.

(b) Figure 9-24: After a while, the pin on the barrel lid meets the pin on the remontoir disk and turns the disk (black arrow). At this point barrel ***A*** and arbor wheel ***B*** are still locked, and so only the remontoir disk turns. As a result, its inclined notch lifts the end of the locking lever.

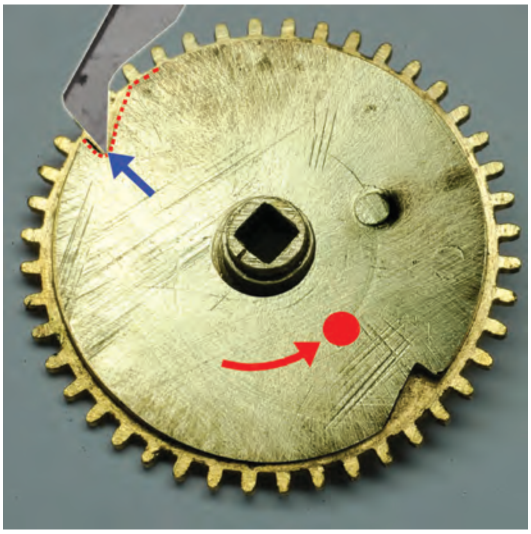


Figure 9-23

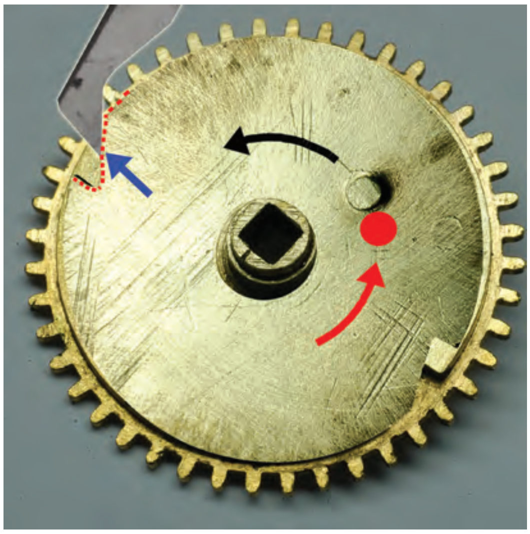


Figure 9-24

(c) Figure 9-25: Once the barrel has rotated far enough, the pins meet, the remontoir disk rotates anti-clockwise and the inclined notch in the remontoir disk lifts the end of the locking lever level with the circumference of the arbor wheel ***B***. At this point the other end of the locking lever releases the rewinding regulator train, and barrel ***A*** starts rotating.

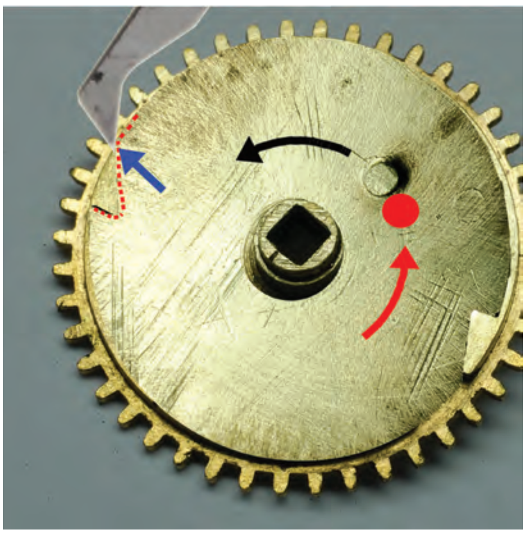


Figure 9-25

Figure 9-26

(d) Figure 9-26: Barrel ***A*** rotates the arbor wheel ***B***, winding the spring in barrel ***B***. The remontoir disk is no longer being pushed, and so the spring coupling it to the arbor wheel ***B*** brings its inclined notches back into alignment with the notches in the arbor wheel. The arbor wheel ***B*** and the remontoir disk then rotate together until, after half a turn, the locking lever drops into the opposite pair of inclined notches. This re-locks barrel ***A*** and arbor wheel ***B*** and winding stops. At this point, the pin on the remontoir disk is half a turn in front of the pin on the barrel lid. And so barrel ***B*** drives the watch train for half a turn, at which point its pin catches up to the remontoir disk pin and the process starts again.

The Breguet and Papillion movements have different teeth counts in the remontoir system, Table 9-1.

First, from the teeth counts of barrel ***B*** and the center pinion, a half turn of barrel ***B*** will run the Papillion movement for 4 hours and the Breguet movement for 3 hours.

Second, from the stop-work on barrel ***A***, the power reserve is about 65.4 hours for the Papillion movement and 54.4 hours for the Breguet movement.

	Breguet	**Papillion**
Arbor wheel ***A***	64	60
Barrel ***A***	70	60
Arbor wheel ***B***	54	44
Barrel ***B***	72	80
Center wheel pinion	12	10

Table 9-1

Because only half a turn of the spring in barrel ***B*** is used, the spring must be set up so that one of the middle turns, with the most even power output, is used.

If the watch is not carried, the spring in barrel ***A*** will eventually run down. This will occur while the remontoir is activated and the spring in barrel ***B*** is being wound, Figure 9-26. Barrel ***A*** and Arbor wheel ***B*** will advance less than half a turn and then Barrel ***A*** will stop rotating with the rewinding regulator train free. Barrel ***B*** will continue to turn, and the watch will run, until the pin on the barrel lid meets the pin on the remontoir disk. But after rotating this disk until its inclined notches are fully out of alignment, as in Figure 9-25, movement of the disk will be blocked by the slot in the arbor wheel ***B***, which in turn is prevented from rotating by barrel ***A***. So barrel ***B*** will stop turning and the watch will stop running.

As soon as the watch is shaken enough to provide some power to the spring in barrel ***A***, it will resume turning arbor wheel ***B***, freeing the remontoir disk, and the normal sequence of events will restart.

Finally, the barrel remontoir is not part of the self-winding system. Using the definition in Section 1.3 (page 6), the weight and every part to the self-winding train pinion in Figure 9.4 can be removed and replaced by a key to turn the arbor of Barrel ***A***.

9.4: Breguet's Side-Weight Mechanism

Although not directly relevant to this book, Breguet's improved mechanism, Figures 9-27 and 9-28, is included for comparison with Recordon's patent in Section 8.2, page 93. It is described by Daniels (1975, pages 344-345) and his diagrams are "taken from one of the first series of these watches and is used in all similar watches".

The weight ***A***, Figure 9-27, is squared onto an arbor passing through the movement. It is held in position by an equilibrium spring in the barrel ***Q***, with its inner end hooked to a boss squared onto the arbor; the tension is adjusted and fixed by turning the barrel, which is locked by the click ***C***.

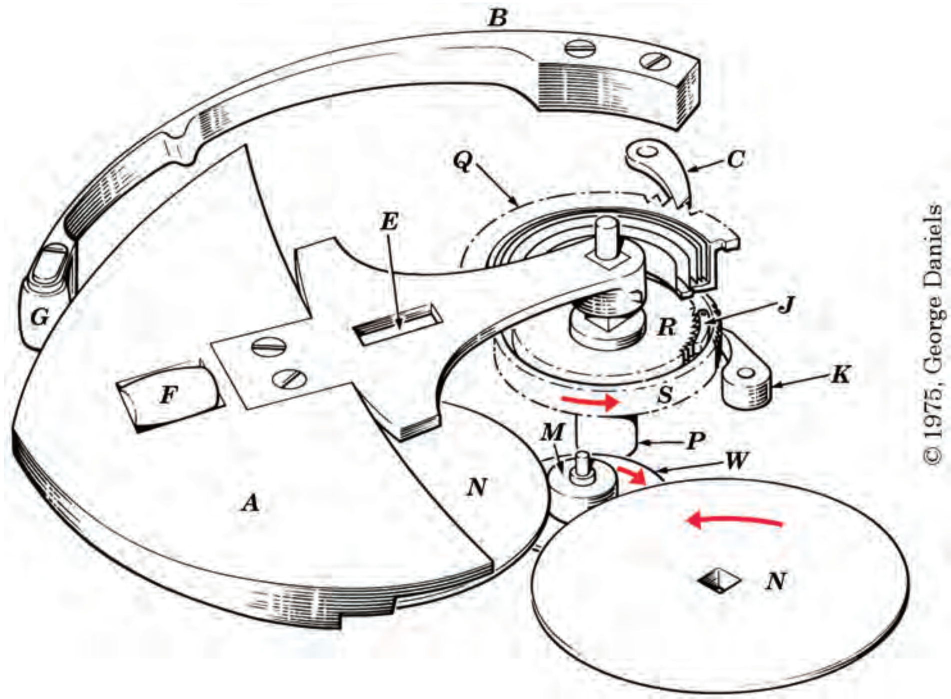


Figure 9-27

Also squared onto the arbor is the ratchet ***R*** which fits inside the loose ratchet ***S***. The click ***J*** is mounted on ***S***, so that as the weight turns anti-clockwise ***R*** turns ***S*** anti-clockwise through the click. When the weight turns clockwise, the click ***J*** rides over the teeth of ***R*** and ***S*** does not turn; the click ***K***, mounted on the plate, ensures that ***S*** cannot turn clockwise. Thus winding takes place in one direction, when the weight drops.

P is a pinion rigidly attached to the ratchet ***S***. It winds the two mainsprings through the intermediate wheel and pinion ***W M***, which rotate clockwise. The pinion ***M*** meshes with the wheels ***N*** squared onto the barrel arbors. So the barrel arbor rotates anti-clockwise to wind the mainspring and, consequently, the barrel rotates anti-clockwise to run the watch. The ratchets have very small teeth and only a small movement of the weight is necessary to wind the mainspring.

The weight oscillates between two banking springs ***B***. These springs have rollers ***G*** to minimise friction between the weight and the springs.

Because some movement of the weight might occur, because of play in the pivots and flexing of the arm that attaches the weight to the arbor, the weight also has a roller ***F*** to prevent it rubbing on the case or the plate. Additionally, in some watches Breguet used spring-mounted jewels for the weight arbor and they increase the possible movement of the weight. The watch on the cover of this book shows a light mark on the top plate caused by the weight rubbing.

The locking mechanism, Figure 9-28, is the same in principle as those in Recordon's patent, the barrel remontoir mechanism, and the center-weight mechanism (see Chapter 12).

It uses stop-work with a finger ***A***, squared onto the barrel arbor, meshing with the wheel ***B*** mounted on the barrel. As in the other mechanisms, ***B*** has a boss at ***C*** which, when the mainspring is fully wound, raises the spring ***D*** which, in turn, raises the lever ***E***, pivoting at ***F***. The end of ***E*** enters the slot ***E***, Figure 9-27, to lock the weight.

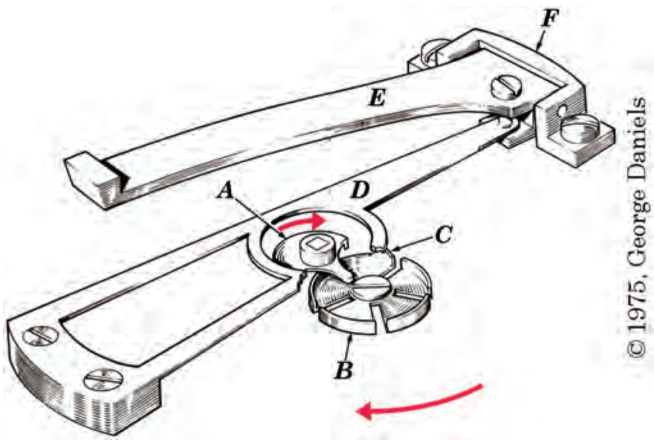


Figure 9-28

Figure 9-28 is incorrect. In the position shown the boss has raised ***D*** to lock the weight, but this can only happen if ***A***, mounted on the barrel arbor, has rotated clockwise, the wrong direction. And the barrel must also rotate clockwise to run the watch, again the wrong direction. Breguet's stop-work is examined in Appendix 7, page 362.

9.5: The Equilibrium Spring

The equilibrium spring is not just an improvement, but it is an essential part of the mechanism.

Consider a watch with a weight that is not supported by a spring. Then the weight acts like a pendulum and must pivot at the pendant so that it can swing freely; Figure 9-29.

But a watch placed in a pocket need not be pendant up, and frequently it will turn to one side or the other. Then the weight can rest against the case or one of the banking springs. In Figure 9-30, winding can only occur if the weight rotates clockwise and, to do so, it must lift up against the force of gravity. Because the weight cannot oscillate, the movement will be quite small and the winding will be very inefficient as the weight bounces against the case or the banking spring.

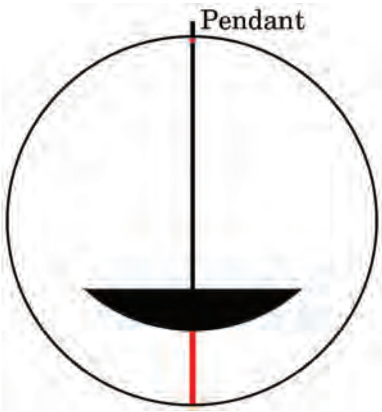


Figure 9-29

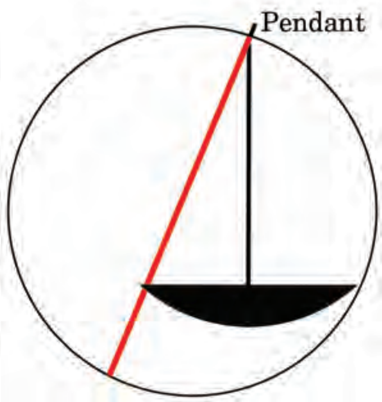


Figure 9-30

The consequence is that the equilibrium spring is essential.

The pivot point is arbitrary, but the ideal is horizontal, Figure 9-31. This is because when the weight drops, the movement created by the motion of the wearer is assisted by gravity. In contrast, when the weight rises, the effect of gravity will be to reduce the motion, and so the movement of the weight is asymmetrical. The side-weight mechanisms of Recordon and Breguet make use of this. They have unidirectional winding where the click and ratchet act when the weight drops and gravity is enhancing the movement of the weight. Which is why some side-weight mechanisms have the equilibrium point above horizontal, as in Figure 9-32. This arrangement maximises the clockwise, downwards motion of the weight and so improves the winding efficiency.

Clearly, unlike the rotor mechanism, the side-weight mechanism is affected by the position of the watch, and its performance deteriorates as the watch is moved from the ideal, pendant up position.

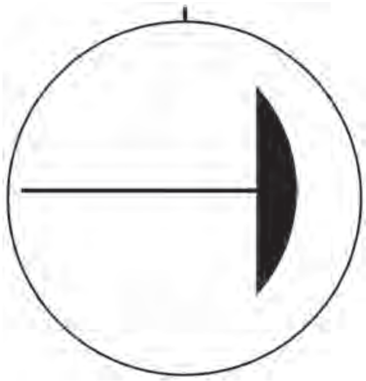


Figure 9-31

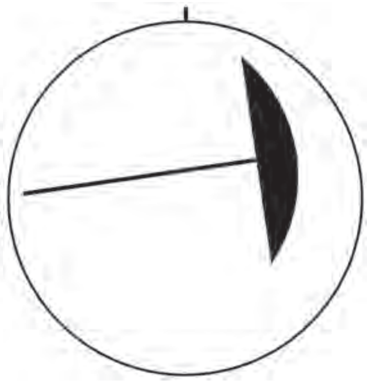


Figure 9-32

The heavy weight moves the center of gravity of the movement away from its physical center. And so the watch, loose in a pocket, will turn to bring the center of gravity to its lowest point, with the weight about vertical. This rotation will be significant every time the weight strikes the bottom banking spring, because that will force the watch to rotate. If the weight ends up in a near vertical position, the behaviour of the mechanism will be similar to that of a rotor mechanism.

Léon Leroy appears to be the only person who has considered this problem (Chapuis & Jaquet, 1952, page 211; 1956, pages 220-221). He suggested a tight-fitting pocket or a short chain to keep the watch vertical.

9.6: Performance of the Side-Weight Mechanism

The performance of the side-weight mechanism is limited by:

(a) The weight can only rotate about 40°, 20° on either side of the rest position. The following analysis assumes large swings when the rest position is not important. Having the rest position high would improve the performance with smaller swings.

(b) The design has unidirectional winding and half of the movement of the weight is wasted.

(c) To be effective, low gear ratios are used in the small train connecting the weight to the barrel arbor. One result is that the weight must be larger and heavier to overcome the reverse power of the mainspring.

Estimating performance is difficult, because there are different designs and often not all the necessary information is provided.

Recordon's patent (Section 8.2, page 91) specifies the pinions, but not the wheels. Assuming Figures 8-1 and 8-2 are to scale (which is very optimistic) and assuming all teeth have the same module, we can estimate the winding train to be ($^{10}/_{33}$) ($^{12}/_{40}$) = $^{1}/_{11}$. This ratio of 11:1 seems too low. We can also estimate the maximum rotation of the weight to be about 40°, 20° on either side of the equilibrium point.

Daniels (1975, page 344) provides no details, but he states that Breguet's winding train has a gear ratio of 24:1, and one turn of the two barrels (which have 4 turns) would run the watch for 15 hours.

Breguet himself is more specific (Chapuis & Jaquet, 1952, pages 99-100; 1956, pages 104-105). His train is ($^{10}/_{36}$) ($^{15}/_{80}$) giving a ratio of 19.2:1. In addition, he states the watch has two barrels of 4 turns giving a running time of 48 hours, 12 hours per turn. It is interesting to note that for this watch to wind the barrels sufficiently to give 15 hours running requires ($^{15}/_{12}$)19.2 = 24 turns, exactly the same as the watch described by Daniels.

Neither source specifies the maximum swing of the weight. An early watch with a single barrel (Daniels, 1975, page 114) appears to have a maximum rotation of about 44°, 22° on either side of the equilibrium point.

Using Breguet's description, when the weight moves 40° it requires ($^{360}/_{40}$)19.2 = 172.8 oscillations of the weight to wind the mainsprings one turn, and 691.2 oscillations to fully wind the watch.

Breguet states that two minutes of shaking are sufficient to fully wind the watch. That is $^{691.2}/_{120}$ or about 5¾ oscillations per second with the weight bouncing off the banking springs. In comparison with the rotor mechanism (page 83), at 4 oscillations per second it will take a little less than 3 minutes, and at 5¾ oscillations per second it will take 122 seconds, which is the same. But this compares rotating the barrel 4 times and the fusee 7 times. If we want to wind a rotor watch for the same 48 hours running time, 4 turns of the fusee, then it will take about 70 seconds.

Breguet also states that 15 minutes of walking *at an ordinary pace* will wind the watch. That is, the barrels rotate 1.6° per second and the weight must move a little more than 30° per second. If there is one oscillation per second, then this suggests the weight hits the bottom banking spring and rises about 10° above the equilibrium position. But Breguet may be referring to two oscillations per second. Thus rotor and side-weight mechanisms have a similar efficiency.

9.7: Watches

Breguet's watches are illustrated in many books, and I will only make a few remarks.

There appears to be only one watch attributed to this period, before 1780, and it is not self-winding. It is watch $^{91}/_{122}$, which is said to have been begun circa 1775, because the case bears hallmarks for July 1774 to July 1775, and it was entered in Breguet's books in 1791. It is a quarter repeater with verge escapement, and is illustrated in Antiquorum (1991, page 22, lot 3) and Breguet (1997, page 35), but there are no views of the movement. It appears that the number is not a serial number, because the same auction includes watch 88 "constructed in 1796-1797 (Antiquorum, 1991, page 22, lot 2), and other watches have numbers which are clearly out of sequence. More important is the obvious question: Would Breguet, just after he had set up in business, purchase an expensive gold case, start making a movement for it, and then leave it in his workshop for sixteen years? Or was the dowry from his wife so generous that he could afford to do this? It seems unlikely.

In addition, Daniels (1975, page 21) provides a facsimile of a 1780 promissory note for a watch made in 1778.

Regarding other early watches, Daniels (1975, page 67) states:

> *"Of the repeaters made before 1787 ... very few survive. Except in their cases they show almost nothing of the potential ability and style that was to create the legend of Breguet".*

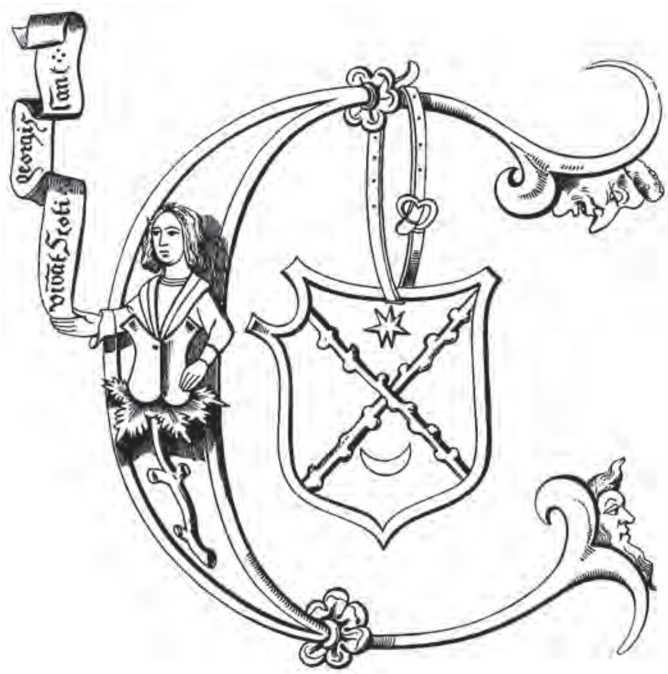
Breguet's early repeaters used an adaptation of Stogden's design (Watkins, 2011b, pages 44-56). For example, watches number 128 5/85, May 1785 (Daniels, 1975, page 140), which is a Stogden minute repeater with an old style, pierced cock. And watch number 155 2/86, February 1786 (Daniels, 1975, page 141), which also has an old style, pierced cock. Later Breguet adopted a more conventional design, still with old style, pierced cocks; for example watches numbered 3/88 and 223 3/88 (Daniels, 1975, pages 118 and 142). Although using cylinder escapements, the watches have fusees. Early watches had conventional cases (Daniels, 1975, pages 126-127).

Ignoring the barrel remontoir watch described above, the oldest known self-winding watch is numbered No. 1 8/82, August 1782 (Sabrier, 2012a, page 91). It is clearly much more sophisticated than the above examples of repeaters and shows the style that made Breguet famous.

Two other early watches are 2 10/82 and 8 10/83 (Daniels, 1975, pages 64, 114 and 139). However, all these watches are too late and they cannot be used as evidence for pre 1780 watchmaking.

Finally, as noted above, Breguet stated that in 1780 he made a self-winding watch for the Duke of Orleans, and a watch exists which is inscribed on the weight *Faite Par Breguet Pour Mr le Duc Dorleans en 1780.* Chapuis & Jaquet (1952, pages 110-111; 1956, pages 116-117), Daniels (1975, page 66) and Sabrier (2012a, pages 102-103) note that the movement could not have been made that early and the inscription is false and a later addition. Unfortunately, this is not the watch made for the Duke of Orleans.

Although not relevant, another example of a false the inscription is *Petrus Hele me f.[ecit] Norimb[erga] 1510* on what could be the oldest surviving watch. Unfortunately, this "Henlein watch" is a marriage of pieces from various mechanisms and it was created later (probably ca. 1850) with the intent to deceive. The hands date to the 17th or 18th century, and some components are machine made late 19th century. The signature and date appear to have been added shortly before it was sold to the Germanisches Nationalmuseum in 1897. (See Eser, 2014.)



10: Amédée Christin

10.1: Biographical Notes

Amédée Christin was the son of Jean-Pierre Christin and Charlotte Vulson, who married in the fall of 1724. Before her marriage, Charlotte was a mistress of Jean-Jacques Rousseau; he mentions her in his "Confessions". Her father, Brigadier Vulson was a commander in the service of Germany and died at the Battle of Minden (1 August 1759), lost by the French. Amédée was born in Bern, Switzerland, probably about 1725 to 1730. (Roobaert, 2014-2015.)

In a letter dated 1779, Christin provided the following autobiography:

> *In my youth I was driven by an unquenchable appetite for mechanisms in general, and I followed the way which is absolutely necessary to succeed in this science, that is, I embraced watchmaking. I practiced all the rules, and I even dare to say all the delicacy of this Art. I applied myself principally to the study of the best authors, so as to know all the results of the materials put in motion in the smallest volume, because this knowledge leads naturally to the most perfect exactitude in the execution of any machine, whatever type and size which it may be. I went to Paris for a suitable time to benefit from the knowledge of the great artists who are there. From there I went to Amsterdam, because I wanted to get some knowledge of the construction of ships, and finally I stopped in that city where I was summoned by the SAS Monseigneur the Margrave de Bade Dourlach, to set up some manufactories in his lands, which occupied me for more than twelve years.* (Mundschau, Roobaert and Watkins, 2014, page 2.)

Fallet (1942) and Pieper (1992) provide histories of watchmaking in Pforzheim from which the following is derived.

On 6th April 1767 the government of Karlsruhe signed a contract with Jean-François Autran to establish in Pforzheim a factory for horology, mainly of watches, financed by His Serene Highness (S.A.S.) the Margrave of Baden-Dourlach. Autran was described as emotional and intemperate.

One objective was to train and employ boys and girls from the Pforzheim orphanage. But in a report of April 24th, Autran expanded the aims to include making jewelry and "hardware" (such as watch chains, swords, trimmings of weapons, loops, buttons, scissors, etc.) partly because

> *the orphanage of Pforzheim is filled with clumsy, stupid, people suitable for nothing, but who could be occupied with smoothing and polishing hardware.*

To help manage this now large business he engaged Jean-Jacques Ador.

On 6th November 1767, the Margrave granted a privilege in the names of Autran, Amédée Christin and Jean Viala. Christin is described as a tinkerer, an inventor who had no understanding of business and commerce. Viala was Christin's brother-in-law, having married his sister Luise Francoise Augustine on 5 January 1768 in the Evangelical church of Pforzheim, Karlsruhe (Family Search, 2014). He was the youngest of the three and relatively immature.

Autran, Christin and Viala insisted on the need for expanding into other branches, including watch case manufacture. To raise money for this expansion, the Margrave granted the right to issue shares.

But this was not very successful and on 2nd November 1767 they asked the Margrave to guarantee 30 to 40,000 guilders.

However, dissensions broke out between the leaders and, at the same time, there were conflicts with the workers who had been engaged as training masters. So on 28th June 1768 the "factory" was split with Christin and Viala taking over the watch and jewellery manufacture, and Autran and Ador the manufacture of hardware, although the latter also manufactured watches. The Margrave financed this, providing 20,000 guilders to Christin and Viala, and 20,000 guilders to Autran.

In 1771, the two factories had 203 workers, 274 people including the children.

The business of Autran and Ador was not successful and their company was liquidated in 1775.

In 1772 Christin separated from Viala and the latter continued the watchmaking venture on his own. (Pieper, nd, page 46. But Pieper, page 45, also indicates the date was 1774.)

On June 14th, 1774, Christin repeated a request, which the margrave had already answered favourably, to allow him to be called a watchmaker of the court and to be established as such in Karlsruhe. Christin added a supplication to take responsibility for the not completed clock which was at the Pforzheim factory and to advance 300 guilders to finish it; the court granted an advance of 200 guilders.

Jean Viala died on 26 December 1774 (Family search, 2014), and the watch company was continued by his widow for nearly ten years; from 1774 to 1783. On 5 October 1783 she remarried with the tradesman Johannes Hoffmann of Schaffhousen, and then the name Hoffman and Viala was used (Family Search, 2014).

After Christin and Viala separated, Christin moved to Karlsruhe, and later he went to Berlin and Amsterdam.

10.2: Christin's Transverse Weight Mechanism

A tantalising reference to a person named Christin appeared in Berlin (1781, page 42). On 26 August 1779, the Académie Royale des Sciences et Belles-Lettres received a letter from M. Christin (Figure 10-1) accompanied by a drawing of a self-winding watch.

In 2014, Heinz Mundschau contacted the President of the Berlin Academy of Science and obtained copies of three letters, a summary of inventions, and a drawing of a self-winding watch and its explanation. We do not know the name of the person to whom these letters were addressed, but it was probably Formey, Conseiller privé and perpetual secretary of the Berlin Academy. The letters and other documentation will be found in Mundschau, Roobaert and Watkins (2014).

Le 26 Août, le Sécretaire a remis des Catalogues envoyés de Hollande, & entr'autres celui de la *Bibliotheca Alpheniana*.
— — — le Programme Anglois de la Société des Arts de Londres.
— — a lu une Lettre de M. *Chriſtin*, (voyez le 1er Juillet,) accompagnée du deſſin d'une montre qui ſe remonte d'elle-même.

Figure 10-1

On 23 July 1779 Christin wrote a letter to which he attached the description of a self-winding watch. The original description and diagram are at the end of this section, Figures 10-6 to 10-10.

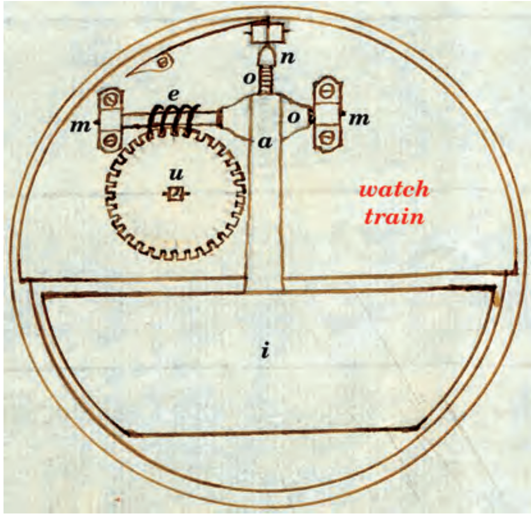


Figure 10-2

Figure 10-2 is a view of the top plate, opposite the dial, showing the self-winding mechanism in situ. Figure 10-3 is a view of the case from the same position. Note that the weight ***i*** oscillates transversely, from front (dial side) to back (top plate side).

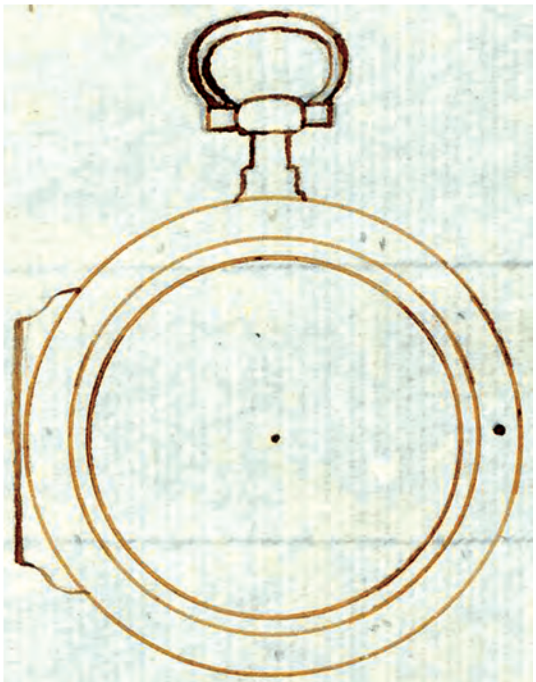


Figure 10-3

Because the weight occupies the whole bottom half of the movement, and the barrel fills the top left quarter, the entire watch train must be placed in the top right quarter.

The wheel ***u*** is attached to the arbor of the going barrel. To wind the mainspring, the barrel arbor and ***u*** rotate clockwise. When the watch runs the barrel rotates clockwise.

Figure 10-4 is the exploded view of the self-winding mechanism and Figure 10-5 is a profile view from the right side of Figure 10-2.

The endless screw ***e*** has a long arbor ***m m*** with pivots at both ends. The weight ***i*** pivots on the arbor ***m m***. It is loose and can turn independently of ***m m***.

The ratchet ***o*** is squared onto the arbor ***m m***. From the point of view of Figure 10-5, when ***e*** and ***o*** rotate anti-clockwise ***u*** rotates clockwise and winds the mainspring.

There are two clicks ***n*** and ***a***, shown in Figure 10-5, and both clicks mesh with the ratchet ***o***.

The click ***n*** is mounted on an arbor attached to the top plate. This click and the ratchet ***o*** form the normal ratchet and click that stops the barrel arbor rotating anti-clockwise and so unwinding the mainspring; this would happen if ***e*** and its arbor ***m m*** could rotate

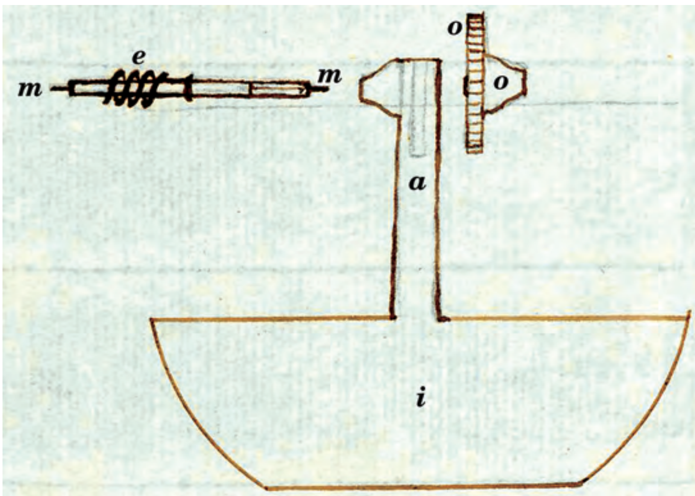


Figure 10-4

Figure 10-5

clockwise. But, although the endless screw ***e*** can drive the wheel ***u***, the wheel cannot drive the endless screw. That is, the click ***n*** is not necessary.

The click ***a*** is mounted on the weight ***i*** and connects it to the ratchet ***o***.

There is no equilibrium spring and the weight ***i*** acts as a pendulum. There are 3 cases:

(a) *The weight **i** does not move*: The clicks ***a*** and ***n*** lock ***u*** and the barrel arbor cannot turn. The barrel will turn and the watch will run until the mainspring fully unwinds.

(b) *The weight **i** rotates clockwise*: The click ***a*** slides over the teeth of the ratchet ***o***, and the self-winding mechanism has no effect on the position of the ratchet. At the same time, the click ***n*** prevents the ratchet ***o*** from rotating clockwise (which would unwind the mainspring).

(c) *The weight **i** rotates anti-clockwise*: The click ***a*** rotates the ratchet ***o*** anti-clockwise, and the self-winding mechanism winds the mainspring through the endless screw ***e*** and the wheel ***u***. The click ***n*** slides over the teeth of the ratchet ***o*** and is inactive.

In theory this mechanism will work, but it has four faults:

(a) *The mechanism has no stop-work*. When the mainspring is fully wound, the weight ***i*** can continue to oscillate and something must break (see Appendix 7, page 375). That is, without stop-work the design is useless.

(b) *The watch is too thick*. The arbor ***m m*** is mounted above the top plate. Assuming Figure 10-5 shows the at-rest position, where the watch is vertical, ***i*** can only rotate anti-clockwise a small distance before it hits the pillar plate supporting the dial. And it can only rotate clockwise until it hits the watch case (there is no mention of buffer springs). There are two possibilities:

First, the weight can rotate equally far either clockwise or anti-clockwise. Then the watch is probably three times as thick as an ordinary watch and the weight can move about 20 degrees.

Second, the space between the case and ***i*** is just sufficient for ***i*** to move into its at rest position and the watch is about twice as thick as an ordinary watch. Then the weight can only move about 10 degrees, bouncing off the case. It cannot act as a pendulum because half of the swing is suppressed.

(c) *It is possible that the weight will not oscillate sufficiently to wind the mainspring effectively*. In the first case above, the weight ***i*** can only rotate about 20 degrees, that is, 18 oscillations for 1 turn of the ratchet ***o***. Assuming one turn of the endless screw ***e*** advances the wheel ***u*** by one tooth and ***u*** has 32 teeth, it requires about 32 x 18 = 576 oscillations to rotate ***u*** once, or about 2,300 oscillations to wind the watch 4 turns. If there are 4 oscillations per second, then the watch can be wound in about 9 minutes.

But the movement of the weight is at a right-angle to the normal motion while walking and it is unlikely to reach this ideal. However, if the watch is worn in a breast pocket (so that the dial or back faces the direction of motion) it may perform adequately.

In the second case above, it will require about 4,600 partial oscillations, or about 18 minutes to wind the watch. However, it is very likely that the weight will only move a little, if at all, and the design probably will not work.

(d) *The watch train is severely restricted*. The train, including the barrel, can only occupy the top half of the movement. Then the wheels and balance are seriously constrained.

Christin's description of the mechanism, with a few comments, follows:

> *Description of a new kind of watch which winds itself, the invention of Amédé Christin, watchmaker of the court of Bade Dourbarch in Carlsrouhe of July 23rd, 1779.*
>
> *No force can overcome its equal by equal levers.*

A strange statement that makes some sense; two equal forces opposing each other equally cannot cause any motion. But in this context the statement is pointless.

> *This truth, known to all watchmaker machinists, does not prevent a large number of those who are inventors to begin their work with research into perpetual motion, the usual effect of the ignorance which is dissipated in this respect only by repeated experiments. I did like others in the first efforts, in my focus on the mechanisms and the number of tests that I keep remembering sometimes the futility of my claims. But having soon confined within proper limits, I know well the power of springs and weights, whose operations are varied enough in the hands of an artist who can employ them suitably. Consequently, I imagined a few years ago what I propose today, to give to the machines intended to measure time a continual movement, without it being necessary to wind them.*

Christin suggests that his design dates from about 1776-77.

> *The knowledge of this matter provides me several ways applicable to the large clocks of cities and the clocks of apartments, I found it very easy to produce, by an interrupted and irregular moving force, another equal and continuous moving force. The application of this rule was used by me for various works, and I formed in this respect a system which can be useful for all nations. My various experiments confirmed it, and my advances in this type were not limited to speculation relative to large machines.*

This suggestion is absurd. Unless the mechanism is moved by an external force, self-winding cannot occur, but tower and table clocks do not move. However, it is probable that Christin is confusing two concepts, those of self-winding and automata. Mundschau, Roobaert and Watkins (2014, page 11) mention a table clock with two automata that is signed *Christin Horloger de la Cour Carlsrouhe*, and the above words are applicable to such automata.

> *The invention, which is the current object of this explanation, is a pocket watch of ordinary size whose engine, no matter that it is very different from those of the project for unmoving clocks which I have just mentioned, have however the same goal.*

When writing *ordinary size*, Christin must be referring to the diameter of the watch, because the thickness is clearly different.

> *When I worked on this discovery, several ways to reach that point arose. Each of them could be used, but I gave preference to simplest, which is also most solid. The construction of the train marking the hours and the minutes, differs from the other watches in that it is less complicated, which promotes a greater perfection in the execution of the work. It is without a fusee, with an escapement at rest, and it occupies only half of the ordinary space, other half being reserved for the vibrations of the winder. This winder is a weight suspended and contained within the movement, it is heavy enough to wind the mainspring of the watch by a resistance divided to the thirty second part, and it operates by gravity or the heaviness that naturally leads it so that the*

least movement that is given to the watch while walking or by doing other things contributes to winding it. As long as the wearer is active in the house, he will only have the watch on him for two hours, for it to be entirely wound up. All other agitations that the watch will receive during the rest of the time, will not harm the mechanism, because the winder remains motionless when it has finished its operation, but it is renewed every now and then on changes of attitude, in proportion to quantity that the spring of the watch unwinds, from which it results that it is wound all the times that it is agitated.

To suggest that *agitations will not harm the mechanism* is clearly wrong, unless Christin has deliberately omitted the stop-work from his description and diagram.

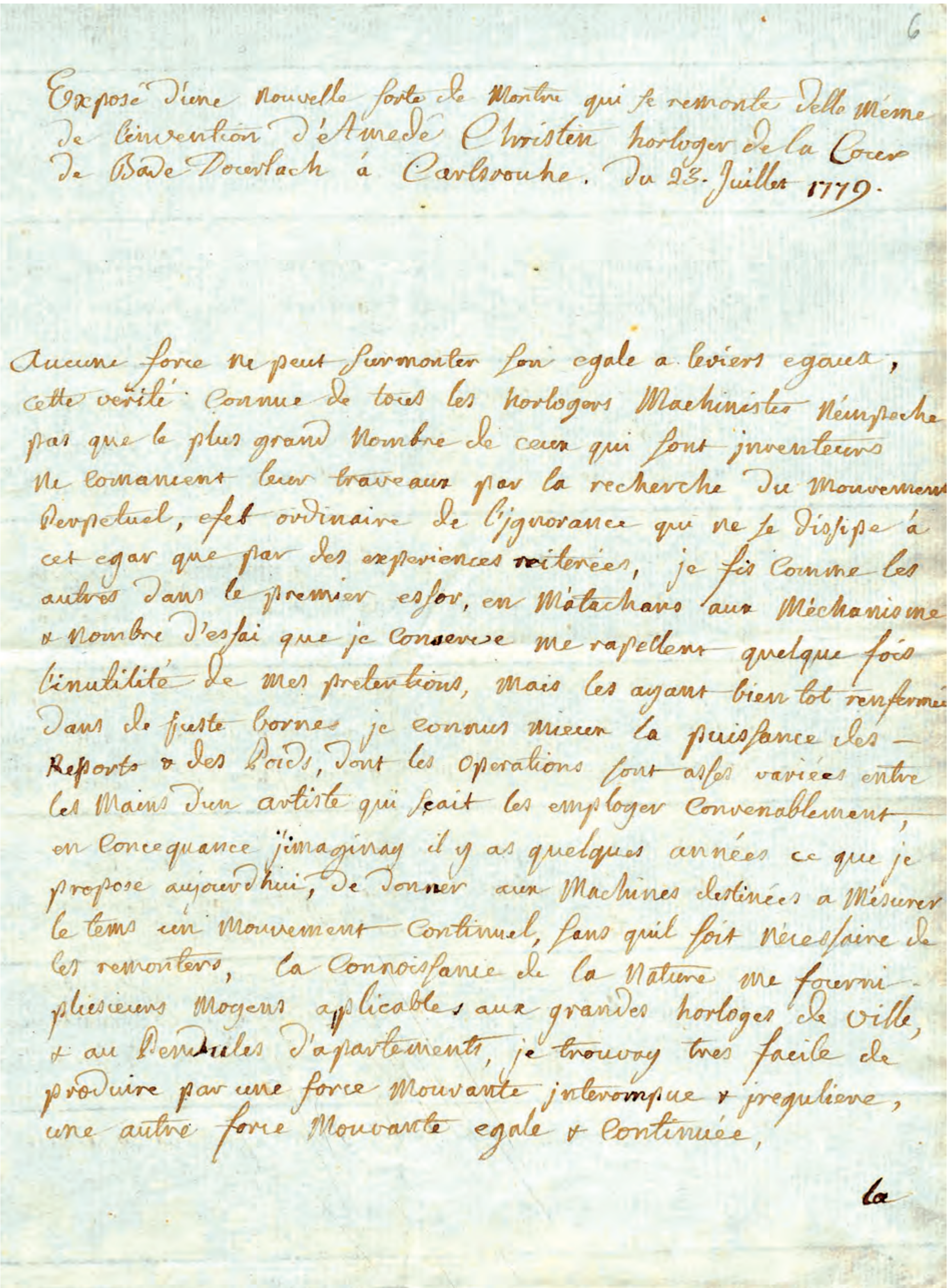
It is made to go 36 hours when remaining in the same place, and it is enough when it has stopped for this reason, to set the hands correctly and put the watch in the pocket, it will wind itself up. Only the movements which one makes by holding it will be enough to automatically start it, the other movements of the body which follow will also produce this effect, and however unequal the time from one action to the other, it does not disturb the watch, more especially as in this new construction, the spring is wound from the inside and unwinds from the outside which acts on the train, so that even during the action of winding, the watch continues to run. The diagram that will follow I drew larger than the watch, so it clarify all these aspects. I avoid the little known terms of watchmaking as much as possible so that it is necessary for a watchmaker to become acquainted with my invention to understand the nature of it (it should not be made public). It is unnecessary to give a description of the train of the watch, and I will restrict myself to mentioning first mobile which receives the impulses of what I call the winder, of which I have indicated the effects. All the mechanism of this invention is reduced to this single part constructed so that the swings only act on the end of the spring that winds it up, an observation which completes the demonstration of this new discovery.

The part marked (a) is made up of the endless screw (e), the weight (i) and the ratchet (o) of the click-and-ratchet work, the whole being joined together to make one moving part on two pivots at the places (m)

This is wrong and it is obvious that the weight must be loose on the arbor. This suggests that the writer did not understand the mechanism.

The wheel (u) is attached to the first mobile of the watch whose spring is wound by the swinging of the part (a)

The click-and-ratchet work seen at the piece (a) shown in profile, explains how a swing does not destroy what the contrary swing will have produced. It is seen that the ratchet (o) is retained by the part (n) so that the endless screw can turn only the way that winds the watch.



6

Exposé d'une nouvelle sorte de Montre qui se remonte d'elle même
de l'invention d'Amedé Christin horloger de la Cour
de Bade Dourlach à Carlsrouhe. du 23. Juillet 1779.

Aucune force ne peut surmonter son egale a leviers egaux,
cette verité connue de tous les horlogers Machinistes n'empeche
pas que le plus grand nombre de ceux qui sont inventeurs
ne comancent leur traveaux par la recherche du Mouvement
Perpetuel, efet ordinaire de l'ignorance qui ne se dissipe à
cet egar que par des experiences reiterées, je fis comme les
autres dans le premier essor, en m'atachans aux Méchanisme
& nombre d'essai que je conserve me rapellent quelque fois
l'inutilité de mes pretentions, mais les ayant bien tot renfermé
dans de juste bornes je connus mieux la puissance des
Resorts & des Poids, dont les operations sont assés variées entre
les Mains d'un artiste qui sçait les employer convenablement,
en consequance j'imaginay il y as quelques années ce que je
propose aujourd'hui, de donner aux Machines destinées a Mésurer
le tems un Mouvement continuel, sans qu'il soit nécessaire de
les remonters, la connoissance de la Nature me fourni
plusieurs Moyens applicables aux grandes horloges de ville,
& au Pendules d'apartements, je trouvay tres facile de
produire par une force mouvante interompue & irreguliere,
une autre force mouvante egale & continuée,

la

Figure 10-6

laplication de cete régle m'as servis a diferents travaux, & je
me suis formes a cet egar un sisteme qui peut etre a lusage
de toutes les Nations, mes experiances diverses l'ont Confirmé,
& mes entreprises dans ce genre ne se sont pas bornées a la
speculation relative aux grandes Machines, linvention -
qui fait l'objet actuel de cet exposé est une Montre de
poche de grandeur ordinaire, dont le Moteur quoi que
tres different de celui du projet des Pendules stable
dont je vien de faire mention, Concour cependant au Mém
but, lors que jag travaillé a cette decouverte plusieur -
Maniéres di parvenir se sont presentée, Chaqune delle -
pourroit etre Mise en usage, Mais jag donné la preference
a la plus simple, qui est aussi la plus solide, —
La Construction du rouage Marquant les heures & Minute
diffère des autre Montre en ce quil est moins Compliqué
ce qui favorise une plus grande perfection dans l'execution
de louvrage, il est sans fusée, avec un echapement a
repos, & il n'ocupe que la Moitié de la place ordinaire,
lautre Moitié etant reservée pour les vibrations du remonteur
ce remonteur est un poids suspendu & renfermé dans le
rouage; il est assés pésant pour remonter le resort de la
Montre sur une resistance divisée a la trentedeuxiéme
partie, & il opére par les gravitations ou la pesanteur lentraine
Naturelement, ensorte que le Moindre Mouvement qu'on donne
a la Montre en Marchant ou en faisant quelque autre
cho

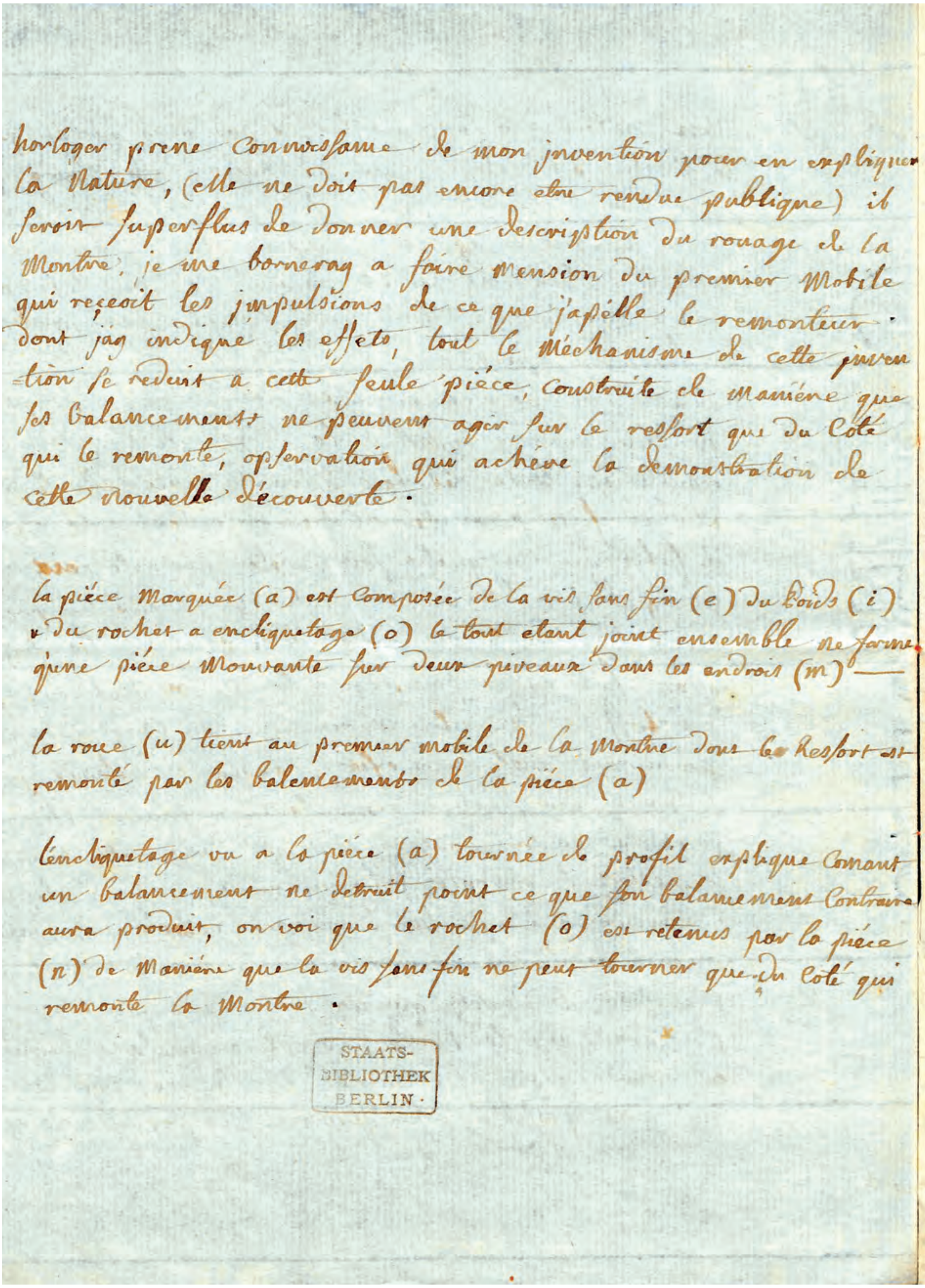
Figure 10-7

7

chose contribue a la remontér, & par peu que la personne qui
la porte soit active dans sa Maison elle n'aura pas sa Montre
deux heures sur elle, qu'elle sera remontée entierement,
toutes les autres agitations que la montre recevra pendant -
le reste du tems ne feront aucun tort au Mechanisme, -
parce que le remonteur reste simplement jmobile lors qu'il
á fini son operation; mais elle se renouvelle de tems á
autre dans les changements d'attitude en proportion de la
quantité dont le ressort de la Montre se develope, d'ou il -
resulte que toute les fois qu'on la quite elle se trouve remonté
elle est faite pour aler 36. heures restant a la même place, &
il sufit au cas qu'elle soit arêtée par cete raison de renger
les eguilles a l'heure, & remetre la Montre en poche, elle
aura soin de se remonter d'elle même, les seuls mouvements
qu'on fait en la prenant a la main sufiront pour Coman
=cer l'office, les autres Mouvemens du Corps qui suivrons —
produiront aussi leurs efet, quelque distance jnegale qui
se trouve d'une action remontante a l'autre elle ne dérange
point la Montre, d'autant plus que dans cete Nouvelle Construction
le ressort se remonte interieurement, & se dévelope par -
l'exterieur qui agit sur le rouage, ensorte que dans l'instant
même de l'action remontante, la Montre continue de
Marcher, le dessein qui va suivre que j'ay tracé une fois
plus grand que la Montre, ajoutera quelque lumiére a tous
ces egars, j'evite les termes d'horlogerie peu connu, autant
qu'il m'est possible, afin qu'il ne soit pas Nécessaire qu'un

hor

Figure 10-8


horloger prene Connoissance de mon invention pour en expliquer
la Nature, (elle ne doit pas encore etre rendue publique) il
seroit superflus de donner une description du rouage de la
Montre, je me borneray a faire mension du premier Mobile
qui reçoit les impulsions de ce que japélle le remonteur.
dont jay indiqué les effets, tout le Méchanisme de cette inven
-tion se reduit a cette seule piéce, construite de maniére que
ses balancements ne peuvent agir sur le ressort que du Coté
qui le remonte, opservation qui achéve la demonstration de
cette nouvelle découverte.

la piéce Marquée (a) est Composée de la vis sans fin (e) du Poids (i)
& du rochet a encliquetage (o) le tout etant joint ensemble ne forme
qu'une piéce Mouvante sur deux piveaux dans les endroits (m) —

la roue (u) tient au premier mobile de la Montre dont le Ressort est
remonté par les balancements de la piéce (a)

lénctiquetage vu a la piéce (a) tournée de profil explique Comant
un balancement ne detruit point ce que son balancement Contraire
aura produit, on voi que le rochet (o) est retenues par la piéce
(n) de maniére que la vis sans fin ne peut tourner que du Coté qui
remonte la Montre.

Figure 10-9

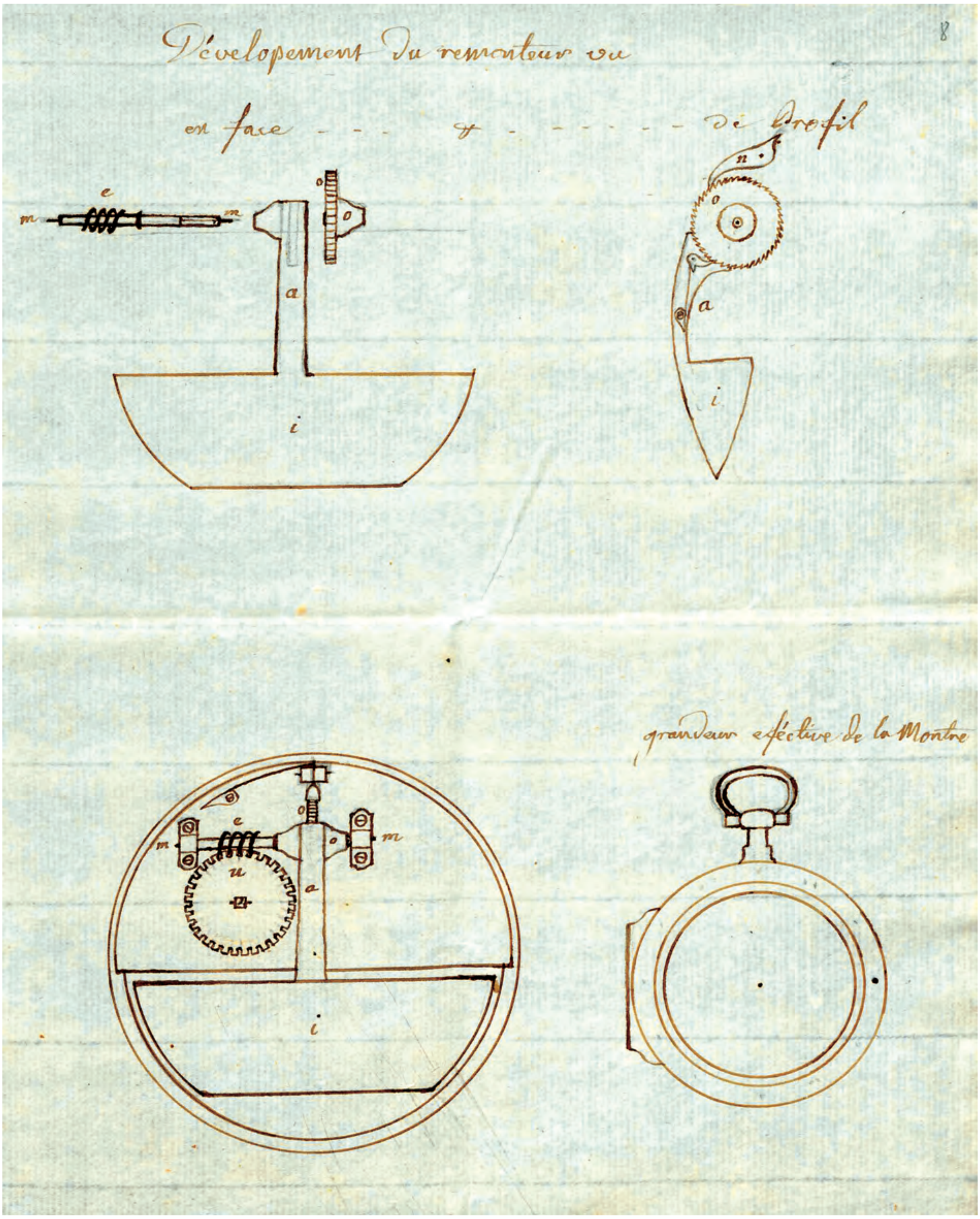
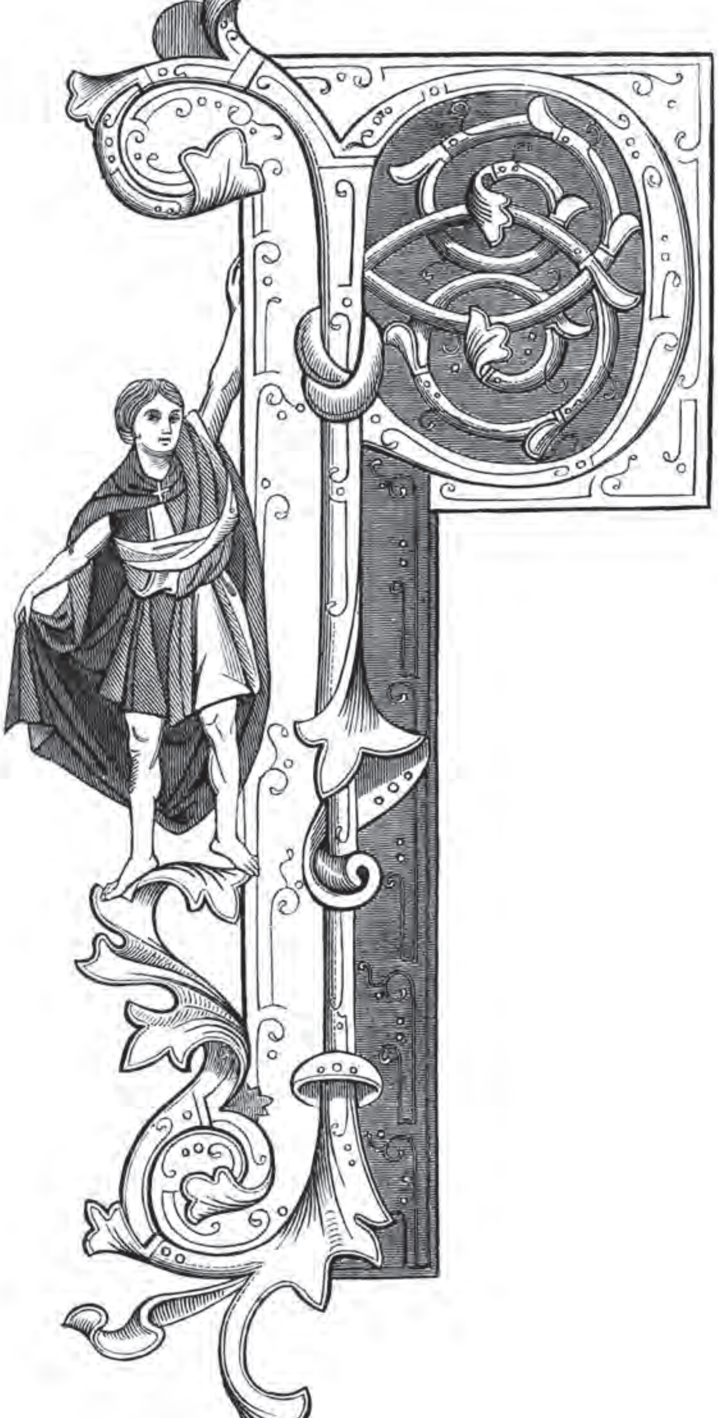

Développement du remonteur vu
en face - - - et - - - - - de Profil
grandeur effective de la Montre
8

Figure 10-10



11: Saint-Martin

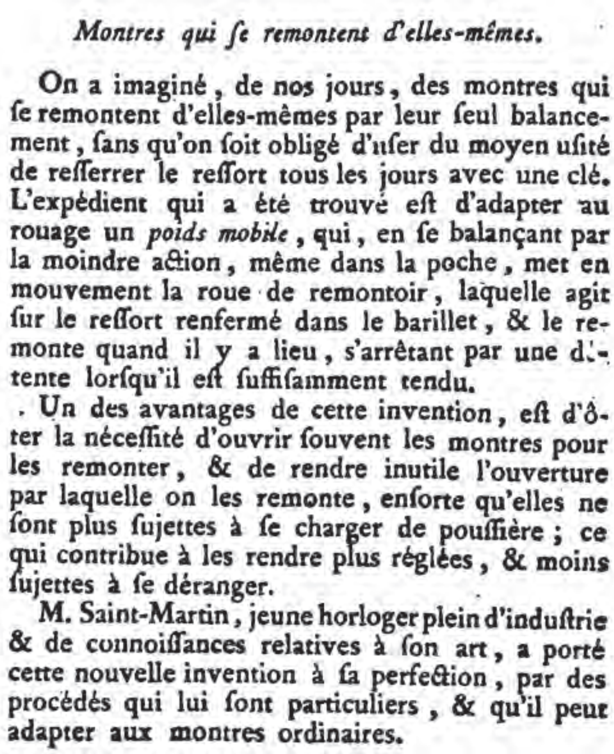
Although probably irrelevant, the Encyclopédie Méthodique (1784) has a 206 page article on horology which includes the following (page 391), Figure 11-1.

Watches that wind themselves

Watches have been created recently which wind themselves by only their swinging, without one being obliged to tighten the spring every day with a key. The method which was found is to adapt to the train a mobile weight, which, while swinging by the least movement, even in the pocket, puts in motion the winding wheel, which operates the spring contained in the barrel, & winds it when it is necessary, stopping by a detent when it is sufficiently wound.

One of the advantages of this invention, is to remove the need for often opening watches to wind them, & for making unnecessary the opening by which one winds them, so that they are no longer prone to pick up dust; which contributes to them being better regulated, & less prone to get out of order.

Mr Saint-Martin, a young watchmaker full of industry & knowledge relative to his art, has brought this new invention to its perfection, by processes which are particular to him, & which he can adapt to ordinary watches.



Montres qui ſe remontent d'elles-mêmes.

On a imaginé, de nos jours, des montres qui ſe remontent d'elles-mêmes par leur ſeul balancement, ſans qu'on ſoit obligé d'uſer du moyen uſité de reſſerrer le reſſort tous les jours avec une clé. L'expédient qui a été trouvé eſt d'adapter au rouage un *poids mobile*, qui, en ſe balançant par la moindre action, même dans la poche, met en mouvement la roue de remontoir, laquelle agit ſur le reſſort renfermé dans le barillet, & le remonte quand il y a lieu, s'arrêtant par une détente lorſqu'il eſt ſuffiſamment tendu.

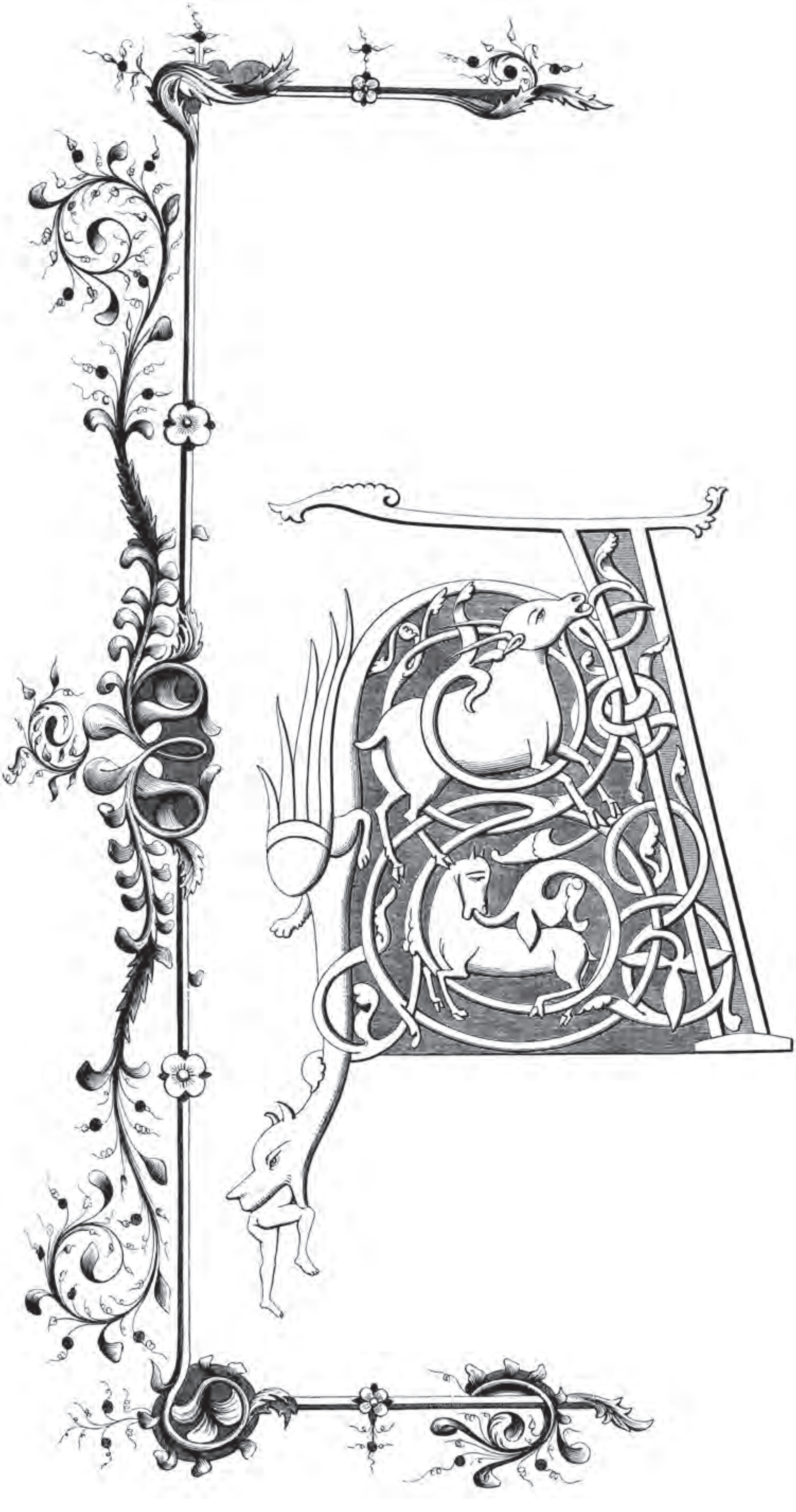
Un des avantages de cette invention, eſt d'ôter la néceſſité d'ouvrir ſouvent les montres pour les remonter, & de rendre inutile l'ouverture par laquelle on les remonte, enſorte qu'elles ne ſont plus ſujettes à ſe charger de pouſſière; ce qui contribue à les rendre plus réglées, & moins ſujettes à ſe déranger.

M. Saint-Martin, jeune horloger plein d'induſtrie & de connoiſſances relatives à ſon art, a porté cette nouvelle invention à ſa perfection, par des procédés qui lui ſont particuliers, & qu'il peut adapter aux montres ordinaires.

Figure 11-1

Tardy (1972, page 583) lists three possible people: Pierre (45 years old in 1784), François-Pierre (master in 1770, so probably about 34 years old), and Jean-Joseph (35 years old), all in Paris.

The problem with this document is the lack of dating. The Encyclopédie Méthodique was developed from the earlier, 1770s Encyclopédie by Diderot and d'Alembert, but it is unlikely that the article came from that edition, and there is no reason to suppose Saint-Martin developed his self-winding mechanism before 1780.



12: Center-Weight Watches

12.1: Watches

There are six known watches using the sixth early design for a self-winding mechanism:

(a) A re-cased watch signed *Guglielmo Meuron*, cylinder escapement, Figures 12-1 and 12-2. In the British Museum Collection in London. It is described below.

(b) An unsigned movement, said to have been made for the English market, Figures 12-3 and 12-4. In a private collection.

(c) A re-cased, unsigned watch, virgule escapement, Figure 12-5. In the Furtwangen Museum.

(d) A watch signed *Choisy à Como*, virgule escapement, Figure 12-6. In the Parisi collection in Milan (Chapuis & Jaquet, 1952, page 202; 1956, page 212).

Figure 12-1

Figure 12-2

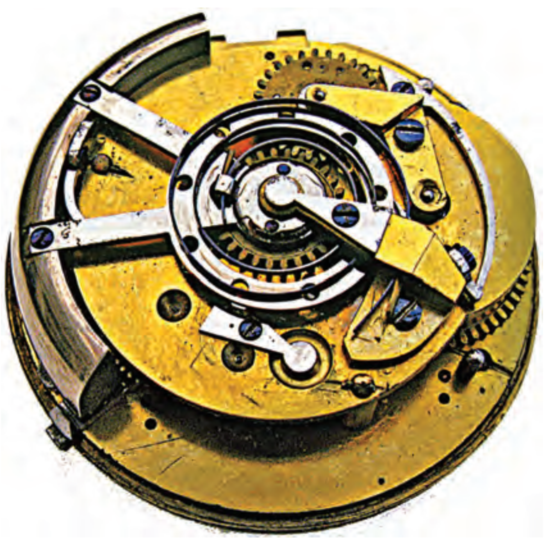


Figure 12-3

Figure 12-4

(e) An unsigned movement without dial and case, Figures 12-7 and 12-8. In the Musée de l'Horlogerie at Le Locle.

This is the movement described by Sabrier & Imbert (1972 and 1974). From these articles, the movement has a cylinder escapement.

(f) An unsigned movement, cylinder escapement, Figure 12-9 (See Crott, 2011, lot 503).

Figure 12-5

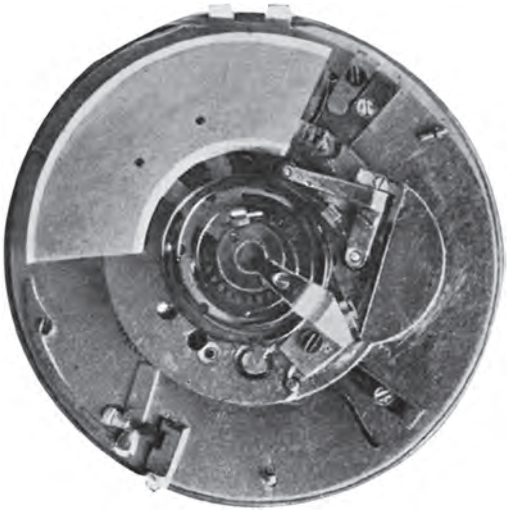


Figure 12-6

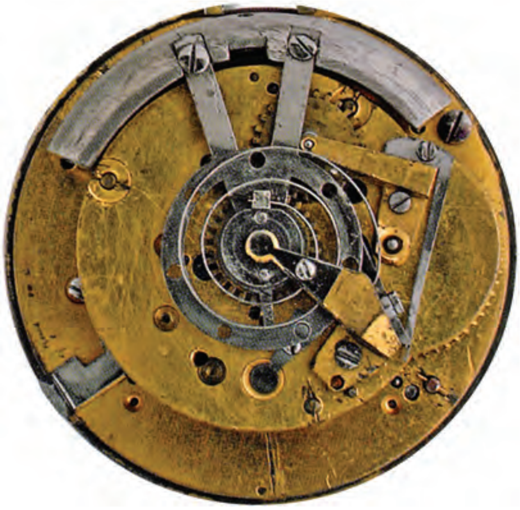


Figure 12-7

Figure 12-8

The dating of these movements is uncertain. Sabrier (2012a, page 44) states that (a) is "in the style of the 1770s", and (c) is "late 18th century" (ibid, page 46). The staff of the Furtwangen Museum estimate (b) was made around 1790-1800. Chapuis & Jaquet say that (d) "was probably made in the 1850's", but this is almost certainly wrong, as it is technically identical to the other four.

In addition, the three watches for which the escapement is not specified must use either the cylinder or virgule escapement to work with their going barrels.

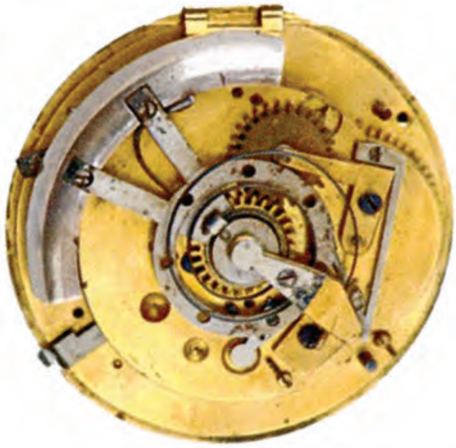


Figure 12-9

12.2: The Center-Weight Mechanism

The mechanism used by these watches is easy to understand, because most of their features appear in other watches that we have already examined. This summary is based on Flores (2002).

The weight, Figure 12-10, is attached by two arms to a complex centerpiece, Figure 12-11. The center consists of a disk with holes (for the locking mechanism) surrounding the central part for the upper pivot; this has a fixed wheel, a loose pinion and a click.

Figure 12-10

Figure 12-11

When the watch is in its normal pendant-up position, the weight assembly is held horizontal or above horizontal by a spiral equilibrium spring, with one end pinned to the weight and the other to the cock that supports the upper pivot.

Beside the pivot for the weight is a second wheel, with a loose pinion and a click, which meshes with the wheel attached to the weight, Figures 12-12 and 12-13. This system is identical to that in the rotor mechanism (Figures 7-26 to 7-28, page 71) and provides bidirectional winding of the mainspring.

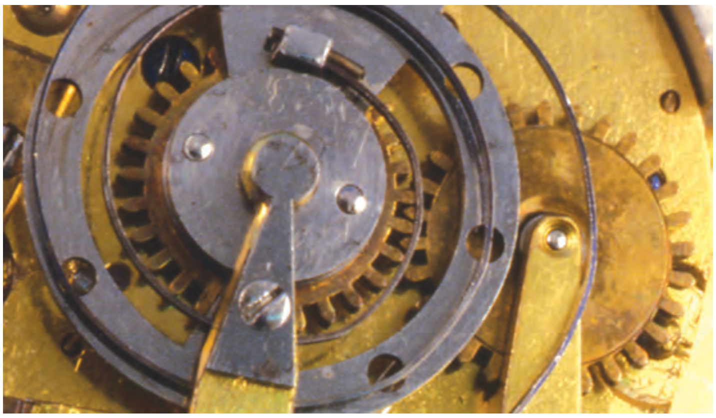


Figure 12-12

Figure 12-13

These loose pinions mesh with the first intermediate wheel, which is between the plates, Figure 12-14.

In turn, that wheel has a pinion meshing with the second intermediate wheel placed on the opposite, dial side of the movement, Figure 12-15. Its pinion meshes with the barrel wheel that is squared onto the barrel arbor. This is, of course, a going barrel and no maintaining work is necessary. Also,

Figure 12-14

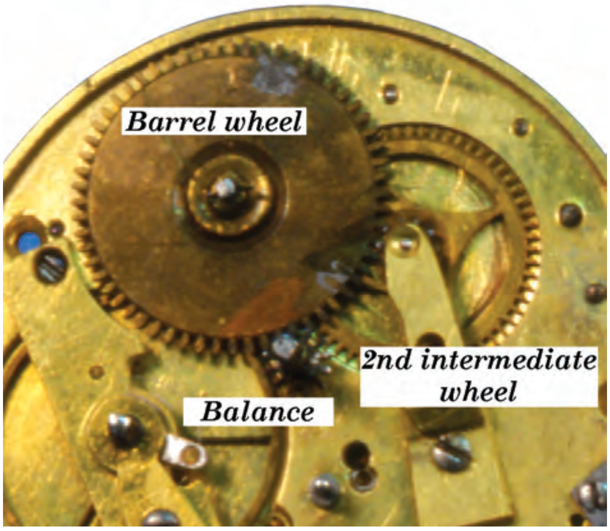


Figure 12-15

the click-work, which is normally on the barrel wheel in going barrel movements, is unnecessary because that is provided by the self-winding mechanism.

Figure 12-16

The balance for the cylinder escapement is also placed under the dial. The square on the balance bridge is for the regulator index on the dial, as in Figure 12-16. (Note that *Retard* has been written upsidedown!)

The weight locking mechanism uses stop-work on the barrel, similar to Recordon, Figure 8-2, page 93, and Breguet, Figure 9-12, page 114.

The first part of the locking mechanism is mounted on the barrel. Figure 12-17 shows the barrel. Its stop-work has a screw by the last tooth that acts as the boss. A lever in the form of a spring, Figure 12-18, is mounted on the barrel lid so that the screw will lift it when the mainspring is fully wound. The end of this spring forms a ring around the barrel arbor.

Unlike the other systems, which have the lever mounted on the plate, the position of this spring never changes in relationship to the stop-work.

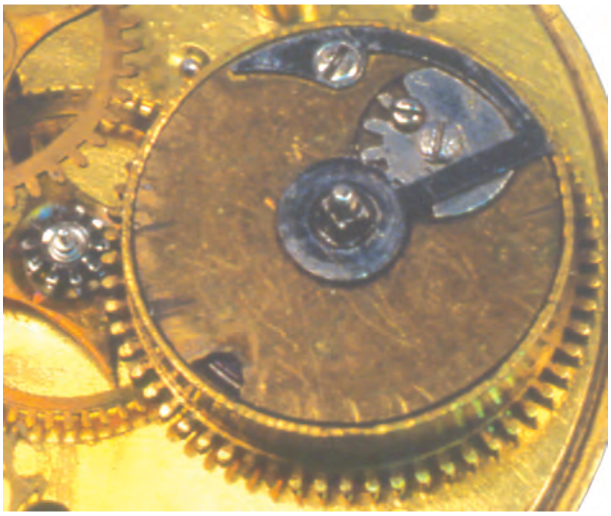


Figure 12-17

Figure 12-18

The second part of the locking mechanism is a lever mounted on the cock for the upper pivot of the weight; three views of it are shown in Figures 12-19 and 12-20.

This lever ***a d*** is loose under a shoulder screw and the end ***d***, which enters the holes in the ring on the weight, is normally held down by the spring ***b***. The piece ***e*** on the lever is over a hole in the plate that corresponds to the ring on the spring mounted on the barrel (Figure 12-17); ***c*** is the barrel arbor pivot.

So when the screw on the stop-work lifts the ring, the lever pivots and ***d*** enters a hole in the ring on the weight and locks it.

Finally, there are at least two different methods of banking.

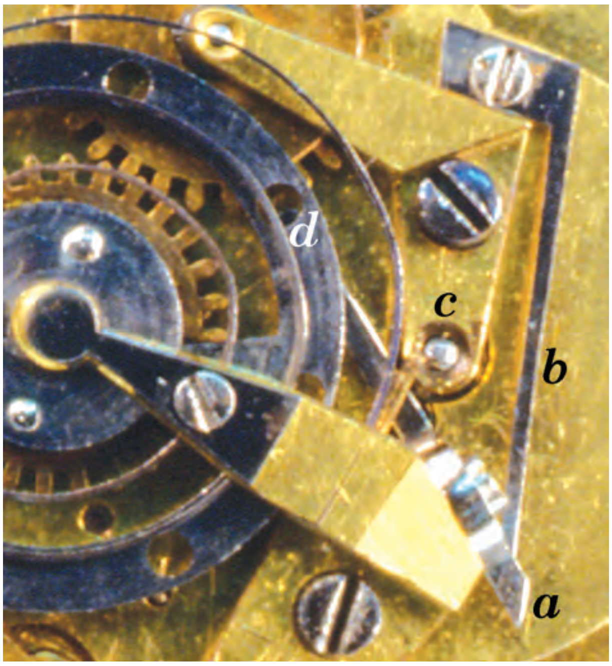


Figure 12-19

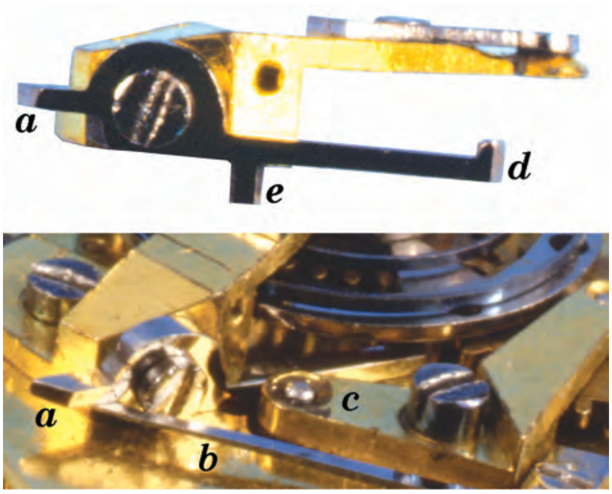


Figure 12-20

The watch in the Furtwangen Museum, Figure 12-5, has a straight spring screwed to each end of its weight. Although not clear from the photograph, the weight probably banks against either side of the cock for its upper pivot.

In contrast, the Guglielmo Meuron watch described here, and the unsigned movement in a private collection have a strange hook mounted on the weight, clearly visible in Figures 12-1, 12-3 and 12-10. But there appears to be nothing for this hook to act on.

Of the other three movements, that in the Musée de l'Horlogerie in Le Locle (Figure 12-7 and Sabrier, 2012a, page 47) has no visible banking system. The watch signed *Choisy à Como* in the Parisi collection in Milan (Figure 12-6 and Chapuis & Jaquet 1956, page 212) appears to have straight springs which are similar to those of the Furtwangen Museum movement, but mounted on the plate and not the weight. And again, the movement in Figure 12-9 has a bent spring mounted on the weight, but in this case it is much longer.

Although not identical, the six movements in Figures 12-1 to 12-9 have the same arrangement of the cocks, winding wheels and balance.

One curiosity is that the lever to lock the weight cannot be seen on the cock of the watch in the Furtwangen Museum, Figure 12-5, whereas the other five known watches have the mechanism with it, as described above. However, outlined in white in Figure 12-21 there is a large ring around the barrel arbor (black arrow) which has a wide extension (red arrow) going towards but not under the locking holes. It is not known how this locking mechanism works.

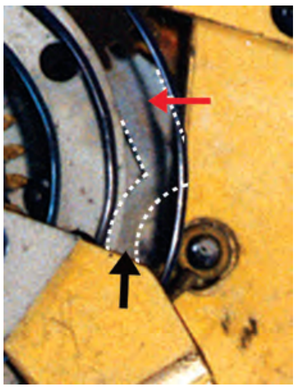


Figure 12-21

12.3: The Gschwind Center-Weight Movement

In addition to the six movements described above, there is a completely different center-weight movement; it is unsigned and has a virgule escapement; Figures 12-22 and 12-23.

Figure 12-22

Figure 12-23

This watch had belonged to the late Dr. Eugene Gschwind, and so I will call this the *Gschwind movement*. The photographs of this movement have been provided by the present owner through Simon Bull (2014-2016).

This mechanism is clearly different from the other six center-weight movements:

(a) The cock supporting the weight is different in shape and position.

(b) The second wheel with its loose pinion and a click, beside the pivot for the weight, has moved about 90° from upper right to upper left.

(c) The balance has moved from the pillar plate to the top plate.

However, the self-winding mechanism is similar to the mechanisms in the other center-weight watches.

The first part of the self-winding mechanism, Figure 12-24, is basically identical to the design used in other center-weight watches. It has two meshing driver wheels with clicks and loose ratchets that provide bidirectional winding. And the locking mechanism uses round holes, in contrast to the rectangular slots used in rotor movements.

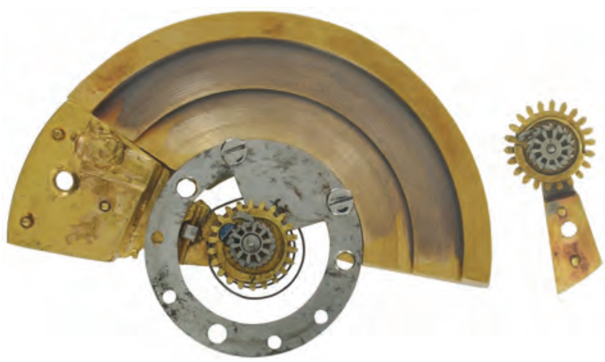


Figure 12-24

The driver wheels mesh with the first intermediate wheel ***I***, Figure 12-25. The

Figure 12-25

Figure 12-26

arrangement, with the intermediate wheel above the top plate, is the same as in the rotor movements (see page 71). In contrast, the intermediate wheel of the other center-weight watches is between the plates.

The arbor of the intermediate wheel ***I*** passes through the movement, and its pinion is above the pillar plate and meshes with the second intermediate wheel ***J***, Figure 12-23. The pinion of ***J*** meshes with the wheel squared onto the barrel arbor.

The first part of the weight locking mechanism is the same as that used in the other center-weight movements, Figure 12-26. Geneva stop-work with a boss is mounted on the barrel and, when the mainspring is fully wound, it raises the spring that is also mounted on the barrel.

The second part of the mechanism, Figure 12-27, is a simple pin ***p*** with a shoulder so that the spring ***s*** holds it down. It is held in place by a small cock. This pin is directly over and rests on the stop-work spring mounted on the barrel, and it is directly under the ring of holes attached to the weight; Figure 12-28 shows that ***p*** is at the intersection of these circles. When the mainspring is fully wound, ***p*** is raised and enters one of the holes of the ring attached to the weight.

Figure 12-27

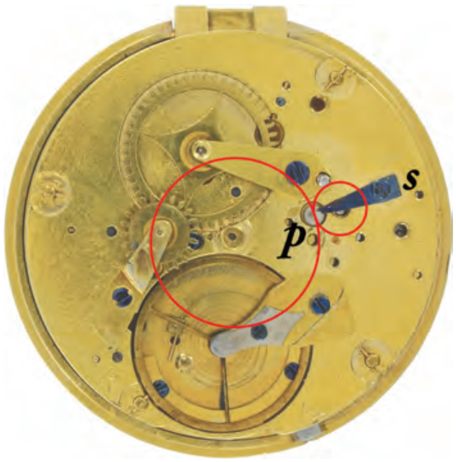


Figure 12-28

Finally, there is a brass annulus with a decorated edge attached to the pillar plate, as shown in Figures 12-23 and 12-27.

As can be seen from Figure 12-29, the annulus was riveted to the outside of the pillar plate after the dial feet holes had been drilled and chamfered. That is, it was added after the movement had been finished; see Section 5.7 (page 53) where the order of operations is described. Also, the annulus covers about half of each pillar rivet. Note that the dial foot hole illustrated is beside a pillar and part of the rivet has been cut away, confirming that the dial feet holes were made after the pillars were riveted.

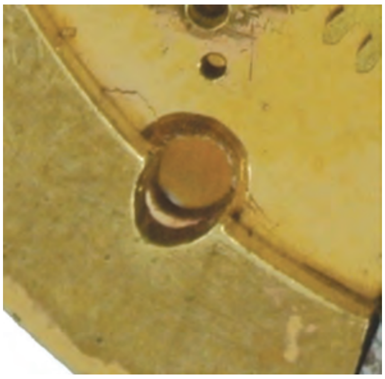
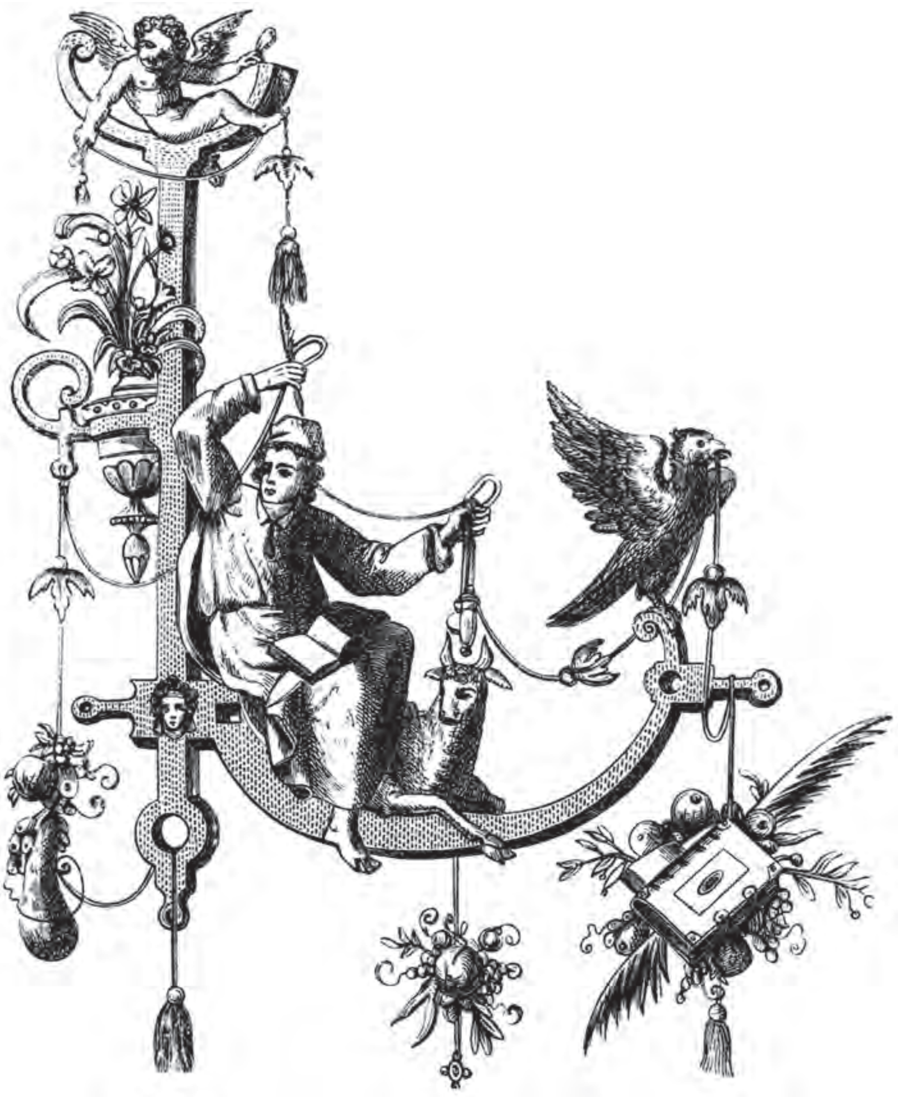


Figure 12-29

It is not known when the annulus was put on the movement. It has not been removed and I do not know if it hides the remains of an original hinge.



13: Philipe DuBois

13.1: Biography

The following biography is based on Chapuis (1957) and my own researches into the existing records of the DuBois company (DuBois, 1758-1824).

In 2012 I visited Le Locle and took photographs of all the existing account books and inventories to 1824. The names I use to identify these books are my classification based on the type of book and the titles used by Philipe DuBois.

Figure 13-1: Philipe DuBois 1738-1808

Although the watchmaking company *Philipe DuBois & Fils* is neither famous nor well known, it deserves recognition for three reasons. First, the company manufactured and sold watches continuously for nearly a quarter of a millennium, probably longer than any other Swiss watchmaker, starting in the 1750s and finally closing its doors at the beginning of the 21st century. Second, it was owned and run by the family throughout its existence, and the heads of the company were all descendants of the founder Philipe DuBois, Figure 13-1. And third, the company always operated from the same, small building, erected in 1684 on the Grande rue in Le Locle, Figure 13-2.

Guillaume DuBois (1660-1712), Philipe's grandfather, ran a drapery business in Le Locle. When Guillaume died his son Moÿse (1699-1766) was only 13 years old, but in 1719 or 1720, when he was 19 or 20 years old, he took over his father's business and produced the first inventory in the archives, dated 1720, giving details of the stock which the business sold and his assets.

Between 1720 and 1732 the business was almost exclusively concerned with drapery and clothing, but in the inventory of 1733 watches appear for the first time: *2 montre de poche pour £60:* (2 pocket watches for £60). Over the following years, a few watches and clocks regularly appear in the inventories: 1741 (1 watch), 1743 (3 watches), 1745 (1 watch and 1 clock), 1747 (1 watch and 1 clock), 1749 (3 pocket watches), 1751 (1 watch and 1 clock), 1752 (1 watch), and 1755 (1 watch and 1 clock).

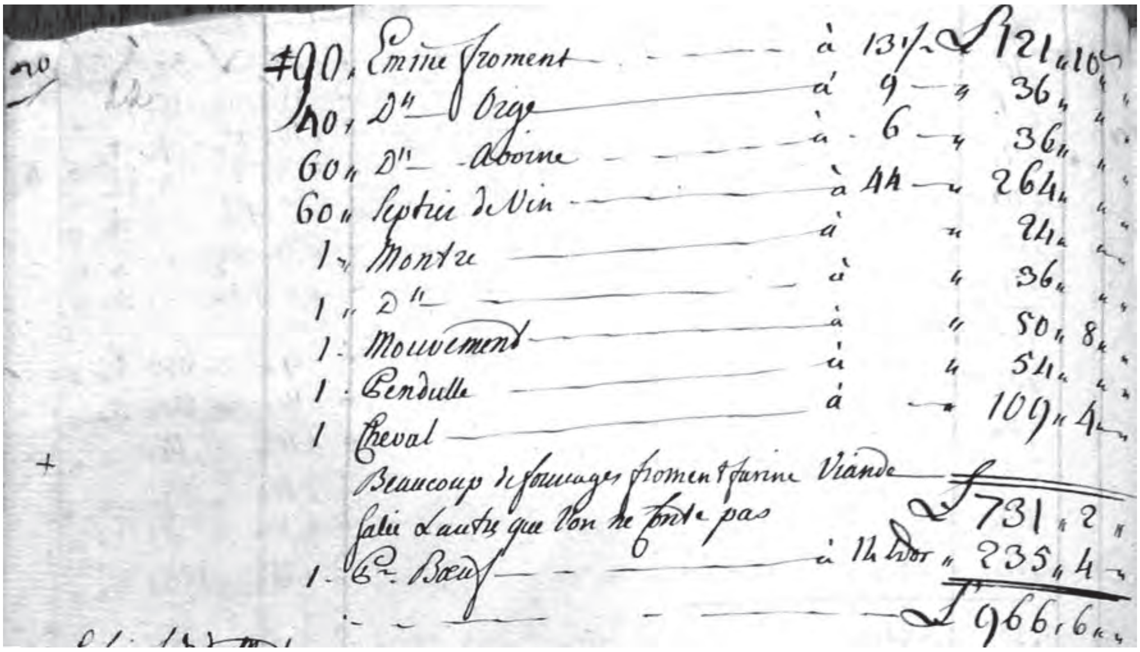
Of course, inventories are snap-shots of a business at specific times, but it is clear from the very small numbers that Moÿse DuBois was not in the watch making or watch dealing business. Indeed, as the inventories include assets as well as stock to be sold, these items might have been personal possessions and not for sale. But, of course, he may simply have been buying and selling a few items, or some horologists bought draperies and paid him in kind.

Figure 13-2: Maison DuBois

In the next inventory of 1757, the house, Maison DuBois, was valued at £4,000, and a farm at Montperreux, inherited from Guillaume, Philipe's grandfather, was worth £6,800. But there is a surprise, Figure 13-3. As well as a horse *(cheval)*, oxen, cheese, 2 watches and a clock we find *1 mouvement £50-8-0*. Why?

A person like Moÿse, who simply bought and sold a few pieces, would not buy a movement without a case. And this movement is worth much more than either of the complete watches (£24 and £36 respectively). So in amongst the expected assets and stock is a mystery.

The answer is probably that the movement was for Moÿse's son, Philipe DuBois.



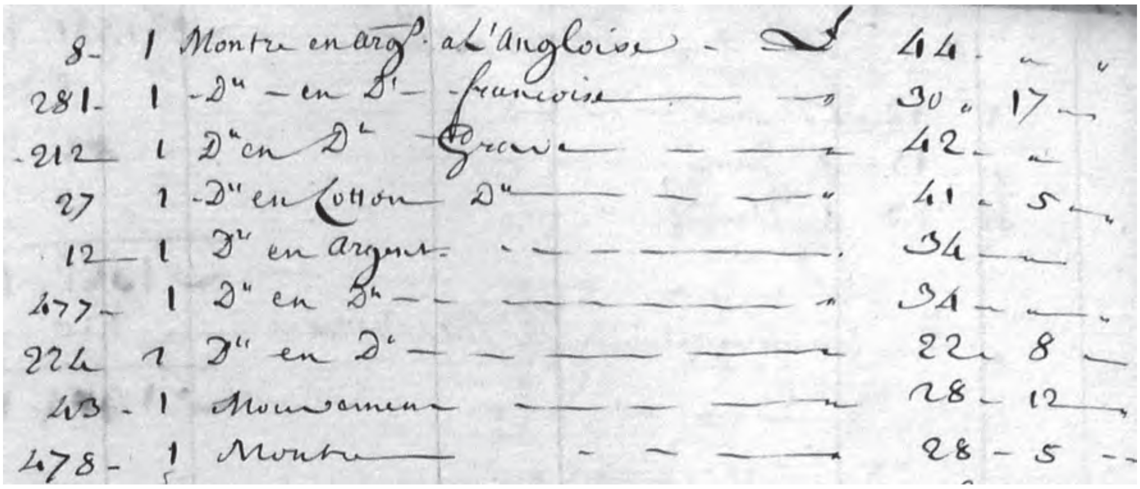
490. Emine froment — à 13½ £121.10.–
40. Dº Orge — à 9 — 36.–.–
60. Dº Avoine — à 6 — 36.–.–
60. Septier de Vin — à 44 — 264.–.–
1. Montre — à — 24.–.–
1. Dº — à — 36.–.–
1. Mouvement — à — 50.8.–
1. Pendulle — à — 54.–.–
1 Cheval — à — 109.4.–
Beaucoup de fromages froment farine Viande salée et autre que l'on ne porte pas — £731.2.–
1. Gr Boeuf — à 14 Louis d'or — 235.4.–
£966.6.–

Figure 13-3

Although we have found no concrete information, we can be sure that Philipe DuBois (1738-1808) was apprenticed to a watchmaker, probably in Le Locle or nearby. In 1757 Philipe would have been 18 or nineteen years old and at the end of his apprenticeship. And so a movement makes sense. Much more tantalising is the possibility that Philipe himself made this movement as part of his training; it is clearly something special and not an ordinary watch movement. But we will never know.

A dramatic change occurs with the next inventory, *Commençons Le 22d Janvier 1759*. As we would expect, it begins with a long list of drapery, but in addition there is more than a page of watches and movements (DuBois, 1758-1824, *Inventory 1759*, pages 29-30), part of which is shown in Figure 13-4. In total there are 28 watches, 11 movements and 2 cases.

The first entry in Figure 13-4 is fascinating: 1 silver *English style* watch £44. Certainly the Swiss watchmaking industry has always depended on exports to other countries, so we must ask: was this watch made for English tourists or for export? Surely an English visitor would not go to a drapery store in Le Locle to buy a watch? And so it seems likely that this watch was meant to go from Switzerland, through France and across the channel to find a buyer. Unfortunately there are no corresponding sales records for us to examine, and so we do not know. But it is certain that Philipe DuBois began selling watches in 1757 or 1758 when he was 19 or 20 years old, barely an adult.



8-	1	Montre en arg.t à l'angloise	44	
281-	1	D.o en D.o françoise	30	17
212	1	D.o en D.o Gravée	42	
27	1	D.o en Cotton D.o	41	5
12	1	D.o en argent	34	
477	1	D.o en D.o	34	
224	1	D.o en D.o	22	8
413	1	Mouvement	28	12
478	1	Montre	28	5

Figure 13-4

At this point Philipe must have been an *établisseur*. There is no English word equivalent to *établissage*, which describes a cottage-industry organisation. The *établisseur*, the watch manufacturer, would visit independent workers operating from their own homes to order watch parts, dials, cases, etc. Then the établisseur would have these parts finished, inspected and assembled in his workshop, the *comptoir*, before selling the watches produced. The workers were paid only two or three times a year, particularly on St. Martin's day and St. George's day, so it is surprising they survived!

This was a very flexible organisation and établisseurs operated in different ways. Actually most, if not all Swiss watchmakers were to some extent établisseurs. For example, dials, cases, balance springs and mainsprings have always been made by separate, specialist companies and purchased by watchmakers. And Longines, definitely a watch manufacturer, used home workers for some tasks as late as the early twentieth century.

In England a similar system was used, although it was not called établissage. A London watchmaker would buy a rough movement from Lancashire and then use sub-contractors to make the escapement, the case, the dial, the hands, and to do other work. At each stage it was returned to the watchmaker to be checked and tested, until the finished watch was ready for sale.

There are two entries in the 1759 inventory that show Philipe DuBois was an établisseur, Figure 13-5.

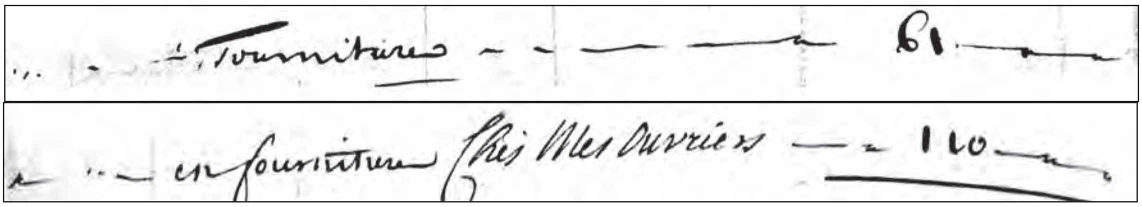

Fournitures — 61
en fournitures chez Mes Ouvriers — 110

Figure 13-5

The first (DuBois, 1758-1824, *Inventory 1759*, page 29) tells us that in January 1759 there was in stock *fourniture* (watch parts) to the value of £61. But the second entry (DuBois, 1758-1824, *Inventory 1759*, page 30) reads *en fourniture chez mes ouvriers £110*; that is, *supplies in the homes of my workers*. This makes it clear that Philipe was using outside workers. So, although the inventory is small, we can deduce that in 1758 the watch company of Philipe DuBois had commenced.

Philipe DuBois was probably taught by his father to keep meticulous records of his watchmaking enterprise. So, in addition to account books, he copied and kept his correspondence and these invaluable documents were preserved in iron trunks. Until one day, sometime in the 20th century, in what can only be described as a short-sighted act,

> *... alas, a board of guardians, in its too great wisdom decided to destroy them and the burning took place.* (Chapuis, 1957, page 17.)

One misguided decision has robbed us, not only of most of the history of the company, but also undoubtedly an insight into the personalities and struggles of the family. All that we have left are some inventories and eight *Grand Livres*, account books, covering the period from 1758 to 1824; a mere fragment of what existed. Indeed, some inventories refer to *Grand Livre F, Grand Livre G* and *petit livre*, but these books have been destroyed. (Many other documents exist, covering the later years to the 20th century, but they are of no interest to us in the context of this book.)

The first of the account books, *N° 1 Grande Livre D'horlogerie pour nous Philipe DuBois & Soeur Du Locle* (for us Philipe DuBois and sister), is a purchases ledger (DuBois, 1758-1824, *Book 1*). It uses a double entry system, with the left hand pages giving the names of suppliers or workers followed by how and when the supplies were paid for (commonly *en argent*, cash, but also in other ways); and the right hand pages give details of the work done and its value. Except for two, the rest of the books are double entry sales ledgers, where the left hand pages give the names of purchasers and the goods purchased, and the right hand pages give details of payments. A number of purchases appear, with the entries reversed as in the first purchases ledger. The exceptions are books containing inventories.

An unfortunate feature of the sales ledgers is that most sales are simply described as *marchandises*, merchandise. A few entries are more specific, usually mentioning repeaters, and we can assume most of the merchandise consisted of ordinary verge watches. But it is likely that some special items are included, unless they are described in missing books.

The first ledger (DuBois, 1758-1824, *Book 1*) indicates that Philipe DuBois, at the tender age of 20, commenced his watch business in October or November 1758, initially financed by his father Moÿse. Moÿse DuBois had included his son Philipe and his daughter Isabeau in his business, to whom he would sell it, while another son, Guillaume, was established in London. From then the house bore the name *Philipe DuBois & Soeur* until, in 1764, Isabeau married D. Gollin, notary at Corcelles, and Philipe then became the sole head of the undertaking. The second book, *N° 1 Grande Livre Pour Philipe DuBois* (DuBois, 1758-1824, *Book 2*), starting on 1 April 1764, begins with payments of £28,116-10-8 to his sister, buying her out of the business, which must have been worth about £56,000 at the time.

Although an accurate comparison is impossible, it is interesting to estimate the value of the business, including all assets, in the currency of today. In 1759 the *Maison DuBois* on the Grand rue was valued at £4,400 (DuBois, 1758-1824, *Inventory 1759*, page 32). If we use property prices to compare costs then the business and assets were worth about 9 million Swiss Francs.

It is clear that initially Philipe DuBois finished watches, because early purchases include many tools. After buying, in 1760, unnamed tools for £24-10 from Pierre Louys Brandt, *feseur d'outil*, master tool maker (DuBois, 1758-1824, *Book 1*, page 36), over the next three years Philipe purchased the following additional tools from him:

4 sets of turns (*tours*), simple lathes, at £4-4 each.

1 figure 8 calliper (*huit de chiffre*) and 1 *outil à trou* (some sort of tool for making holes), both for £1-1.

1 mainspring winder (*estrapade*) for £2-2.

1 fusee cutting machine (*outil à fendre les fusées*), but as no value is recorded Philipe probably didn't buy it. (But on another occasion Philipe bought an unnamed tool for £30-12 and this very large amount means it was most likely a wheel cutting or fusee cutting machine.)

6 pillar gauges and 6 pinion gauges at £0-14 each.

1 set of turns (*tour*) for £5.

2 dancing masters (*maitre danser*, a calliper for measuring inside heights) at £2-2 each.

However, as is apparent from the small size of the building, Figure 13-2, as the company grew it must have become increasingly a wholesaler, buying complete watches locally and distributing them throughout Europe, eventually including sales to Russia and the United States of America.

This company continued until the end of 1785 when it was reorganised and named *Philipe DuBois & Fils*, the sons being Philipe Henry and Charles (DuBois, 1758-1824, *Inventory Book 2*, title page). It is the date of formation of this new company that is generally used as the starting point, even though the old company had been in existence for 27 years! The company was restructured in 1801 and 1809, after the death of Philipe DuBois (*Book 4*, page 115).

All companies relied upon travelling salesmen, making long journeys through Europe to their customers and to the many fairs, showing their valuable samples, taking orders to be filled on their return, and collecting payments.

The sons that Philipe DuBois took into his business undertook long trips in their own carriages; the inventory of 1823 mentions three post chaises:

> *These healthy and robust mountain dwellers did not fear tiredness nor the difficulties that these voyagers faced at this time. Sometimes disorders (wars or revolutions) burst in the regions that had to be crossed. Thus Charles DuBois tells in his memoires that he had to pass by Waterloo*

> *shortly after the famous battle, and that the spectacle of thousands of unburied corpses and the burned farms was horrible to see, so that the image of this field of carnage haunted the spirit of this Neuchâtel man for a long time. However the results of these voyages were always considerable.* (Chapuis, 1957, pages 43-44.)

Although the movements were usually ordinary, sometimes the cases and dials would be luxurious:

> *The first suppliers of the comptoir, around 1760, are the brothers Favre-Bulle who made ordinary dials and dials with days of the month. There were "English" and "French" dials. Other makers were Paul Fage and, a little later, Moÿse Gevrille* [or Gevril]. *Around 1780 it would be Friedrich-Louis Jeanneret. At this time Boidard and Prevost, L'Hoste and Henry Benedik, all in Geneva, sent enamelled dials and other objects to Le Locle.*
>
> *In this last quarter of the 18th century, rich watches with painted enamel cases become numerous in the Mountains, and the inventories also announce precious snuffboxes, including those that Claude DuBois painted.*
>
> *In 1785, undoubtedly for watches of great luxury, Ph. DuBois also resorted to reputed enamel artists, such as Loiron and Lissignol in Geneva, who provided no less than 15 paintings in a few months. Let us mention that Jean-Abram Lissignol, student of Jean Marc Roux, made several portraits of Saint-Ours. As for Jean-Francois Soiron, also a noteworthy artist, he went on to be established in Paris in 1800, and one knows of his several portraits of Napoleon and the Empress Joséphine, as well as various paintings of the genre.* (Chapuis, 1957, pages 32-33.)

Undoubtedly such watches would not be common.

After trading throughout Europe for many years, Philipe DuBois entered the American market in 1793. The company sold to Nothnagel & Montmollin, Piesch & Mayerhoff and Othenin Girard, all in Philidelphia, between 1793 and 1800. And in 1796 the company sold watches to Himely & Landolt in Charlestown.

13.2: Company Organisation

In addition to a "head office" in Le Locle, Philipe DuBois had two major agencies in Frankfurt and London.

As early as 1766 DuBois dealt with Mr Fischer (probably Conrad Jerome Fischer) in Frankfurt. In 1767 the inventory listed a small amount of stock, and then a page of items in 1769; this slowly grew over the following years. By 1774 it is clear that this had become a major materials agency with the stock owned by DuBois; the inventory for that year listing one and a half pages of items; in particular tools, dials and a large number of files. By 1776 this had expanded to four pages, including 300 English and 864 French watch keys, 48 feet of steel, about 2,900 files, 2,000 gravers and assorted tools. But in 1778 and 1780 it had reduced to three pages, and in 1785 there were four, smaller pages.

It must be noted that this agency did not sell watches. But DuBois and his salesmen attended the Easter and September Frankfurt fairs and sold watches to customers who came to them; including Nilon who travelled from London to attend the fairs from 1781 to 1784 (DuBois, 1758-1824, *Book 3*, page 51).

From the very large numbers in the inventories, far too high for use within the comptoir, this trade in materials and tools also took place in Le Locle. And so the Maison DuBois housed a drapery store, a watch comptoir, and a tools and materials supplier.

The second agency in London was run by the DuBois family and, unlike the Frankfurt agency, it does not appear in the inventories. The only transactions that have been recorded in the existing books do not mention watches directly.

Up to about 1771 Abram, the brother of Philipe, was in London and the trade was mainly draperies sent from London to Switzerland. Then the company became DuBois and Lucas for a few years until, about 1780, it changed to DuBois & Fils. And throughout this period, certainly to 1791, most of the trade was from London to Switzerland. So it is probable that any dealing in watches was a minor part of the business.

As well as selling directly to customers, Philipe DuBois sold on commission. It is clear from the inventories that he had his own stock in different houses in Europe, and we presume he was only paid when the items sold. For example, in the 1776 inventory we find clocks, watches and cases *pour mon compte ches* (on my account in the house of) Jaquet (Frankfurt), Lemmes (Frankfurt), Besson, Meyer, Zollicoffer, Lichtenauer (Cologne) and Fourneau (Liège).

Finally, DuBois had a vineyard at Bevaix, on the lake to the South of Neuchâtel and Book 4 (Grand Livre No. 5 1788-1807) contains many transactions together with inventories of wine.

In December 1785, Philipe DuBois valued his business, after allowing for bad debts, at £171,319 and the Maison DuBois at £12,000; that is, he was worth about 10 million Swiss Francs.

13.3: Watches

The DuBois account books and inventories to 1794 include the following entries for self-winding watches:

1780 DuBois & Lucas, London: 8 August "pour 2 montres sans remonter, £32-11" (*Book 3*, page 122), Figure 13-6.

1780 P. Fs. Jaquet, Frankfurt: "9893, 1 montre en or s/remonter 24d 13, £181-8" and "10092, 1 montre en or s/remonter 22d 22, £177-16", Figure 13-7 (*Inventory Book 1*, page 343). 22d 22 refers to the weight of the case in deniers and grains.

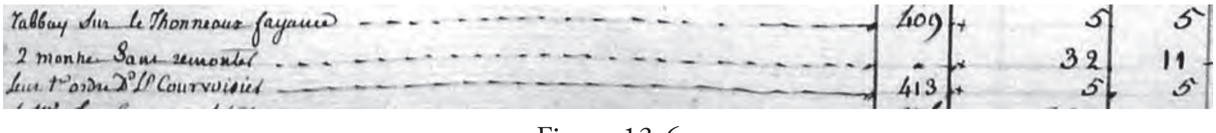


Figure 13-6

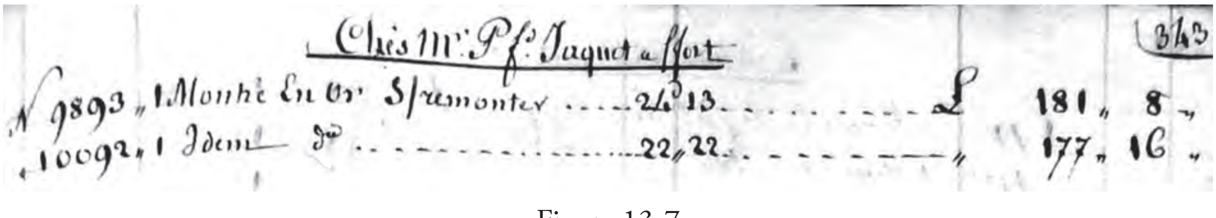


Figure 13-7

1782 P. F. Jaquet (Frankfurt): “14186, 1 montre en or s/r 31d 22 £213-18” and “14174, 1 montre en or sr 22d 20, £189-15” (*Inventory Book 1*, page 374).

1782 5 “montre en or s/r”, numbers 13963, 13715, 13976, 13975, and 13717, with an average price of £179-2 (*Inventory Book 1*, page 378).

1787 1 montre “en or sans remonter en poche de DuBois pere, £151-4” (*Inventory Book 2*, page 71), Figure 13-8.

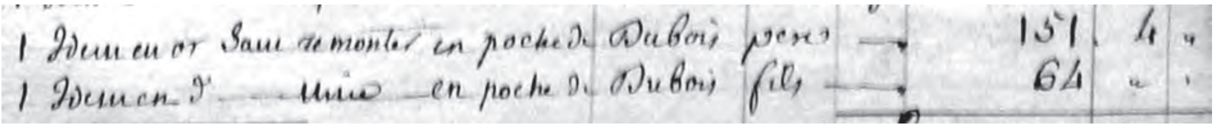

1 Idem en or Sans remonter en poche de DuBois pere — 151 4
1 Idem en d° — unie — en poche de DuBois fils — 64

Figure 13-8

1789 “1 montre a secousses avec Et [with etuy, outer case] dans la poche de Du pere, £134-8” (*Inventory Book 2*, page 117), Figure 13-9.

The 1787 and 1789 entries must refer to the same watch, confirming that the expression *sans remonter* means self-winding.

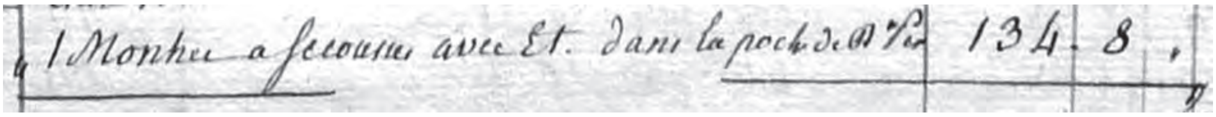

1 Montre a secousse avec Et. dans la poche de Du Pe 134 8

Figure 13-9

1791 “43587, 1 montre en or a secousses S/Etuy [without etuy], £147-0” and “idem en poche de DuBois pere, £134-8” (*Inventory Book 2*, page 152).

Sabrier (2012a, pages 187-188) illustrates two self-winding watches signed *DuBois & Fils*, and four which have other signatures but are of the same design. Sabrier also notes that DuBois made many such watches.

Another is illustrated in Figures 5-21 to 5-23, page 51. The mechanism is basically the same as that described in Recordon’s patent; see Figures 8-1 and 8-2, page 93. These watches can be wound by a key. Note that if the barrel arbor is turned clockwise by a key, to wind the watch, then the self-winding train turns with it and turns the wheel ***P*** clockwise. As it does so, the click mounted on ***P*** slides over the teeth of the ratchet ***C*** and winding is not prevented from happening by the self-winding mechanism.

Although Sabrier fails to provide any dates for these watches, the signature *DuBois & Fils* means they cannot have been made before December 1785 when the company was reorganised and first used the name *DuBois & Fils*. However, the above list shows that some self-winding watches were made before 1785.

13.4: Self-Winding Watch Values

Of the above entries, the earliest, Figure 13-6, creates two problems.

First, we do not know the source of these watches, but because the entry is on a left-hand page we must assume Philipe DuBois made them and sent them to London.

Second, at that time DuBois valued ordinary silver watches at about £25 to £30, and ordinary gold watches at about £60 to more than £100 depending on the type of case. So the amount of £32-11 appears to be far too low for even ordinary silver watches.

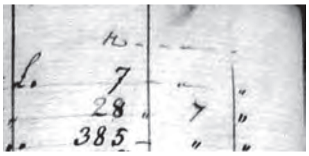


Figure 13-10

However, Bernard Roobaert (2014-2015) suggested this amount could be in pounds sterling, and this is confirmed by other entries. Many pages in the DuBois account books have the amounts headed "currency of Neuchâtel" or "currency of France". This page (Figure 13-10) is headed by the letters *stg* for sterling and the amounts have not been converted to livres. However, other pages of London accounts are converted, the amounts given in sterling and then converted to the currency of Neuchâtel or of France; for example DuBois (1758-1824, *Book 2*, page 44 and *Book 5*, page 7) The entries for 1786 and 1787 use exchange rates which vary but which are around 1 pound sterling = £17 Neuchâtel. In comparison, Jérôme Lalande (2012, page 138) gave a conversion table for 1786 where 1 pound sterling = £23-11-5 France.

Ignoring the fact that exchange rates vary and the data is for 6 years later, the self-winding watches in Figure 13.6 were worth about £290 Neuchâtel or £376 France.

One consequence is that we can be reasonably confident that the inventory books give the wholesale values of watches. This is supported by the prices given by Magellan (page 101) of £40 to £50 sterling, or about £800 to £1000 France, and the following letter which specifies 30 louis or about £600 France.

13.5: Relationship with Perrelet

Philipe DuBois had relationships with many people who were involved with self-winding watches.

The first is Abram Louys Perrelet. As shown in Table 13-1, there were four people with this name. Although unlikely, there may be five people if the entries without occupation represent a separate person.

Name	Occupation	Dates	Notes
Abram Louys	None given	1767, 1769, 1773, 1774	
Abram Louys	Watch maker	1761, 1767, 1773, 1776, 1780	au cour du Village
Abram Louys	Repeater maker	1765	
Abram Louys	Case maker	1773, 1776, 1780, 1782, 1786, 1791	Le Comun
Abram Louys le Gros	(Watch maker)	1774, 1778, 1782	

Table 13-1

In addition, there is an entry in 1798 for *La Veuve Abr Ls Perrelet*, the widow of Abram Louys, but we do not know which person died.

Although there were two watchmakers with the name Abram Louys Perrelet, it is very likely that the *horloger au cour du Village* is Abram Louys Perrelet l'Ancien. The absence of the qualification *l'Ancien* is not surprising; at the time of these transactions he was between 35 and 54 years old and may not have become a church elder. And so, the qualification *le Gros* for the other Abram Louys Perrelet would have been more likely during this period.

There are four transactions for Abram Louys Perrelet that contain interesting details; these are given below. The remaining five transactions are inventory entries (for 1767, 1769, 1773, 1776 and 1780) simply listing outstanding amounts of money.

In the first entry, Figures 13-11 and 13-12, between January 1761 and June 1763 Perrelet was paid a total of £151-14-0 for finishing ten movements. (DuBois, 1758-1824, *Book 1*, page 82.) The numbers 414, 455, 456, etc., are the serial numbers of the movements.

The second entry, Figure 13-13, is in the 1767 inventory (DuBois, 1758-1824, *Inventory Book 1*, page 46), where the case for a watch is in the house of Dl Hugnin Wirchaux, but its movement is in the house of Abram Louys Perrelet.

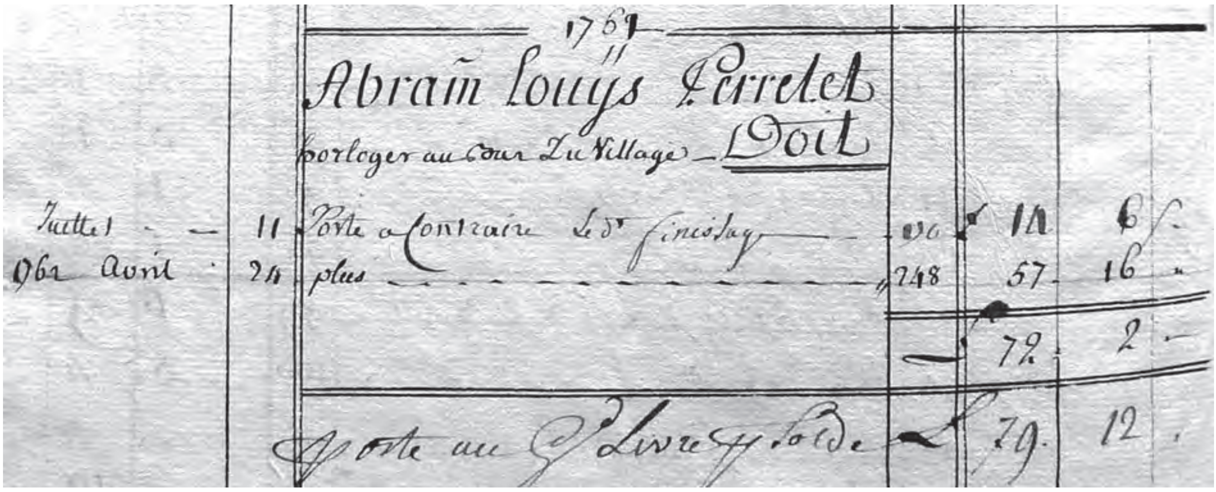

1761
Abram louys Perrelet
horloger au Cour Du Village Doit
Juillet 11 Porte a contraire le dt finissage 96 £ 14 6
1762 Avril 24 plus 248 57 16
72 2
Porte au G Livre y solde £ 79 12

Figure 13-11

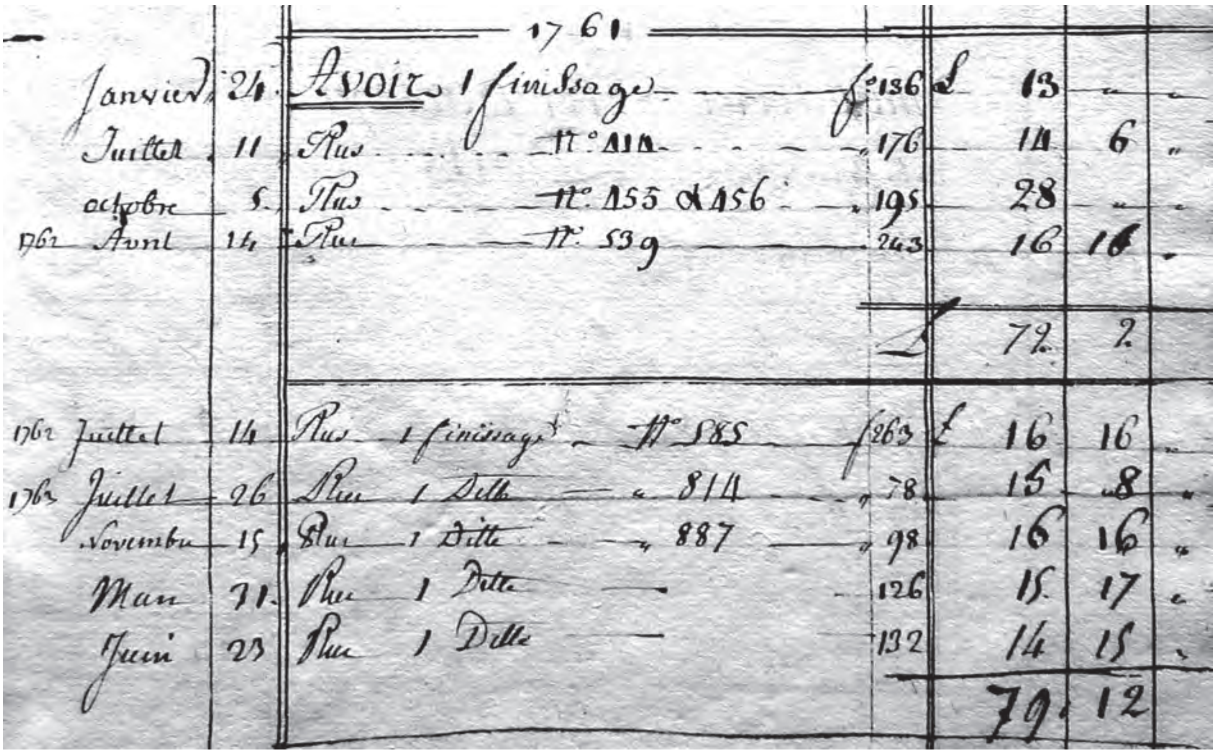

1761
Janvier 24 Avoir 1 finissage f.136 £ 13
Juillet 11 Plus N° 414 176 14 6
octobre 5 Plus N° 455 & 456 195 28
1762 Avril 14 Plus N° 539 243 16 16
72 2
1762 Juillet 14 Plus 1 finissage N° 585 f.263 £ 16 16
1763 Juillet 26 Plus 1 Ditto 814 78 15 8
Novembre 15 Plus 1 Ditto 887 98 16 16
Mars 31 Plus 1 Ditto 126 15 17
Juin 23 Plus 1 Ditto 132 14 15
79 12

Figure 13-12

The next entry is in the 1773 inventory, Figure 13-14 (DuBois, 1758-1824, *Inventory Book 1*, page 182). It lists six movements at the house of *Abr. L. Perrelet*. From their values, these six movements are clearly ordinary and cannot be self-winding movements.

And later, in a list of debtors and creditors on page 211 of the same inventory, we find *Abram Louys Perrelet horloger*, Figure 13-15. Both presumably refer to the same person.

The last interesting entry, for *Ab. L. Perrelet*, appears in the 1774 inventory (DuBois, 1758-1824, *Inventory Book 1*, page 229), Figure 13-16.

The double line above the entry for a repeater suggests that this is a separate entry and Perrelet had only two rough movements.

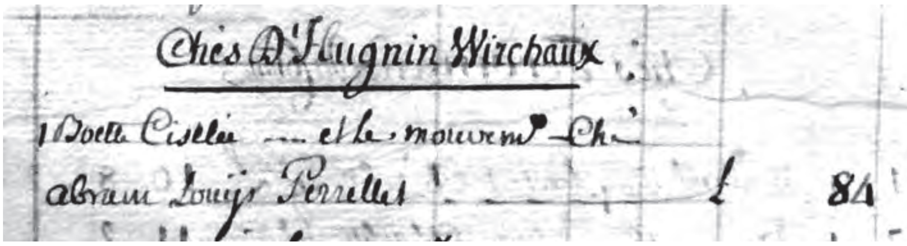

Chés D. Hugnin Wirchaux
1 Boete Ciselée ... et le mouvemt Ch.
abram Louijs Perrellet ... 1 84

Figure 13-13

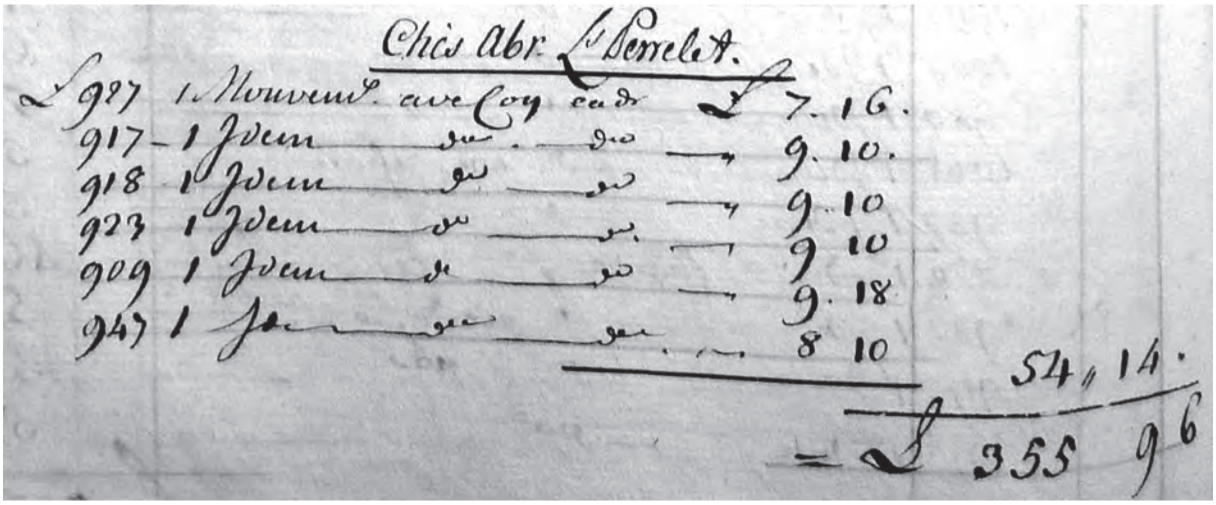

Chés Abr. L. Perrelet.
987 1 Mouvemt avec Coq cadr 7.16.
917 1 Idem do do 9.10.
918 1 Idem do do 9.10
923 1 Idem do do 9.10
909 1 Idem do do 9.18
947 1 Idem do do 8.10
54,, 14.
355 9 6

Figure 13-14

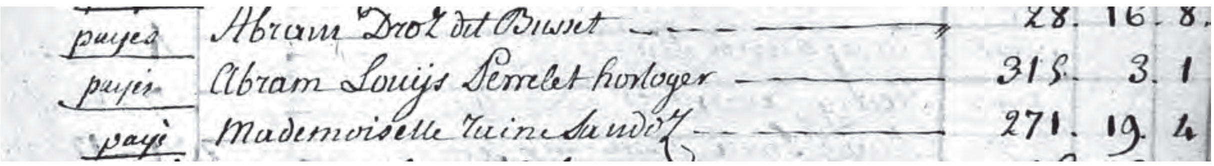

payés Abram Droz dit Busset 28. 16. 8.
payés Abram Louijs Perrelet horloger 315. 3. 1
payé Mademoiselle Tuine Sandoz 271. 19. 4

Figure 13-15

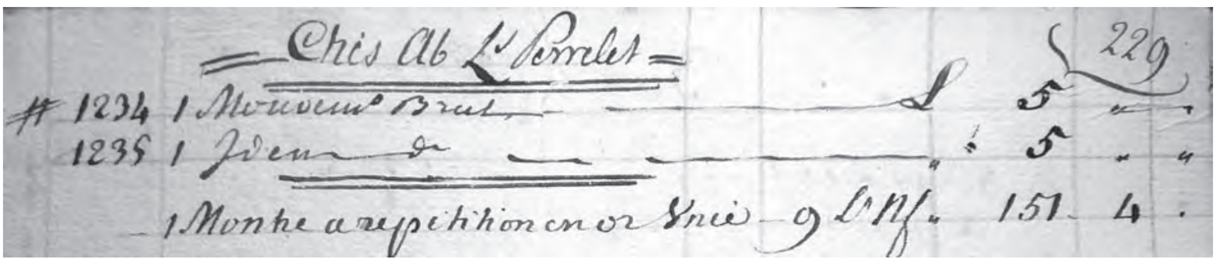

Chés Ab L. Perrelet 229
1234 1 Mouvemt Brut 5
1235 1 Idem do 5
1 Montre a repetition en or Unie 151. 4.

Figure 13-16

13.6: Relationship with Sarton

The second person of importance is Hubert Sarton who, in 1785, is described as *M[tre] Horloger a Liège*; Figure 13-17 (DuBois, 1758-1824, *Book 3*, page 82). Unfortunately the French term *maitre horloger* is ambiguous and this means master clock and/or watch maker.

The earliest record, Figure 13-18 (DuBois, 1758-1824, *Book 3*, page 83), covers the purchase of merchandise from 8 October 1777 to 1785, during which time Sarton purchased goods to the value of £45,887-10-10.

More disappointing is that there are no details for what Sarton purchased; *marchandises* are probably ordinary watches of the time, but could include other items. We do not know. Sarton next appears as a creditor in the 1789 inventory for the amount of £13,128-3-0 (DuBois, 1758-1824, *Inventory Book 2*, page 127). Most, but not all, of the purchases and payments occurred at the Frankfurt fairs.

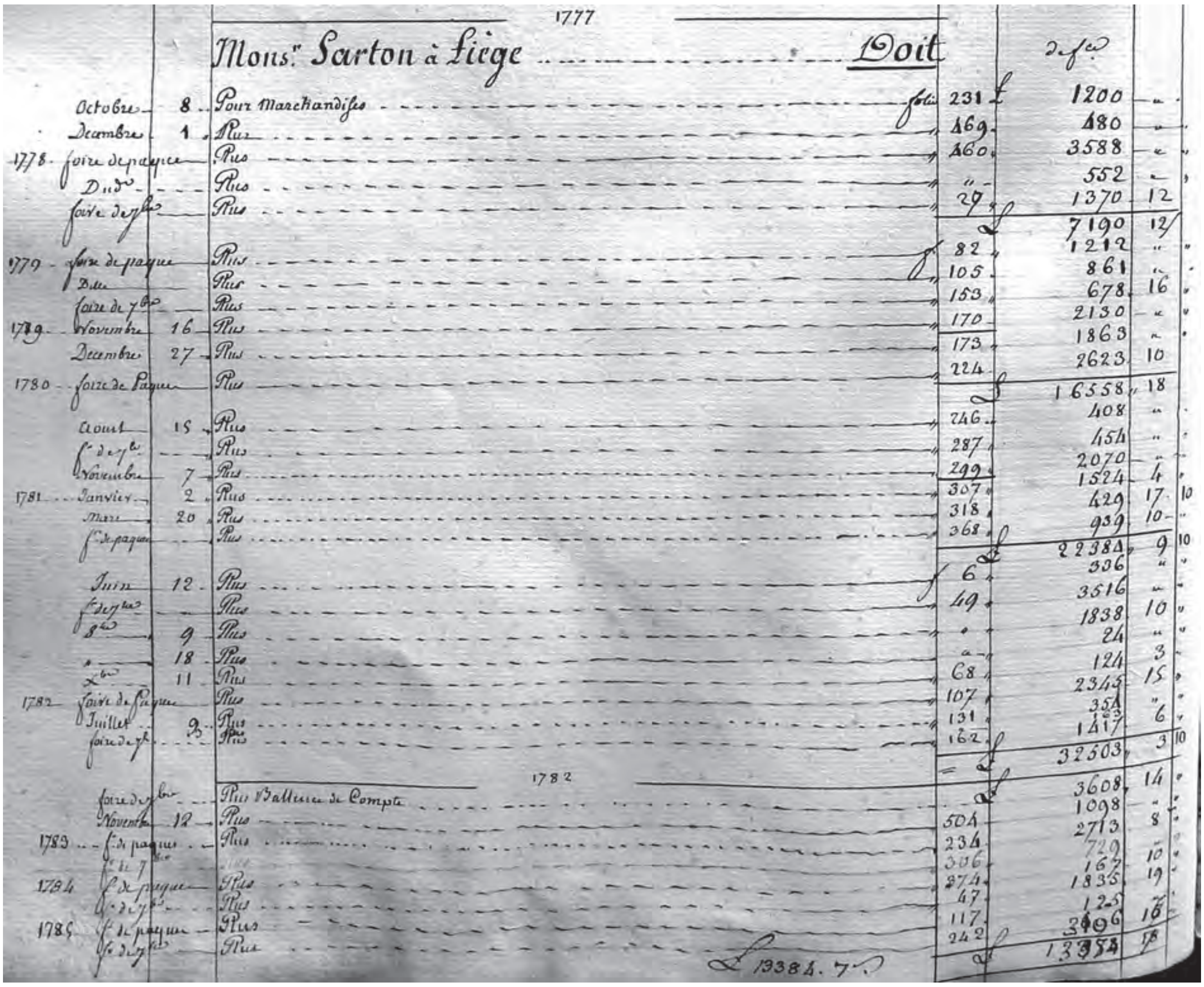
And then, Figure 13-19, in the eight years from 1786 to 1793 he spent £155,028-16-2; a little less that £20,000 each year (DuBois, 1758-1824, *Book 5*, page 209). Reflecting this very large

1785

Monsieur Sarton. M[tre] Horloger a Liege Doit

foire de Septembre	Tire du present livre	f. 81	£ 2696	17

Figure 13-17



1777

Mons.r Sarton a Liege Doit

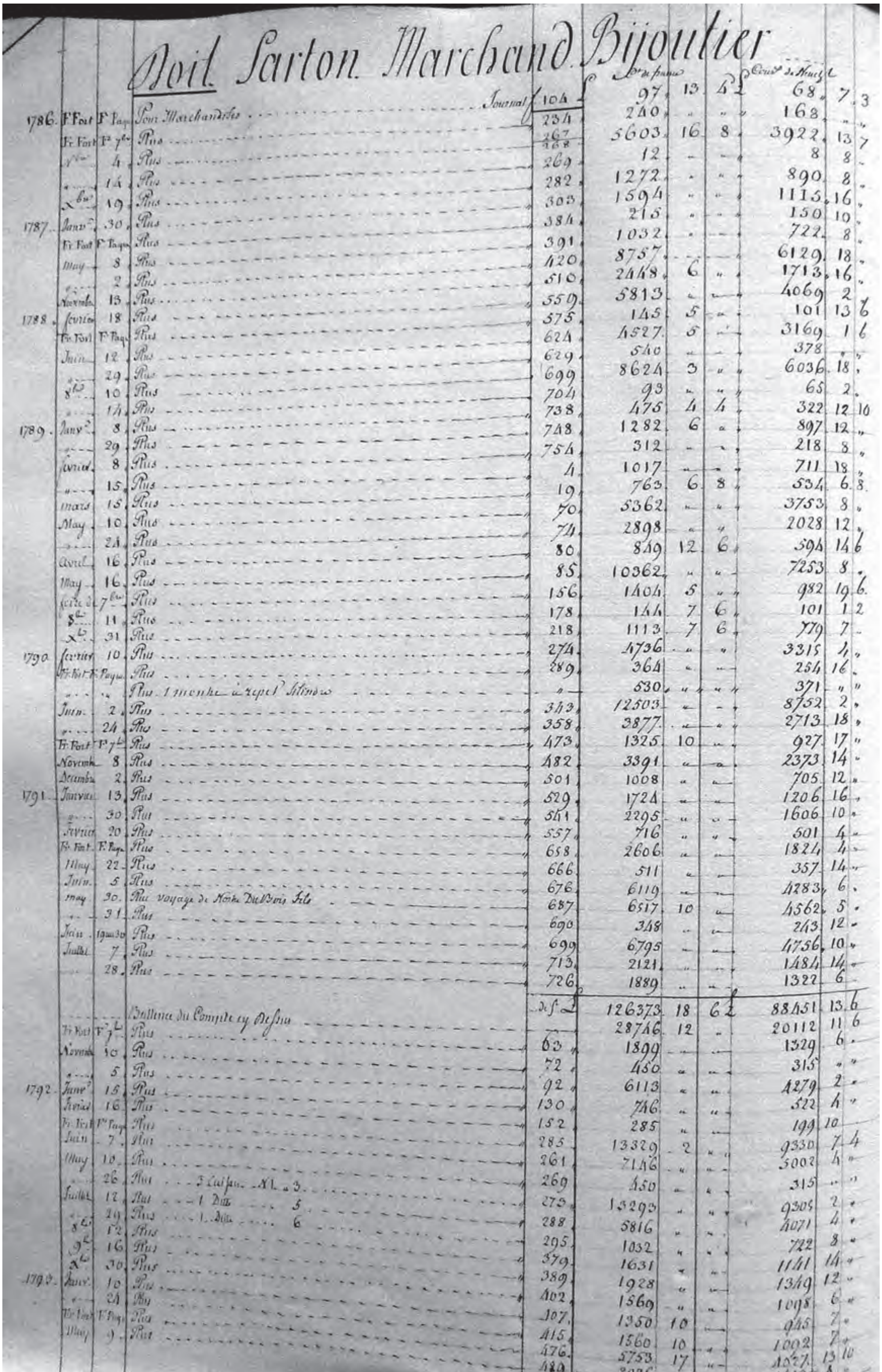
	Octobre	8	Pour marchandises	folio 231	£ 1200		
	Decembre	1	Plus	469	480		
1778	foire de paque		Plus	460	3588		
	D.o		Plus	"	552		
	foire de 7bre		Plus	27	1370	12	
					7190	12	
1779	foire de paque		Plus	82	1212		
	D.o		Plus	105	861		
	foire de 7bre		Plus	153	678	16	
1779	Novembre	16	Plus	170	2130		
	Decembre	27	Plus	173	1863		
1780	foire de Paque		Plus	224	2623	10	
					16558	18	
	aout	15	Plus	246	408		
	f. de 7bre		Plus	287	454		
	Novembre	7	Plus	299	2070		
1781	Janvier	2	Plus	307	1524	4	
	Mars	20	Plus	318	429	17	10
	f. de paque		Plus	368	939	10	
					22384	9	10
	Juin	12	Plus	6	336		
	f. de 7bre		Plus	49	3516		
	8bre	9	Plus		1838	10	
		18	Plus		24		
	xbre	11	Plus	68	124	3	
1782	foire de Paque		Plus	107	2345	15	
	Juillet	9	Plus	131	354		
	foire de 7bre		Plus	162	1417	6	
					32503	3	10

1782

	foire de 7bre		Plus Ballance de Compte		3608	14	
	Novembre	12	Plus	504	1098		
1783	f. de paque		Plus	234	2713	8	
	f. de 7		Plus	306	729	10	
1784	f. de paque		Plus	274	167	19	
	f. de 7bre		Plus	47	1835		
1785	f. de paque		Plus	117	125	16	
	f. de 7bre		Plus	242	3496		
					13354	18	

£ 13384. 7

Figure 13-18



Doit Sarton Marchand Bijoutier

Year	Month	Day	Entry	Journal	L. de France	s	d	Cours de Neuch. L	s	d
				f. 104	97	13	4	68	7	3
1786	F. Fort	F. Payé	Pour Marchandises	234	240	"	"	168	"	"
	Fr. Fort	Pr 7bre	Plus	267/268	5603	16	8	3922	13	7
	9bre	4	Plus	269	12	–	–	8	8	–
	"	14	Plus	282	1272	"	"	890	8	"
	Xbre	19	Plus	303	1594	"	"	1115	16	"
1787	Janvr	30	Plus	384	215	"	–	150	10	"
	Fr. Fort	F. Payé	Plus	391	1032	"	–	722	8	"
	May	8	Plus	420	8757	–	–	6129	18	"
	"	2	Plus	510	2448	6	"	1713	16	"
	Novembre	13	Plus	559	5813	–	–	4069	2	"
1788	fevrier	18	Plus	575	145	5	–	101	13	6
	Fr. Fort	F. Payé	Plus	624	4527	5	–	3169	1	6
	Juin	12	Plus	629	540	–	–	378	"	"
	"	29	Plus	699	8624	3	"	6036	18	"
	8bre	10	Plus	704	93	"	"	65	2	"
	"	14	Plus	738	475	4	4	322	12	10
1789	Janvr	8	Plus	748	1282	6	"	897	12	"
	"	29	Plus	754	312	–	–	218	8	"
	fevrier	8	Plus	4	1017	–	–	711	18	"
	"	15	Plus	19	763	6	8	534	6	8
	mars	15	Plus	70	5362	–	"	3753	8	"
	May	10	Plus	74	2898	"	"	2028	12	"
	"	24	Plus	80	849	12	6	594	14	6
	Avril	16	Plus	85	10362	"	"	7253	8	"
	May	16	Plus	156	1404	5	"	982	19	6
	fête de 7bre		Plus	178	144	7	6	101	1	2
	8bre	11	Plus	218	1113	7	6	779	7	–
	Xbre	31	Plus	274	4736	"	"	3315	4	"
1790	fevrier	10	Plus	289	364	"	–	254	16	"
	Fr. Fort	F. Payé	Plus		530	"	"	371	"	"
	"	"	Plus 1 montre à repet. Silindre	"						
	Juin	2	Plus	343	12503	–	–	8752	2	"
	"	24	Plus	358	3877	–	"	2713	18	"
	Fr. Fort	Pr 7bre	Plus	473	1325	10	–	927	17	"
	Novembre	8	Plus	482	3391	–	–	2373	14	–
	Decembre	2	Plus	501	1008	"	–	705	12	"
1791	Janvier	13	Plus	529	1724	–	–	1206	16	"
	"	30	Plus	541	2295	"	–	1606	10	"
	fevrier	20	Plus	557	716	"	"	501	4	–
	Fr. Fort	F. Payé	Plus	658	2606	"	–	1824	4	–
	May	22	Plus	666	511	–	–	357	14	–
	Juin	5	Plus	676	6119	–	–	4283	6	"
	may	30	Plus voyage de Mons. DuBois fils	687	6517	10	–	4562	5	"
	"	31	Plus	690	348	"	–	243	12	–
	Juin	19 au 30	Plus	699	6795	–	–	4756	10	"
	Juillet	7	Plus	713	2121	"	–	1484	14	–
	"	28	Plus	726	1889	"	–	1322	6	
				d. f.	126373	18	6	88451	13	6
			Ballance du Compte cy Dessus		28746	12	–	20112	11	6
	Fr. Fort	F. 7bre	Plus	63	1899	–	–	1329	6	"
	Novembre	10	Plus	72	450	"	–	315	"	"
	"	5	Plus	92	6113	"	–	4279	2	"
1792	Janvr	15	Plus	130	746	"	"	522	4	"
	fevrier	16	Plus	152	285	"	–	199	10	
	Fr. Fort	Fr. Payé	Plus	285	13329	2	"	9330	7	4
	Juin	7	Plus	261	7146	"	–	5002	4	"
	May	10	Plus	269	450	–	"	315	"	"
	"	26	Plus ... 3 Caisses N. 1. 3.	273	13293	"	"	9305	2	"
	Juillet	12	Plus ... 1 Dito ... 5	288	5816	"	–	4071	4	"
	"	29	Plus ... 1 Dito ... 6	295	1032	"	–	722	8	"
	8bre	12	Plus	379	1631	"	–	1141	14	"
	9bre	16	Plus	389	1928	"	–	1349	12	–
	Xbre	30	Plus	402	1569	"	–	1098	6	"
1793	Janvr	10	Plus	407	1350	10	–	945	7	"
	"	24	Plus	415	1560	10	–	1092	7	"
	Fr. Fort	F. Payé	Plus	476	5753	17	–	4027	13	10
	May	9	Plus	489	2026	"	–	1418	4	"
				d. f.	221498	9	6	155028	16	2

Figure 13-19

amount, Sarton's title has changed to *Marchand Bijoutier Comissaire à Liège*, merchant jeweller and commissioner, and he is clearly acting as an intermediary wholesaler between DuBois and local retailers.

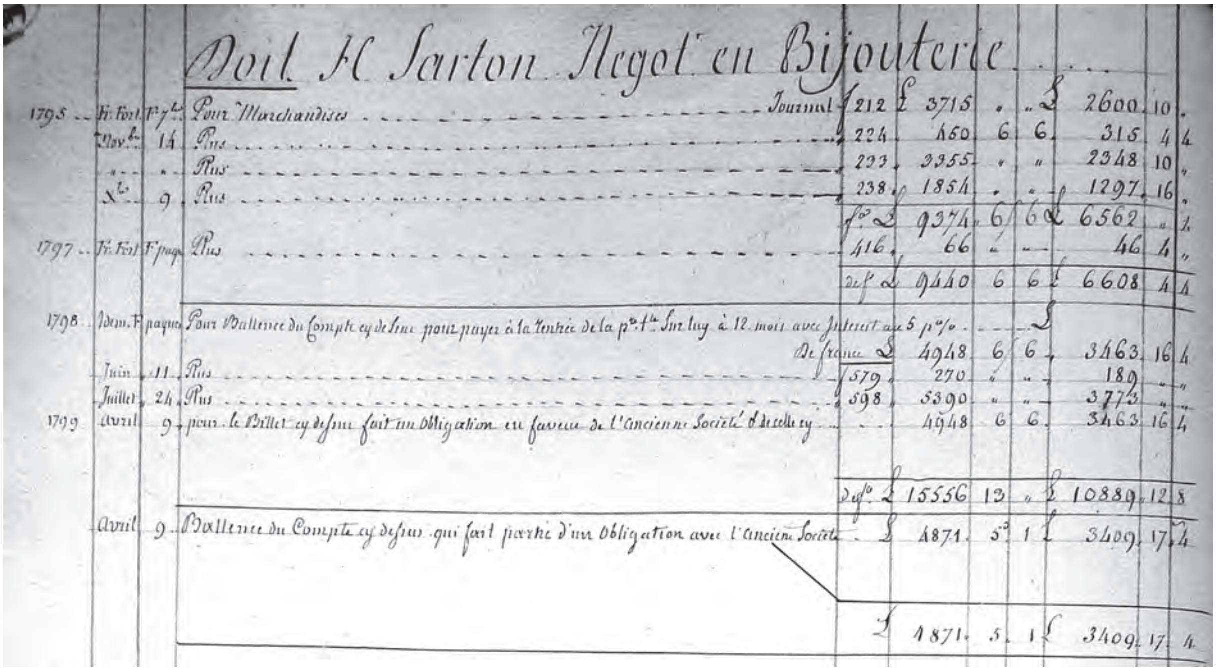
A few entries are more specific than the usual *marchandises*.

First, there is one *montre à repet silindre*, a cylinder escapement repeater, for £371.

Then on 30 May 1791, there is *voyage de Nostre DuBois Fils*, travel of our DuBois sons, costing £4562-2-0. This must have been a special trip to Liège.

Finally, in May and June 1792, there are a total of five *caisses* (boxes), numbered 1 to 5, costing £9,304 for the first three, £4071 and £722. Unfortunately, we do not know what they contained.

The next entries, Figure 13-20 (DuBois, 1758-1824, *Book 6*, page 179), show a dramatic decline in activity with only £20,707-14-4 being spent in the five years 1795 to 1799. And Sarton is now described as a *Negot en Bijouterie*, a jewellery dealer. This period corresponds to the invasion of Belgium by the French Revolutionary armies in 1794, which caused a downturn in Sarton's business.



Doit H Sarton Negot en Bijouterie

1795	Fr. Fort	F°7	Pour Marchandises ... Journal	212	£ 3715	.	.	£ 2600	10	.
Nov.	14		Plus	224	460	6	6	315	4	4
			Plus	223	3355	.	"	2348	10	"
X.	9		Plus	238	1854	.	.	1297	16	.
				f°	£ 9374	6	6	£ 6562	.	1
1797	Fr. Fort	F paq.	Plus	416	66	.	.	46	4	"
				Ref	£ 9440	6	6	£ 6608	4	4
1798	Idem.	F paque	Pour Ballence du compte cy dessus pour payer à la tenue de la p. Sur lui à 12 mois avec Interet a 5 p% De france		£ 4948	6	6	3463	16	4
Juin	11		Plus	579	270	.	..	189	.	"
Juillet	24		Plus	598	5390	"	"	3773	"	"
1799	Avril	9	pour le Billet cy dessus fait un obligation en faveur de l'Ancienne Société		4948	6	6	3463	16	4
					£ 15556	13	"	£ 10889	12	8
	Avril	9	Ballence du Compte cy dessus qui fait partie d'un obligation avec l'Ancienne Société		£ 4871	5	1	£ 3409	17	4
					£ 4871	5	1	£ 3409	17	4

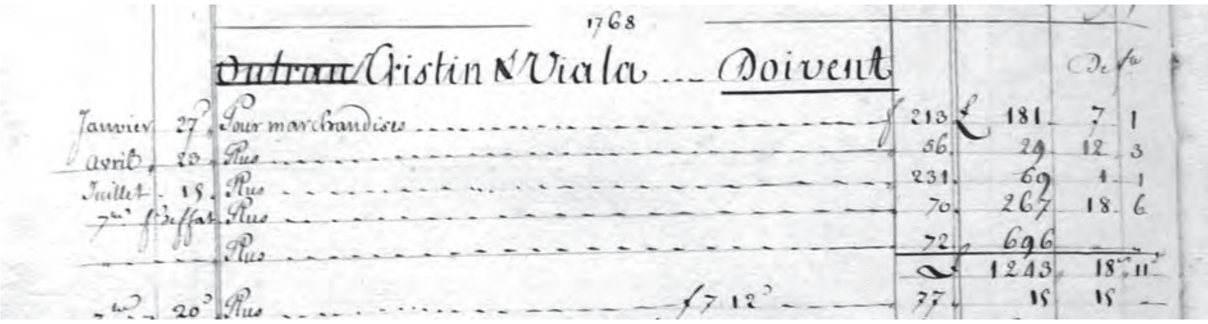
Figure 13-20

13.7: Relationship with Perret Jeanneret

Philipe DuBois had a relationship with Jonas Perret Jeanneret from 1767 to 1782. Unfortunately the only information is one financial transaction and five mentions in inventories, so we have no information about what was purchased or sold.

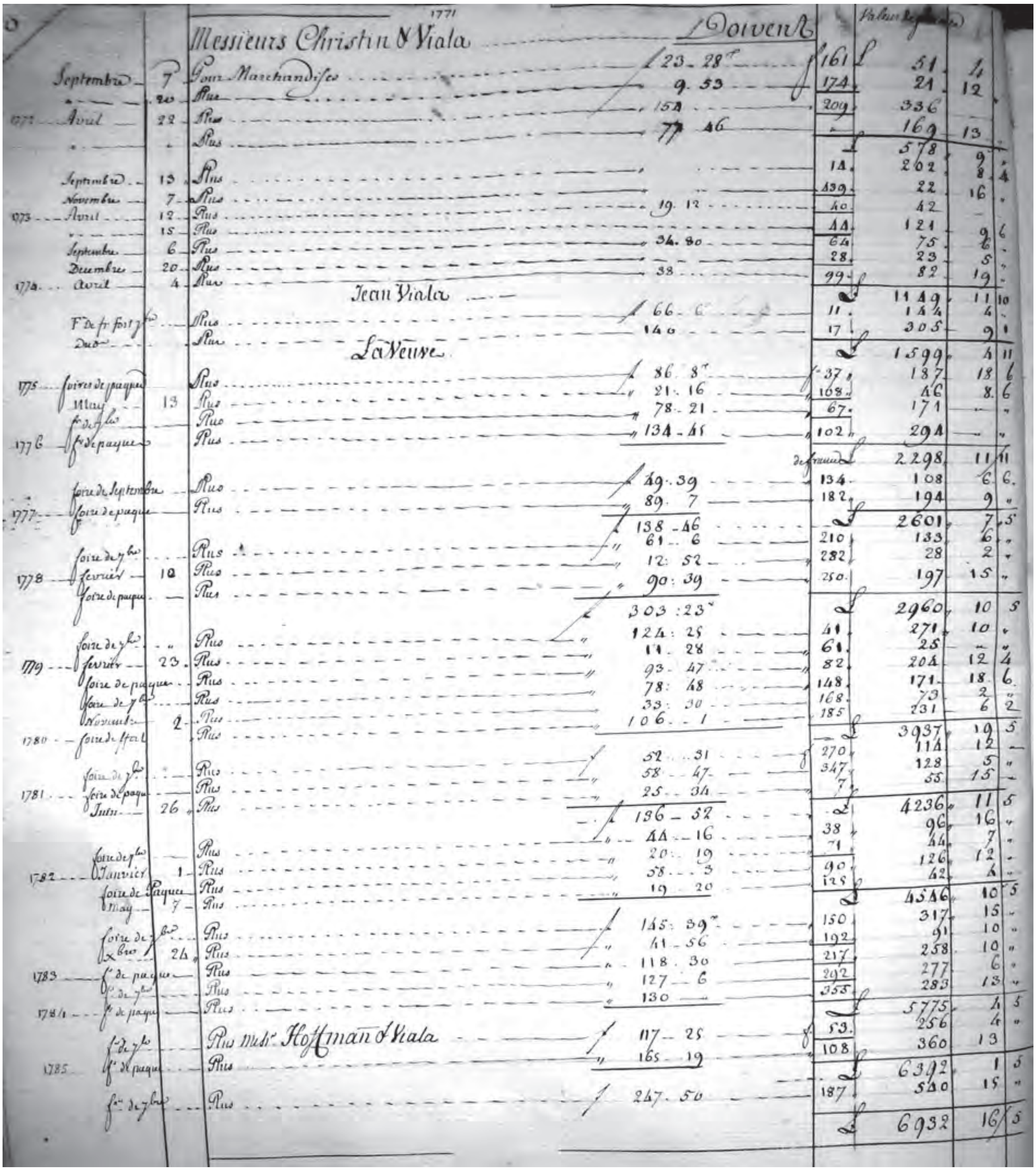
13.8: Relationship with Christin

The records of Philipe DuBois & Fils confirm the history of the Pforzheim factory given in Chapter 10 (page 125). The first entry on 27 January 1768 (Figure 13-21, DuBois, 1758-1824, *Book 2*, page 64) is under the name Outran [sic]. Then Outran was crossed out and replaced by Christin and


1768
~~Outram~~ Cristin & Viala ... Doivent

Janvier	27	Pour marchandises	f 213	£ 181	7	1
avril	20	Plus	56	29	12	3
Juillet	15	Plus	231	69	1	1
7bre	foire	Plus	70	267	18	6
		Plus	72	696		
				1243	18	11
	20	Plus £712	77	15	15	

Figure 13-21


1771
Messieurs Christin & Viala ... Doivent

Septembre	7	Pour Marchandises	23 . 28	161	51	4	
	20	Plus	9 . 33	174	21	12	
1772 Avril	22	Plus	154	209	336		
		Plus	77 . 46		169	13	
					578	9	
Septembre	13	Plus		14	202	8	4
Novembre	7	Plus		139	22	16	
1773 Avril	12	Plus	19 . 12	40	42		
	15	Plus		44	121	9	6
Septembre	6	Plus	34 . 80	64	75	6	
Decembre	20	Plus		28	23	5	
1774 Avril	4	Plus	33	99	82	19	
		Jean Viala			1149	11	10
F de fr		Plus	66 . 6	11	144	4	
		Plus	146	17	305	9	1
		La Veuve			1599	4	11
1775 foire de paques		Plus	86 . 8	37	187	18	6
May	13	Plus	21 . 16	108	46	8	6
		Plus	78 . 21	67	171		
1776 f de paques		Plus	134 . 45	102	294		
					2298	11	11
foire de Septembre		Plus	49 . 39	134	108	6	6
1777 foire de paques		Plus	89 . 7	182	194	9	
			138 . 46		2601	7	5
foire de 7bre		Plus	61 . 6	210	133	6	
1778 fevrier	10	Plus	12 . 52	282	28	2	
foire de paques		Plus	90 . 39	250	197	15	
			303 . 23		2960	10	5
foire de 7bre		Plus	124 . 25	41	271	10	
1779 fevrier	23	Plus	11 . 28	61	25		
foire de paques		Plus	93 . 47	82	204	12	4
foire de 7bre		Plus	78 . 48	148	171	18	6
Novembre	2	Plus	33 . 30	168	73	2	
1780 foire de Ha		Plus	106 . 1	185	231	6	2
					3937	19	5
foire de 7bre		Plus	52 . 31	270	114	12	
1781 foire de paques		Plus	58 . 47	347	128	5	
Juin	26	Plus	25 . 34	7	55	15	
			136 . 52		4236	11	5
foire de 7bre		Plus	44 . 16	38	96	16	
1782 Janvier	1	Plus	20 . 19	71	44	7	
foire de Paques		Plus	58 . 3	90	126	12	
May	7	Plus	19 . 20	125	42	4	
					4546	10	5
foire de 7bre		Plus	145 . 39	150	317	15	
Xbre	24	Plus	41 . 56	192	91	10	
1783 f de paques		Plus	118 . 30	217	258	10	
f de 7bre		Plus	127 . 6	292	277	6	
1784 f de paques		Plus	130	355	283	13	
					5775	4	5
f de 7bre		Plus mdes Hoffman & Viala	117 . 25	53	256	4	
1785 f de paques		Plus	165 . 19	108	360	13	
					6392	1	5
f de 7bre		Plus	247 . 56	187	540	15	
					6932	16	5

Figure 13-22

Viala. From then until April 1774 (Figure 13-22, DuBois, 1758-1824, *Book 3*, page 20) Christin and Viala bought merchandise to the value of £1,149-11-10. Then in 1774 Jean Viala purchased a further £449-13-1 of merchandise in his own name.

Jean Viala died in the same year, 1774, and the company was continued by his widow for nearly ten years; from 1774 to 1784 transactions with Philipe DuBois & Fils were in the name of his widow. In 1783, she remarried with the tradesman Hoffmann of Schaffhousen, and then the name Hoffman and Viala was used by Philipe DuBois & Fils.

In support of the statement that Christin and Viala separated in 1772 (or perhaps 1773) Christin purchased merchandise by himself in September 1773 (Figure 13-23, DuBois, 1758-1824, *Book 3*, page 59). But this was only partly paid three years later, in September 1776; two cylinder escapement movements were supplied to DuBois and the balance of £42-18-6 is marked as transferred to debtors. The last mention of the partnership is in April 1774 (Figure 13-22 above), but this is probably for orders placed before they separated.

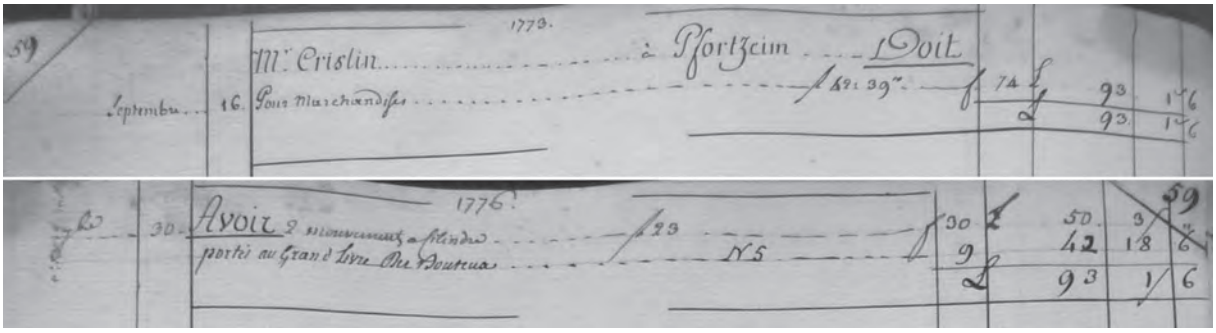


Figure 13-23

The above transaction is the only time when Christin bought merchandise from DuBois. The inventories for 1774, 1776, 1778 and 1780 record the outstanding debt, initially the full £93-1-6 and then £ 42-18-6 or £30-1-0 depending on whether the amount was given in livres of France or livres of Neuchâtel. The last inventory entry is under the title “Losses of 2 years”.

The last two entries referring to Christin are in the *Grand Livre Philipe DuBois No. 5*, which covers the years 1788-1807 (DuBois, 1758-1824, *Book 4*). This book begins with many undated entries that refer to outstanding debts, some as early as 1761; these pages would have been written in 1788. Page 9 includes the entry in Figure 13-24, noting the outstanding debt from 1773, fifteen years earlier, and transferring to a later page in the book. Finally, on page 117 of the book (Figure 13-25) Christin is included in a list of bad debts and described as *insolvent* (other people in the list are described as *dead*, *bankrupt* and *pauper*).

Figure 13-24

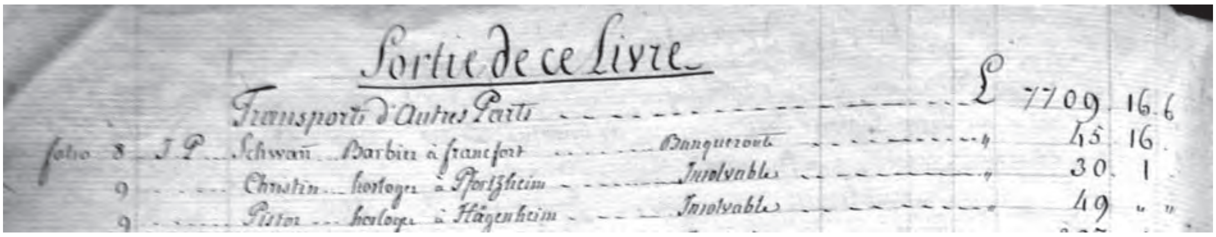

Sortie de ce Livre
Transports d'Autres Parts £ 7709 16 6
folio 8 J. P. Schwan Barbier à francfort Banqueroute 45 16
9 Christin horloger à Pforzheim Insolvable 30 1
9 Pistor horloger à Hagenheim Insolvable 49

Figure 13-25

Some time after this entry in Figure 13-24 was created, that is after 1788, Christin's address was changed to Amsterdam, but we do not know when this change was made.

13.9: Relationship with Recordon

There are five tantalising references to Recordon.

The first two are in the transactions of DuBois & Lucas, negotiants in London (DuBois 1758-1824, *Book 3*, page 122); see Figure 13-26. The majority of the transactions, covering 1778 to 1779, are purchases by Philipe DuBois from London; boxes and barrels, whose contents are unknown except one barrel appears to have contained steel. And there are a few purchases from Switzerland, including cheese and a clock. As noted in Section 13.4, these amounts are English pounds sterling.

The entry for 22 February 1780 reads *pour restant d'un effet sur recordon*, for the rest of an *effet* (a financial instrument?) to Recordon £4-9-3. And the entry for 9 May 1780 is a *remis a Abr Favre Fils pour Recordon* for £12-12-0. It is tempting to relate these to the following entry on August 8 for two self-winding watches (see Section 13.3 and Figure 13-6, page 153), but there is no obvious link.

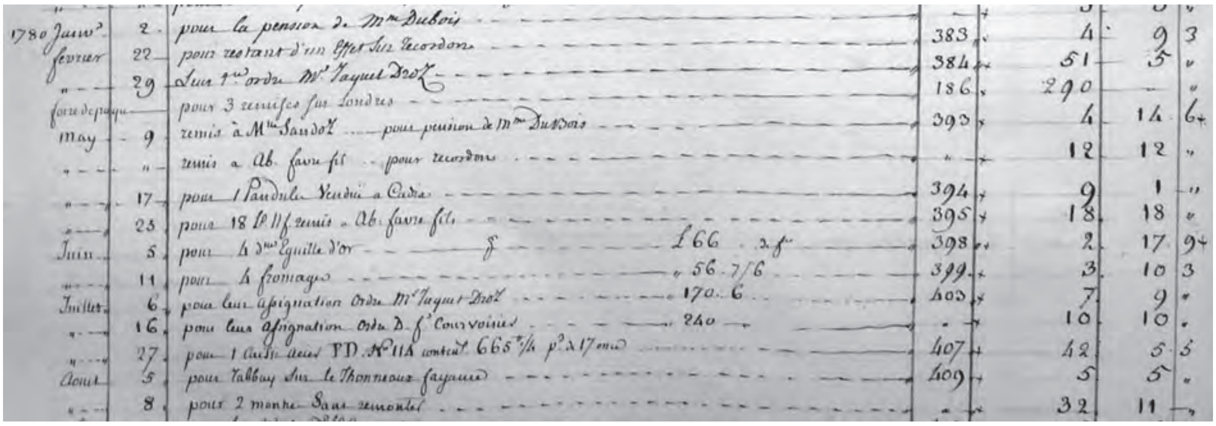

1780 Janv 2 pour la pension de Mme Dubois 383 4 9 3
fevrier 22 pour restant d'un effet sur recordon 384 51 5
29 sur 1er ordre Mr Jaquet Droz 186 290
pour 3 remises sur londres
May 9 remis a Mlle Sandoz pour pension de Mme DuBois 393 4 14 6
remis a ab. favre fils pour recordon 12 12
17 pour 1 Pendule Vendue a Cadix 394 9 1
23 pour 18 remis a Ab. favre fils 395 18 18
Juin 5 pour 4 doz Eguille d'or £66 398 2 17 9
11 pour 4 fromages 56.7/6 399 3 10 3
Juillet 6 pour leur assignation ordre Mr Jaquet Droz 170 6 403 7 9
16 pour leur assignation ordre D. f. Courvoisier 240 10 10
27 pour 1 caisse 407 42 5 5
Aout 5 pour Talbay sur le Thonneaux fayance 409 5 5
8 pour 2 montres sans remonter 32 11

Figure 13-26

The other three entries are in the transactions of DuBois & Fils in London, the same company with a change of name (DuBois 1758-1824, *Book 3*, page 158). As before, the company sent barrels, boxes and other items to Switzerland in exchange for money and a few items, including cheese. The first entry, Figure 13-27, is for 13 February 1781 and the transaction with Recordon was for £40-3-3 and again it is pounds sterling or about £680 Neuchâtel.

The second entry for 20 September 1783 on the same page is for about £509 Neuchâtel; see Figure 13-28.

Finally, Figure 13-29, on 26 December 1783 Philipe DuBois recorded the unpleasant fact *Pour le Bt de recordon qui n'est pas payés*, for the billet (?) of Recordon which is not paid, to the value of £29-18-6. This is the same amount as in Figure 13-22.

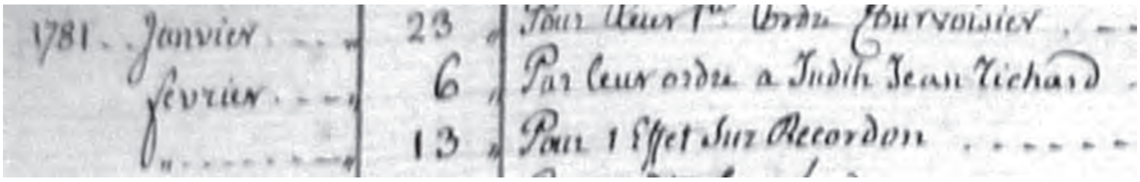


Figure 13-27

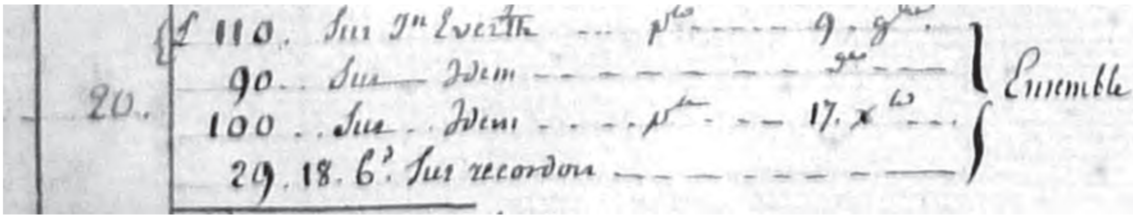


Figure 13-28

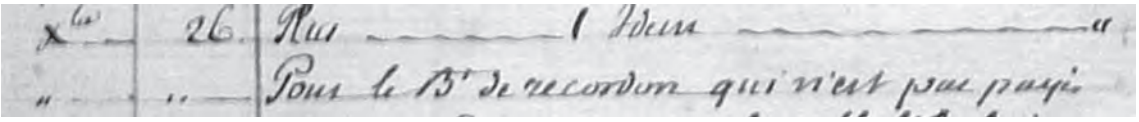


Figure 13-29

13.10: Relationship with Moÿse Gevril

The watchmaker Moÿse Gevrille, as the name is spelt by Philipe DuBois, was one of two people with that name. The other, listed in Bourdin (2012) was an enameller and dial maker, and he was also used by DuBois. Unfortunately DuBois did not specify occupations in all entries, but he refers to the enameller in 1769 (DuBois, 1758-1824, *Inventory Book 1*, page 115) and probably in 1780 (DuBois, 1758-1824, *Inventory Book 1*, page 351) where Moÿse Gevrille is listed as having 5 gold cases.

The watchmaker appears in 1769 (DuBois, 1758-1824, *Inventory Book 1*, page 82), Figure 13-30, and in 1782 where he is owed £229-12-0 (DuBois, 1758-1824, *Inventory Book 1*, page 403).

But there is one detailed entry for 1786 to 1791, in which Moÿse Gevrille is described as a Master Watchmaker; see Figure 13-31 (DuBois, 1758-1824, *Book 5*, page 140).

The most important point is that the 18 movements sold to DuBois cost more than £100 each. And they are unlikely to be repeaters, because making repeater work was a separate speciality.

We can compare the 4 movements sold in 1787 for £117-12-0 each, with movements listed in the 1787 inventory (DuBois, 1758-1824, *Inventory Book 2*, pages 56-58).

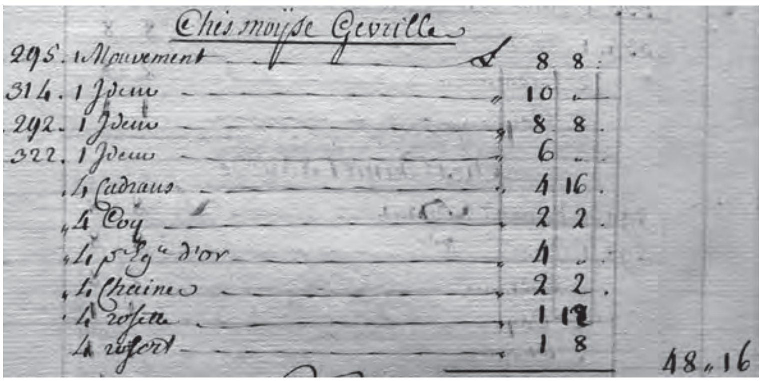


Figure 13-30

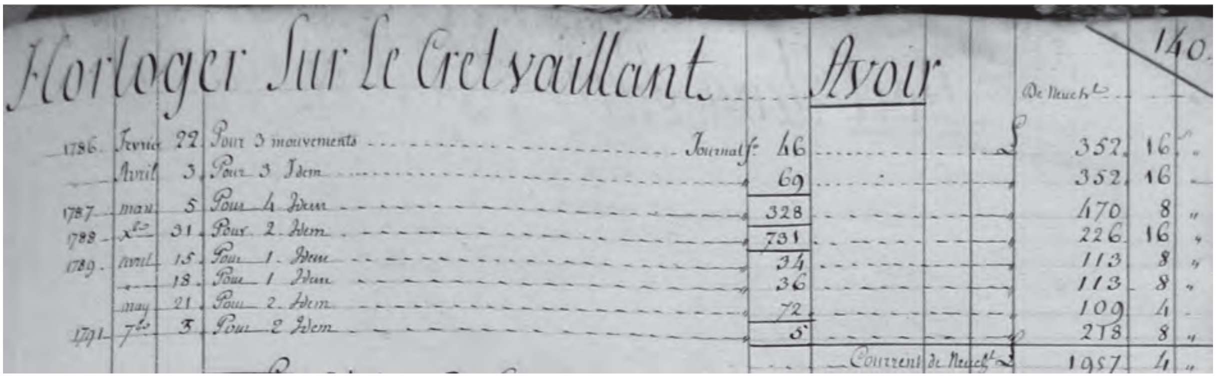


Figure 13-31

The prices in the inventory vary considerably, but an indication of the range is given in Table 13-2.

A rough movement (*mouvement brut*) could vary from little more than the plates to an almost complete movement, and some entries are quite specific. For example, *1 mouvemt Brut avec ressort £6-12* (with spring); and *1 mouvemt Brut avec ressort coq & pign rouage £15-13* (with spring, balance cock, pinions and wheels). The spring is probably the mainspring.

It is clear that the movements produced by Moÿse Gevrille must be special. And, as they are not described as repeaters, it is possible that they are self-winding movements.

Type	**Price Low**	**Price High**
Rough	£4-14	£15-13
Rough with repeater work	£48-6	£65-2
Finished with parts (before gilding?)	£17-10	£33-19
Finished (gilded?)	£28-0	£40-2
Finished with repeater work and cylinder escapement	£100-2	

Table 13-2

13.11: Relationship with Meuron

In addition to the meagre information in Chapter 6, page 56, the DuBois account books provide a little more. There are 34 entries that are summarised in Table 13-3. Unfortunately neither the given names nor the location of the watchmaker are provided.

Name	**Location**	**Dates**	**Occupation**
Lardy & Meuron	Neuchâtel	1782-1794	Negociants
Meuron		1759 (1785?)	Watchmaker
Meuron	Chaux-de-Fonds	1785-1787	Negociant
Meuron & Bovet	Neuchâtel	1791-1799	Negociants
Meuron & D'yvernons	St Sulpice	1787	
Meuron & Silliman		1775-1780	

Table 13-3

14: Methodology

14.1: Historical Method

The problems facing historians are fundamentally the same as those faced by a jury or a judge at the end of a criminal trial.

Throughout a trial, evidence is presented by witnesses who are asked to state "the truth, the whole truth and nothing but the truth". Unfortunately this does not happen in practice.

First, the prosecution and the defence only elicit evidence that is helpful for their cases. And so, frequently only fragments of the "truth" are presented. Second, because of contradictions, it is often apparent that some witnesses lie. As a result, the jury is given a mixture of partial truths and lies. And third, usually the evidence does not conclusively prove what happened, so that alternative, conflicting interpretations are possible. Indeed, if that was not the case, juries would be unnecessary.

Thus juries and judges are required to reach an interpretation of the evidence *beyond reasonable doubt* and to decide the matter on that basis. Often this is not too difficult. By examining different possible explanations it can become apparent that one explanation is much more credible and so much more likely to have taken place.

Unfortunately, some people believe in a clear true/false dichotomy, where evidence is absolutely true or absolutely false. But this is not correct. Indeed, there is a continuum from absolutely false to absolutely true, and explanations of events lie somewhere on that line with different probabilities of being correct.

Another way to view historical research is to see it as similar to putting together a jigsaw puzzle where a number of pieces are missing. And, to make it worse, some parts of the picture are interchangeable and can be fitted in different places. The problem is to arrange the pieces correctly and to decide what probably existed in the missing parts.

So, historical method, although simple in principle, is very difficult in practice. It is based on *sources*, *hypotheses* and *analysis*.

Sources can be categorised into three classes:

(a) *Primary sources*. Primary sources are contemporary documents and artefacts. They provide hopefully reliable testimonies on the subject. Fundamentally, primary sources should be eyewitness accounts and precisely datable objects. But it is possible for later documents to be treated as primary sources; for example, when there is a clear link between the report and the original events. However, as views of what happened may be blurred or modified with the passage of time, these sources should be treated with care.

(b) *Secondary sources*. Secondary sources are later, non-contemporary documents. In general these will base their statements on primary sources, and their main purpose is to analyse those sources and draw conclusions about the history of the subject.

Unfortunately, some secondary sources fail to specify the primary sources on which their statements are based. Without some corroborative evidence these sources must be treated with care.

Obviously later, non-contemporary artefacts cannot be sources for earlier events, unless they have a clear link to the past.

(c) *Tertiary sources*. Tertiary sources are documents based on secondary sources. They frequently fail to provide references and often make statements as though they are facts. Generally, tertiary sources simply repeat information from secondary sources or other tertiary sources and so add nothing to our knowledge or understanding of the subject. Consequently, they should be ignored unless there is a compelling reason to do otherwise.

For convenience, some of the tertiary sources I have examined are listed in Appendix 1.

Hypotheses are essential because the primary sources are almost always equivocal and fail to provide an accurate, complete picture of events. Consequently, it is necessary for the historian to assess the evidence and propose the *most likely* explanation for the events and artefacts. In doing so:

(a) Only primary sources can be used.

(b) *All* primary sources must be considered impartially. Most importantly, inconvenient "truths" cannot be ignored.

(c) All hypotheses must be expressed as *opinions* and not as facts.

The basic aim is to fill in the gaps, to propose a complete sequence of events that describes the history of the subject. In doing so, it is necessary to seek the most likely explanation, which best fits the evidence:

(a) It makes use of and explains more of the primary sources than any other explanation.

(b) It relies on the least number of (or least significant) deduced events that are not described in the primary sources.

One useful tool is Ockham's Razor, the law of parsimony, economy or succinctness. It is a principle urging one to select from among competing hypotheses that which makes the fewest assumptions and thereby offers the simplest explanation. The principle is often incorrectly summarized as "other things being equal, a simpler explanation is better than a more complex one." However, the razor asserts that one should proceed to simpler hypotheses until simplicity can be traded for greater explanatory power; the simplest available hypothesis need not be the most accurate.

Deduced events create the most problems. They range from sensible links between known events to what can be considered flights of fantasy that cannot be justified.

In order to test the credibility of such deductions, it is necessary for the historian to *analyse* each hypothesis. In doing so:

(a) If the hypothesis is contradicted by evidence then it must be rejected and a new hypothesis developed.

(b) Some hypotheses are based on deductions from the *absence of evidence*. For example, because someone wrote about only one person making a self-winding watch, it is deduced that no one else at that time and location had made self-winding watches; therefore the first person was the inventor. Such deductions are very dangerous and their credibility must be carefully assessed.

(c) Alternative hypotheses need to be examined. Generally events can be interpreted in several ways, and the relative merits of different opinions have to be assessed in order to decide which interpretation is most likely.

(d) Hypotheses generally have consequences. That is, having proposed an interpretation of the evidence it is necessary to examine the impact it has on the interpretation of other aspects of the history.

The historian needs to be a devil's advocate and deliberately attempt to disprove his own opinions. He should examine and assess alternatives even if they may seem, at first sight, to be unlikely.

Qualitative assessment is necessary, because in the majority of cases it is not possible to know if a statement is absolutely true or absolutely false. A simple example is the statement: *smoking causes lung cancer*. It is impossible to determine, absolutely, if this is true or false, because there have been smokers who have never contracted lung cancer and others who did. But it would be absurd to suggest that, because we cannot prove the link absolutely, smoking does not cause lung cancer; the statistical evidence is unequivocal, and the probability of a smoker dying of lung cancer is much higher than for non-smokers.

To make comparisons between different hypotheses it is convenient to use a scale of probabilities ranging from 0, absolutely false, to 100, absolutely true. That is, we can rate the quality of the evidence for each hypothesis and estimate the likelihood that it is true. Of course, this scale is too fine because it is impossible to assess historical hypotheses with such accuracy, and even a scale of 0 to 10 may be too fine. However, using percentages, which are well understood, is more convenient.

14.2: Teapots and Tlustos

As noted above, deductions from the absence of evidence must be treated with great care.

In 1952, the same year that Chapuis and Jaquet published their book on self-winding watches, the philosopher and mathematician Bertrand Russell proposed the teapot hypothesis:

> *If I were to suggest that between the Earth and Mars there is a china teapot revolving about the sun in an elliptical orbit, nobody would be able to disprove my assertion provided I were careful to add that the teapot is too small to be revealed even by our most powerful telescopes.* (Wikipedia, 2013b.)

First, if we look at this hypothesis *out of context*, it is impossible to assert if it is true or false. This will be more obvious if we replace *a china teapot* by *a specific object*. That is, the two statements:

> *There is a specific object revolving about the sun in an elliptical orbit.*

> *There is no specific object revolving about the sun in an elliptical orbit.*

are meaningless, because there is no evidence by which they can be assessed and allotted a probability between 0 and 100. More interesting is that the statement

> *We do not know if there is a specific object revolving about the sun in an elliptical orbit*

is also meaningless. This can be re-expressed as:

> *There is or there is not a specific object revolving about the sun in an elliptical orbit.*

But, without evidence, we cannot allocate this hypothesis a probability of 50, neutrality. We simply cannot state anything at all about the hypothesis and it is meaningless.

The teapot hypothesis is relevant. Consider the Perrelet hypothesis, which will be discussed in Chapter 15:

> *Abram Louys Perrelet l'Ancien designed the rotor watch and made several of them.*

Ignoring the historical context of this statement, we will see that there is no evidence relevant to this specific hypothesis. And so it is meaningless.

This will become clear if we propose another hypothesis:

> *In 1775 Joseph Tlustos designed the rotor watch and made several of them.*

Again, there is no evidence relevant to this specific hypothesis. And so it is meaningless.

These hypotheses could both be true, false or uncertain, but we cannot assess them and so cannot make any statement about them. But we will note that both hypotheses are possible, because documents state that both Perrelet (Section 5.1, page 33) and Tlustos (Section 4.2, page 19) invented self-winding watches.

At this point, it is reasonable to suggest another hypothesis:

> *Abram Louys Perrelet l'Ancien made rotor watches to the design of Joseph Tlustos.*

Again, because there is no evidence, the hypothesis is meaningless. In particular, we cannot say, "I do not know". Obviously it is impossible to allocate a probability of 50 (do not know) to all three, because there are inherent contradictions. So we cannot allocate a probability to any of them.

However, such hypotheses may be useful if they are viewed in the *context of other evidence*.

Bertrand Russell added to his teapot hypothesis:

> *But if I were to go on to say that, since my assertion cannot be disproved, it is intolerable presumption on the part of human reason to doubt it, I should rightly be thought to be talking nonsense.* (Wikipedia, 2013b.)

That is, the hypothesis exists in a context, and that context makes the idea of an orbiting man-made object absurd. (In 1952. Now we could suggest that the Americans, Russians or Chinese could have put a teapot in orbit and perhaps the hypothesis is true!)

A more realistic example is: If archaeological sites with Roman occupation always yield a particular type of evidence (the context) and another site does not produce that evidence, then it can be assumed that the was no Roman occupation at that other site. But it is not absolutely certain, and some doubt must remain.

14.3: Objective and Subjective Evidence

The reliability of documentary evidence is, to some extent, dependent on the relationship between the reporter and the information. For example:

(a) The report in the *Münchner Intelligenzblätter* (Munich, 1779, pages 194-195) is *subjective evidence*. It begins (see page 29):

> *Mr Joseph Gallmayr born in Weltenburg, Bavaria, mechanic of the Electoral Prince would like by this to present once more to an honoured and intelligent public his latest invention*

It is clear that the information was provided by Gallmayr, and he had a particular interest in making sure the report was favourable to him.

(b) In contrast, the entry in Saussure's diary (see page 34) is almost certainly *objective evidence*. There is no indication that Saussure knew Perrelet and he simply reported on what he saw and was told.

14.4: Inventors, Designers and Makers

Unfortunately, it is often the case that writers discuss watchmakers without clearly distinguishing whether they are inventors, designers, makers, or merely sellers.

To state the obvious, an *inventor* is someone who conceives of or devises a previously unknown device, method or process.

If we are to take this definition literally, the inventor creates the *entire* device from entirely new ideas. It is this hard-line view that causes problems. If, for example, if we are to say that Perrelet *invented* the self-winding watch, then we must assume that he knew nothing about them beforehand. For if he had heard of Breguet's Reverend Father (see Chapter 3, page 13), he would have known of the idea of using an oscillating weight and he could not then be called the inventor.

In practice the inventor rarely conceives everything, and the majority of "inventions" include the use of earlier ideas, although perhaps in a new context. So the invention can either be a change or addition to someone else's idea or it can be a new and different application. So to describe someone as an inventor actually requires us to stipulate what was invented and what, if anything, was old.

The word *inventor* also has an emotional value. It is clearly associated with words like "superior", "the first" and "respect", and to describe someone as an inventor imbues them with positive emotional values.

Unfortunately, these emotional values may replace rational thought, and people can write in glowing terms about an inventor without properly considering the invention.

To *design* is defined in one dictionary as "to work out or create the form of something", but another states that it is "to conceive, invent, contrive". Although closely allied to *inventor*, *designer* lacks the emotional values of the former and is a more neutral term. It also more correctly describes both a person who creates a new application of an existing idea and a person who creates part, but not all, of a new design.

An obvious example is: Did Breguet invent the self-winding watch? The answer is "no", but the question is silly because there are a number of different designs. So we should ask: Did Breguet invent *a* self-winding watch? If we rely on extant watches, then we would say "yes" because some early watches are signed *Inventé et Perfectionné par Breguet à Paris* (Daniels, 1975, page 63). But, in contrast, Breguet himself stated that he only improved the design; that is, he invented only part of the mechanism.

In order to avoid the problems associated with the word *inventor*, we will use the word *designer* wherever possible. And there is no doubt that Breguet designed a self-winding watch.

Although it is obvious, we must stress that watch *makers* are not designers. Although they may vary a watch in minor ways, they do not create new designs. Of course, the majority of people we call watchmakers did not make watches; they simply bought and sold watches made by other people.

It is clear that the distinction between designer and maker is very important. To be pedantic, the designer of a watch need not have made it, and the maker of a watch need not be the designer. This creates a serious problem with the interpretation of artefacts, watches, because the signatures on them may or may not be significant.

Many of the important self-winding watches are not signed, and many of those that are signed probably carry the name of a retailer. In which case we can expect that three different people were involved in the creation of the watch, the designer of the mechanism, the maker and the seller.

14.5: Examples

To illustrate the process of historical research, we will examine a statement made by Jean-Claude Sabrier (Antiquorum, 2007, page 640). Although the authorship is not given in the catalogue, it has been confirmed by Lemenager (2010). Sabrier wrote:

> *In the late 1770s,* [Hubert Sarton] *made a trip to Le Locle, where he was able to examine self-winding watches made by Abraham-Louis Perrelet. Afterwards, upon his return to Paris, he filed a document with the Paris Académie des Sciences, dated December 23, 1778. It concerned self-winding watches with fusee and chain and verge escapement.*

First, this statement cannot be correct because the evidence presented in Chapter 7, page 57, shows:

(a) Sarton submitted a watch, not a report, to the Academy.

(b) In July 1778, Sarton had several self-winding watches for sale, most likely of the same type.

(c) Sarton did not live in Paris and he would have "returned" to Liège.

That is, this is clearly an hypothesis which must be rejected, and not a factual statement.

Second, the hypothesis does not state that it refers to a specific design, a self winding watch where the mechanism uses a rotor which can turn a full 360°.

However, it is possible to construct an alternative hypothesis that fits the evidence:

> *Before July 1778, Hubert Sarton made a trip to Le Locle, where he bought several self-winding watches made by Abram Louys Perrelet. In December, after his return to Liège, he submitted one of these watches to the Paris Académie des Sciences. It was a self-winding watch with rotor, fusee and chain, and verge escapement.*

Before accepting this possibility, we should ask the question: What is the purpose of this hypothesis? It is, simply, to show that Abram Louys Perrelet designed the watch described in the report to the Academy, and to do so it is necessary to explain how such a watch could have gone from Le Locle to Paris via Liège. There are two consequences of this. First, and obviously, Perrelet must have designed the rotor mechanism. Second, Sarton must have lied, committing a fraud by submitting a watch to the Academy as if he was the designer. As a result, the hypothesis cannot be studied in isolation and, to determine its validity, we must examine these points as well. In particular, it is necessary to provide evidence that supports the view that Perrelet invented this particular design and that Sarton lied.

Of course several alternative hypotheses can be proposed:

(a) There is no evidence showing that Sarton visited Le Locle. Instead the transaction may have taken place using an intermediary or, although very unlikely, Perrelet may have visited Sarton in Liège. These alternatives have no effect on the purpose of the hypothesis, and all such variants can be covered by deleting the words referring to Le Locle and Liège.

(b) Although there is evidence suggesting Perrelet had designed a self-winding watch, we will show later that there is no evidence that indicates that it was of the specific type submitted to the Academy, with the rotor mechanism. So an alternative hypothesis is that Sarton got Perrelet to make these watches for him to Sarton's design.

Thus we have two alternative hypotheses to consider:

> *Before July 1778, Hubert Sarton bought several self-winding watches made and designed by Abram Louys Perrelet. In December he submitted one of these watches to the Paris Académie des Sciences. It was a self-winding watch with rotor, fusee and chain, and verge escapement.*
>
> *Before July 1778, Hubert Sarton had several self-winding watches made by Abram Louys Perrelet to Sarton's design. In December he submitted one of these watches to the Paris Académie des Sciences. It was a self-winding watch with rotor, fusee and chain, and verge escapement.*

Both hypotheses have essential consequences.

The first requires us to find evidence that supports the view that Sarton was a liar, because such an accusation must be treated with great care.

The second must be expanded to include an answer to the following question: As the evidence indicates that Perrelet designed a self-winding watch and it was not the type described in the report, what mechanism did it have?

The above is just an example of analysis, and several other, significantly different hypotheses have been proposed. All of these aim to explain how Perrelet invented the rotor mechanism and yet Sarton submitted an apparently identical design to the Paris Académie des Sciences. And, in attempting to resolve this problem, all these hypotheses must be carefully examined and evaluated.

However, it is an unfortunate fact that most writers fail to use historical research methods. Two examples of poor historical method will illustrate this.

The web site Greenwich Mean Time (2010) has a translation of a *Communique de Presse* that was first published in 2004 for the Basel Watch Fair (Montres Perrelet, 2004). It fails because:

(a) Analysis. The article states the hypothesis *Perrelet invented the rotor mechanism* as though it is a fact and fails to analyse it and its consequences. In particular, the article goes on:

> *For reasons unknown, the Belgian* [Sarton] *patented a movement which resembles the Perrelet one. So: theft, usurpation?*

Other than the accusation of theft there is no attempt to explain this event. (To be correct, the report of the Paris Académie des Sciences is not a patent. Patent laws were not created until 1791 in France, the first half of the nineteenth century in other European countries (Machlup and Penrose, 1950, page 3) and 1888 in Switzerland. Also, the movement was identical to those claimed to have been designed by Perrelet.)

(b) Selectivity. No-where does the article mention Joseph Flores and his work, nor does it consider any of the doubts raised by him. Only evidence that supports Perrelet is included.

(c) Impartiality. For example, it is stated that:

__Poor__ Abraham-Louis Perrelet is no longer around to defend his __genial__ invention against his detractors who __insinuate__ that a certain Belgian watchmaker, Hubert Sarton, __completely unknown__ to the battalion of technicians, researchers and other precision maniacs, ..." [my emphasis].

Thus there is a deliberate attempt to use emotional blackmail to detract from Sarton, who actually was and is known by many.

Strangely the article ends:

For some reason, Hubert Sarton has disappeared from the saga of the self-winding watch!

That is obviously not true.

(d) Misuse of tertiary sources. The article presents secondary and tertiary sources as if they provide additional proof. In fact, all the tertiary sources merely repeat previous opinions uncritically and add nothing new. They most certainly do not represent new evidence.

I wonder if the author of this article is a disciple of Schopenhauer (1830)?

Although the Greenwich Mean Time report can be dismissed with disdain, the same cannot be said of the book *The Self-Winding Watch* by Jean-Claude Sabrier (Sabrier, 2012a), the publication of which prompted me to produce this work. As has been pointed out (Flores, 2012b; Flores 2012c; Watkins, 2012), Sabrier is a highly regarded expert and his book is considered by some to be the first significant contribution since Chapuis and Jaquet's 1952 book.

The description on the back cover states: "This new book by Jean-Claude Sabrier exemplifies the increasingly scientific and methodical procedure adopted by researchers and historians since the 1960's." Unfortunately, it is nothing of the sort. The most obvious failing is that Sabrier does not mention Flores, despite his 17 years of study and copious publications. In particular, he makes only the vaguest of references to the 1778 report (see Section 7.2, page 58), which is absurd, especially as, in contrast, he uses several pages to reproduce Breguet's writings on self-winding watches. But this is just an obvious symptom. Sabrier is selective, presenting only some of the available evidence. And he is not impartial, making definitive statements even though there is no definitive evidence; that is, presenting hypotheses as if they were facts. Indeed, he is not "scientific" (whatever that means) in that he fails to analyse the hypotheses that he favours.

In the context of this section, we are not suggesting that the conclusions drawn by Greenwich Mean Time and Sabrier are necessarily wrong. However, their failure to use good historical research methods means that we cannot rely on their opinions. To decide if they are right or wrong requires us to undertake the historical research that they have failed to do. This includes describing and analysing the hypotheses implicit in these and other books, articles, and web sites.


Plus est en vous

15: The Perrelet Hypothesis

15.1: The Hypothesis

Although we have not seen this hypothesis stated succinctly, it is very simple:

> *Abram Louys Perrelet l'Ancien designed the rotor watch and made several of them.*

This hypothesis has two specific requirements. First, it concerns one *particular person Abram Louys Perrelet l'Ancien*. And second, it concerns the *particular mechanism* described in Section 7.3, page 64, and so it must be compatible with the five known rotor watches.

The following sections will examine these points, and I will restrict the analysis to evidence relating to the rotor mechanism. (Other evidence and other mechanisms will be examined later.)

15.2: The Documents

All known documents are provided in Sections 5.1 (page 33) and 5.4 (page 42). To summarise their content:

(a) Two contemporary documents and one later document refer to a person with the name Perlet or Perelet, but the given names are not specified. (Figures 5-1 and 5-2, pages 33-34, and Figure 5-6, page 36.)

(b) One contemporary document refers to a person with the name Perrelet, but the given names are not specified. (Figure 5-5, page 36.)

(c) The association with *Abram Louys Perrelet* was not made until 1838 (Meissner and Caumont, page 266), 1859 (Andrié, page 156) and 1863 (Jeanneret and Bonhôte, volume 2, pages 193-195).

(d) One of the three contemporary documents states Perrelet to be the *inventor* of a mechanism, but the other two state that he is the *maker*.

(e) All three later documents state that Perrelet is the *inventor* of a mechanism.

(f) None of these documents specify the type of mechanism.

As we have shown, there is very little doubt that the person referred to in (a) is a person named Perrelet. In addition, the statement by Meissner and Caumont and the reliability of the biography provided by Jeanneret and Bonhôte makes it very likely that all five documents refer to the one person *Abram Louys Perrelet l'Ancien*.

To suggest that we do not know the name of the person referred to in the contemporary documents, because he is not specifically identified, requires us to answer the question:

> *If it was not Abram Louys Perrelet l'Ancien, then who was it?*

I have considered this possibility and I am unable to name anyone who might, *with more likelihood*, be the person. Unless compelling evidence contradicting this attribution is found, Abram Louys Perrelet l'Ancien is the most likely person to be that mentioned by de Saussure and others.

Because none of the documents describe the mechanism, it *cannot be assumed* that it was the rotor mechanism.

Whether Perrelet designed a mechanism, or merely made watches using a mechanism, rests on Saussure's diary alone, and the later documents cannot be considered reliable in isolation. So we must ask:

> *Is it more likely than not, that Perrelet designed a mechanism?*

Again, without new evidence we are obliged to conclude that Perrelet probably designed a mechanism.

With regard to designing, the Perrelet hypothesis has always been presented in isolation with no attempts to examine the relationship between Perrelet and other makers of self-winding watches, except for Hubert Sarton. As we will show, the role of Sarton has been considered primarily in the context of deciding that the Perrelet hypothesis is true and that he designed the rotor mechanism. That is, a prejudiced approach has been taken based on the assumption that Perrelet designed the rotor mechanism, even though that cannot be justified by the documentation.

Not even one of the relevant documents, from 1777 to 1863, mentions the type of mechanism; indeed, the first document to associate the rotor mechanism with Perrelet is Chapuis & Jaquet (1952). To state the obvious, the mechanism used in the watches made by Perrelet could be any one of the six described above, or even another, unknown design.

15.3: The Leroy Watch

This watch, examined by Chapuis & Jaquet and described in Section 7.3, page 64, will be considered in detail later, but here we need to make a few points:

(a) The movement is not signed, or marked in any way, and the name Abram Louys Perrelet l'Ancien can only be associated with the watch through other evidence. (The same is true of the other known rotor watches.)

(b) The only evidence to show that the movement was made in the Principality of Neuchâtel is the mainspring, which is signed by the maker *AFV*, Antoine Friedrich Vincent.

(c) The movement is not dated and cannot be dated accurately.

(d) The case is stamped with the Principality of Neuchâtel hallmark which was *adopted in 1754* and *remained unchanged until 1881* (Chapuis & Jaquet, 1952, page 52; 1956, page 53). That is, the case cannot be dated accurately. However, see the discussion of the case hallmarks given below.

It is necessary to conclude that:

> *The Leroy watch cannot be used as evidence to support the Perrelet hypothesis.*

Any evidence must clearly name the person and be definitely dated to 1777 or earlier. But the *Leroy watch* cannot be dated and could have been made by anyone in the Principality of Neuchâtel, including Jonas Perret Jeanneret or Moÿse Gevril (Chapter 6, page 55). Indeed, the evidence is so weak that the movement could have been made elsewhere.

If we are to rely on the documentary evidence and the *Leroy watch*, then the Perrelet hypothesis cannot be accepted.

15.4: Inventing the Missing Link

As noted in Section 1.1, Chapuis and Jaquet were faced with the problem of having a rotor watch and documents referring to Perrelet, but there was nothing to link the two together. As documents cannot be changed, the only possibility was to find some evidence that linked the *Leroy watch* to Perrelet.

And Chapuis & Jaquet (1956, page 56) did this in a single sentence:

> *The assumption that the movement of the "Leroy" watch may probably be attributed to Perrelet, and its case to A.-L. Robert, seems to us justified therefore,* ***especially as the fine workmanship of the movement does very much resemble Perrelet's style of execution****."* (My emphasis.)

In the original edition (Chapuis & Jaquet, 1952, page 55) the statement is:

> *Cela paraît une quasi certitude, d'autant plus que la bienfacture du mécanisme correspond tout à fait à la manière de travailler de ancien Perrelet.*
>
> *This seems a near certainty, especially as the craftsmanship of the mechanism is entirely consistent with the manner of working of old Perrelet.*

This is the *only* "evidence" presented by Chapuis and Jaquet to link the watch to Perrelet. (But it is considerably more than Sabrier, 2012a, who provides no evidence at all.)

But what style of execution? What manner of working?

These questions are very important, because the *Leroy watch* is not signed and the only evidence for attributing it to Perrelet is Perrelet's "style of execution".

But in order to discuss the "style of execution" of Perrelet, or any other watchmaker, we need the following:

First, we must have several watches that absolutely certainly were made by Abram Louys Perrelet l'Ancien.

Second, we must have several watches that absolutely certainly were *not* made by Abram Louys Perrelet l'Ancien.

Third, we must examine all these watches in great detail and describe the features that *always* occur in Perrelet's watches and *never* occur in the other group of watches. (Obviously, if a feature appears in both groups it cannot be used to identify watches made by Perrelet.)

Fourth, we must examine unsigned watches whose makers are not known and determine the presence or absence of the defining features. Then, if the features are present we can conclude that the watch was made by Perrelet.

For example, I have been told that all self-winding watches with a slot in the weight (for key winding) were made by DuBois & Fils, and this slot clearly distinguishes these watches from those of other makers; see Figure 5-22, page 51. Thus, an unsigned watch with this feature can be confidently (but not absolutely certainly) attributed to DuBois & Fils.

In contrast, distinctive features do not guarantee the origin of a watch. The obvious examples are copies of Breguet's watches, such as the souscription watch described by Piguet (2008). So an unsigned watch that exhibits the characteristics of a Breguet movement may have been made by someone else. But Perrelet was not famous and it is unlikely that his "style" was copied.

However, ten pages earlier than the missing link sentence, Chapuis & Jaquet (1952, page 45; 1956, page 46) make a stunning admission:

> *It is probable that even Perrelet, a notoriously modest man, never signed one of his watches* [n'en a peut-être signé aucun].

That is, *Chapuis and Jaquet admit they had not seen even one watch signed by Perrelet*, and we can be confident that they had never seen the watch now in the MIH collection (see Figures 5-16 and 5-17, page 49). Indeed, two pages earlier they mention the only watch that they knew of, that *attributed* to Perrelet in the Maurice Robert collection (see Figures 5-18 to 5-20). But they do not illustrate or describe it!

And so Chapuis and Jaquet based their understanding of Perrelet's "style of execution" on a single, *attributed* watch. They do not explain the features of that watch which distinguish it from other watches, and they do not provide any information about the other watches they had examined which were not made by Perrelet. Finally, they do not describe the features of the unsigned Leroy watch which enabled them to suggest it was made by Perrelet. *They provide precisely no evidence to support their claim.*

That is, it appears that Chapuis and Jaquet lied. They knew that they had seen zero watches signed by Perrelet, but they pretended that they had seen several such watches, so that they could invent the missing link and associate the *Leroy watch* with Perrelet.

Despite an extensive search, we have been able to find only one watch with a signature that can be attributed to Abram Louys Perrelet, that shown in Figures 5-16 and 5-17 (page 49).

This cylinder escapement movement cannot be described as good workmanship. As shown in Figure 15-1, the center wheel cock has been roughly cut away so that it does not touch the barrel. And the pivot hole and oil sink for the escape wheel have been moved; the wheel has been replanted or a different escapement has been put in. We accept that, at 96 years old, Perrelet may not have been able to produce his best work, and the movement appears to be unfinished, but there is nothing to indicate a superior watchmaker; it is simply an ordinary watch, like many others produced by many makers.

Figure 15-1

There is one feature that might indicate Perrelet's "style of execution", the shape of the wheel arms. I do not know if the "crossing out" is important, but it is likely that a watchmaker used a particular style for all his watches. If it is a distinguishing feature then it is unlikely that Perrelet made the Leroy watch. Comparing Figure 7-10 (page 65) with Figure 15-1, it is clear that the style of the wheels is different, suggesting two different makers. Figure A5-12 (page 327) shows the crossing out of all five rotor movements. Perhaps Perrelet made the *Mazzi à Locarno* movement?

Of the three watches signed ALP on the dial (see Section 5.6, page 51) there are views of two movements: the watch in the style of a Breguet souscription watch (Figure 15-2; Piguet, 2008, page 157), and the watch signed Sarton (page 52). Both have the same style of crossing out as Figure 15-1. Of course, the number of different styles is very limited, and many different makers would have used this shape. Also, there are watches with two styles of crossing out. But despite these problems, the similarity is interesting and possibly important.

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Figure 15-2

The second watch, in the Maurice Robert collection, is best described as mysterious. Originally I had to draw conclusions from the very bad drawing, Figure 5-18, page 50. The movement appears to be typical of English style watches circa 1840 or later; the top plate, and especially the balance cock, suggests a late English design. Further, Perrelet has not signed the movement and the inscription could have been added at any time. Until I had the photographs, I tentatively concluded that Perrelet could not have made it. And, although we will never know, I wondered if Chapuis & Jaquet (1952; 1956) did not include a photograph and information about this watch because they were aware that the inscription could be a fake.

However, the photographs of the watch, Figures 5-19 and 5-20, show that it is wound through the dial, indicating a continental origin, and Swiss makers, including DuBois, produced English style watches, presumably for sale in England. So Perrelet could have made it.

But why use a Litherland rack lever? That escapement had a very short life in England, being overtaken by the Massey lever from about 1815 on. And so we must ask, why would Perrelet make a rack lever movement as late as 1823, and not use a conventional lever escapement? It seems very unlikely.

I also obtained a low resolution photograph of the inscriptions on the case, Figure 15-3, that provides two useful pieces of information:

(a) The inscription *T13* is the control mark specifying that the case is 13 lötigs, about 81.25% silver. Bachelin (1888, page 184) states that the December 13 1775 laws required goldsmiths to use "silver of thirteen loetigs, that is nine deniers eighteen grains, under penalty of the crime of forgery." The Neuchâtel chevrons are not punched into the case, but the specification of quality may have been regarded as sufficient.

Figure 15-3

(b) The initials are probably the case signature *DLI* with the *D* and *L* joined. The alternative, *D.I*, is unlikely, because none of the signatures listed in Appendix 2, page 275, include stops within them.

DLI may be the signature of David Louys Jacot or Daniel Jeanneret (see Appendix 2.4, page 288). But if the case was made by *DLI* then, based on the serial numbers given in the DuBois inventories, the number 8235 probably dates from about 1816; according to the serial numbers, *DLI* made about 13,000 cases in 13 years, indicating that he must have employed several people. Also, I do not know if there is a serial number or inscriptions on the plate under the dial. So, although it is likely, it is not possible to know if the movement was made for Philipe DuBois.

These deductions make sense. They indicate that the movement was made in Neuchâtel (probably Le Locle) for the English market, and the earlier date of 1816 (which invalidates the inscription) makes the use of a rack lever escapement more likely.

However, such speculation is irrelevant. What matters is that this movement is ordinary. It does not exhibit any *distinguishing features* that would enable other, unsigned watches to be attributed to the same maker. In particular, the *Leroy watch* has no characteristics in common with either of the two watches attributed to Perrelet.

Finally, attributing signed, let alone unsigned, watches to Abram Louys Perrelet is very dangerous. As we have noted in Section 5.3, page 39, there were at least two makers to whom unsigned watches could be attributed, Abram Louys Perrelet l'Ancien and Abram Louys Perrelet le Gros.

Although not directly relevant, we wonder what Chapuis and Jaquet would have written if the watch found by Leroy had been the one signed *Berthoud a Paris*, Figure 7-45, page 85. Would they have attributed the design to Ferdinand Berthoud?

All the above is interesting, but of no use. Even if the Leroy watch could be attributed to Perrelet this would tell us nothing about the designer of the movement. Perrelet could have made watches to the design of someone else.

In the first edition (Watkins, 2013c, page 158) I wrote, regarding the missing link: "We can only conclude that Chapuis & Jaquet lied." I have never been happy with this statement, particularly because everything in their book suggests they had integrity and were honest. But how else can the missing link sentence be explained?

The backgrounds of the authors provide a better explanation. Alfred Chapuis was the Professor of Economic Geography, Literature and History at the University of Neuchâtel, and he had interests in horology, magic and other topics. In 1938 his work earned him an honorary Doctor of Letters of the University of Neuchâtel. As we know, he wrote extensively on the history of watches and watchmaking (H.A.L, 1958; Calame 2008; Chapuis, 2014). In contrast, Eugène Jaquet (who died in 1951) was a trained watchmaker who served as Professor of Horological Theory at the Bienne Technical College and then Principal of the Geneva School of Horology (Chapuis & Jaquet, 1952, page 11; 1956, page 13).

Jaquet was a highly respected watchmaker and, even if he had little knowledge of 18th century watchmaking, I cannot believe that he would be a party to the missing link sentence. It is likely that Chapuis knew nothing about watchmaking and watch technology, which is why several of his books have technically competent co-authors. So I think the involvement of Jaquet in the book was limited to technical descriptions. Because the description of the rotor watch was copied from Leroy

& Huguenin (1949), Jaquet probably only advised on Breguet and wristwatches. In this context it is likely that Chapuis wrote all the nontechnical text in *La Montre Automatique Ancienne*.

I assume Chapuis was educated in *narrative history*, the practice of writing history in a story-based form. In this style of history, it is acceptable to introduce fictional characters and their lives in order to create the narrative that describes historical events from their perspective. And so trivial fictional events might be added to create a coherent story. However:

> *This means that what distinguishes "historical" from "fictional" stories is first and foremost their contents, rather than their form. The content of historical stories is real events, events that really happened, rather than imaginary events, events invented by the narrator. This implies that the form in which historical events present themselves to a prospective narrator is **found** rather than **constructed**.* [White, 1984]

In 1952, Chapuis knew that Perrelet had invented a self-winding watch, and that the rotor mechanism was the only design not attributed to others people (Breguet and Recordon in particular) and the center-weight design was clearly too late to be considered. And so it seemed perfectly sensible to him to attribute the rotor design to Perrelet. In this context, it was probably acceptable to introduce "trivial" fictional evidence, Perrelet's style of execution. Unfortunately, what might have been seen as trivial at that time has now become an extremely important error. An error that, together with the other errors discussed below, has led to the myth that Perrelet invented the rotor mechanism.

15.5: The Leroy Watch Movement

Central to the argument presented by Chapuis & Jaquet is their conclusion that the *Leroy watch* movement was made in Neuchâtel.

However, the only evidence for the origin of the *Leroy watch* movement (as opposed to its case) is the signature on the mainspring, *AFV,* for Antoine Friedrich Vincent. Because Vincent lived and worked in the Principality of Neuchâtel (at Brenets in 1786-89) it is assumed the movement was made in the Principality of Neuchâtel. However, Flores (2009, page 41) illustrates a watch signed *Le Noir à Paris* that has a mainspring with the same signature. Either Vincent (perhaps through DuBois) sold springs to French makers, or the LeNoir movement was made in the Principality of Neuchâtel. Either way, this watch casts some doubt on the origin of the *Leroy watch*.

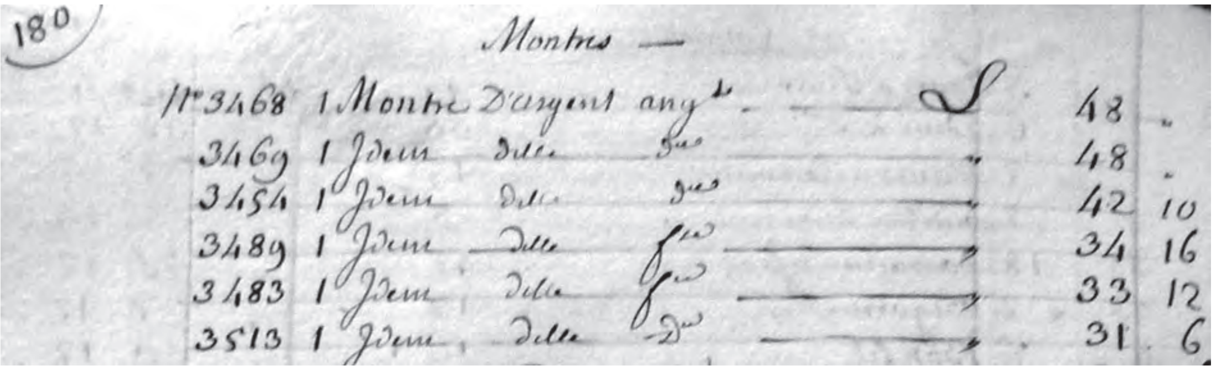
In both instances the mainspring signature consists of the initials *AFV* without a date. DuBois (1758-1824) used Vincent to make mainsprings and there are 11 entries in the books, dating from 1759 to 1789. Therefore the mainspring cannot be used to date the *Leroy watch* movement.

As noted in Section 7.7, page 85, three of the five known rotor watches have the serial numbers 3246, 3483 and 3616. As these strongly suggest établissage, the obvious question to ask is:

> *Were these movements made for or by Philipe DuBois?*

Appendix 3 (page 297) analyses the serial numbers used by DuBois. If these watches were made for Philipe DuBois then we know, from Table A3-1 in Appendix 3, that they must have been produced between 1772 and 1774, or in 1802, or in 1815. The latter dates are too late and only the early dates need be considered.

However, by luck number 3483 (on the unsigned movement in the Goud'Zilver Klokkenmuseum) appears in the 1773 inventory, Figure 15-4 (DuBois 1758-1824, *Inventory Book 1*, page 180).



180

Montres —

N° 3468	1 Montre D'argent	ang^e		₶	48	
3469	1 Idem	Dito	D°		48	
3454	1 Idem	Dito	D°		42	10
3489	1 Idem	Dito	D°		34	16
3483	1 Idem	Dito	D°		33	12
3513	1 Idem	Dito	D°		31	6

Figure 15-4

It is clear that this watch, *montre d'argent anglois* is an ordinary silver watch made for the English market and cannot be a self-winding watch.

And so it is very unlikely that the rotor watches were made by or for DuBois.

I say *very unlikely* because only a fragment of the original account books and documents remain. And it might be the case that DuBois recorded special orders in a separate account book and special order watches may have been given serial numbers unrelated to the sequence of serial numbers normally used by DuBois. This is possible because it is unlikely that DuBois would make very expensive watches without at least some being pre-ordered. However, the argument is weak and it is more likely that DuBois was not the maker.

Probably to support the missing link, Chapuis made two important statements regarding Perrelet and, indirectly, the *Leroy watch*.

First, commenting on *Perrelet's career*, he states (Chapuis & Jaquet, 1952, page 43):

> *Dans les archives de la Maison d'horlogerie Ph. DuBois, au Locle, nous trouvons de nombreuses mentions de livraisons de mouvements de montres par A.-L. Perrelet à partir de 1761: des finissages, des cadratures, des montres à répétition (1774).*

> *In the archives of the watchmaking house of Ph. DuBois, in Le Locle, we find many references to deliveries of watch movements by A.-L. Perrelet from 1761: finishing, dial-work* [repeater work], *repeater watches (1774).*

The English translation contains a significant error, where *finissage* is misinterpreted, and it omits the mention of dial-work:

> *Files in the archives of the Philipe DuBois watch factory, dating from 1761 onwards, contain several references to consignments of watch movements by A.-L. Perrelet:* ***train wheel bridges****, repeaters, etc.* (Chapuis & Jaquet, 1956, page 45)

The obvious error in this is that the dial-work and repeaters were made by A. L. Perrelet the repeater work maker and not by A. L. Perrelet l'Ancien (see Section 13.5, page 155). With regard to watch making, the only concrete information in the books of DuBois (1758-1824) is that given in Section 13.5:

(a) 1761-1763: Finished 10 movements.

(b) 1767: 1 movement.

(c) 1773: 6 movements.

(d) 1774: 2 movements.

This is an insignificant amount of work on ordinary watches. However, as we have noted in Section 5.7, page 53, Perrelet probably only made about 400 movements in his entire life, and so we would expect the transactions with DuBois to be small.

Second, Chapuis & Jaquet (1956, page 62) state:

> *Perrelet, however,* ***as he says himself****, tried out several systems and must have finally come to the conclusion that the pedometer weight* [rotor] *did not secure sufficient winding for the pocket watch. It was for this reason that,* ***tireless researcher as he was****, he finally adopted the banked weight* [side-weight] *which Breguet and his emulator Recordon later adopted to the exclusion of all other systems.* (My emphasis.)

This statement is reinforced by Huguenin (Chapuis & Jaquet, 1952, pages 58-60; 1956, pages 60-61), who also believes Perrelet designed two mechanisms.

But we have no choice but to make another serious accusation:

> *This is obviously a fabrication because no documents written by Abram Louys Perrelet l'Ancien exist.*

There is no evidence at all that Perrelet tested several systems, and if Chapuis is referring to Saussure's diary then he has misinterpreted it. There is no evidence that Perrelet designed both rotor and side-weight mechanisms. After all, Chapuis & Jaquet quote Mr Pierre Huguenin, who stated that:

> *This [rotor] self-winding system works well* [Chapuis & Jaquet, 1952, page 50; 1956, page 51].

That statement, the analysis in Section 7.6 (page 83), and the tests in Appendix 6.5 (page 352), contradict the statement that rotor watches *did not secure sufficient winding* and make it very unlikely that Perrelet would have discarded the rotor design.

We must note that the above remark is not the result of poor translation, the original book stating:

> *Mais Perrelet qui essaya,* ***il le dit****, plusieurs systèmes, constata sans doute que celui qu'on appelle aujourd'hui "rotor" n'assurait pas alors, dans le gousset, un remontage suffisant. C'est pourquoi,* ***chercheur infatigable comme il l'était****, il en vint au système oscillant limité que Breguet et son émule Recordon, comme nous allons le voir, adoptèrent exclusivement.* [Chapuis & Jaquet, 1952, page 61.]

Thus the statement appears to be a figment of the imagination of Chapuis that, in the context of historical narrative, he probably thought would be acceptable.

But it is not. Possibly deliberately, Chapuis has misinterpreted the biography by Jeanneret and Bonhôte (1863, volume 2, pages 194). After mentioning self-winding watches, they began *a new paragraph* with:

> *Chercheur continuel, il essaya une foule de systèmes et s'efforça aussi de découvrir le mouvement perpétuel; il faisait de temps en temps douze montres ayant chacune un échappement différent, et lorsque ses nombreux amis le félicitaient de ses découvertes, il leur disait en souriant avec modestie: «il y en a plusieurs qui ne valent pas grand chose.»*
>
> *A continual researcher, he tried a variety of systems and also endeavoured to discover perpetual motion; he occasionally made twelve watches each one having a different escapement, and when his many friends congratulated him on his discoveries, he told them, while smiling with modesty: "there are a few which are not worth much."*

Except for the last phrase, there is no doubt that this does not *quote* Perrelet and clearly it does not refer to self-winding watches.

15.6: The Leroy Watch Case

With regard to the *Leroy watch* case, Chapuis makes two claims. First:

> *[It] ... must have been made to measure for the movement ... Everything fits so perfectly to the very last detail that the most exacting expert must concede that both movement and case were made under the supervision of one man, by one master.* [Chapuis & Jaquet, 1952, page 51; 1956, page 52.]

That is, the existing case is the original case. Note that on one point, this statement must be wrong. Watch making and case making were entirely separate crafts. The supervisor, if he could be called that, would have been the établisseur who got the watch made for him, and he would not have been directly involved in making either component.

And second:

> *In the DuBois archives appeared the name Abraham-Louis Robert, mentioned during the years 1760-1794 as "master casemaker resident at Eplatures, near Locle" ... The assumption that the movement of the "Leroy" watch may probably be attributed to Perrelet, and its case to A.-L. Robert, seems to us justified.* [Chapuis & Jaquet, 1952, pages 54-55; 1956, pages 55-56.]

This attribution comes from the initials of the case maker, Figure 15-5, which Chapuis decided were the initials of Abram Louys Robert.

In addition, he notes:

> *[Robert] apparently supplied the firm of DuBois with a number of fairly luxurious cases, and during the years 1792-1794 many of gold (no less than 178 in the year 1793).* (Chapuis & Jaquet, 1952, page 54; 1956, page 55)

It seems that they consider Abram Louys Robert to be an important case maker.

Figure 15-5

In order to assess these statements, we must examine the evidence relating to case makers and Abram Louys Robert in particular.

The inventories 1759 to 1798 and the account books to 1794 (DuBois, 1758-1824) include 211 references to people with the family name *Robert* and 15 people with related names, such as *Calame Robert*. Table 15-1 includes the most relevant entries, in order of date, either with no given names or with all or part of the given names *Abram Louys*.

I also append two other people with the same family name who lived in Eplatures.

It is clear from the table that the statement made by Chapuis, that Abram Louys Robert was

> *... mentioned during the years 1760-1794 as "master casemaker resident at Eplatures, near Locle" ...*

is wrong. He was never listed as a *master* case maker and, more importantly, there is no specific mention of him before 1791.

We do not know if these errors are the result of very careless research or if they are another deliberate manipulation of the evidence to suit the narrative that Chapuis was creating.

Given Names	Date	Occupation	Location
Abram Louys	1760	Watch maker*	
	1761	Watch maker	Eplatures
Abram	1761	Finishing	haut du village
A	1765	Repeater maker?	
Abram	1765, 1767, 1769	Repeater maker	
Abram	1767, 1769, 1771, 1773, 1778, 1780		
Abram Louys	1767, 1769, 1771, 1773, 1774, 1776	File maker	Verger
	1769, 1774, 1777, 1780, 1782, 1794		
Ab	1771		
Abram Ls	1771		
Abr Ls	1776		
Abram Louys	1776		Verger
Ab Ls	1791	Case maker	
Abram Louys	1791, 1793, 1794	Case maker	Eplatures
Charles Fredrich	1774-1791 (10 entries)	Watchmaker	Eplatures
Jonas Simon	1761	Supplied cocks	Eplatures

* 1760 entry: The occupation is not specified, but the transaction is for the supply of *3 montres en argent uni*.

Table 15-1

What we might be able to deduce is that Abram Louys Robert, the case maker living in Eplatures, could have been the son of Abram Louys Robert, the watch maker living in Eplatures. The 30-year difference between their earliest entries makes this possible.

Ignoring an inventory entry for 1791 (which provides no useful information) the remaining four entries for Abram Louys Robert are all in DuBois (1758-1824, *Book 5*, pages 253, 271, 274 and 349). In date order these purchases are:

(a) 1791: 59 gold cases.

(b) 1792: 85 gold cases.

(c) 1793: 174 gold cases.

(d) 1794: 253 gold cases.

These 571 cases were valued at £37,922-14-4 and the average price for each case was £64-8-4; there are variations in value from about £48 to about £81. Gold cases listed in the 1791 inventory (DuBois, 1758-1824, *Inventory Book 2*, pages 135-171) vary in value between about £50 and £75, the latter being cases specifically for repeaters. Obviously, the value of a case depends mainly on the amount of gold in it.

So it is apparent that Abram Louys Robert made ordinary gold cases and the *number of fairly luxurious cases* is probably very small; although we have not checked every entry, a quick inspection showed only three cases that might be luxurious, with values of £81 and £83.

Finally, it is not possible to suggest that Abram Louys Robert was an important case maker without seeing his work in context. For this purpose, Table A2-2 in Appendix 2, page 281, gives a complete list of case purchases by DuBois from 1758 to 1794. It is apparent that making 571 cases over four years is not exceptional. For example, Jeremie Parisse made 564 in 4 years; David François Baillod made 1,031 in 7 years; Daniel Fredrich Matthil made about 1,300 in just 3 years.

And so the implication that Abram Louys Robert might have been special is nonsense.

The attribution of the case to Abram Louys Robert has been cast into doubt by the existence of cases with different initials, for example Figure 15-6.

Figure 15-6

So the problem is:

Which set of initials belongs to Abram Louys Robert?

In Appendix 2 (page 275) I have examined the case signatures given in DuBois (1758-1824). From this, it is very likely that the initials in Figure 15-6 with the joined *A* and *L* are the case signature of Abram Louys Robert, because he worked for DuBois and this signature is the only possible one listed by DuBois.

If, despite the different case signature, we assume the Leroy watch case was made by Abram Louys Robert and the case is the original case, then we can estimate when the watch was made. Three inventories provide case serial numbers for Abram Louys Robert (DuBois, 1758-1824, *Inventory 1798*, pages 62-67; *Inventory 1801a*, page 87; *Inventory 1804 No 2*, page 122). The largest number is 3886 indicating an average production of 278 cases per year if Robert started work in 1791. This is credible. Assuming a constant rate the *Leroy watch* case (number 2692) must have been made about 1800, at least 20 years too late for the movement. Therefore, Abram Louys Robert did not make the Leroy watch case.

So who made the case?

I have found only two possible makers for the other signature in Figure 15-5. Bourdin (2012) lists:

Leroy, Abram, Maitre monteur de boîtes en 1776.

Leroy Frères, Monteurs de boîtes au XVIIIe siècle.

The latter is very unlikely because Bourdin adds that the brothers were probably Jean Henry Leroy, Jean Jaques Leroy, and Pierre Adam Leroy.

However, the name *Leroy* was often written *Le Roy.* For example, Philipe DuBois used Leroy Frères (who were at Crêt Vaillant in Le Locle) and usually wrote the name as *Le Roy*, but on one occasion he wrote *Leroy*.

And so the initials *ALR* shown in Figure 15-5 probably refer to Abram Le Roy. If the remaining books are relied on, DuBois never employed Abram Leroy to make cases.

We can take this argument further. Because it is likely that these movements were made for an établisseur, we can conclude that the établisseur employed both the movement maker and the case maker. But, as Philipe DuBois did not make the movements, it is very unlikely that one of his case makers made the case. We admit this is a weak argument, but it does suggest that the case maker is more likely to be Abram Le Roy, because DuBois employed Abram Louys Robert and the volume of cases suggests he was probably working full time for DuBois.

One final point needs to be made regarding the case initials in Figure 15-5.

As shown in Figure 15-7, it appears that the *L* has been modified from a *D*. First, an area to the right appears to have been scraped out. Second, the bottom of the *L* appears to be an over-punch. If so, the original signature was *ADR*. However, no case maker with these initials is listed in Bourdin (2012) and we do not know when this modification was made. Also we do not know if this possible over-punching is significant.

Figure 15-7

As well as the initials of the case maker, the case has the Neuchâtel hallmark (chevrons) shown in Figure 15-8. Although badly punched, it appears that a border surrounds the chevrons. Chapuis based his decision that the case was made in the 18th century on three sources, Huguenin, Alfred Godot and Marius Fallet, all of whom state that the chevrons were in use throughout the 18th and 19th centuries (Chapuis & Jaquet, 1952, pages 51-52; 1956, pages 52-53).

Figure 15-8

However, Clerc (1993, page 31 and 59, and Figure 15-9) provides the following information on the chevrons:

> *The regulation of 30 August actually came into force on 27 November 1820, it was realized after its publication that the new control system should correspond to a distinct legal guarantee. The punch with the simple chevrons was therefore replaced by a new punch with the chevrons surrounded by a border, used exclusively by the assay offices.*

And a new law in 1866 changed the hallmark yet again.

Two examples illustrate the pre 1820 hallmark. Figure 15-6 above shows the case hallmarks for a DuBois & Fils repeater (Flores 2009, page 43). And Figure 15-10 shows the case hallmarks for a DuBois & Fils watch with calendar (Flores 2009, page 46). In addition to case signatures (see Appendix 2), the DuBois inventories often include case serial numbers. If the attribution of the case signature to Abram Louys Robert is correct, then it is likely that these cases were made in 1802 and 1800 respectively.

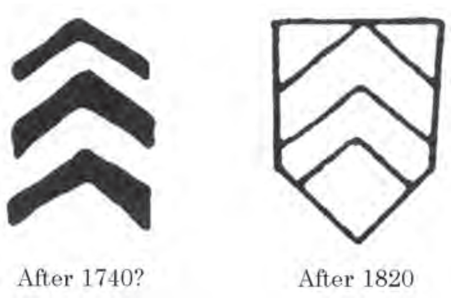


Figure 15-9

It is appears from Figure 15-8 that the punch was held at an angle to the case and not vertical, and so the marks, which appear to be a border, could have been made by the body of the punch touching the case. This doubt means that the case could have been made at any time between 1777 (the probable date of manufacture of the movement) and 1866 (when the hallmark was changed).

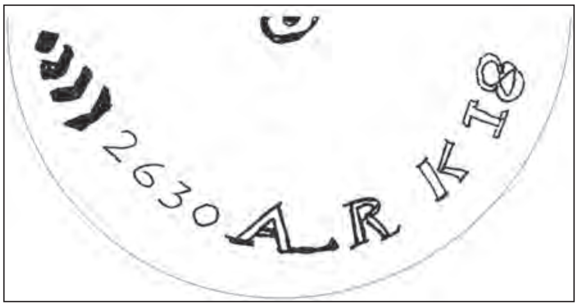


Figure 15-10

In addition to the problem of the hallmark, the interior of the Leroy case was decorated with circular brushing, Figure 15-11. (Also see Figure 14 in Chapuis & Jaquet, 1952, page 46; 1956, page 47.)

We, and others, have not seen such decoration on early watch cases. Simon Bull (2014-2016) notes that the circular brushing, or spotting,

> *was a late 19th century finish which was easier to do than mirror polishing, particularly if the case was assembled ... [a watchmaker] of 50 years experience confirms that, apart from certain marine chronometers, the spotted decoration is effectively a 20th century "invention" ... that it appears to have been a feature of major overhaul Swiss work in the 1950's ... it was not used in the 18th century.*

Figure 15-11

Although not certain, enlarged photographs appear to show the circular marks over the punch marks and the decoration was added after the case had been made. But that only tells us that the case was made before the late 19th century, and how long before is not known. That is, the circular brushing, being a late addition, is irrelevant to dating the case. Unfortunately this decoration no longer exists because the Patek Philippe Museum removed it and polished the case. We do not know if this was done to remove evidence that contradicted the desired 1770s dating.

The problems posed by the case are only important if we agree with Chapuis & Jaquet (1952, page 51; 1956, page 52) that the case is original and not a replacement made some 40 years after the movement was made. However, their argument is not credible.

The re-casing of movements in cases that do not fit perfectly (and are often of the wrong date) is a modern phenomenon. It has come about because interesting movements have often been found where the cases have been removed and scrapped for their gold value. Then substitute cases are found to preserve the movement. This is discussed in Appendix 6.4, page 348.

However, this was not done two centuries ago. Instead, if a new case was required, it would be made to *fit perfectly* by a skilled case maker. And it would not be possible to determine if such a case was a replacement except by dating the case and the movement, and so discovering a discrepancy.

There are two possible interpretations of the evidence:

First, it is possible that the chevrons do not have a border and the case is original.

Second, the chevrons have a border and show that the case was made circa 1820 or later. It is not credible to suggest that rotor watches were made over a period of more than 40 years and it is very likely that all such watches were made in a short period from the end of 1777. Therefore if the chevrons have a border then it is likely that the case is a replacement and not original. If so, my attribution of the case signature to Abram Leroy is probably wrong.

However, we must ask: Why was the original case replaced? It is almost certain that the other four known rotor movements were originally housed in gold cases that have been removed and scrapped in the 20th century, and it is almost certain that the Leroy watch originally had a gold case. If so, why scrap a gold case only to replace it with another gold case? The explanation of Sabrier (2012a, page 42) that the *Mazzi à Locarno* movement was fitted with a larger dial and housed in one of the large-diameter cases then fashionable, is not relevant because the "new" case for the Leroy watch fits the movement perfectly and it is likely to be identical in appearance to the original. That is, there is no reason for the original case to be scrapped and, despite the circular brushing, it is likely that the present case is the original one and it was made by Abram Leroy.

15.7: Conclusions

Before summarising my conclusions, one important point needs to be made.

Let us assume Chapuis and Jaquet did not manipulate the truth. That is, they had examined several watches (about which we know nothing) made by Abram Louys Perrelet l'Ancien, and found specific features (about which we know nothing) that linked these watches to that maker and no other maker. And then they found that the *Leroy watch* exhibited exactly the same features, showing, without any doubt, that Perrelet had made the *Leroy watch* movement.

But we know nothing else.

We do not know who designed the mechanism. In particular, there is nothing in the evidence that prevents the designer from being Hubert Sarton, because he could have asked Perrelet, directly or indirectly, to make rotor watches for him.

And *we do not know* when the watch was made. Certainly it must have been made before 1826, when Perrelet died, and it was probably made in the 1770s. But we cannot specify the date.

That is, the missing link and attributing the case to Abram Louys Robert achieve nothing, because they do not help us determine the designer.

The only possible conclusion is that there is no evidence at all which supports the Perrelet hypothesis:

(a) None of the documents specify the type of self-winding mechanism.

(b) The *Leroy watch* movement cannot be attributed to Perrelet and, even if it could be, it does not indicate the designer of the movement.

(c) The *Leroy watch* case may be a post 1820 replacement. But it does not matter because, again, it does not tell us the name of the movement designer.

15: The Perrelet Hypothesis

So looking back over this chapter, it is clear, in the words of White (1984), that Chapuis did not *find* any evidence to link Perrelet and the rotor watch, and so he *constructed* evidence to create his historical narrative. And so it is not surprising that his conclusions cannot be accepted.

But also, there is no evidence that contradicts the Perrelet hypothesis. And so:

> *Without considering other related and circumstantial evidence, it is impossible to decide if the Perrelet hypothesis is correct or not. That is, it cannot be evaluated.*

I will return to this point in Chapter 20, page 223.

16: The Sarton Hypothesis

16.1: The Hypothesis

The Sarton hypothesis is also very simple:

> *Hubert Sarton designed the rotor mechanism.*

The most interesting aspect of the Sarton hypothesis is that it did not appear until 1993 (Flores, 1993), forty-one years after Chapuis & Jaquet (1952). It was only after Joseph's work became known that the Sarton hypothesis emerged.

Again, this hypothesis has two specific requirements. First, it concerns one *particular person Hubert Sarton*. And second, it concerns the *particular mechanism* described in Section 7.3, page 64, and so it must be compatible with the five known rotor watches.

16.2: Evidence

The Sarton hypothesis rests on two pieces of evidence:

(a) The 1778 report of the Paris Académie Royale des Sciences (Section 7.2, page 59) which describes *a watch presented to the Academy by Mr Sarton, watchmaker of Liège*.

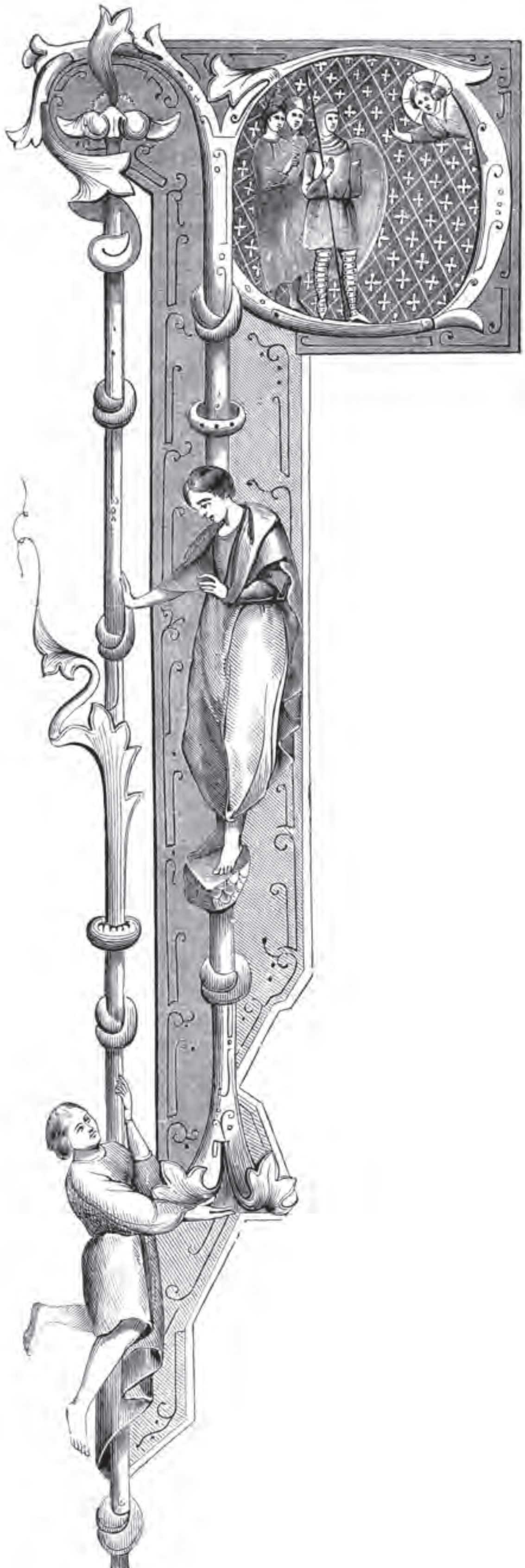
(b) A 1778 diagram of the mechanism (Figure 7-7, page 63), which was not discovered until 2009. This is inscribed *Montre de M. Sarton. 23 X 1778* (23 December), the same date as the report.

As we have shown, both unambiguously describe the rotor mechanism.

However, it is necessary to note here that this document does not explicitly state that Sarton was the designer of the watch. But the act of submitting a watch to the Academy implies Sarton created it.

As we know, none of the existing rotor watches are signed by Sarton. But, because Sarton was primarily a clock maker and engineer, he may have had these watches made in Neuchâtel. Although Sarton was a customer of DuBois from October 1777 (Figure 13-18, page 158), we have shown that the rotor watches were probably not made by or for DuBois (Section 15.5, page 183), and the maker is unknown. However, the analysis in Appendix 5 (page 319) makes it almost certain that the existing rotor movements were made to the same calibre, using the same ébauche.

Finally, we have shown that there is no evidence at all which indicates that Abram Louys Perrelet designed the rotor mechanism. It is necessary to give preference to the hypothesis which is best supported by evidence, and so we must conclude that Sarton designed the rotor mechanism.



17: Responses to the Sarton Hypothesis

17.1: Introduction

It seems the Sarton hypothesis infuriated the horological world, and the debate has been likened to a war, with the massed armies of Swiss and English horologists on one side fighting a lone Frenchman, Joseph Flores, on the other. It is reminiscent of a Salvador Dali painting!

Like all wars, this disagreement is largely irrational, and very few (if any) of the participants have done more than blindly follow their leader, Alfred Chapuis. Good examples are the Montres Perrelet 2004 article discussed in Chapter 14, page 173, and the statement by Sabrier (2012a, page 50):

> *Perrelet solved this problem by using the complex differential wheel train described in detail to the Paris Académie des sciences by Hubert Sarton in 1778.*

These writers and others have failed to analyse the available evidence, and they present assertions as though they were facts.

One important point is that:

> *The debate concerns only the invention of the rotor mechanism.*

One consequence of this war is that the invention of the other five types of self-winding watches has been almost completely ignored. Certainly Chapuis & Jaquet and Sabrier provide photographs and diagrams of the center-weight, side-weight, barrel remontoir, and side-weight with fusee mechanisms, but, other than an excessive coverage of Breguet's later work, they make no attempt to explain the role of these mechanisms in the history of self-winding watches.

Because of this lack of balance, it is necessary to examine the rotor watch debate in detail before looking at other aspects of the early history of these watches, even though this requires me to present information out of chronological order.

In addition to the many superficial statements of support for Perrelet, some people have presented alternative hypotheses to show that the Sarton hypothesis is incorrect, and we will examine these below. All these hypotheses have one point in common:

> *All alternative hypotheses assume, without justification, that Perrelet designed the rotor mechanism.*

17.2: The Sarton Lied Hypothesis

Put simply, this hypothesis states:

> *Hubert Sarton lied. He did not design the rotor mechanism, Perrelet designed it.*

However, this is too simplistic because the hypothesis only concerns Perrelet and Sarton, and no other persons or watch designs.

I examined this hypothesis in Chapter 14, page 172, where I concluded that it should be rewritten as:

> *Before July 1778, Hubert Sarton bought several self-winding watches made and designed by Abram Louys Perrelet. In December he submitted one of these watches to the Paris Académie Royale des Sciences. It was a self-winding watch with rotor, fusee and chain, and verge escapement.*

The first point is that it is impossible to prove, *absolutely*, that Sarton lied using the evidence available to us. And, of course, it is impossible to prove, *absolutely*, that Sarton did not lie! The best we can do is ask:

> *Is there any evidence which allows us to assess Sarton's character and integrity, or lack of it?*

There are four arguments in favour of Sarton.

First, it is clear from his biography (Chapter 7, page 57) that Sarton was a well-respected, gifted clock maker and engineer, and there can be little doubt that his appointment as court mechanic to the Prince of Lorraine in 1772 was merited and not simply a meaningless honour. The two pamphlets by Sarton (1789; 2012) and Hognoul (1822; 2012) support this view. In these circumstances, it is unlikely that he would have risked his reputation by dishonesty.

Second, his training included watchmaking, and it is possible that some of the movements signed *Sarton* were made by him. That this training was not superficial is made clear by Hognoul (1822, page 30; 2012, page 15). In addition to noting his design of the rotor mechanism, this summary of Sarton's achievements includes "*a new observation watch, invented by Mr Sarton*", and the following:

> *In 1789, I made my chronometrographic watches for observations.*
>
> *I will restrict myself here to say, in honour of this discovery, that they were required in our provinces and by foreigners to the point that, not being able to make enough by myself for the quantity of orders, I was obliged to employ foreigners to manufacture some for me; witnesses the following declaration transcribed literally:*
>
> *We undersigned, declare that it is to Mr Hubert Sarton, of Liège, that we owe the discovery of chronometrographic watches, etc. and that it is according to the plan that he agreed to provide us, that we have made them. In Le Locle on February 8, 1789. Signed Philippe DUBOIS et Fils.*

Given this ability, it makes no sense to suggest that Sarton would lie about the rotor mechanism.

Unfortunately, the DuBois books are not helpful and the relevant entries (see Figure 13-19, page 159) refer to *marchandises* without specifying what the items were. And I do not know of any extant chronometrographic watches and cannot check them for serial numbers. The only interesting fact is that February 8 corresponds to an order worth £218 and it is likely that the testimonial was sent with this consignment. But, unless there were special-order account books, we can probably assume that some of the 18 consignments in 1788 and 1789, totalling more than £31,990, included chronometrographic watches.

Third, Sarton had nothing to gain from the 1778 report. This report was *not a public document* and it was *not a patent*. It was transcribed into the minutes of the Paris Académie Royale des Sciences and was *never published*. Indeed, the report remained unknown and unread for about 178 years and the accompanying diagram for 231 years! It served no useful purpose other than, perhaps, to be a claim for priority of invention. But even that was pointless as almost no one would have known about the claim. Certainly Sarton publicised the report, Sarton (1789, page 18; 2012, page 5) and

Hognoul (1822, pages 12-13; 2012, page 7), but these "advertising" pamphlets probably had very few readers. And they do not describe the self-winding mechanism, so the readers would not know that it was a rotor mechanism.

Unlike a patent, which is a public document, Sarton could not gain financially from the report by controlling manufacture. And, as only a few rotor watches were made, no useful income would have been possible.

Finally, we believe that if a person lies about something important, that person probably lies about other important things. So, are we to conclude that, despite the testimonial from DuBois, Sarton also lied about the observation and chronometrographic watches? It seems very unlikely.

There is one piece of evidence that suggests Sarton may have lied. As we have noted, the diagram accompanying the 1778 report (Figure 7-7, page 63) contains an error, because one click faces in the wrong direction. Figure 17-1 illustrates this.

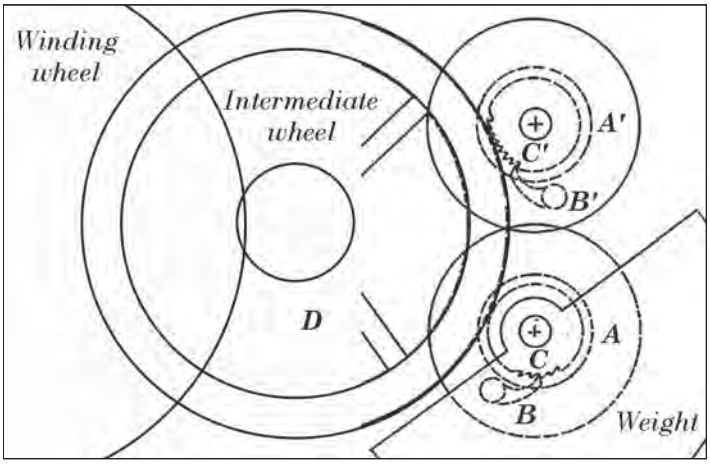


Figure 17-1

When the weight rotates clockwise, click ***B***, attached to the wheel ***A***, slides over the ratchet ***C***. At the same time, wheel ***A*** rotates wheel ***A′*** anti-clockwise, and its click ***B′*** also slides over the ratchet ***C′***. So the intermediate wheel is not turned. (Of course it is free to turn, but in the wrong direction, unwinding the chain from the fusee.)

When the weight rotates anti-clockwise, the click ***B*** will rotate the ratchet ***C*** anti-clockwise and try turn the intermediate wheel *clockwise*. At the same time, wheel ***A*** rotates wheel ***A′*** clockwise, and its click ***B′*** will rotate the ratchet ***C′*** clockwise and try to turn the intermediate wheel *anti-clockwise*. This is, of course, impossible, and the weight cannot move.

This error must be seen in context.

Seven of the drawings reproduced in this book are wrong: Sarton (above), Thiout (page 77), Massotéau (page 375). Christin (page 245), Recordon (page 92), and Daniels (page 121 and page 366). And one (Coviot, page 317) is doubtful. Other examples of incorrect drawings can be found in Watkins (2011b).

In addition, four descriptions are wrong: Sarton (above), Christin (page 130), Breguet (page 367) and Daniels (page 366). Although the errors made by Sarton and Christin can be excused, the errors made by Breguet and Daniels suggest a surprising lack of understanding. But that clearly cannot true and surely they must be genuine mistakes?

Errors in published drawings can be the result of artists not understanding the technical aspects of the mechanism, and they make mistakes because they do not realise the importance of apparently minor features. A modern example is in Watkins (2013c, pages 106 and 110) where I illustrate and describe the barrel remontoir stop-work incorrectly.

Because we do not know who made the drawing of the rotor mechanism and annotated it, we do not know if the error is the result of a simple mistake or if it represents a lack of understanding of the mechanism. Although we admit that the error in this diagram creates some doubt, we do not think it is sufficient to accuse Sarton of dishonesty.

Ann alternative hypothesis is possible. The report and diagram in Chapter 7 (page 59 and page 63) do not mention Sarton's given name, and the evidence is entirely consistent with the rotor mechanism being designed by Dieudonné Sarton (Hubert Sarton's uncle) and Dieudonné giving the design to Hubert before leaving Liège in 1778. That could explain the errors in the diagram; Hubert did not fully understand the mechanism designed by his uncle when he made the drawing. However the 1778 advertisement (page 58) refers specifically to Hubert Sarton and this hypothesis is very unlikely.

17.3: The Ordinary Watch Hypothesis

Attacking Sarton has proved to be unproductive. And so some people have tried to defend Perrelet by looking for evidence to support the Perrelet hypothesis. One argument that has been developed was promoted by the readers of the English translation of Chapuis & Jaquet.

In that book, Saussure's description of his visit to Perrelet is translated as:

> *The device is fitted to an ordinary mechanism and the watch is sold at a price of fifteen to twenty louis."* (Chapuis & Jaquet, 1956, page 41)

And:

> *The mechanism operates in conjunction with an ordinary movement.* (Chapuis & Jaquet, 1956, page 60)

The ordinary watch hypothesis is based on these statements:

> *The ordinary movement of that time was one which had a fusee and verge escapement. Therefore, Perrelet's watch had a verge/fusee movement to which he added a self-winding mechanism. The only mechanism used with verge/fusee movements is the rotor mechanism, and so Perrelet must have invented the rotor mechanism.*

Actually this argument can be changed to state that Perrelet invented the side-weight and fusee mechanism described in Recordon's patent, pages 94-99, which is also fitted to an ordinary movement. However, I am willing to ignore this possibility because the rotor mechanism is much more likely.

The only problem with this hypothesis is that it *cannot* be correct, because the quotations from the English edition of Chapuis & Jaquet are wrong. The diary (Figure 5-1, page 33) actually reads:

> *Le travail est en double de celui d'un mécanisme ordinaire ...*

> *The work is double that of an ordinary mechanism ...*

There is no doubt at all. Saussure does not specify the type of movement to which the self-winding mechanism was attached, and it could have been of any design. What he wrote is that the self-winding watch was double the amount of work or double the value of an ordinary watch. And so the whole argument in favour of Perrelet fails, because he could have invented anything, and it need not have been based on a verge-fusee movement. As with the Perrelet hypothesis, we have a proposal that is not supported by evidence and which cannot be assessed. It might be right, it might be wrong, but it is impossible to decide. And again we must give preference to the Sarton hypothesis because it is supported by evidence.

How did this dramatic change in meaning come about? Chapuis & Jaquet (1952, page 39) give an almost correct transcript of the diary in French:

> *Le travail est doublé de celui d'un mécanisme ordinaire ...*

So somewhere between 1952 and 1956 this text was mistranslated.

If we compare the original French (Chapuis & Jaquet (1952, pages 39 and 58-61) with the English (Chapuis & Jaquet (1956, pages 41 and 59-61) we can find five discrepancies:

(a) The French (page 39) transcribes the diary entry incorrectly as *Le travail est doublé de celui d'un mécanisme ordinaire*, with an accent on *doublé*, when it actually reads *Le travail est en double de celui d'un mécanisme ordinaire;* also see (e) below. The English reads *The device it fitted to an ordinary mechanism ...*

(b) A statement that Saussure's diary is an authentic and dated document is changed to state that it provides a definite date (for the watch).

(c) *The work is double that of an ordinary mechanism* (page 59, bottom) is changed to *The mechanism operates in conjunction with an ordinary movement.*

(d) The sentence (pages 59-60):

[An] ordinary watch means unequivocally that there was at the watchmaker what we would call today "a calibre" preceding the innovation consisting of the watch examined by the scholar.

is changed to:

An "ordinary watch" can mean only one thing: a watch which requires to be wound by a key in the conventional manner.

Both statements are absurd!

(e) The French text has the strange sentence (page 60):

Work "is doubled" means, one dares to conjecture, that the movement of the mass wound the spring while both going and returning, while the original model would have used the swinging of the counterweight in only one direction.

The original, given above, uses the word *double* and not *doublé*, which changes the meaning completely, and the conjecture is pure fantasy. But the English is completely different:

We have noted that the weight winds the watch as it moves in either direction and not in one direction only as do some of the modern self-winding watches.

This is a cautionary tale:

> *Historians must always use original documents and they must never rely solely on transcripts and translations.*

17.4: The Maintaining Power Hypothesis

This hypothesis can be seen as a compromise between the Perrelet and Sarton hypotheses:

> *At some time before 1777, Abram Louys Perrelet l'Ancien designed the rotor mechanism, but it did not have maintaining power. Later, Hubert Sarton modified the design to include maintaining power.*

In addition, the hypothesis has been extended by adding:

> *But Sarton lied because he did not admit that he copied the idea of planetary gears.*

The origin of this hypothesis is the 1778 report, which includes the following:

> *This watch is not absolutely new. The late Prince de Conti whom one knows was interested in watchmaking, had one of this kind, so we have been assured. But Mr Sarton claims that all those which were made before his, did not have the property of running while being wound up, which much decreased their merit.*

We are assuming Perrelet designed the rotor mechanism. In which case, the watch submitted by Sarton must have been made by Perrelet or may have been a copy of a watch made by Perrelet. But this watch did not have maintaining power, which Sarton added (showing indirectly that he was a competent watchmaker!). That is, when Sarton submitted the watch to the Paris Royal Academy, he only claimed the maintaining power, which he had copied.

There are two reasons for rejecting this hypothesis.

The first reason is that a self-winding watch without maintaining power cannot keep correct time, a problem that the writers of the 1778 report were aware of:

> *It is necessary not only that it is wound up by the effect of the weight of which we will speak, but that while winding the watch still continues to go, without which there would be too many delays in its running.* (See Figure 7-4, page 60)

As we have noted in Section 7.3, page 65, during winding, when the fusee is turning in the opposite direction to that when the watch is running, no power is delivered to the first wheel of the train (mounted under the fusee) and to the verge escapement, and the watch will stop. Winding with a key takes only a few seconds, during which time power is transmitted to the train intermittently. This will cause a small error of a few seconds that, in a verge watch, is not important.

However, even assuming there were periods when the wearer and the watch were at rest, the rotor mechanism must be active for a substantial part of the time when it is carried, probably several hours; see Section 7.6, page 83. And, as we know, a rotor mechanism is bidirectional and winds the watch with the weight moving either way. Consequently, the only time when power will be delivered to the verge escapement will be during the extremely short periods when the rotor reverses direction, and this is probably not enough to keep the escapement functioning. In effect, for several hours almost no power would be delivered to the watch train and the watch could loose almost as many hours compared to the correct time.

In comparison, assume the watch is fully wound and the rotor mechanism is locked. Then the watch will run. But after a few minutes, the locking mechanism will disengage, winding will start again and the watch will loose time. If this keeps repeating all day, the watch will loose a considerable amount of time. That is, the watch is useless.

The second reason for rejecting this hypothesis is even more damning.

If the hypothesis is true, then Perrelet designed a rotor mechanism with a different fusee that did not contain planetary gears, the part that provides maintaining power. However, there must be a link between the fusee cone and arbor in order to wind the watch, and if we remove the planetary gears this can only be done by rigidly attaching the cone to the arbor. I have already considered this situation in Section 7.5, page 82, and I have shown that, with such a fusee, the watch cannot run because the fusee cone cannot turn in both directions; the watch can be wound, but the fusee cannot drive the train. The rotor mechanism will wind the watch until the rotor is locked, at which point the entire mechanism of the watch will be jammed.

It has been suggested that this problem can be overcome if the intermediate wheel pinion is loose and driven by a click mounted on the intermediate wheel; see Figure 17-2.

However, this ignores an important point. When the watch is wound the intermediate wheel pinion is *driven* by the intermediate wheel and rotates clockwise. But when the watch runs the pinion is the *driver*, and its anti-clockwise motion will force the intermediate wheel to turn with it. This is impossible because the two meshing driving wheels would have to turn in the same direction. If the click is reversed the watch will run, because the pinion will slide under it. But then it would be impossible to wind the watch, because the intermediate wheel will not drive the pinion.

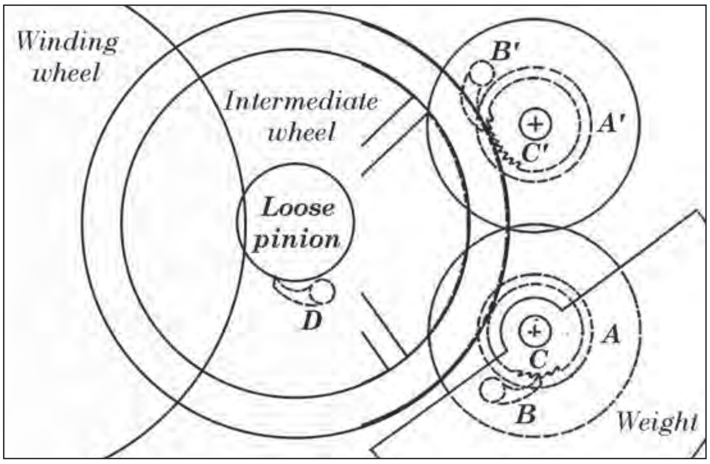


Figure 17-2

That is:

> *The rotor mechanism cannot work unless it is complete, and so Perrelet or Sarton must have designed the entire mechanism including the planetary gears.*

Although Jean-Claude Sabrier originally stated that Sarton had copied everything, that is he lied (see Section 14.4, page 172, and Section 17.2), he later changed his mind. In a letter to Jean-Loup Caron, president of AFAHA (Sabrier, 2012b) he wrote:

> *Je suis désolé de vous décevoir, mais je ne changerai pas de position quand* [sic] *à Hubert Sarton, qui a sans aucun doute apporté à l'Académie une montre construite sur le modèle de celle de Perrelet, mais c'était seulement pour en revendiquer le dispositif de maintien du ressort sous tension, pendant le remontage, qui faisait défaut sur la montre de Perrelet, qui pour cette raison, ne pouvait fonctionner correctement.*

> *I will not change my position on Hubert Sarton, who undoubtedly brought to the Academy a watch built on the model of Perrelet, but he only claimed the device for keeping the spring under tension during winding* [the planetary gears], *which was lacking in the Perrelet watch, which for this reason could not function properly.*

This, as we have seen, is best described by the English expression "jumping out of the frying pan into the fire"; that is, moving from a bad situation to one that is even worse.

17.5: The Shaking Watch Hypothesis

The failure of the maintaining power hypothesis means that the words "*those which were made before his, did not have the property of running while being wound up*" remained unexplained, and another hypothesis was proposed to resolve this problem:

> *At some time before 1777, Abram Louys Perrelet l'Ancien designed the rotor mechanism, but with an ordinary fusee and no maintaining power.*

> *Normally, when the watch was running, the self-winding mechanism was decoupled from the fusee, so that it did not prevent power reaching the watch train. To wind the watch, a button was pressed or a lever moved to engage the self-winding mechanism and the watch was shaken. When it had been shaken enough and wound sufficiently, the button was released or the lever was returned to its original position, and the watch would run.*
>
> *Later, Hubert Sarton modified the design to include maintaining power by changing the fusee to have planetary gears, but he lied because he did not admit that he copied the idea.*

The obvious fault with this hypothesis is that the mechanism is not a self-winding mechanism, it is a *keyless mechanism*.

As we have stated in Section 1.3, page 6, a keyless mechanism requires the owner of the watch to make a decision to wind it and then to perform a specific task; that is, the winding is *not* automatic. This is exactly what the shaking watch hypothesis requires.

In addition, this design is very inefficient as a keyless mechanism. A watch can be wound with a key in a few seconds, less than about 14 seconds to turn a fusee 7 times. But we have seen that to wind a rotor watch by shaking requires 175 seconds, about 3 minutes (see Section 7.6, page 83). If the watch is wound every day, then only 2 turns of the fusee are required. That will take about 4 seconds using a key or 50 seconds of shaking. And during that time the watch will stop and loose as much time.

Given a choice between an efficient key-wound watch and an inefficient, very expensive watch with a rotor mechanism, we have no doubt the former would be preferred. No one would buy rotor watches, and so no one would have made them.

As we have seen, hypotheses need to be mechanically correct. In this case, because there are no known watches using the shaking watch design, we must see if the rotor mechanism can be modified appropriately.

Decoupling requires disengaging one or more wheels, and in the rotor mechanism there are three possibilities: the winding wheel on the fusee; the two driving wheels, with their ratchets and clicks; and the intermediate wheel. The only practical way to move the wheels is to support them on or under a bar that pivots.

Figure 17-3 shows the actual positions of the barrel ***b***, winding wheel ***w*** (under the plate), intermediate wheel and pinion ***i***, and the two driving pinions ***d*** and ***d′*** with their clicks. These are the positions when winding the watch by shaking, and after winding one or more of ***w*** (and the fusee), ***d*** and ***d′*** (and the weight) or ***i*** must move. An important consideration is that the intermediate wheel ***i*** may rotate while this decoupling is happening:

(a) The intermediate wheel cannot rotate anti-clockwise. To do so it must rotate the fusee clockwise, the direction for running the watch, but the watch train prevents this. In addition it would try to rotate ***d*** and ***d′*** clockwise, which is not possible because of the clicks.

(b) If the intermediate wheel tries to rotate clockwise then it will turn both the driving pinions ***d*** and ***d′*** anti-clockwise, which it can do. It may also turn the winding wheel ***w*** anti-clockwise, the direction for winding the watch. This is not possible if the watch is fully wound and the fusee chain cannot move further; but that can be avoided by making sure the stop-work is activated a little earlier.

Two of the options are not possible. Suspending the fusee or the weight and the drivers underneath a pivoting bar is not practical.

The third option is to mount the intermediate wheel on a pivoting bar so that it disengages from the two driving pinions. This might be done, Figure 17-4, by suspending the intermediate wheel from a bar ***s*** pivoting at the fusee arbor ***f***. The outward movement, at the end of winding, will tend to rotate the wheel clockwise, which is possible.

However, this is not simple. The addition of the bar ***s*** means the weight has to be raised to pass over it. And, because the drivers ***d*** and ***d'*** (and their wheels) *cannot* be raised, ***d*** and its wheel must hang beneath the weight (compare with Figure 7-22, page 70). Or, the cock for the upper pivot of the fusee ***f*** could be removed and the pivot planted in the plate. Then the bar ***s*** can be lowered.

A better method is to rotate the intermediate wheel and pinion ***i*** so that it disengages from the winding wheel ***w***. This can be done, Figure 17-5, by removing the existing cock ***c*** (under the plate) and replacing it with a bar pivoting at ***s*** under the plate.

However, this may not work, because the intermediate wheel will need to rotate a little anti-clockwise, which cannot happen.

So, although theoretically possible, the shaking watch is probably not a practical idea.

Figure 17-3

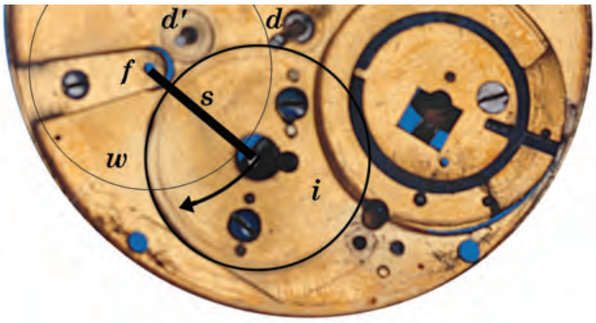


Figure 17-4

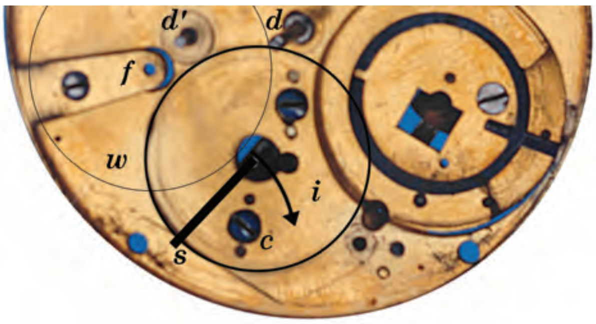


Figure 17-5

Finally, there is one piece of evidence which shows that, irrespective of whether such a watch can or cannot be made, the shaking watch hypothesis cannot be correct. In his diary (see Section 5.1, page 33), de Saussure wrote:

> *Mr Perlet ... had to remake the first one because he had not put in a stop-work, and the winding always acting had broken the watch of a man who ran to the post office.*

And, because this must be viewed in the context of the hypothesis, it can be re-expressed:

> *Perrelet had to remake the first* ***rotor watch*** *because he had not put in a stop-work, and the winding always acting had broken the watch of a man who ran to the post office.*

It is perfectly clear that Perrelet's first self-winding watch was meant to wind while it was in use and going, and so it could not have been a shaking watch. And this is confirmed by the 1780 letter of Jacques-Louis Perrot (Figure 5-3, page 36):

> *The Perpetual pieces invented 2 or 3 years ago in our mountains ...* [that] *wind themselves as one carries them ...*

Thus the shaking watch hypothesis must be rejected.

The order in which I have presented the above arguments is deliberate. If I had discussed Saussure's diary first, analysing the possible mechanisms would be pointless. But then someone could argue that I have interpreted the diary incorrectly, and the person who ran to the post office had accidentally moved the lever or pushed in the button of a shaking watch. In order to respond to such an argument I have included the possible mechanisms.

17.6: Two Consequences

First, a necessary corollary to both the maintaining power and the shaking watch hypotheses is:

> *Hubert Sarton modified the design to include maintaining power by changing the fusee to have planetary gears, but he lied because he did not admit that he copied the idea.*

It is likely that Sarton learned of planetary gearing from someone else. Sources we can reject are Huygens (Section 7.4, page 76), because his description was in a manuscript that was not published until 1934, and Arnold (page 80), because he did not publish his use of planetary gears and it is very unlikely that Sarton would have known about his chronometers. But it is quite possible that Sarton had read Thiout's book, and even Massotéau's article. Also, it is possible that planetary gearing is described in other contemporary books, but not with regard to fusees. However, Sarton's application is in a new context and it is not reasonable to condemn him for his insight and a new application of an existing design.

Perhaps a better question to ask is: Why didn't Perrelet add maintaining power? He was, we are told, a tireless researcher (Chapuis & Jaquet, 1952, page 61; 1956, page 62) and surely we would expect him to be equally well educated and equally capable of realising the possibility of using planetary gears? Certainly, if he designed the rotor mechanism Perrelet must have had some ability. But then, why didn't he realise that his design without maintaining power, which must have been a shaking watch, was, at best, poor and, at worst, simply stupid?

The second and more serious consequence of the above analysis is that we do not have an explanation for the references to maintaining power in the 1778 report. Having previously noted:

> *It is necessary ... that while winding the watch still continues to go, without which there would be too many delays in its running.*

Leroy and Defouchy state (Section 7.2, page 62):

> *Cette montre n'est pas absolument nouvelle, feu M. le Prince de Conti* [Mort en 1776] *qu'on sait qui était curieux d'horlogerie, en avait une dans ce genre à ce que l'on nous a assuré. Mais M. Sarton, prétend que toutes celles qui ont été faites avant la sienne, n'avaient pas la propriété d'aller pendant qu'elles se remontent, ce qui diminuait par là beaucoup de leur mérite.*

> *This watch is not absolutely new. The late Prince de Conti whom one knows was interested in watchmaking, had one of this kind, so we have been assured. But Mr Sarton claims that all those which were made before his, did not have the property of running while being wound up, which much decreased their merit.*

There are two other statements regarding maintaining power. The first is from “Extrait des registres de L’Académie des Sciences de Paris, le 23 décembre 1778” (Hognoul, 1822, page 12-13; 2012, page 7):

> *... qu’elles ne sont pas absolument nouvelles, y en ayant déjà eu de faites dans ce genre; que ces dernières ayant cependant l’inconvénient considérable de ne point aller pendant qu’elles se remontent, Mr Sarton a très bien remédié a cet inconvénient dans la sienne, par la construction qu’il lui a donnée ...*

> *... they are not absolutely new, having already been made of this type; that these latter however have the considerable disadvantage not to run while they are wound, Mr Sarton has cured this disadvantage very well by his construction ...*

The second is from Sarton (1789, page 18; 2012, page 5):

> *... l’Académie des Sciences de Paris (en 1778) qui a déclaré que l’auteur avait très-bien remédié aux inconvénients et variations occasionnées dans les autres Montres de ce genre par le mécanisme du Remontoir ...*

> *... Academy of Science of Paris (in 1778) which declared that the author had cured very well the disadvantages and variations caused in other watches of this kind by the winding mechanism ...*

Because the precise wording is important, the original French has been provided. Leroy and Defouchy could not realise that some 230 years later their words would cause so many problems!

The common interpretation of these words assumes that Sarton is referring specifically to the rotor mechanism. Certainly the statements only make sense in the context of a fusee. If this is correct, then *all those that were made before his* must have been shaking watches, because we have shown that the maintaining power hypothesis is mechanically impossible. Which raises an interesting distinction:

A watch without maintaining power *cannot run while it is being wound*. In principle, it can be wound at any time, as is the case with ordinary fusee watches, but it will not run during winding. However, a shaking watch *cannot be wound while it is running*, and must be wound in a special way. This is an alternative expression of the fact that it is a keyless mechanism and not a self-winding mechanism.

Leroy and Defouchy make it clear that they had not seen other self-winding watches, and such a distinction would not mean anything to them. But Sarton must have seen shaking watches for him to make his claim. Indeed, we can suggest that Sarton bought or borrowed one, disassembled and examined it, and then designed his version, removing the pivoting bar and inserting planetary gears into the fusee. In which case he must have understood the distinction we have made. If so, surely he would have said:

> *But Mr Sarton claims that all those that were made before his, were useless, which much decreased their merit.*

Or words to that effect.

Two other interpretations are possible:

(a) Prince de Conti's watch was *not* a rotor watch and *one of this kind* simply refers to a self-winding watch and not to a particular design. But the watch must have had a fusee and, unless there existed self-winding watches of some unknown design that no one has seen, it would have to be a shaking watch based on Recordon's fusee design. (If it used a small train as in Figure 8-4, page 94, it would be very easy to construct.)

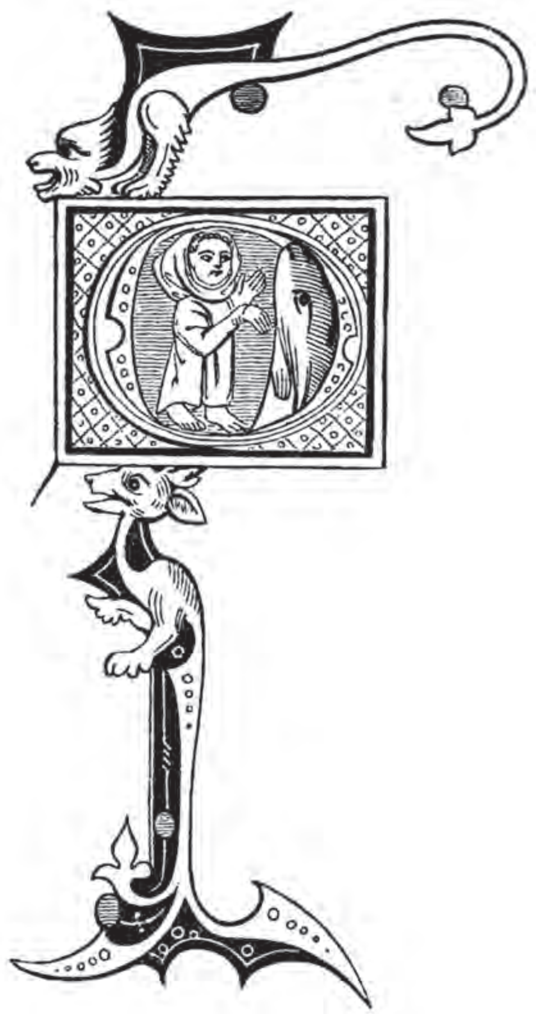
(b) The wording is sufficiently ambiguous for us to suggest that Sarton was *not* referring to self-winding watches at all. Instead, he was simply stating the obvious: Watches *of this kind* are ordinary verge-fusee watches, which do not have maintaining power. And the confusion has been caused by Leroy and Defouchy misinterpreting Sarton's statement by relating two separate and independent remarks. Which is quite possible, as they had never seen a self-winding watch before.

This interpretation is supported by Joseph Tlustos (Figures 4-1 and 4-2, pages 20-21):

... the movement is not interrupted by the winding and thus is more correct than common watches

In which case Prince de Conti's watch could have had any type of self-winding mechanism.

Only the last interpretation seems likely, but the significance of the statements may never be fully understood.



18: The Origin of the Rotor Mechanism

18.1: The Inventor and Joseph Flores

Unfortunately, we cannot go back in time and talk to Perrelet, Saussure, Sarton and the other people involved in the development of the rotor mechanism. Instead, we must rely on the incomplete evidence that has survived to this day.

The result is that we do not know, with *absolute certainty*, what happened in the 1770s. All we can do is study the evidence and decide, hopefully *beyond reasonable doubt*, what is most likely to have occurred.

In this situation, we can conclude the following:

(a) The Perrelet hypothesis: There is no evidence. Therefore, *unless evidence is found*, the hypothesis cannot be assessed.

(b) The Sarton hypothesis: There is documentary evidence that supports this hypothesis but, because there are some doubts regarding the diagram, it cannot be regarded as absolutely true. I consider that its probability is about 90%.

(c) The Sarton lied hypothesis: There is evidence which suggests Sarton was honest. However, the error in the 1778 diagram (Section 16.2) could be interpreted to mean he lied. This hypothesis is the inverse of (b), and I consider that its probability is about 10%.

(d) The ordinary watch hypothesis: This is the result of bad translation and its probability is 0%.

(e) The maintaining power hypothesis: This has a probability of 0% because the required mechanism cannot work.

(f) The shaking watch hypothesis: Although it might be possible to construct a working mechanism, the idea is not sensible. Further, in the context of Perrelet, it cannot have existed. So this hypothesis has a probability of 0%.

Only one conclusion can be drawn from the above analysis. Using Chapuis & Jaquet's words:

> *It is a near certainty that in 1777 Hubert Sarton designed the rotor mechanism.*

For 23 years, since 1993, Joseph Flores has been working to show that Sarton invented the rotor mechanism, but he has been ignored by most people.

In a news report dated 24 March 2016, the Federation of the Swiss watch industry (FH) noted that there was a new exhibition on recent acquisitions by the Musée international d'horlogerie. The report included:

> *In the field of pocket watches, MIH will now be able to illustrate the lively debate conducted in watchmaking circles concerning the automatic watch, thanks to the acquisition of one of the world's five known automatic movements with rotor attributed to Hubert Sarton.*

To my knowledge, this is the first time that his work has been publicly recognised.

18.2: Context

It is apparent that either Sarton designed the rotor watch or he lied, the other hypotheses being impossible. However, this creates a problem, because the Sarton lied hypothesis is independent of and unrelated to the Perrelet hypothesis (Chapter 15, page 177). There is no evidence linking the two hypotheses. Indeed, there is no evidence linking Perrelet to the rotor watch.

This is important because the argument:

> *Perrelet designed the rotor watch, therefore Sarton lied ...*

is irrational. There is no link between the two assertions and other equally good, and equally irrational conclusions are possible:

> *Perrelet and Sarton independently designed the rotor watch.*

> *Neither Perrelet not Sarton designed the rotor watch.*

> *Perrelet and Sarton designed the rotor watch together.*

Also, the conclusion that Sarton designed the rotor watch *cannot* be made in isolation.

First, we cannot reject the remarks made by Saussure in his diary. And so, if Sarton designed the rotor mechanism, then we must answer the question:

> *What type of self-winding mechanism did Abram Louys Perrelet design?*

Second:

> *The rotor watch must be examined in context, and its relationship with the other five designs must be assessed. That is, Sarton and Perrelet cannot be considered in isolation.*

In Chapters 15 to 17, I have deliberately followed the example set by other writers, and limited my study to just two people and a single mechanism. However, by doing this I have ignored other evidence which might have a significant impact on the conclusions.

For example, Sarton claimed that the watches made before his did not have the property of running while being wound up. But the September 1775 statement that Joseph Tlustos had made self-winding watches in which *the movement is not interrupted by the winding* contradicts this. This, and other problems, make it essential that we consider other questions; for example:

> *What did Perrelet know that led him to design a self-winding watch?*

> *What did Sarton know that led him to design a self-winding watch?*

> *Were there a number of entirely independent inventions, or were the various people interrelated in some way?*

Without examining *every* aspect of the history between 1773 and 1779 it is not possible to draw any conclusions with confidence.

19: 1773 to 1776, a False Start

19.1: Tlustos and Thustas, a Single Person?

The earliest documents to mention self-winding watches are the three reports in 1773 and 1775.

First, in May 1773 there is the report of Joseph Tlustos inventing a self-winding watch. This report was published in Vienna; see Section 4.2, page 19.

Second, in August 1775 there is the report of Joseph Thustas inventing such a watch. This report, coming from Prague, was published in Leipzig; see Section 4.3, page 23.

Third, in September 1775 there is the report of Joseph Tlustos inventing a self-winding watch. This report, apparently coming from Vienna, was published in Munich; see Section 4.2, page 21.

Both Thustas and Tlustos are described as *imperial and royal court* mechanics, but it is not clear which courts they served.

Because of the similarity of the names, it is sensible to ask if Joseph Thustas and Joseph Tlustos were one and the same person. There are three reasons to believe this is true:

(a) A Google search on possible name variations yielded the results in Table 19-1.

Although all variants are rare, only Tlustos appears often.

(b) It must be remembered that books were typeset from hand written documents and typesetters, although competent with the language, had no special knowledge. As a consequence, errors almost never occur with normal text, but are likely to occur with strange words.

Name	Frequency
Tlustos	19
Tlustas	0
Thustos	1
Thustas	0
Tlusios	0

Table 19-1

Figure 19-1 (Mundschau, 2012-2015) and Figure 19-2 (Wikipedia, 2013a) give examples of the two important names written in the German script Kurrent. Both are examples of "perfect" handwriting. But actual handwriting is often poor when compared with the ideal, and letters are frequently formed badly.

Figure 19-1

Figure 19-2

First, the difference between *a* and *o* is small, and these letters are easily confused. Second, the letter *l* is similar to the letter *h*, and if it was written carelessly, so that it protruded below the line, the two could be confused. Certainly a typesetter could interpret a very uncommon family name in any of the first four ways in Table 19-1. But he would never spell *Joseph* incorrectly. Tlusios has been included in Table 19-1 because the name is listed by Abeler (2010) and Kaltenböck (1993, page 256).

Abeler (2010, page 356) also lists *Lustus (Tlustus) Josef, Wein (von Budweis) erw. 1767*, but it is not clear if the name is correct or an error.

(c) Most new developments involve only a very small number of people. It is only after new ideas have become well known that more people become involved, and these people usually create minor variations on the original designs. Their activity then prompts others to join in.

Jean-Jerome Casalonga (2013) provides an interesting example of this phenomenon. With regard to patents for repeaters, only about 6 patents were taken out between 1849 and 1884, but more than 100 patents were granted from then until about 1899. After that date it seems people lost interest (perhaps they had run out of new possibilities?) and this burst of activity had ended completely by 1917.

In the case of self-winding watches, very few people showed interest in them until the advent of the wristwatch. Indeed, as I have indicated in Chapter 2, I believe three people (Perrelet, Sarton and Breguet) created the basic designs in just two and a half years, from the middle of 1776 to the end of 1778. After this, a few people made these watches, but there was never any great interest in them, and only a few patents were taken out in the 19th century.

Thus it seems unlikely that two people, Thustas and Tlustos, would have reported separate inventions within a month of each other.

(d) In October 1776 Joseph Gallmayr mentions an invention based on mercury (Figure 4-5, page 25):

It goes without saying this invention is not a so-called perpetuum mobile, and even those with only an average knowledge of mechanics must admit the great error of those who, in the news announced from Vienna, wanted to explain the movement of the mechanism by mercury or quicksilver being in the machine.

A similar statement was made in 1779 (see page 29).

But the mercury invention was by Thustas and the report of it came from Prague and was published in Leipzig! It is the *first* and *third* reports referring to Tlustos that emanated from Vienna and one was published in Gallmayr's home town of Munich.

Was Gallmayr confused or did he know that Thustas and Tlustos were one and the same person? Clearly a contemporary report by someone with an interest in the subject must be considered important and more reliable than later reports.

(e) Both Tlustos and Thustas are described as *Imperial and Royal Court Mechanics*, but which courts are not clear. Indeed, one person could describe himself as the court mechanic to two different courts if he had done some minor work for both, or even pretended to have been so appointed. The situation is similar to royal appointments in England (Jagger, 1983). Appointments were sometimes granted for the slightest reason and the title was sometimes used even when the person had never been appointed. And bogus appointments, such as *Watchmaker to the Admiralty* (which never existed), were used. Mundschau (2012-2015) notes that the term *Hofuhrmacher* does not mean a real distinction. Every watchmaker who had repaired a clock for some noble gave himself this denomination. However, for the large courts an appointment was often (but not always) merited.

Consequently, there must be some doubt regarding the court referred to in the Prague report and its significance. Unfortunately, although ICON (2013) includes Czech Republic publications, a brief search did not find any references to Thustas.

The above argument is not very strong, especially because of the 1773 report, and there may have been two different people. For example, we can imagine that Tlustos had designed a self-winding watch, and the August report of the invention of Thustas forced him to republish his claim for a design. But in that case, why was the report published in Munich and not in the same Leipzig newspaper?

Thus it seems more likely that we a dealing with one person, and my estimate is that the probability of one person is about 70% and of two people about 30%.

19.2: Perpetual Motion?

The most important point in the August 1775 report (Figure 4-4, page 23) is the sentence:

> *The trick is, reportedly, mercury, which takes the place of the spring, and so prepared that it does not attack the metal.*

It is clear that mercury is not used as a conventional weight to drive a self-winding mechanism; indeed, a mercury weight would have no advantages over a solid metal weight and many disadvantages. Thustas may be referring to a stable mercury amalgam of some sort, but this also would have no advantages over an ordinary metal weight.

But which spring is replaced? There are two possibilities:

(a) *The mainspring*: The first point to note is that the mainspring of a watch with a fusee cannot be wound directly; it must be wound by the fusee. And so this watch must be based on one with a going barrel. Second, the German is perfectly clear and *welches die Stelle der Feder vertritt* states that the mercury is not additional to the spring, but replaces the spring.

This suggests the barrel is replaced by a container of mercury. But although the momentum of the mercury might provide a force to the watch train, it would alternate with an opposite force, when the train would not be driven or would be driven in reverse! However, the statement "the watch no longer works when it remains still for a long time" is confusing and contradictory because, with a mercury "barrel", the watch would immediately stop when it ceases moving. The idea is impossible.

(b) *The balance spring*: It is possible to design a watch in which the balance not only regulates the speed, but also drives the mechanism; this approach has been used in electric clocks and a few watches, where the mainspring is replaced by a system to impulse the balance.

But once again this is not practical, because the mercury has to be kept in motion and the watch can never be left still.

It is apparent that this design has more in common with the perpetual motion idea discussed in Chapter 3, page 14, than a practical solution to self-winding, a point Gallmayr makes. And the unavoidable conclusion is that Thustas could not have made such a watch and the report describes a *perpetuum mobile*, a fantasy and not a reality.

The May 1773 and September 1775 reports, Figures 4-1 and 4-2, page 20, are more difficult to interpret, and they appear show that Tlustos had developed a practical solution. In particular:

(a) It is clearly stated that carrying the watch for one hour will wind it enough to run for three days; that is, the watch probably had a fusee (see Section 5.2, page 37). In contrast, Thustas stated that *the watch no longer works when it remains still for a long time since it must be shaken to make it run*. The two statements are consistent, but from different perspectives.

(b) It runs while it is being wound. The statement by Thustas that his watches *run continuously when worn on the person and are so kept in motion* implies the same property.

(c) The (fusee) chain cannot break. Sabrier wrote (see Section 4.2, page 19) *the elimination of the common problem of the chain breaking*, which must be interpreted to mean the watch had a going barrel. But the two reports state *die Kette nicht zu zersprengen*, which is quite different, and it can be interpreted to mean that the watch did have a chain (and fusee) but the chain cannot break. However, *all* chains (and gut cords) are liable to break because of the force of a fully wound mainspring and the statement does not make sense. So it is likely that Sabrier's interpretation is correct.

(d) A simple watch cost 100 ducats and a repeater cost 200 ducats. Thustas specified the same amounts.

And so the statements regarding Thustas and Tlustos are not incompatible, and they could be referring to the same mythical mechanism.

19.3: But if there were Two People?

Although the above argument is credible it is not strong, and we must consider the possibility that Tlustos and Thustas were two different people.

But this creates a serious problem. The reports in 1773 and 1775 (Figures 4-1 and 4-2, page 20) have enough detail that they appear to describe a practical solution to the problem of self-winding. In which case Tlustos designed something about 3 years before Gallmayr and Perrelet. Although I will show that Gallmayr did not make anything, the same cannot be said of Perrelet, and the three year gap is so large that we can be confident that the design of Tlustos must have been created before Perrelet designed a self-winding watch.

And so, unless new evidence is found Tlustos was the first person to make a practical self-winding watch.

In support of this view are four, admittedly vague, statements given in Sections 3.2, page 17, and 4.1, page 19:

Ferdinand Berthoud (1802, volume 2, pages 172-173):

> *This remontoir watch, invented in Germany, was brought to France around 1780...*

Moinet (1853, Volume 2, page 507):

> *This German invention, imitated in France ...*

Chapuis & Jaquet (1952, page 24; 1956, page 26):

> *... a Nuremberg watchmaker had been the inventor of a perpetual watch ...*

Dubois (1849, page 343):

> *... a French ecclesiastic and a watchmaker from Vienna disputed this invention ...*

Except for the mention of Nuremberg, these statements are consistent with the 1773 and 1775 reports. And if they are taken literally, in particular the word *imitated*, then they suggest the watch had a side-weight. This is supported by the negative argument (see Section 20.1, page 229) that the inventors of the other four designs can be allocated to particular people, and only the side-weight with going barrel remains a possibility.

I must also note that, although Gallmayr mentions mercury and hence Thustas (Section 19.1), the fact that he appears to ignore the two reports concerning Tlustos may indicate that he deliberately hid his knowledge of them, because they show that he was not the first inventor. And so he may have known that there were two different people.

It should be noted that the names Tlustos and Thustas appear from nowhere and are not mentioned again after the three reports were published. In contrast, we have several references, over a period of time, to nearly all other people who claim to have designed self-winding watches (Gallmayr, Perrelet, Sarton, Recordon and Breguet); the exceptions are Christin and Forrer. Of course, new documents may be discovered in the future. But at this point in time it is reasonable to decide that Tlustos/Thustas were ignored for a reason, and that reason, I believe, is that the “invention” was not practical or simply did not exist.

19.4: Gallmayr the Fretter

Unlike Sarton, who was a competent watch and clock maker, Joseph Gallmayr appears to have been the opposite.

His biography (Section 4.4, page 23) indicates that his education did not include clock and watchmaking, and he was described as a *Fretter*. Mundschau (2012-2015) notes that today this German word means a bad teacher or miser, but in the context of Gallmayr, in the 18th century, it meant that he was somebody without any education. Abeler (2010, page 172) and Stahl (2000) state that his contemporaries described him as a *Pfuscher* (a botcher, blunderer or bungler) and a *Brotabzwacker* (an insult, literally a bread extortionist who hindered real clockmakers from earning their living). Mundschau states, in slightly different words, that Gallmayr was someone who pretended to be what he was not, a confidence trickster, and he was never accepted by his colleagues.

The list of 29 inventions (Munich, 1779, pages 273-276) is interesting; it is given at the end of this section in Figures 19-4 to 19-9, with a modernised transcript. Nowhere does Gallmayr include his name, but it is clear that he wrote it.

I will comment on five of these 29 items:

(a) Item 1: The Apostle clock. If König (1982) is correct (it must be remembered that she does not provide sources) then he did not make it, he just repaired it. The date, 1741, is interesting. It appears that he did not repair the Apostle clock until he was 28 years old, and so he probably arrived in Munich when he was 26 or 27 years old.

(b) Item 2: *In the year 1746, for the highness, the Elector, I have made a pair of shoes. In one heel a watch, and in the second a carillon with seven bells.* (See Figure 3-5, page 15)

These creations are irrational and would probably be beyond the ability of even the greatest watchmakers:

First, in order to determine the time, the Elector would have to remove one of his shoes!

Second, at every step a weight of about 70 kg would be put on the heel and this force would be transmitted to the winding mechanism and the stop-work. Even if there was some gearing, which would probably be external to the watch, the likelihood of the watch surviving more than a few steps is negligible. The same problem occurs with the music box in the other heel. And the forces would be too great even if the watch was mounted vertically in the side of a very high heel.

Third, in order to wind the watch the heel must be able to move relative to the watch in it, which means there must be a gap somewhere. But, unless the Elector avoided all water, the watch would soon become wet and rust.

Fourth, the watch could not face outwards, because walking on any rough surface would break the glass, hands and dial. (This would be inevitable even if there was a hunter cover.) It could face inwards if it was protected from the heel of the Elector; otherwise his weight would cause the same damage. As above, it could have been placed in the side of the heel, which would avoid most of this problem.

Fifth, Gallmayr was *not* a watchmaker.

We must conclude that Gallmayr had a fantasy and probably lied. This is not surprising, because König (1982, page 64) notes that:

He tortured himself with the fashionable craze of the time regarding perpetual motion.

(c) Item 3: *In 1747. A machine with musicians, two of them playing violins, the third sitting on a canopic jar [playing another string instrument], beneath their feet are a pair of dressed figures who dance neatly. These statues naturally grip with their fingers, and use the violin bow as does a living man.*

This should be compared with other automata, such as "The Writer" by Pierre Jaquet-Droz, Figure 19-3, and the "Draughtsman-Writer" by Henri Maillardet (Franklin Institute, 2013).

The Jaquet-Droz mechanism has about 6,000 parts and moves one arm so that it can write a sequence of letters:

The text is coded on a wheel (at the bottom) where characters are selected one by one. He uses a goose feather to write, which he inks from time to time, including a shake of the wrist to prevent ink from spilling. His eyes follow the text being written, and the head moves when he takes some ink" (Wikipedia, 2013c).

But Gallmayr's automaton is vastly more complex, requiring three coordinated mechanisms and each must move both arms and the fingers on both hands. It is much more complex than the automata of Jaquet-Droz, Maillardet and Jacques de Vaucanson (a flute player and a digesting duck that no longer exist).

Figure 19-3

That is, after little education, no experience, and at the start of his career, Gallmayr was the greatest automata maker of the time. It is not credible.

If this automaton existed, and it probably did not, then most likely it was very simple, with the figures crudely mimicking the movements and the music generated by a separate music box.

(d) Item 7: A Turkish flute player. This is also not credible. As well as the complexity of the mechanism, we are told that:

… and when I asked him if he starts to play soon, like a person he gave me the answer, yes! and then played four pieces.

Either the automaton could detect sound, impossible with 18th century technology, or it was a fraud with a human dressed as and behaving like a statue, as was the famous "automaton" of a chess player (Wikipedia, 2013d).

(e) Item 17: A self-propelled carriage. Gallmayr admits that this carriage was a fraud, stating that it was moved by a person hidden in it. And, as he was not a carriage builder or a wheelwright, his only involvement would have been its design. It is surprising that this rather trivial idea is included in the list, especially as a single person moving a carriage with people in it would soon become exhausted.

From these examples I can only conclude that Gallmayr was indeed a *fretter* and a fraud.

This consistently negative view of Gallmayr raises an important question:

What is the significance of the October 1776 report in which Gallmayr claims to have made a self-winding watch? (See Figure 4-5, page 25)

Five aspects of this report are important:

(a) It begins with the statement:

Joseph Gallmeyr, the current Court mechanic of his Highness the Elector, has just brought a new invention to an unsurpassed perfection ...

Although vague, this suggests that Gallmayr did not invent a self-winding watch, but improved an existing design.

(b) The report notes that:

This invention was announced some months ago in various gazettes in Vienna. However, we have reliable information that neither the invention nor the inventor can be called into question ...

... those who, in the news announced from Vienna, wanted to explain the movement of the mechanism by mercury or quicksilver being in the machine.

Searches of the *Wienerisches Diarium* and *Gothaische gelehrte Zeitung* using ANNO (2013) found no mention of Gallmayr, and only two relevant articles were found: Tlustos (Figure 4-1, page 20), dated 1773, and Magellan (Figure 8-21, page 104), dated 1780. The search covered 1768-1780 and a number of spelling variations for Gallmayr were tried. Also, other searches used the words *sackuhr*, *sack uhr*, *sackuhren, sack uhren* and *uhren*. That is, the only possible report was three years earlier and not some months earlier. And the only contemporary report (Figure 4-2, page 21) was published in Munich and not Vienna.

It is clear that Gallmayr was referring to Tlustos and accusing him of stealing his invention. But as we have been told that he had "just brought a new invention to an unsurpassed perfection" he cannot be referring to the 1773 report and he probably did not know that it existed.

(c) The information given in the 1773 and 1775 reports (Figures 4-1 and 4-2, pages 20-21) is the same as that in Gallmayr's 1776 report, page 24, with one exception. Tlustos states that his watch will run for 3 days, whereas Gallmayr suggests his will run for only 30 hours:

Should one leave the watch lying for more than 30 hours until it stops, ...

But in the 1779 report, page 29, Gallmayr agreed with Tlustos:

It runs as long as you take it with you and even does its duty for three days after putting it away.

So is the 1776 report repeating the 1773 and 1775 reports? That is, did Gallmayr steal the idea from Tlustos?

(d) The report states that:

He has made hundreds of tests and models, for which he can provide evidence, before arriving at his successful idea.

To have made so many tests and so many models indicates that Gallmayr had been working on the idea for many years, which is very unlikely. But the only earlier references are to Tlustos and Thustas. This also suggests that Gallmayr "borrowed" the idea.

(e) The report ends:

Now the watch is perfected and complete, the inventor will be delighted to disclose his secret, as soon as he receives the richly deserved reward for his troublesome labours.

This refusal to disclose the design is strange.

Finally, it is important to note that the 1779 report (page 29) includes the statements:

which even found the good appreciation of the late Elector as of the now governing Her Highness Mecklenburg-Schwerin, and who has been paid 60 ducats two times.

We already said that the watch is already known by two Majesties, but therefore they are publicly unknown ...

That is, from 1776 to 1779 Gallmayr sold not even one self-winding watch to the public. Is this credible when he had offered them for sale?

On the basis of the evidence we can be sure that Gallmayr did not make a self-winding watch and, more importantly, he could not have designed such a watch. Either Gallmayr lied and he never had a watch, or he obtained a watch from someone else and implied that it was his invention.

Artic. VIII. Neue Erfindungen, und Bücher-Anzeigen. Dass es in unserm Vaterlande Baiern auch Künstler gebe, die zu neuen Erfindungen aufgelegt sind; wollen wie zum Beweise, und der Nachwelt zur Nachricht folgende Anzeige hierher bringen.

1) Im Jahre 1744. Das Erste, was ich in der Mechanik probiert, und mit meinem heiligen Schutzengel zu stand gebracht habe, ist, mich des Holzes zur Bewegung zu bedienen, das nicht, wie das Metall mit Öl einzuschmieren braucht: (allerlei Versuche werden ohnehin erst durch die Erfahrung zum Resultat gebracht, welches den Mechanikum weiters belehrt). Eine Uhr von Holzte welche die Planeten Zeigt, wie die zwölf Apostel die Stunde schlagen, der Engel unter wehrender vier Viertelstunde zu der Mutter Gottes herauskommt, und der heilige Geist aus der Wolken sich auf die Mutter Gottes herunter lässt, und wie der himmlische Vater mit der Zepter in der Hand die Benediktion gibt.

2) Im Jahre 1746. Sr. Churfl. Durchl. hab ich ein paar Schuhe gemacht, in einem Schuhsteckel eine Uhr, in dem zwenten eine Carilion, wo sich 7 Glocken in dem zwenten Steckel befunden, und alle 15 Tritt von sich selbst auf den Glocken ein Stückl gemacht, und auch die Uhr im ersten Steckl mit 15 Tritt sich selbst aufgezohen, welche 24 Stund gegangen.

3) Im Jahre 1747. Eine Maschine v.z Musikanten, von denen 2 die Violine geigen, der Dritte mit dein Pass auf einem Kanope sitzend; unter ihren Füssen sind ein paar gekleidete Figuren, welche ordentlich tanzen. Diese Statuen haben in Natura ihre Griff mit den Fingern, und ihre Strich mit den Geigen-Bogen gemacht, wie es ein lebender Mensch macht.

4) Im Jahre 1748. Ein Globus caelestis, den das Werk treibt; die Sonne, welche alle Täge in ihren Grad steigt, und in einem Jahre alle 12 Himmelszeichen durchgegangen hat, so den Wachstum oder Abnahm des Tages verursachet; die Sonn muss alle Tage um 12 Uhr unter den Meridian sehn, der Sternlauf aber muss alle Tag um einen Grad weiter gehen: und in einem Jahr muss das primum mobile um einmal mehr als die Sonne herumgehen.

5) Im Jahre 1749. Habe ich inventiert, dass bei U. L. Frau Stift der Hahn auf der Uhr krähet, wenn man ihn aufzieht. Eine Wasser-Uhr, auf der sich ein Schiffer in einem Schiffel befindet, und mit einem Angel die Stunden auf den Ziffern weiset, nämlich mit magnetischer Kraft: er fährt um das Ufer herum; wenn man ihn herausnimmt, und wieder hineinwirst, so fährt er Vexirweise herum, endlich aber kommt er wiederum auf seine gehörige Stund.

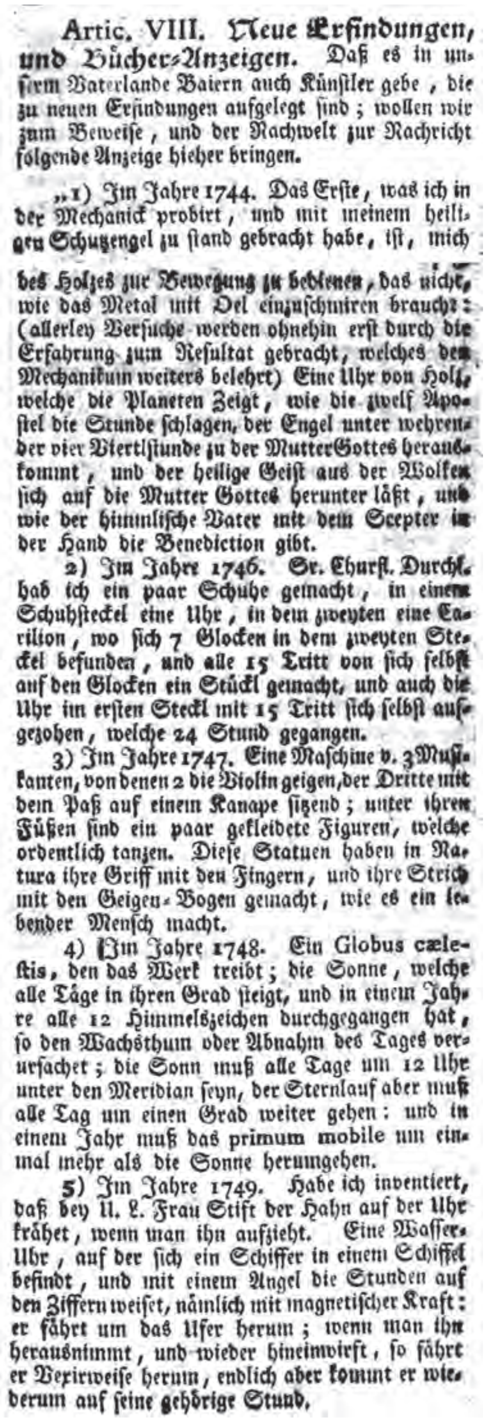

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Figure 19-4

6) Im Jahre 1750. Einen Kanarienvogel, welcher in seinem Käfig von einem Spreißel zum andern hüpft, und unterschiedliche Stücken zu pfeifen anfängt.

7) Im Jahre 1751. Ein türkisch gekleideter Flauto-Traversist in Mannsgrösse, der die Flauto-Travers wie ein lebend gelernter Mensch bläst, mit Vorschläg und Mantren, und mit dem Fuße den Takt giebt; wenn ich ihn fragte, ob er bald zu blasen anfängt, gab er mir wie ein Mensch zur Antwort, ja! und blies sodann vier Stücke.

8) Im Jahre 1752. Ein Moperhund, der auf einen Prif aus seinem Häusgen herausspaziert, wie ein lebender Hund bellet, und solang fortgeht, bis er endlich Wasser machen muss; wenn er fertig ist, geht er wieder fort: bis ihn endlich die Hauptnotdurst angreist, als dann hockt er nieder auf die hintern 2 Füße, und macht etliche drockne weisse Pölleln von Stopselholz, die man wieder zusamklauben, und dem Hund eingeben muss: dieses mechanische Knuppückgen hat ein grosser Prinz bestellt, für die Kunpkammer.

9) Eine Organistin Cäcilia [saint Cecilia] genannt mit einer schön gezierten Orgel. Diese schlagt mit ihren Finger und Füssen das Pedal so vortreplich, dass der Organist, ein Franziskaner P. Ehrnsogonus genannt, der die Stücke selbst komponiert hat, gesagt: er wär nicht im Stande diese Stücke besser zu schlagen, als es diese von Wachs poussierte Cäcilia gemacht, welche Figur Se. Königliche Hoheit der Prinz Carl in Brüssl, wie auch den türkische gekleideten Flauto-Traversisten bekommen, und gekauft hat.

10) Im Jahre 1756. Aus höchster Anbefehlung Sr. Churfl. Durchl. von Kölln habe ich zu Bonn in der neu - erbauten Capuciner-Kirche einen Tabernakel verfertiget, an dem sich die Thür selbst eröffnet, und in zwei Theile wieder verschließt: aus diesem Tabernakel kommen auf beeden Seiten zween Engel auf einem Gewölfe mit brinnenden Kerzen heraus, und stellen alsdann die Kerzen auf die Seite: indessen kommt die Monstranze hervor, die sich selbst wehrendem Herauskommen mit Stralen beleuchtet: vor dieser sind zween Cherubim in Mannsgrösse, diese fallen langsam auf ihre Knie nieder, von denen jeder wehrendem Riederbengen die grösste Ehrfurcht bezeuget: obenauf seht ein Pelikan mit seinen Jungen, der die Flügel langsam bewegt, woben sich die Jungen bewegen.

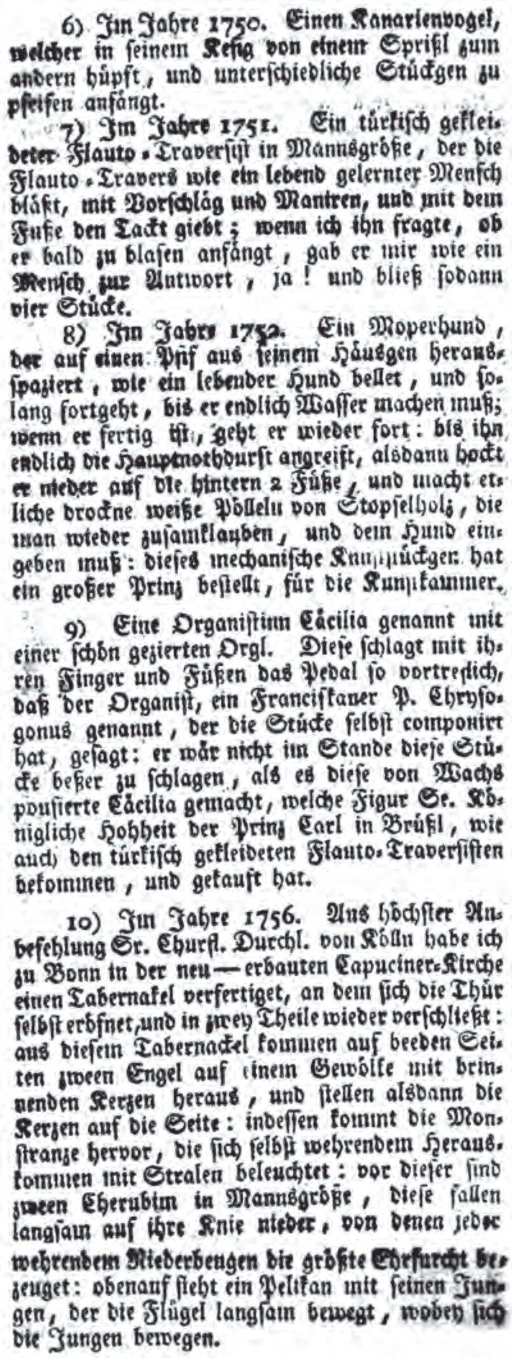
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Figure 19-5

11) Im Jahre 1761. Eine perpetuierliche Optik; wenn man mit einem Perspektiv hineinsteht, jederzeit eine andere Vorstellung von terminierten Kupfer vorkommt: üben diesen befindet sich eine Schubladen in dieser Schatulle, welche, wenn man sie herauszieht, ein Gartenbeet formiert, und in selben ein merkurialische Springbrunnen sich befindet, der 4 bis 5 Minuten springt: nach diesem darf man die Schubladen nur hineinschieben, und wieder heraus, so springt er wieder wie vor: neben diesem befinden sich zwen andere Schubladen mit etlichen Rumern; tut man diese Rumern in der unteren verändern wie man will, so werden doch in der Obern Schubladen allzeit eben diese Rumern sehn, obenher befinden sich etliche illuminierte Figuren, zieht man oben eine heraus, ist unten die nämliche vor einem Fensterl; steckt man diese oben wieder hinein, und nimmt eine andere heraus, kommt eben diese unten wieder vor, die man von der Obern herausgenommen: diese Schatul ist bei hiesiger Akademie. (Die Einleger ins Lotto könnten manchen Estrate da gewiss machen.)

12) Im Jahre 1762. Ein Lämsetzl, den ich zu Ehren Sr. Churfl. Durchl. Geburtstag gemacht habe: wenn man sich auf diesen fetzt, dass er allzeit ein Stückgen hören lässt, als wenn drei die Flauto-Travers blieben. Kann niemals aufgezohen werden, sondern durch das Riedersitzen zieht es sich selbst wieder auf, soviel als es ein Stück nötig hat; es macht 6 bis 8 Stücke, und auf jedes Riedersitzen ein Stück, man mag hernach sitzen bleiben, oder aufstehen, so macht es doch sein Stuck aus.

13) Im Jahre 1762. Eine Schatulle mit 5 Schubladen: wenn man in jede einen baieris. Thaler hineinlegt, und sperrt selbe zu, so ist alles Geld, wenn man wieder hineinsieht, verschwunden, und niemand findet dasselbe wieder; außer man müsste, der den Vorteil nicht weiß, das ganze Werk zerbrechen, diese Schatulle ist kleiner als ein Trüchel, auf welchen man die Vögel abrichtet.

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14) Im Jahre 1763. Eine Feldschlange aus Holz gedrehet, mit Meßing überzohen. Diese wird mit Wind und eisenen Kardätschenkugln geladen: dieses Stück wurde Sr. Churfl. Durchl. zu Nymphenburg ao. 1763. vorgezeigt, welches über 200 Schritte auf ein jenseit des Wassers ausgesteckten Ziel gereicht, und durch das sehr dicke Brett mit einer Kardetschenkugel durchgeschlagen. Dieses Windstück wurde in das hiesige Zeughaus ordiniert.

Figure 19-6

14) Im Jahre 1763. Eine Feldschlange aus Holz gedreht, mit Messing überzohen. Diese wird mit Wind und eisenen Kardätschenkugln geladen: diese Stück wurde Sr. Churfl. Durchl. zu Rymphenburg ao. 1763 vorgezeigt, welches über 200 Schritte auf ein jenseits des Wassers ausgestecktes Ziel gereicht, und durch das sehr dicke Brett mit einer Kardetschenkugel durchgeschlagen. Dieses Windstück wurde in das hiesige Zeughaus ordiniert.

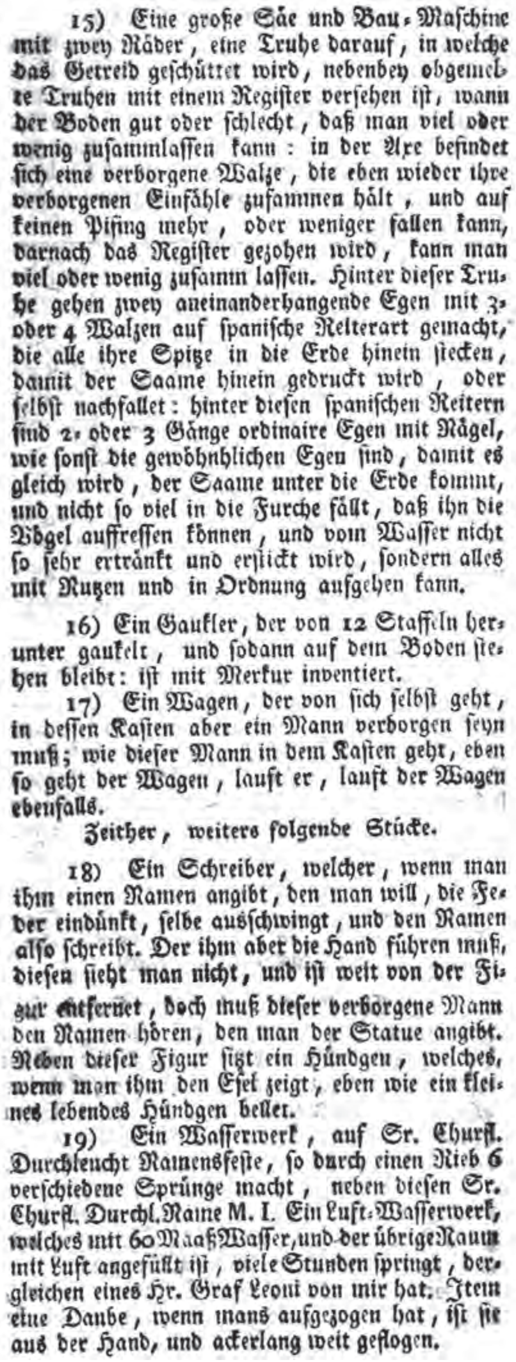
15) Eine Große Säe und Bau Maschine mit zwei Räder, eine Truhe darauf, in welche das Getreide geschüttet wird, nebenbei obgemalte Truhen mit einem Register versehen ist, wann der Boden gut oder schlecht, dass man viel oder wenig zusamm lassen kann: in der Are befindet sich eine verborgene Walze, die eben wieder ihre verborgenen Einfähle zusammen hält, und auf keinen Pifing mehr, oder weniger fallen kann, darnach das Register gezohen wird, kann man viel oder wenig zusamm lassen. Hinter dieser Truhe gehen zwei aneinanderhängende Egen mit 3 oder 4 Walzen auf spanische Relterart gemacht, die alle ihre Spitze in die Erde hinein stecken, damit der Saame hinein gedruckt wird, oder selbst nachfallet: hinter diesen spanischen Reitern sind 2 oder 3 Gänge ordinäre Egen mit Nägel, wie sonst die gewöhnlichen Egen sind, damit es gleich wird, der Saame unter die Erde kommt, und nicht so viel in die Furche fällt, dass ihn die Vögel auffressen können, und vom Wasser nicht so sehr ertränkt und erstickt wird, sondern alles mit Rutzen und in Ordnung aufgehen kann.

16) Ein Gaukler, der von 12 Staffeln herunter gaukelt, und sodann auf dem Boden stehen bleibt: ist mit Merkur inventiert.

17) Ein Wagen, der von sich selbst geht, in dessen Kraften aber ein Mann verborgen sehn muss; wie dieser Mann in dem Kraften geht, eben so geht der Wagen, lauft er, lauft der Wagen ebenfalls.

Zeither, weiters folgende Stücke.

18) Ein Schreiber, welcher, wenn man ihm einen Namen angibt, den man will, die Feder eindünkt, selbe ausschwingt, und den Namen also Schreibt. Der ihm aber die Hand führen muss, diesen sieht man nicht, und ist weit von der Figur entfernet, doch muss dieser verborgene Mann den Namen hören, den man der Statue angibt. Neben dieser Figur sitzt ein Hündgen, welches, wenn man ihm den Esel zeigt, eben wie ein kleines lebendes Hündgen bellet.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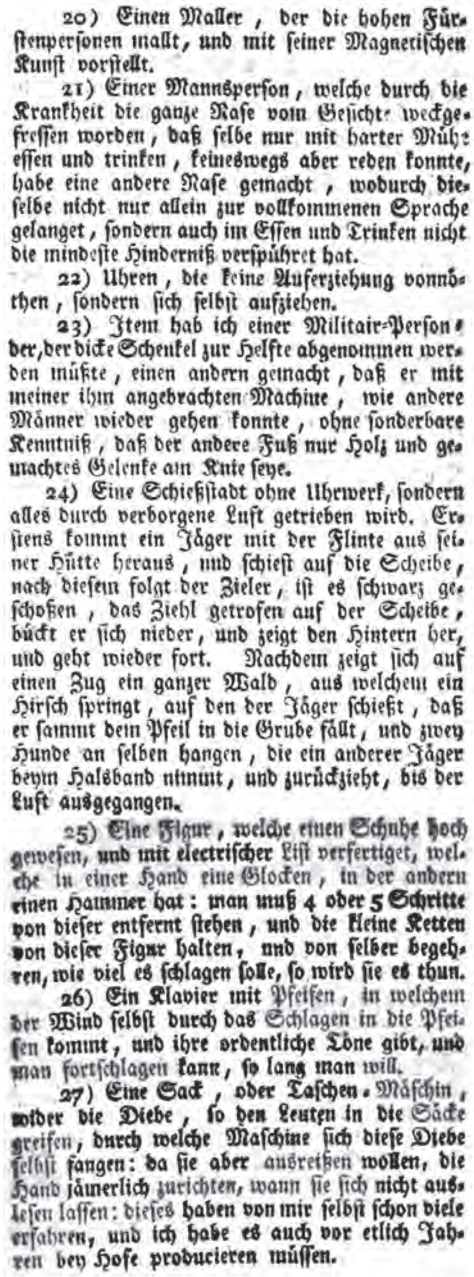
19) Ein Wasserwerk, auf Sr. Churfl. Durchleucht Namensfeste, so durch einen Rieb 6 verschiedene Sprünge macht, neben diesen Sr. Churfl. Durchl. Name M. I. Ein Luft-Wasserwerk, welches mit 60 Maaß Wasser, und der übrige Raum mit Luft angefüllt ist, viele Stunden springt, dergleichen eines Hr. Graf Leoni von mir hat. Item eine Daube, wenn mans aufgezogen hat, ist sie aus der Hand, und ackerlang weit geflogen.

Figure 19-7

19) Ein Wasserwerk, auf Sr. Churfl. Durchleucht Namensfeste, so durch einen Reib 6 verschiedene Sprünge macht, neben diesen Sr. Churfl. Durchl. Name M. I. Ein Luft-Wasserwerk, welches mit 60 Maaß Wasser, und der übrige Raum mit Luft angefüllt ist, viele Stunden springt, der gleichen eines Hr. Graf Leoni von mir hat. Item eine Daube, wenn mans aufgezogen hat, ist sie aus der Hand, und ackerlang weit geflogen.



20) Einen Maller, der die hohen Fürstenpersonen mallt, und mit seiner Magnetischen Kunst vorstellt.

21) Einer Mannsperson, welche durch die Krankheit die ganze Nase vom Gesicht weckgefressen worden, daß selbe nur mit harter Mühe essen und trinken, keineswegs aber reden konnte, habe eine andere Nase gemacht, wodurch dieselbe nicht nur allein zur vollkommenen Sprache gelanget, sondern auch im Essen und Trinken nicht die mindeste Hinderniß verspühret hat.

22) Uhren, die keine Auferziehung vonnöthen, sondern sich selbst aufziehen.

23) Item hab ich einer Militair-Person, der, der dicke Schenkel zur Helfte abgenommen werden müßte, einen andern gemacht, daß er mit meiner ihm angebrachten Machine, wie andere Männer wieder gehen konnte, ohne sonderbare Kenntniß, daß der andere Fuß nur Holz und gemachtes Gelenke am Knie seye.

24) Eine Schießstadt ohne Uhrwerk, sondern alles durch verborgene Luft getrieben wird. Erstens kommt ein Jäger mit der Flinte aus seiner Hütte heraus, und schießt auf die Scheibe, nach diesem folgt der Zieler, ist es schwarz geschoßen, das Ziehl getrofen auf der Scheibe, bückt er sich nieder, und zeigt den Hintern her, und geht wieder fort. Nachdem zeigt sich auf einen Zug ein ganzer Wald, aus welchem ein Hirsch springt, auf den der Jäger schießt, daß er sammt dem Pfeil in die Grube fällt, und zwey Hunde an selben hangen, die ein anderer Jäger beym Halsband nimmt, und zurückzieht, bis der Luft ausgegangen.

25) Eine Figur, welche einen Schuhe hoch gewesen, und mit electrischer Lift verfertiget, welche in einer Hand eine Glocken, in der andern einen Hammer hat: man muß 4 oder 5 Schritte von dieser entfernt stehen, und die kleine Ketten von dieser Figur halten, und von selber begehren, wie viel es schlagen solle, so wird sie es thun.

26) Ein Klavier mit Pfeifen, in welchem der Wind selbst durch das Schlagen in die Pfeifen kommt, und ihre ordentliche Töne gibt, und man fortschlagen kann, so lang man will.

27) Eine Sack, oder Taschen-Mäschin, wider die Diebe, so den Leuten in die Säcke greifen, durch welche Maschine sich diese Diebe selbst fangen: da sie aber ausreißen wollen, die Hand jämmerlich zurichten, wann sie sich nicht auslesen lassen: dieses haben von mir selbst schon viele erfahren, und ich habe es auch vor etlich Jahren bey Hofe producieren müssen.

Figure 19-8

20) Einen Maller, der die hohen Fürstenpersonen mallt, und mit seiner Magnetischen Kunst vorstellt.

21) Einer Mannsperson, welche durch die Krankheit die ganze Rase vom Gesichte weckgefressen worden, dass selbe nur mit harter Mühe essen und trinken, keineswegs aber reden konnte, habe eine andere Rase gemacht, wodurch dieselbe nicht nur allein zur vollkommenen Sprache gelanget, sondern auch im Essen und Trinken nicht die mindeste Hindernis verspüret hat.

22) Uhren, die keine Auferziehung vonnöten, sondern sich selbst aufziehen.

23) Item hab ich einer Militär-Person der, der dicke Schenkel zur Hälfte abgenommen werden müsste, einen andern gemacht, dass er mit meiner ihm angebrachten Maschine, wie andere Männer wieder gehen konnte, ohne sonderbare Kenntnis, das der andere Fuß nur Holz und gemachtes Gelenke am Knie sehe.

24) Ein Schießstadt ohne Uhrwerk, sondern alles durch verborgene Luft getrieben wird. Erstens kommt ein Jäger mit der Flinte aus seiner Hütte heraus, und schiest auf die Scheibe, nach diesem folgt der Zieler, ist es schwarz geschossen, das Ziel getroffen auf der Scheibe, bückt er sich nieder, und zeigt den Hintern her, und geht wieder fort. Nachdem zeigt sich auf einen Zug ein ganzer Wald, aus welchem ein Hirsch springt, auf den der Jäger schießt, dass er samt dem Pfeil in die Grube fällt, und zwei Hunde an selben hangen, die ein anderer Jäger beim Halsband nimmt, und zurückzieht, bis der Luft ausgegangen.

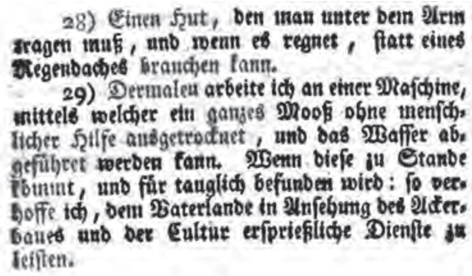
25) Eine Figur, welche einen Schuhe hoch gewesen, und mit elektrischer Lift verfertiget, welche in einer Hand eine Glocken, in der andern einen Hammer hat: man muss 4 oder 5 Schritte von dieser entfernt stehen, und die kleine Ketten von dieser Figur halten, und von selber begehren, wie viel es schlagen solle, so wird sie es tun.

26) Ein Klavier mit Pfeifen, in welchem der Wind selbst durch das Schlagen in die Pfeifen kommt, und ihre ordentliche Töne gibt, und man fortschlagen kann, so lang man will.

27) Eine Sack, oder Taschen Maschine, wider die Diebe, so den Leuten in die Säcke greifen, durch welche Maschine sich diese Diebe selbst fangen: da sie aber ausreißen wollen, die Hand jämmerlich zurichten, wann sie sich nicht auslesen lassen: dieses haben von mir selbst schon viele erfahren, und ich habe es auch vor etliche Jahren bei Hofe produzieren müssen.

28) Einen Hut, den man unter dem Arm tragen muss, und wenn es regnet, statt eines Regendaches brauchen kann.

29) Dermalen arbeite ich an einer Maschine, mittels welcher ein ganzes Moos ohne menschliche Hilfe ausgetrocknet, und das Wasser abgeführte werden kann. Wenn diese zu Stande kommt, und für tauglich befunden wird: so verhoffe ich, dem Vaterlande in Ansehung des Ackerbaues und der Kultur ersprießliche Dienste zu leisten.


28) Einen Hut, den man unter dem Arm tragen muß, und wenn es regnet, ſtatt eines Regendaches brauchen kann.

29) Dermalen arbeite ich an einer Maſchine, mittels welcher ein ganzes Mooß ohne menſchlicher Hilfe ausgetrocknet, und das Waſſer abgeführet werden kann. Wenn dieſe zu Stande kömmt, und für tauglich befunden wird: ſo verhoffe ich, dem Vaterlande in Anſehung des Ackerbaues und der Cultur erſprießliche Dienſte zu leiſten.

Figure 19-9

19.5: Fact or Fantasy?

Unfortunately the evidence we have is ambiguous, but three points can be made:

(a) Berthoud and Moinet (Section 4,1, page 19) both refer to a German invention. This is consistent with the reports, published in Germany, referring to Tlustos (Figure 4-2, page 21), Thustas (Figure 4-4, page 23) and Gallmayr (Figure 4-5, page 25). And Edward Brown refers to Nuremberg, which is consistent with the report referring to Gallmayr (Figure 4-7, page 26).

Less certain is the statement by Dubois (page 17) that "a French ecclesiastic and a watchmaker from Vienna disputed this invention". Except for the word "French", this could be referring to Gallmayr (who was educated in a monastery) and Tlustos, because Gallmayr (page 24) "disputed" the invention of Tlustos (page 23).

But there is no reason to conclude that Berthoud, Moinet and Dubois had seen a self-winding watch, and it is likely that they were referring to reports that they had seen or had been told about.

(b) Gallmayr and Thustas were charlatans. They claimed to have invented self-winding watches when the evidence clearly indicates that these claims could not be true.

(c) The one common feature in these early reports is that the watch must be carried, and when at rest it will run for three days (Tlustos) or thirty hours (Gallmayr). That is, the motion of the watch wound the mainspring.

Are these statements advertising, making apparently sensible but misleading claims? Is it possible because they say very little.

Or do these reports prove that a working self-winding watch had been made in 1773? After all, the reports consistently refer to carrying the watch to wind it.

At present there is no satisfactory explanation. But given the evidence points to these people being charlatans, it is very difficult to believe a successful design was created by them.

20: 1776 to 1777, First Successes

20.1: Perrelet and the Side-Weight Watch

Chapuis & Jaquet believe that Abram Louis Perrelet first made self-winding watches in about 1770, and Sabrier (2012a, page 65) writes:

> *... the automatic winding system invented by Abraham Louis Perrelet around 1770 ...*

This and other frequent statements repeat this view. But the only evidence used to support these statements appears late Sabrier's book (page 182), where he adds that:

> *... the motto Non Plus Ultra ... is relatively common on the oldest self-winding watches, made in the Le Locle region around 1770-1775.*

However, the phrase *Non Plus Ultra* was used later than 1775. Sabrier (2012a, page 126, Figure 81) shows a watch dated circa 1790, and the watch in Figure 3-7 (page 17) is circa 1780 but probably later. Sabrier also illustrates watches with this inscription that are ascribed to Moÿse Gevril & Fils, but he does not date them. The few watches by them that we have seen are all dated circa 1780 and one is signed 1781. So, unless an accurately datable watch is found, this inscription cannot be used to claim early manufacture. Thus Sabrier provides no evidence or argument to justify backdating Perrelet's work by five or six years, although, of course, the lack of evidence does not disprove his assertion.

This dating raises two other questions: Why are there no documents or artefacts relating to Perrelet in the long period 1770 to 1776? And is it likely that such a significant invention was ignored for this long? These questions do not disprove Sabrier's suggestion, but they do require us to take great care in interpreting what we know and what we are told, and to clearly recognise that such interpretations *cannot* be expressed as statements of fact.

Sabrier's decision to backdate Perrelet's design by five to seven years raises another important point: When analysing evidence we must be *consistent*. As we have a document dated 1778 concerning Hubert Sarton, should we backdate his work to 1771? Perhaps more important is that we can no longer be sure which of the two takes precedence. In both cases we can only state that *at some time in the previous seven year*s an event took place, but we do not know precise when, and so Sarton's watch may pre-date Perrelet's watch.

These considerations are critical. Ignoring the inconclusive evidence for a pre 1770 discovery, the development of self-winding watches occurred in the very short, seven-year period 1773 to 1779. Which means any doubt regarding dating can significantly change our interpretation.

There are seven reasons to believe that the watch made by Perrelet was designed in 1776 or early in 1777:

First, although Saussure's diary entry of Thursday 5 June 1777 (Figure 5-1, page 33) makes no mention of the type of mechanism used by Perrelet, he felt it necessary to mention Perrelet's first watch, which did not work. That is, Perrelet must have *deliberately* told Saussure about this first watch, which he made without stop-work, and the need to redesign it. However, if he had been making these watches for up to seven years, there would be no reason to mention a single failure that had occurred a long time ago, and which had been followed by a number of successful watches. Even if Saussure had asked Perrelet "Are these watches difficult to make?" it is unlikely that he would mention a single early failure that had been corrected.

Thus we must conclude that the original watch had been made only a short time before Saussure visited Perrelet.

Second, in the first edition of this book (Watkins, 2013c, page 34) I provided a transcript and translation of de Saussure's diary that I copied from Chapuis & Jaquet (1952, page 39) without checking the original document:

> *Le travail est double de celui d'un mécanisme ordinaire et il la vend 15 à 20 louis.*

Bernard Roobaert (2014-2015) pointed out that this transcript contains errors.

The first error is that the price is actually *18 à 20 louis*. This is clear by comparing the *8* with the numbers in the heading *Jeudi 5* and the statement, seven lines from the bottom of Figure 5-1 (page 33), that the watch ran for *8* days.

In 1777 the exchange rate was fixed at 1 louis d'or = £20 of France; that is, Perrelet wanted £360 to £400 for his watch. At that time DuBois (1758-1824, *Inventory Book 1*, pages 261-263) valued simple gold watches for between £61 and £130, depending on the complexity of the case and the amount of gold in it, with an average price about £90. Perrelet wanted about four times that amount. Saussure's statement, that the work is double that of an ordinary watch, suggests DuBois valued watches at the prices for which he sold them, and the retailers doubled that amount. This agrees with the prices given in section 13.4, page 154.

Although not directly relevant, DuBois sold gold coins to be used in case making, and he also sold gold coins for gilding. For example, in 1798 he sold 200 *louis d'or neuf* to the case maker Daniel Fredrich Matthil (DuBois, 1758-1824, *Book 6*, page 42), for which he was paid £3360 of Neuchâtel or £16-16 per coin. Bowring (1836, page 38) quotes Houriet:

> *With respect to gold and silver we have no other resource but to melt current money; and this circumstance has often induced me to think that the countries which possess these metals might advantageously send them to this country, for our wants and consumption. They would obtain the same price as for money, and save the expense of coining.*

This Houriet was not the famous Frédéric, who died in 1830, but probably Henry Houriet (Bourdin, 2012).

The second, and much more important error is that the last two lines, Figure 20-1, read:

> *Le travail est en double de celui d'un mécanisme ordinaire et il v... la vendre 18 à 20 louis.*

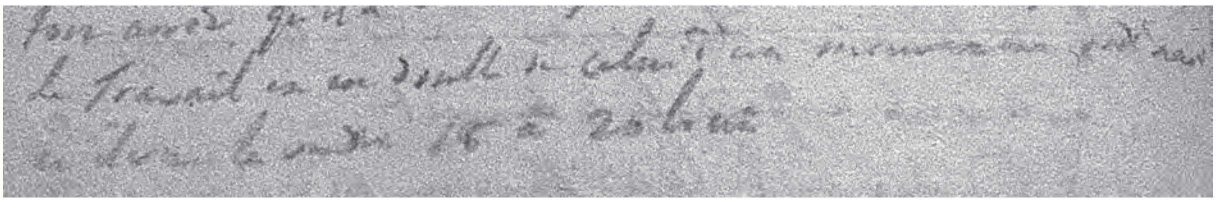


Figure 20-1

Chapuis & Jaquet have omitted *en* and replaced *il v... la vendre* by *il la vend*. The omitted word beginning with *v* is unclear. After discussing this with several people, there appear to be only two possibilities which make sense in the context:

(a) *veut*: he wants to sell it [for] 18 to 20 louis.

(b) *va*: he is going to (will) sell it [for] 18 to 20 louis.

Because of the available space, the second is more likely.

In either case it is clear that Saussure was referring to a single watch (otherwise it would read *il va les vendre*) and to a future sale (otherwise it would be something like *il les vend*). That is, at that time Perrelet had a single watch and he probably started making it only a few months before, perhaps late 1776.

We must ask two important questions:

Why did Chapuis & Jaquet (1952; 1956) provide facsimiles of Breguet's notes and four letters, but they did not provide a facsimile of Saussure's diary?

And why did they write (Chapuis & Jaquet, 1952, page 39; 1956, page 41):

> *These notes are [taken hastily] in pencil and a few lines, now almost obliterated, are practically illegible.*

It is difficult to avoid the suggestion that Chapuis deliberately omitted the facsimile and the true transcript because the diary contradicts his view of history.

Third, neither Saussure nor the Société des Arts suggest that Perrelet had already made many of these watches, and the wording of both imply that he had just started making them. Certainly Saussure describes Perrelet as the inventor of the *watches*, indicating more than one, but the words are ambiguous and cannot be taken to mean *many* watches. Also, the Société des Arts in Geneva (Figure 5-2, page 34) states that *Mr Perelet en a déjà une forte commission*. That is, a *single* commission for several watches. If he had been making these watches for several years we would expect him to have several separate orders.

Again the exact words are important. Saussure did not write *Mr Perelet has a large commission* (*Mr Perelet a une forte commission*), but *Mr Perelet already has a large commission*. In this context, the inclusion of the word *already* (*déjà*) changes the meaning to *Mr Perelet has a large commission earlier than expected*. That is, he had only just started making self-winding watches.

In addition, a commission suggests an order from an établisseur. The obvious possibility is that this was Philipe DuBois, but there is nothing in the existing records to support this suggestion.

Fourth, when commenting on the letter written by Perrot in 1780 (Figure 5-3, page 36), Chapuis & Jaquet (1952, page 30; 1956, page 32) state:

> *It seems very probable, therefore, that the invention of the "perpetual" watch by Perrelet can be attributed to the period 1770-1775, or even earlier.*

However, Perrot's letter states the *perpetual pieces invented 2 or 3 years ago* ... which puts the date at 1777-78.

Fifth, commenting on the manufacture of perpetual watches in Geneva, Chapuis & Jaquet (1952, page 40; 1956, page 42) write:

> *It is evident that if this "perpetual" watch was so widely known and apparently sold in fairly large quantities, its inventor must have been working on it a fairly long time, and it is not an*

> *exaggeration to say this creation must have originated a few years previously, perhaps in 1772, if not earlier.*

However, they note that the enterprise in Geneva was launched *a few years later* than the report to the Société des Arts in Geneva (Figure 5-2, page 34); that is, *about 1780*. In which case *a few years previously* would be about 1776-1777 and not 1772.

Sixth, in 1780 the *Nouveau Journal Helvétique* (Figure 8-21, page 103) states that:

> *... it is more than three years since pieces of this kind have been manufactured in our mountains, which have already spread into Russia, Germany, Spain and France.*

That is, these watches were made about 1776-1777.

And seventh, Jeanneret and Bonhôte (1863, volume 2, pages 193-195) state:

> *The first of the [self-winding] watches that he made were bought by Breguet and by Louis Recordon in London.*

Recordon was born in 1756 and, more importantly, moved to London at the end of 1778 or the beginning of 1779 (see pages 101-104). Even though he and Breguet cannot have bought the very first watches, Perrelet must have started making them only a short time before.

Clearly there is no evidence to support the 1770-1775 dating, and Perrelet's design dates from not long before Saussure visited him.

But what did Perrelet design? It is my opinion that:

> *In 1776 or the beginning of 1777 Abram Louys Perrelet designed and made a side-weight watch with a going barrel and probably a cylinder escapement.*

The evidence for a side-weight mechanism with a going barrel is circumstantial because no documents exist which specify the type of mechanism made by Perrelet.

First, as we have noted (Section 5.4, page 42), in 1766 Osterwald (1766, pages 72-73; 2008, page 20) stated that:

> *His son Abraham Louis* [Perrelet] *makes watches with ratchet and with cylinder.*

Irrespective of the meaning of *ratchet*, it is clear that Perrelet had been making cylinder escapement watches for about ten years prior to making a self-winding watch. The important feature of the cylinder escapement is that it does not require a fusee, and it is reasonable to assume some or all of Perrelet's watches had going barrels.

That Perrelet made cylinder escapement watches is very important, because a self-winding watch with a going barrel is much simpler than one with a verge-fusee mechanism, and the problems of maintaining power and decoupling do not occur. Given a choice between the two, I am sure Perrelet would have used the former.

Although cylinder escapement watches were rare compared to verge-fusee watches, they were not uncommon. One example is in the 1769 inventory (DuBois, 1758-1824, *Inventory Book 1*, page 78), where four cylinder escapement watches are listed, Figure 20-2.

Second, the watches made at that time in the Mountains, the Neuchâtel region, are described as *à saccade* (Figure 5-4, page 36) and *à secousse* (Figure 13-9, page 154). There can be no doubt that both words are used in the sense of *jerk*, a sudden, sharp movement.

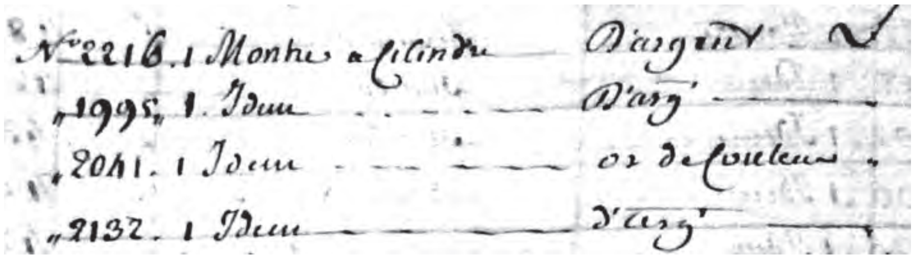

N° 2216. 1 Montre a cilindre D'argent
1995. 1 Idem D'arg
2041. 1 Idem or de couleur
2132. 1 Idem D'arg

Figure 20-2

The 1781 letter of Abbé Desprades (Figure 5-4, page 36) is especially important, because he is quite explicit, writing:

> *Several people … were soon frightened by the jerky movement felt while walking* [with] *this new type of weight added to the watch …*

Unfortunately, *cette espèce de nouveau balancier* is ambiguous, but in this context it must mean *this new type of pendulum* or weight.

It is obvious that the side-weight design, with a very heavy weight pivoting at the edge of the movement, will cause the whole movement and case to jerk in response to the weight hitting the case or the banking springs. Banking springs would reduce the effect, but not eliminate it. In contrast, a rotor watch will not jerk. Certainly there might be some sympathetic movement, but it would be very small.

In addition, Jeanneret and Bonhôte (1863, volume 2, pages 193-195) state: *It was he* [Perrelet] *who invented perpetual or jerking* [à secousse] *watches*.

And Dubois (1849, page 343) notes:

> *C'est à lui que nous devons les montres à masse, qui se remontent d'elles-mêmes par l'effet des petites secousses qu'elles éprouvent en les portant.*
>
> *To* [Breguet] *we owe the watches with weights, which wind themselves by the effect of the small jerks they experience while carrying them.*

As Breguet is supposed to have got his idea from Perrelet (via Recordon), the latter's watches must also have been *à secousses*.

The terms *à saccade* and *à secousse* do not apply to rotor watches. During my tests of the *Mazzi à Locarno* movement (see Appendix 6, page 352) the watch never jerked and there was no external sensation when the weight was moving.

Third, the inscription on the DuBois & Fils watch in Figures 5-21 to 5-23 (page 51) links Perrelet to the side-weight mechanism with going barrel.

Figure 20-3

It has been possible to date this watch accurately. The inscriptions on the case, Figure 20-3, are the Neuchâtel chevrons with a border, the case maker *PHMD*, with the *M* and *D* joined, and the case serial number 1490.

Although the name of this case maker is not known, he supplied cased to Philipe DuBois and he appears in three inventories, Table 20-1 and Figures 20-4 to 20-7.

Inventory	High Serial Number	
30 January 1819	37	Figure 20-4
4 January 1821	403	Figures 20-5, 20-6
11 January 1823	1001	Figure 20-7

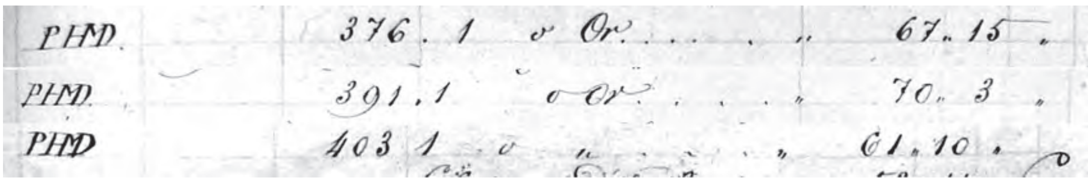
Table 20-1

We can deduce that *PHMD* started making cases at the end of 1818. In the two years 1819 and 1820 he averaged 200 cases per year, and in the two years 1820-1822 he averaged 300 cases per year. Extrapolating these figures indicate that case 1490 was made in the second half of 1824.

Abram Louys Perrelet was alive when this watch was made (he died in 1826). And many people in Le Locle, including DuBois & Fils, would have known of Perrelet's involvement with self-winding watches. So the case inscription *Systeme Abram-Louis Perrelet au Locle* can be regarded as primary evidence.

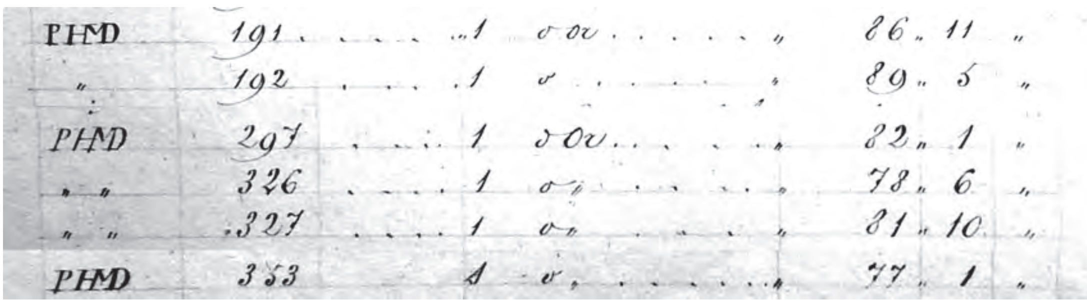
PHMD	36 & 37	2 ditto	170.14

Figure 20-4



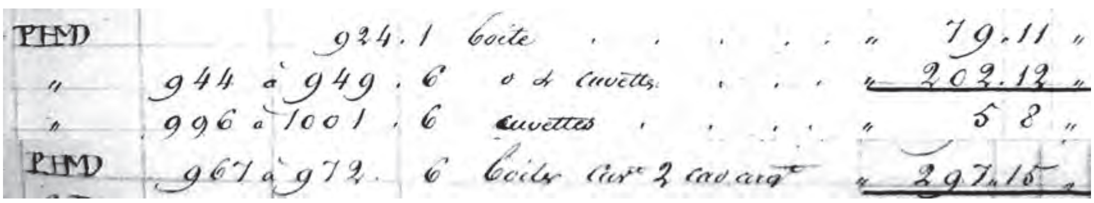
PHMD	376 . 1	o Or	67 . 15
PHMD	391 . 1	o Or	70 . 3
PHMD	403 1	o "	61 . 10

Figure 20-5



PHMD	191 . 1	o Or	86 . 11
"	192 . 1	o	89 . 5
PHMD	297 1	o Or	82 . 1
" "	326 1	o	78 . 6
" "	327 1	o	81 . 10
PHMD	353 1	o	77 . 1

Figure 20-6



PHMD	924 . 1	boite	79 . 11
"	944 à 949 . 6	o & cuvettes	202 . 12
"	996 à 1001 . 6	cuvettes	5 8
PHMD	967 à 972 . 6	boites [illegible]	297 . 15

Figure 20-7

The case inscriptions have been used to date the watch because there is no visible serial number on the movement, although it might be punched on the inside of a plate. Not all of the watches in Figures 13-6 to 13-9 (pages 153-154) are listed with serial numbers. This again raises the possibility that some special watches were made without serial numbers.

Although not directly relevant, I should note that Jeanneret and Bonhôte (1863, volume 2, pages 193-195) state that Perrelet

> *adapted a device to them which made it possible to wind them with a key when they were not carried.*

Perhaps this indicates that Perrelet designed the self-winding watches made by DuBois.

Finally, it is said that Louis Recordon got his design from Perrelet and, from his patent and the documents presented in Section 8.5 (page 100) it is clear that this was a side-weight mechanism.

Therefore we can be confident that the watches made by Perrelet used a side-weight mechanism with going barrel.

Another approach to this question is possible. At the moment six different designs are known and, ignoring minor variants, it is unlikely that there are any others. So which designs could be attributed to Perrelet? Although I have not yet discussed all the designs, the origins of five are:

(a) Rotor: Hubert Sarton.

(b) Transverse weight: Christin.

(c) Barrel remontoir: Abraham-Louis Breguet.

(d) Verge-fusee in Recordon's patent: Probably Breguet.

(e) Center-weight: This is almost certainly derived from the rotor and side-weight designs and so is a later development.

These attributions are likely. In which case the only design that Perrelet could have created, if he did not copy someone else, is the side-weight with going barrel.

20.2: Perrelet in Context, the Prince de Conti and Gallmayr

Consider the evidence presented in Chapter 5, but omit everything related to self-winding watches. We are left with only two documents, Osterwald (see page 42) and Jeanneret and Bonhôte (see page 43). Saussure would not have visited Perrelet (it is very likely that he did so only because he had been told about self-winding watches), the Geneva report would not exist, most other mentions of Perrelet would not have been written, and Ephrem Jobin would not have written his biography. All that we would have is an unimportant biography noting that Perrelet was a respected member of the Le Locle community and a good, complete watchmaker. But there are no watches which show his ability and nothing to indicate he was an inventive person, other than the very dubious statement about making 12 watches at a time with different escapements. However, Houriet (Bowring, 1836, page 36) suggests a reason for Perrelet being noteworthy:

> *Others settled in Paris, and among them Berthoud and Breguet, and more lately Perrelet, acquired a well-merited celebrity. The grandfather of the latter, who recently died, aged ninety-seven, told me that he had been one of the four watch-makers who were first established at Locle.*

In these circumstances we must ask an important question:

> *Why did Perrelet, an unknown Swiss watchmaker, design a self-winding watch?*

Probably because he was told about them.

Events very rarely, if ever, occur independently, but it is common for them to have precursors and form part of a chain of events. And news of anything new in the world of watchmaking would have travelled swiftly to Switzerland.

Although some postal services may have existed, the main contacts would have been through the networks of customers and bankers set up by the établisseurs and their travelling salesmen. So, did Perrelet get news from Philipe DuBois? Although there is no reason to assume that he heard of self-winding watches and then waited several years before making one (that is, we should concentrate on 1776), the following discussion includes earlier years.

Figure 20-8 shows most of the locations where Philipe DuBois had contacts between 1773 and the end of 1776.

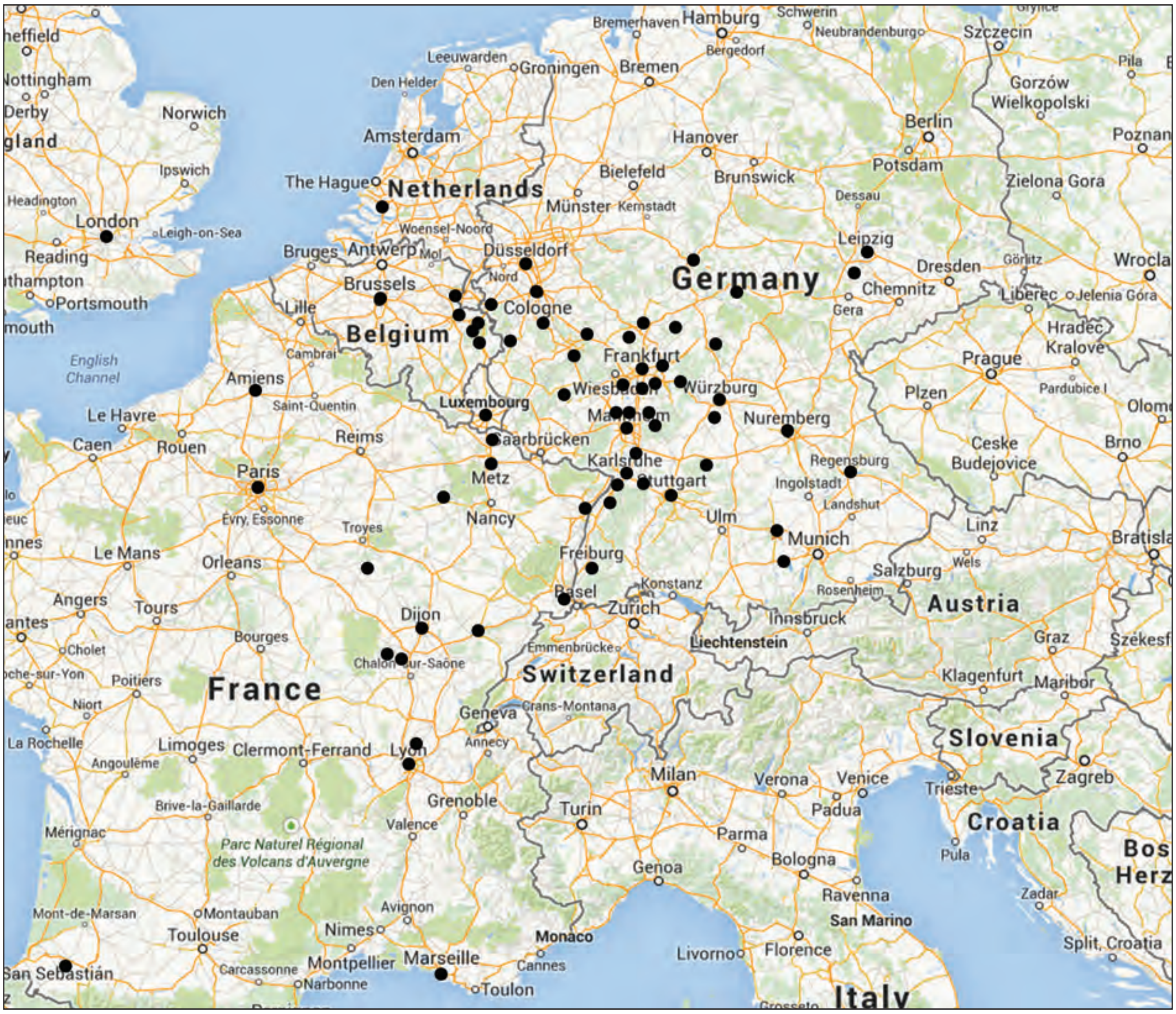


Figure 20-8

But the map, by itself, is misleading, because the salesmen used by DuBois went to the Frankfurt fairs twice a year, at Easter and in September. And many customers travelled from their homes and purchased watches at these fairs. Consequently there are places on the map that were never visited by DuBois. For example, François Joseph Meyer lived in Regensburg (about 125 km North-East of Munich) and he made many purchases from DuBois in all the years from 1775 to 1785 (DuBois, 1758-1824, *Book 3*, page 83). Looking at the map it would seem likely that the travelling salesmen would have gone from Le Locle to Regensburg via Hagenheim and Munich, and could have obtained information about Tlustos and Gallmayr on their journeys. But Meyer attended every fair in Frankfurt in those years and every purchase and every payment made by Meyer was at those fairs. So it is likely salesmen never went near Regensburg. And Meyer may never have gone to Munich, instead travelling to Frankfurt via Nuremberg.

With respect to the documents published in this period:

(a) Tlustos, May 1773, published in Vienna (see page 20):

DuBois had no contacts in Vienna or anywhere else in Austria.

(b) Thustas, August 1775 published in Leipzig (see page 23):

This report about Thustas came from Prague, but DuBois had no contacts in Prague or anywhere else in Bohemia (the Czech Republic).

Jean Fred'k Semer, living in Leipzig, sold unknown merchandise to DuBois in 1772, 1774 and 1777 (DuBois, 1758-1824, *Book 2*, page 218). The purchases and payments occurred at the Frankfurt Easter and September fairs and it is likely that the salesmen of DuBois never visited Leipzig. Because there are no entries for 1775 and 1776, it is unlikely that Semer provided any information about Thustas.

(c) Tlustos, published in Munich on 23 September 1775 (see page 21):

This report on Tlustos came from Vienna but, as noted above, DuBois had no contacts in Vienna or anywhere else in Austria.

DuBois had no contacts in Munich. But Piston (or Pistor?), a watchmaker who lived in Hagenheim about 50 km west of Munich, purchased merchandise between October 1767 and October 1776 (DuBois, 1758-1824, *Book 2*, page 61; *Book 3*, page 15), and there are inventory entries referring to him in December 1774, 1776 and 1778. But there are no entries between July 1774 and September 1776.

These transactions were handled by Keller & Fils at Basle, who delivered the merchandise and received payments on behalf of DuBois. But it must be remembered that only some of the account books of DuBois have survived. And, although the last purchase by Piston is dated 1777, the entries for Keller (on the same page) mention Piston to January 1779. To confuse matters, Keller also sold merchandise to DuBois (DuBois, 1758-1824, *Book 2*, page 215) with transactions dated October and November 1775 and June 1776, but these are too early for the report on Tlustos, and it is unlikely that DuBois heard of Tlustos from Piston.

In addition to Piston, DuBois had two customers in Augsburg, about 80 km from Munich.

First, Adam Fd Grille purchased goods at the Frankfurt September 1775 fair and paid for them six months later at the 1776 Easter fair. He then purchased at the 1776 Easter fair and paid at the September 1776 fair, purchased at that fair and paid at the 1777 Easter fair. (DuBois, 1758-1824, *Book 2*, page 154). Because the publication referring to Tlustos was at the end of September 1775, the earliest that Grille could have communicated it would have been at the 1776 Easter fair.

Second, Andres Ekuard purchased goods and paid for them at the Frankfurt September 1775 fair (too early for Tlustos), and purchased and paid at the 1776 September fair (DuBois, 1758-1824, *Book 2*, page 50). So the news would not have reached DuBois until a year after its publication.

Finally, if the news came from François Joseph Meyer (mentioned above) then it would have reached DuBois after Easter 1776.

From this, Perrelet could have received news via Grille or Ekuard.

(d) Gallmayr, published in Munich on 5 October 1776 (see page 24).

Of the people living near Munich, Piston can be eliminated. He purchased from DuBois in September 1776 (too early) and his next transaction was in October 1777 (too late).

All of the other three customers, Grille (DuBois, 1758-1824, *Book 3*, page 63), Ekuard and Meyer, attended the September Frankfurt 1776 fair (too early) and the 1777 Easter fair. Because the Easter fair was on 30 March is possible that Perrelet heard of Gallmayr, then having two months to develop his first watch.

This evidence suggests that DuBois (and therefore Perrelet) could have received news of Tlustos after the 5-7 April 1776 fair and Gallmayr after the 28-30 March 1777 fair .

DuBois was not the only établisseur and it is likely that Perrelet sold watches through another person. And we can be sure that the different établisseurs, some of whom would have supplied these cities, shared information. Also, visitors to the Frankfurt fairs would have discussed news and DuBois could have received information from someone with no connection to him who lived in Munich.

If this view is correct, then it confirms my conclusion that Perrelet designed and made a self-winding watch in 1776 or at the beginning of 1777. And he is probably the first person to create a working, practical mechanism.

Other than suggesting possible dates for Perrelet's work, the above explanation does not consider the context in which he developed a self-winding watch. The discussion only considers how Perrelet may have been influenced by the reports that Tlustos, Thustas and Gallmayr had made self-winding watches. But we must also consider the reverse. Most importantly, it is possible that Perrelet made self-winding watches early enough to sell them to the Prince de Conti and Gallmayr.

With respect to the Prince de Conti, the 1778 report to the Paris Academy (Figure 7-6, page 62) includes the interesting statement:

> *This watch is not absolutely new. The late Prince de Conti, whom one knows was interested in watchmaking, had one of this kind, so we have been assured.*

As I have noted, the Prince de Conti is Louis François de Bourbon, born 13 August 1717, died 2 August 1776. That is, the Prince may have had a self-winding watch some time before August 1776.

So, from whom did he get it? The only possibility is Perrelet, and the above evidence shows that this could have happened. If Perrelet heard of Tlustos after the April 1776 Frankfurt fair, then he could have made a self-winding watch and sold it to the Prince de Conti in June or July 1776.

This assumes that the Prince had such a watch, but this may not be true. Leroy & Defouchy had not seen it and simply report a vague, third-hand statement that someone said he had one.

One piece of evidence appears to support this. On 8 April 1777, seven months after he died, the Prince de Conti's effects were sold (Remy, 1777) and pages 396 to 403 of that book list the clocks and watches. There are 19 clocks, 11 gold watches and one silver watch, but none of the watches are self-winding. It could be argued that there was a self-winding watch and a member of the family retained it as a keepsake. But other watches in the sale were far more interesting, both for their appearance and their makers, and it does not seem credible that these would have been passed over and a less notable watch chosen. In addition, there are no pedometers in the collection; if there had been, then we might conclude that the person who informed Leroy & Defouchy was confused.

It is interesting to compare this sale with the sale of the effects of Duc Charles de Lorraine (Bruxelles, 1781) only four years later. That catalogue (pages 31-34) lists over 100 clocks and 52 watches, two of which are self-winding. (Given the link to Sarton, these may have been rotor watches.) It is apparent that the Duc Charles de Lorraine was a collector, but the Prince de Conti was not.

So it is possible that the Prince de Conti never owned a self-winding watch and the third-hand report was wrong. However, it is reasonable to accept the 1778 report and that the Prince de Conti had a watch made by Perrelet.

With regard to Gallmayr, there is one important reason to suspect that he had a self-winding watch. The 1776 and 1777 reports (Section 4.4, page 23) state:

> *the watch of our Mr Joseph Gallmayr has, at the behest of our enlightened and gracious Highness the Elector, been tested in every imaginable way*
>
> *the Elector made various tests himself*
>
> *S.A.S.E. himself did various tests*

Although the 1776 and 1777 reports may be referring to a single source, it unlikely that Gallmayr would have lied about the Elector testing his watch. Would he threaten his position as court mechanic for the sake of a little fame?

Again we must ask, who made this watch? Certainly it was not Gallmayr. And again the only credible answer is Perrelet. That is, Perrelet did not hear of Gallmayr, but Gallmayr heard of Perrelet and bought one of his watches, perhaps at the September 1776 Frankfurt fair. (Or perhaps he purchased the watch that had been owned by the Prince de Conti?) This is supported by the fact that 1776 report states "*Should one leave the watch lying for more than 30 hours until it stops …*" (see page 24). That is, the watch probably had a going barrel (see Section 5.2, page 37) and could have been made by Perrelet.

The 1779 report indicates that Gallmayr sold the watch to His Serene Highness Elector Maximillian III Joseph for 60 ducats (see page 216). Although information about exchange rates is hard to find, Kindleberger (1984, page 475) suggests a ducat was worth about half a louis d'or. That is, Gallmayr would have bought the watch from Perrelet for 20 louis and sold it to the Elector for 30 louis, a nice profit.

The Elector died on 30 December 1777 and some time between then and 1779 Gallmayr sold a self-winding watch to the new governor, Her Highness Mecklenburg-Schwerin, again for 60 ducats. However, this watch is described as doing "*its duty for three days after putting it away*" (see page 29) and we can conclude that it might have had a fusee. That is, it was probably a rotor watch purchased in 1777 or 1778.

Although irrelevant, the Elector's death is interesting. According to Wikipedia (2015a), in December of 1777 Maximilian Joseph rode in his carriage through Munich. On the ride, as he passed one of the tower clocks, the mechanism broke, and the clock struck 77 times. (There are 78 hour strikes from 1 to 12 inclusive. So 77 strikes cover the hours 2 to 12 and the event probably happened after 1 pm.) Commenting to the passengers, Maximillian Joseph decided this was an omen, and that his years had run out. Within days, he was stricken with a strange disease and he died at the end of the month. It is hard to imagine the Elector patiently counting to 77, even if the clock hands were rotating. But he may have been in Gallmayr's "self propelled" carriage (see page 215) and the driving engine was having a rest! And we can speculate that Gallmayr killed his benefactor by incompetently repairing the clock.

In summary:

> *In early 1776, Perrelet heard of the report that Tlustos had made a self-winding watch, and he designed and made two watches during May and July 1776. These watches were acquired by the Prince de Conti and Joseph Gallmayr.*

This hypothesis fits the evidence better than a hypothesis suggesting the Prince de Conti and Gallmayr did not have self-winding watches. And it is not contradicted by the analysis in Section 20.1. In particular:

(a) Saussure's diary states that Perrelet *"is going to (will) sell it [for] 18 to 20 louis"* and I have interpreted this to mean that Perrelet had made a single watch. However, an equally good (if not better) interpretation is that Perrelet had just one watch for sale when Saussure visited him, and it does not preclude Perrelet having made and sold self-winding watches before June 1777.

(b) Although Perrelet mentioned his first watch to Saussure, and the fact that it did not work, it is possible that the watch had been made some months earlier and had been followed by only a small number of successful watches.

It can be argued that this is pure speculation, because there are no documents or watches that link the Prince de Conti and Gallmayr to any watchmaker, let alone to Perrelet in particular. However, the dates of the evidence must be considered and we know, almost to particular months, when various claims were made. If we arrange all the evidence by date then it becomes clear that some relationships are possible and others impossible. In particular, there is no evidence that suggests Gallmayr could have obtained a watch from anyone other than Perrelet, because the documents indicate that all the other makers worked after October 1776.

By the end of 1777, it is likely that Perrelet could have made at most eight self-winding watches (at one every two months), but probably only four or five; see Section 5.7, page 53. The purchasers would have been royalty and the very wealthy, who travelled around Europe reasonably frequently, except when wars and other problems intervened. So news of Perrelet's work would have become known quite quickly.

20.3: Breguet and the Barrel Remontoir Watch

Breguet himself said that he "perfected" the self-winding watch about 1780 (Section 9.2, page 109), a date confirmed by his grandson in 1832 (Salomons, 1921, page 72; Chapuis & Jaquet, 1952, page 67; Chapuis & Jaquet, 1956, page 72).

However, Emmanuel Breguet (1997, page 36) states:

> *In a first survey of his inventions, drawn up in 1796, Breguet dated the start of his studies and 'meditations' on the subject [of perpetual watches] back to about 1771 ... taking credit merely for the invention of a system that was reliable and effective: an oscillating weight 'à secousses' [with shakes or with jerks] ... In the absence of any documentation, it is impossible to date this invention precisely. 1778? 1779? Or perhaps as early as 1775?*

Emmanuel Breguet (2013) has confirmed the date 1771, noting that in the survey of inventions Breguet speaks about the result of "25 years of meditation".

Backdating the invention only to 1775 or later, four or more years after Breguet's date is interesting. Relevant to this is Breguet's circumstances. In 1775, being newly married and having just set up in business (Section 9.1, page 107), his main concern must have been putting food on the table for his wife and sister. In addition, although he may have been introduced to the Court earlier, without a reputation and without a wealthy clientele he would not find a market for the idiosyncratic and very expensive watches which were to become his hallmark. And so we can expect that during the early years Breguet would have depended on selling ordinary watches, to give him the income and time to start developing his style. Which means that at least some of the ordinary verge watches that are signed *Breguet à Paris* probably came from his shop. Such watches are generally ignored by Breguet's biographers and are usually considered fakes, but Chapuis & Jaquet (1952, page 68; 1956, page 73-74) note that "Breguet's earliest watches were fitted with [the verge] escapement". Also, the study of Breguet's watches begins about 1780 and earlier watches, if any, are ignored.

There are two consequences. First, the self-winding watches of 1780 were the first, successful complicated watches made by Breguet. It is these watches that caused royalty and the rich to become interested in him, and they formed the basis for his later work. This is probably the reason why Breguet stated that his work on self-winding watches dated from about 1780 and not 1771. Second, it is likely that before 1780 all his watches were simple (although including some repeaters) and used the verge escapement. That is, at that time Breguet had little or no knowledge of and experience with cylinder, lever and other escapements.

The barrel remontoir mechanism, described in Section 9.3 (page 110), is relevant to this view of Breguet's early work.

Because the mechanism is very complex and extremely sophisticated, it is unlikely that a completely unknown person could have designed this watch. To do so, he would have to be a master whose creativity would be on a par with that of Abraham Louis Breguet, and it is very unlikely that someone with such skills would be completely forgotten. So it is reasonable to attribute these watches to Breguet.

But, unless Breguet was a masochist he would not have developed this design if he already had experience with the cylinder and other escapements, and going barrels. There can be no doubt that he would not have used the verge escapement and he would not have created a beautiful, very expensive dinosaur.

However, by about 1780 Breguet was making self-winding watches using a far simpler mechanism based on an ordinary going barrel coupled with a cylinder escapement, effectively identical to that described in Recordon's patent (Section 8.2, page 91). In these circumstances, we can be sure that these barrel remontoir movements were made some time before 1780.

But why did Abraham Louis Breguet, as Emmanuel Breguet (1997, page 36) states, start thinking of self-winding watches about 1771? Was he interested in the myth of perpetual motion? Or did he see a report at least two years earlier than any document we know about? Or did the idea just materialise from nowhere? Or was his memory faulty in 1796?

That he did nothing from 1771 to 1775 is not surprising. During this time he worked for someone else and he would not have had the opportunity to do anything, even if he had thought of a practical design. And even when he set up in business, in 1775, he probably did nothing. Although it might be reasonable to date the barrel remontoir watch to 1775 we must ask: If that is the case, what did he do for the next four or five years? Although very complex and very expensive to make, the barrel remontoir mechanism works, and perhaps there should be more of them in existence today if he had several years in which to make them? So it is likely that he "meditated" for a while and the forgot about the idea.

Until the second half of 1776 or early in 1777. We know Breguet had contacts in Le Locle (see page 108) and it is very likely that Breguet heard about Perrelet's success. But we can be sure he did not examine a watch made by Perrelet; if he had, he would have used a going barrel from the start. But knowing of an *à secousse* watch with a weight would have rekindled his interest and provided the basis on which he could design and make a self-winding watch himself.

In these circumstances it is most likely that the barrel remontoir watches were designed and made near the end of 1776 or early in 1777, not long before he learnt of the much superior design using a going barrel with a cylinder or virgule escapement.

Of course, it can be argued that Breguet heard of the reports referring to Tlustos (Section 4.2, page 19). But this would backdate the Barrel remontoir design and that, as I have indicated, is unlikely.

20.4: The Mysterious Christin

Christin is a mystery because the documentary evidence is contradictory. To make sense of it we need to consider where he lived and what he invented before suggesting a likely explanation.

Christin's biography (Section 10.1, page 125) and other documents enable us to determine where he lived at different times in his life:

Amédée Christin was born about 1730 in Berne Switzerland, where he trained to be a watchmaker and/or clockmaker. He then went to Paris to improve his education, and in 1755 he designed a watch escapement.

About 1760 Amédée returned to Berne (Mundschau, Roobaert and Watkins, 2014, page 10). He lived there until about 1764 when he went to Amsterdam to study ships. While in Amsterdam he was contacted by the Margrave of Bade Dourlach and asked to establish manufacturing of watches in Pforzheim.

In 1767 Christin went to Pforzheim with Jean Viala and the latter became his brother-in-law, marrying his sister in 1768 (Family Search, 2014). The involvement of Christin in the watch factory ceased about 1773, at which time he had large debts. The church (where his brother-in-law was married?) loaned Christin the money to pay off his debts and he moved to Carlsrouhe as a watchmaker to the court. While in Carlsrouhe he designed the transverse-weight self-winding watch.

About 1780 Amédée Christin moved to Berlin where he lived until about 1788, when he probably returned to Amsterdam (Section 13.8, page 162). Nothing is known about his life after that time.

The documents we have mention fourteen inventions, but most cannot be dated accurately. The following summary suggests likely dates and, in consequence, where the inventions were probably designed:

(a) 1755, watch escapement, *Paris* (Academy of Sciences, 1755, page 168; Berne, 1755, page 2; Mundschau, Roobaert and Watkins, 2014, pages 6-9): Christin is described as a native of the Canton of Berne and he would have been living in Paris at the time of this invention. The escapement is plausible, but Lepaute (1755, 1767, pages 129-135) stated:

Although this escapement is defective, one could be seduced by the property it has of being applied to watches, removing the contrate wheel, and being quite easy to make, which is what brought Sieur Christin, in March last, to apply it to watches, and to publish it in newspapers as the newest and most perfect of all escapements. Experience will show everyone that he was far from correct.

(b) 1763, eight day watch, *Berne* (Berne, 1763, page 4; Mundschau, Roobaert and Watkins, 2014, page 10): Amédée Christin is described as a watchmaker established in Berne for several years. No information on the design is given, but the idea is plausible.

(c) Before 1767, an oar for high free-board ships, *Amsterdam* (Christin, 1778; Mundschau, Roobaert and Watkins, 2014, page 13): Christin's proposal to use oars to move large vessels does not make sense and is mechanically unsound.

(d) Before 1767, machines for moving rather large sails in a head wind, *Amsterdam* (Mundschau, Roobaert and Watkins, 2014, page 13): Christin states that he made a small model where the motion of the sails will move the oars (above) so that the ship can move directly into the wind without tacking. The idea appears to be absurd.

(e) Before 1767, a small mechanism to measure the distance travelled by a ship, *Amsterdam* (Mundschau, Roobaert and Watkins, 2014, page 13): Christin states that this mechanism used the movement of a ship's log. A ship's log was used to measure speed and not distance. The simple form, a knotted rope played out behind the ship, could only measure the length of the rope and would be useless. Later logs using rotating vanes could be used and presumably Christin's device counted the number of rotations of the log. However, this is unlikely to *show perfectly the distance that the vessel has travelled*. For example, a ship sailing into an ocean current may be stationary or even moving backwards, but the log would show a relative advance.

(f) Before 1767?, a machine for piercing metal, *Amsterdam?* (Christin, 1778; Mundschau, Roobaert and Watkins, 2014, page 13): Christin states that he had made a small model of a machine to pierce canons. It used rotating saws to make a hole and is plausible. This most likely relates to Christin's study of ships.

(g) Before 1767?, a rifle, *Amsterdam?* (Mundschau, Roobaert and Watkins, 2014, page 14): Christin describes this as:

A rifle of a new construction that launches, without fire or powder, about twenty darts with much force, within the space of 15 seconds.

The idea is perhaps plausible, but it is clearly absurd.

(h) Before 1767?, several designs for hydraulics of various kinds and with various uses, *Amsterdam?* (Christin, 1771, page 22; Christin, 2014, page 7): This work may refer to draining the lowlands.

(i) Before 1771, a machine suitable to beat grain, *Pforzheim?* (Christin, 1771, page 22; Christin, 2014, page 7): Christin had made a small model *by means of which, when made full size, one man can do the work of six.* This is unrelated to the other inventions and could have been developed in Amsterdam.

(j) Before 1771, machines to write from two to six copies at the same time, *Pforzheim?* (Christin, 1771, page 22; Christin, 2014, page 7).

(k) Before 1778, a file cutting machine, *Pforzheim?* (Christin, 1778; Mundschau, Roobaert and Watkins, 2014, page 14): Although not stated, this was probably an idea and Christin had not made it. This is not plausible because at that time files were made by hand, and successful file-making machinery was not created until the 19th century (Manufacturer and builder, 1889).

(l) Before 1779, a self-winding watch, *Carlsrouhe*: Invented by Amédée Christin. The design is plausible, but not good; see Section 10.2, page 126.

(m) 1783, a correspondence system, *Berlin*: See below.

(n) Before 1784, a snail for a sundial, *Berlin* (Berlin, 1786, page 284; Mundschau, Roobaert and Watkins, 2014, page 36): The idea is to use a snail to adjust the angle of the style. This is plausible, but it would only be useful on portable sundials and it seems an unnecessary complication.

Of these fourteen inventions, only three are described: the escapement, the self-winding mechanism and the correspondence system.

Before examining the implications of these inventions, it is necessary to explain the correspondence system. The following is an extract from Christin's description (Paris, 1783, December, pages 17-20; Mundschau, Roobaert and Watkins, 2014, pages 28-29):

> *Here is the announcement of a mathematical correspondence invented by the watchmaker mechanic Christin, a native of Berne in Switzerland, and made in Berlin in 1783.*
>
> *Each friend is conveniently placed near a desk in his office, where he can convey his thoughts as intelligibly as he would in the ordinary way of writing.*
>
> *The propositions are known in the office of the recipient at the same time as they are dictated in the first; and the distance, I suppose a hundred leagues, though divided into many stations, could only delay the effect by the minutes required to repeat the actions at each station, and it would then depend on the interested to deprive the intermediate offices of knowledge of the thing dictated.*
>
> *The use of this invention is easy, and it can be used to correspond in all known languages, as one can be convinced by the machine that I made. It is composed of specific metals to last more than a century. The communication of the mechanical movement is contained in a small wooden pipe placed one foot below the ground, like the pipes of a fountain, but the arrangement is such that the moisture or even the water that might be introduced, would not prevent the functions of the instruments in each office; they are always safe in this regard.*

To this description the reporter added:

> *Mr Christin offers to set up his mathematical correspondence by subscription, at 40 ducats for both writing offices containing the inventions of the correspondence, and half a ducat per toise for the underground communication* [a toise is about 6 feet]*; one pays 20 ducats when subscribing, and the rest when the finished work has been tested. You can subscribe at The Hague, the house of P. F. Gosse, bookseller & printer to the Court.*

No help is needed to realise that the mathematical correspondence system is an absurd fantasy which has nothing at all to do with mathematics. In a book on *magic, or the magical powers of nature*, the system is described in detail (Halle, 1785, pages 141-145; Mundschau, Roobaert and Watkins, 2014, pages 29-31). The following extract and Figure 20-9 comes from Halle:

> *I lived in Berlin without having heard a word of the inventor, and the wonderful correspondence room. Now I have at last researched the same, and the watchmaker Christin, Swiss born and a resident here, led me into a garden of the city, where the secret was fenced off for a rehearsal in miniature. At the beginning of it, I found a room made of planks in which there was a kind of small writing desk, and on the console lay a horizontal disk of cardboard whose radius was divided into the 24 letters of the alphabet and the ten digits 0, 1 to 9. He had me sit down in front of this disc, which has a crank attached to the side of the cabinet that is turned until the metal pointer coming from the center of the cardboard disc indicated the first letter of the word which I wanted to send into the distance. After every word I should take a little break in turning the crank, and he assured me that at the same moment he read my communication at the other end of the corridor in an identical room made of planks, and he would respond to my words immediately afterwards on my disc, at a distance of several fathoms by air.*
>
> *When the question turning was over, my pointer moved by itself. It stood still to remain on one of the letters and I wrote it with a pencil on paper; and the pointer then moved to the second letter, and so forth, and now as soon as I had written the letters on the paper I read the answer to my question.*
>
> *I will immediately describe the mechanism. Mark two circles on cardboard or wood, of which their outer size is about 9 to 10 inches and their inner size about 8 to 9 inches, and divide them equally into 24 parts. In these 24 places write the 24 letters of the alphabet, writing the letters on one disk from the right to the left, and on the other from the left to the right. An axle goes through the center of each disc to which the pointers are attached. Under the pointers there is a long trench under the ground, where a long, four-sided box of wood runs from one correspondence room to the other, in which there are horizontal wheels, as we are accustomed to*

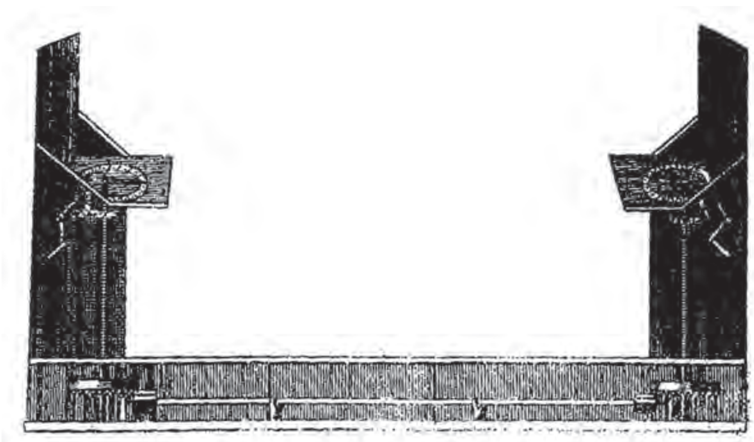


Figure 20-9

> *use in clocks which have multiple dials* [contrate wheels]. *These wheels have the same number of teeth.*
>
> *These axles may have, instead of expensive crown wheels, only two rollers that are as large as possible. The alignment of the disks can thus be obtained by a cord, which is fixed by its ends to the two rollers.*
>
> *When you consider this machine, the axles go from two discs into the wooden box under the earth with the mechanism, and are covered with earth so that you do not suspect it. They are of steel and the ends have brass wheels under the ground, thin steel shafts gear with them, that curve because of their length and weight, and it would ridiculous to think of a rod of iron which is half a mile, let alone one hundred miles long, and supported by forks, nor could it move a lot of wheels. The slightest repair is invisible under the ground, because it would not be possible to find the site to excavate, as the mile long box would soon go mouldy in the wet earth. So the ridiculousness is soon apparent to the reader.*

In addition to being ridiculous, Christin (living in Berlin) wanted subscribers to his system to send payments to The Hague in the Netherlands, more than 620 km away. The only rational explanation for this is that Christin was carrying out a deliberate fraud, where a friend received payments which would then vanish. Perhaps this is the reason why Christin may have moved to Amsterdam about 1788.

The details of the *mathematical correspondence* have been included because it raises a serious question:

> *How could a competent watchmaker put forward such a stupid and fraudulent idea?*

Four of the above inventions concern horology, and they are plausible designs. So there is no doubt that Amédée Christin was well trained and inventive. Indeed he was described as:

> *... Mr Christin, a Swiss from the Canton of Bern and a very clever watchmaker and machinist, who is established in Berlin* (Berlin, 1786, pages 259-296).
>
> *He was the born technician, who did not have the smallest understanding of business ... Christin was a tinkerer ...* (Pieper, nd, pages 44-45).
>
> *[Amadee Christin] was a tinkerer and mechanic of the first rank, but unable to think in business terms.* (Schaber, 1999, page 53).

But the other ten inventions range from plausible (perhaps) to nonsense, and they suggest a person who had little or no understanding of the mechanisms involved and probably no understanding of mechanics. So how did a *mechanic of the first rank* come up with these ideas?

In addition, if Christin was a skilled watchmaker, and possibly a skilled clockmaker, he would have easily found work as watchmaker to the court, and paying off his debts may have been difficult but not impossible.

A possible explanation comes from Fallet (1942). (Unfortunately Fallet does not provide references and it is not possible to check his sources.) In chapter 10 I deliberately edited Fallet's history. What he actually wrote is:

> *On 14 June 1774 Christin was no longer an entrepreneur of the watchmaking factory of Pforzheim. On this date* **he and his brother** *repeated the request, which the margrave had already answered favourably, to allow them to be called watchmakers of the court and to be established as such in Karlsruhe. To this request, Christin added a supplication to the Marquis*

> *Sérénissime for him to take responsibility the unfinished clock which was in the Pforzheim factory and to advance 300 guilders to them to finish it. The court granted an advance of 200 guilders to them. Under the date 1 October 1774, the older Christin wrote to the margrave of Karlsruhe that a school of watchmaking would be of a great utility for his subjects and would support the factory of Pforzheim. The answer to this request was negative.*

The roles of Christin and Viala are discussed throughout Fallet's article, but nowhere is their relationship mentioned, and the impression given by Fallet is that they were not related. But there is no doubt that Fallet refers to Christin's brother: *Lui et son frère réitèrent à cette date la demande* and *Sous la date du 1er octobre 1774, Christin l'aîné ....* These clearly refer to Christin's brother (frère) and not to his brother-in-law (beau-frère) Jean Viala.

Unfortunately, no other history mentions two brothers, one with the given name Amédée and the other with an unknown given name, and I have been unable to confirm Fallet's statements. But two brothers make sense of the contradictory evidence. To avoid confusion in the following, I will refer to *Amédée* Christin and *Brother* Christin.

There are several reasons to believe Christin had a brother:

First and most important is that Viala would not use the name *Christin* to describe himself, and Fallet would not write *the older Christin* to distinguish Amédée Christin from Jean Viala. Also, before June 1774 Christin and Viala separated and advancing money to *them* does not make sense unless it refers to someone else. (Fallet is vague and Pieper dates the event to either 1772 or 1774. The transaction of DuBois with Christin indicates it was probably in 1772 or 1773; see Section 13.8, page 160.)

Second, in the 18th century medicine and surgery were primitive. This is clearly indicated by the number of deaths during childhood. For example, the Gentleman's Magazine (1751, and other years) provided information on births and deaths in London, and Table 20-2 gives the statistics for four different years.

	1732	**1751**	**1769**	**1792**
Total Deaths	23358	21028	21847	19348
Deaths under 2	9502 (40.7%)	7483 (35.6%)	8016 (36.7%)	6542 (32.4%)
Deaths under 5	11019 (47%)	8968 (43%)	10061 (46$)	8702 (45%)
Cured deaths	16709 (71.5%)	15321 (72.9%)	17020 (77.9%)	14435 (71.4%)
LE at birth	25	26	24	26
LE at 10	48	47	46	48
LE at 20	50	49	48	50
Births	18425	15263	17843	20120
Deaths in childbirth	219 (1.2%)	172 (1.2%)	185 (1.1%)	201 (1.0%)

Table 20-2

About a third of all deaths were children who had not reached 2 years old, and nearly half of all deaths were children under the age of 5. Nearly three-quarters of all deaths (listed above as cured deaths) were due to diseases which have been nearly or completely eradicated in the 21st century: tuberculosis, convulsions (including epilepsy), scarlet and other fevers, small pox and bad teeth. (Other causes of death were evil, itch, lethargy, lunatick and worms.) The result was that at birth your life expectancy (LE at birth) was only about 26 years. But if you lived to see your tenth birthday then you could expect to live to about 47 (LE at 10), and if you lived to 20 then you could expect another 30 years (LE at 20). Obviously the first two years were vital, and if you survived them your live expectancy was about 39 years.

The majority of mothers survived, the deaths in childbirth (including miscarriage) being about 1.1% of deaths. The percentages are based on the number of births (number christened plus number stillborn), from which the number of pregnancies was calculated using Wikipedia (2014).

At a time of effectively no contraception, most mothers would have lived to produce many children a year or two apart.

For comparison, in Le Locle, Switzerland, Philipe DuBois had 9 children in 21 years, of which 4 died under the age of 3 years; that is, 44.4% died. (DuBois, 1758-1824, *Book 4*, page 42).

Although we do not have exact information (because relevant records of births and deaths have not been found) it is likely that Amédée Christin was born about 1725 to 1730, but Luise Francoise Augustine Christin, Jean Viala's wife, was probably born between 1742 and 1747, because we know that in 1767 Viala was probably about 20 to 25 years old:

> *[Viala] was the youngest of them. His personality was not yet fully developed because of his youth.* (Pieper, nd, page 46).

That means Amédée Christin's parents, Jean-Pierre Christin and Charlotte Vulson, produced children for 17 or 22 years and we would expect they had between 8 and 12 children of whom 5 to 7 survived. That is, there are another three to five brothers and sisters about whom we know nothing, and Amédée probably had at least one younger *Brother* Christin.

Third, the name Amédée is associated with only two inventions, the eight-day watch and the self-winding watch. Most important is that all of the letters written to Berlin (see below) are signed *Christin, watchmaker to the Court* and could have been written by either Amédée or his brother. From this we can assume that Amédée was the trained, skilled watchmaker, and the younger Brother Christin was the untrained charlatan.

Fourth, the eight-day watch was invented in 1763 by Amédée Christin and, as noted above, he was a *watchmaker established in Berne for several years*. But according to Brother Christin's biography he was in Amsterdam in 1763:

> *I went to Paris ... From there I went to Amsterdam, ...*

There is no mention of him returning to Berne and spending several years there before going to Amsterdam. That is, the writer of the letters to Berlin and the inventor of the mathematical correspondence system was Brother Christin and not Amédée Christin.

Fifth, why would the Margrave contact someone in Amsterdam and another person in Switzerland to establish watchmaking in Pforzheim? It is not sensible. But it is sensible if the Margrave contacted both Amédée Christin and Jean Viala *in Berne*. And Brother Christin in Amsterdam heard of this project through his brother or his future brother-in-law and decided to join them, seeing an opportunity which, considering his implausible "inventions" dealing with ships, Amsterdam could not offer.

Sixth, Pieper (nd, page 45) includes the following interesting statement:

> *Christin was certainly not a dishonest man. When he had to give up his heavily indebted operation in 1774, his backers still trusted him. For example, the Reformed Church congregation allowed him to pay back his loan of over 2,000 florins from their funds if he rebuilt a new life.*

And Schaber (1999, page 53) adds:

More or less he collected watches of his own production and sold them at domestic and foreign fairs because of an acute need for money. But the revenue generated only covered the costs ...

But, as the correspondence system shows us, Christin was certainly dishonest. However, if there were two brothers then, when the partnership with Viala failed, Amédée left Pforzheim to rebuild his life in Carlsrouhe, and his brother followed him.

Like the assumption that there was only one person, Amédée Christin, this hypothesis has its faults: Who went to Paris? Who went to Amsterdam? Who went to Berlin and designed the sundial snail? A credible explanation is that Amédée Christin was given responsibility for the care of his younger brother and they travelled around Europe together. But then, who wrote the begging letters to Berlin?

An entirely fanciful, but possible explanation is that Amédée Christin died in Carlsrouhe, perhaps at the beginning of 1779 and after he had designed both the self-winding watch and the sundial snail.

Having no support and probably no way to earn a living, Brother Christin started writing to Berlin in the hope of getting employment. And he "stole" Amédée Christin's qualifications and his invention of a self-winding watch to bolster his claims. In this context his three letters to the Berlin Academy are fascinating.

The first letter includes:

> *The object of this letter is to request that you, Sir, do me the favour to direct me in what should be done to achieve my goal. The gracious protection that you grant to artists and to all that can contribute to the progress of the arts, assures me that you will view my intentions in a favourable way, and I have taken the liberty to attach here the notice of the new inventions that I have produced. Later I will be able to provide others no less useful, in the case that the King finds me able to be employed in his service, and I have the honour to be with the most perfect consideration* (Mundschau, Roobaert and Watkins, 2014, page 2)

The attached list of inventions includes the self-winding watch, but *not* the earlier inventions of an escapement and an eight-day watch. Because Brother Christin signed himself as *watchmaker to the Court* and wanted to be employed in watchmaking, the escapement, the eight-day watch and the self-winding watch are much more important than his other "inventions" and we would expect Christin to list all three. But perhaps Brother Christin did not know about the early inventions and was only aware of Amédée Christin's work in Pforzheim and Carlsrouhe?

Brother Christin received a reply which led him to write a second letter, attaching his description of the self-winding watch (Mundschau, Roobaert and Watkins, 2014, pages 14-15). It includes:

> *These new types of watches and the idea I have to form an establishment in Berlin should be investigated. I believe that if the report of the Academy is favourable to me, I could request from the King the grace of an exclusive privilege, to be the only manufacturer in all the Kingdom, unless His Majesty judges in connection with me to employ me with more considerable things, relating to the other inventions of which I would produce the models. In the latter case His Majesty could reward me in another manner and order the production of my new kind of watch to make the invention real. It would be a small favour which the King could make to all the amateur of watchmakers, as the King of France did by printing, in Paris in 1768, the book concerning the longitude watches invented by Mr Le Roy.*

Now Brother Christin is much more specific, requesting the right to establish a factory at His Majesty's expense! Also interesting is that he was unmarried (and had never married) at the age of about 37 years:

> *... and I will go to Berlin to give demonstrations of [the inventions] if you think, Sir, that is appropriate, as am still unmarried the voyage would not be embarrassing, ...*

There was no reply to the second letter. We can assume the Berlin Academy examined the self-winding watch design and rejected it, a sensible decision. The Academy may also have noticed that Brother Christin's explanation is both strange and, on one point, wrong. It is probable that His Majesty was not informed of Brother Christin's request.

The third and last letter is rather pathetic (Mundschau, Roobaert and Watkins, 2014, page 25):

> *Dear Sir*
>
> *You undoubtedly received the letter that I had the honour to write to you on July 23rd, containing a drawing and a detailed explanation of my new invention of a watch which winds itself. Filled with hope that you will have had the kindness to present it to the academy, I would wish only to know when I could be informed of the outcome. The assemblies being frequent, they have had time to determine it, and you would do me, Sir, a great favour to inform me of it, as I have other more important inventions to expose. I would be delighted to benefit from the most prompt and favourable circumstances, to merit the approval of your illustrious company.*
>
> *Please, Sir, forgive my eagerness and be convinced that I particularly want to honour your benevolence. You will get the satisfaction of me giving you the evidence of them, by supporting my intention to enter into the service of your Court. All my aptitudes tend to occupy me with new and useful objects, some distinguished people at the Court of France know me for that, where I have already made a few proposals, but I would give the preference to the Court of Prussia, if I found a suitable place in Berlin. I dare to hope for something of your kindness in this regard, by the interest that you take in the advancement of the arts, and the well being of the artists who seek to distinguish themselves by their talent and good conduct. I have the honour to be with the most perfect consideration*
>
> *Sir*
>
> *Your very humble and very obedient servant*
>
> *Christin, watchmaker to the Court*
>
> *Carlsrouhe*
>
> *9 September, 1779*

It appears that this desperate plea was ignored. But despite this rejection, Brother Christin went to Berlin, perhaps because he was no longer welcome in Carlsrouhe. And there he created the absurd mathematical correspondence system.

This argument is weak. Of the five histories of the Pforzheim watch factory, Leiter (1995, page 15), Pieper (nd, page 44) and Schaber (1999, page 52) note that Christin and Viala were brothers-in-law, but Fallet (1942) and Maschke (1968) do not mention this relationship. Only Fallet refers to Christin's brother, and his history has not been verified. However, it does explain the commonly held view that Christin (presumably Adémée) was a first class tinkerer and mechanic. And we would expect the histories to focus on Viala's partner and ignore the person in the background who was not directly involved in the factory.

Before commenting further, we must note that the description of the self-winding mechanism (see page 129) has two important errors:

First, as noted before (page 130) Christin states that the weight and the arbor supporting it are *joined together to make one moving part on two pivots.* This is obviously wrong because the weight must move independently of the arbor.

Second, and more important, is that there is no mechanism to lock the weight.

The very confusing Figure 20-10, which shows the weight in three different positions, illustrates the problem. The position of the weight ***i*** is that shown in Figure 10-5 (page 127) and the positions of the top plate ***t*** and the dial (pillar) plate ***d*** are estimates of their locations. (I am assuming the click ***n*** is drawn incorrectly. Otherwise the top and dial plates must be further to the left to leave space for the arbor for ***n***.) This position cannot be the "at rest" position because the center of gravity of ***i*** must be directly under the pivot point and it is obviously to the left. But that makes the mechanism worse! and so I will use the drawn position. The position of the case back ***c*** produces a case twice as thick as cases for "ordinary" watches. However, if the case back is in this position the weight cannot act like a pendulum because half of the swing is obstructed and the weight must hit against the back with every oscillation. If the case back is moved to ***c'*** then the weight can act as a pendulum, but the watch is then three times as thick as an "ordinary" watch case.

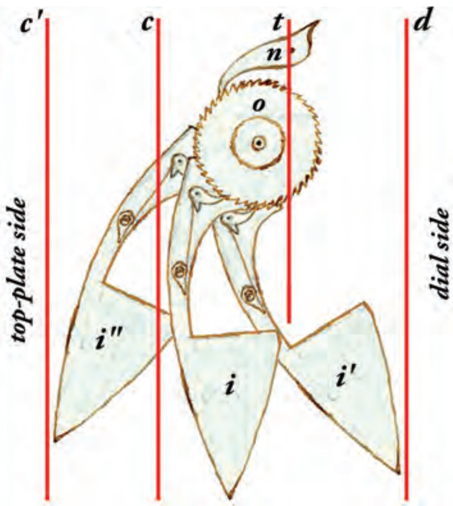


Figure 20-10

The problem is:

How can the weight be locked when the mainspring is fully wound?

There are two possibilities:

(a) A vertical pin which holds the weight at one extreme of its oscillations. This is impossible because the mechanism would impede the normal motion of the weight.

(b) A transverse pin entering a hole in the side of the weight. The hole needs to be at the "at rest" position and the weight designed to ensure the pin enters the hole and does not lodge elsewhere. However, the end of the weight where it is attached to the arbor is the only part of it that might be suitable. This is not possible because the magnified force of the weight would almost certainly bend and damage the pin and the mechanism that moves it. Also, Geneva stop-work cannot be used. The position of the boss when the mainspring is fully wound is arbitrary and it cannot be used to move a lever sideways.

That is, there is no part of the weight that can be used to stop its motion and the design makes the addition of a weight locking mechanism probably impossible.

It is clear that three of the four "inventions" concerning timepieces are not original (the escapement), bad (the self-winding watch) and trivial (the sundial snail). And we know nothing of the fourth "invention" (the eight-day watch). That is, there is nothing to indicate that Christin was a first class inventor and mechanic. Rather, the fourteen "inventions" support the view that he was a tinkerer, a person who is clumsy and a bungler rather than a first class mechanic. From which we must conclude that although Amédée Christin may have trained as a watchmaker he was ordinary and had no special skills.

So it is possible that there was only one person, Amédée Christin, a person who had a flawed personality (a psychiatric disorder?) and was simultaneously a mediocre watchmaker and a charlatan.

However, there is no doubt that someone with the name Christin invented the transverse-weight mechanism, and the important question is: When did he invent it?

In 1779 (Chapter 10, page 129) Christin wrote:

> *I imagined a few years ago what I propose today, to give to the machines intended to measure time a continual movement, without it being necessary to wind them.*

This indicates that the date of the invention is circa 1777. However Christin does not mention it in his September 1778 letter to Benjamin Franklin (Mundschau, Roobaert and Watkins, 2014, page 10). That letter is strange because it mentions only the inventions (c), (f) and (k) above. But surely he would have included his self-winding watch? Its omission suggests a later date is more realistic, but we must allow for the possibility that it was invented in 1777, because Christin probably had contact with Le Locle through Philipe DuBois, who sold merchandise to customers in Pforzheim and Carlsrouhe, and he could have learned of Perrelet's watch.

20.5: Hubert Sarton and the Rotor Watch

At about the same time, but quite independently, Hubert Sarton designed the rotor watch (Chapter 18, page 207).

Dating this design is easier. The earliest report is the July 1778 advertisement (Figure 7-2, page 58) and, allowing enough time to design the mechanism and make several watches, we can reasonably date this development to late 1777.

It is likely that Sarton's involvement parallels that of Breguet. Like Breguet, Sarton probably heard of Perrelet's success (through Philipe DuBois) and, being a very creative person, he also set himself the task of designing a self-winding watch. Like Breguet, but because he was primarily a clock maker, he used the escapement he was familiar with, the verge escapement. And like Breguet, he had to devise a way to overcome the problem of decoupling. But at this point, the watchmaker and the clock maker took two different approaches.

Breguet's design is the product of a creative genius. Sarton's design has an elegant simplicity. But neither design had a future, both being overtaken by the side-weight mechanism with a going barrel.

Two important questions remain.

First, why did Sarton send a watch to the Paris Académie Royale des Sciences in December 1778, about a year after he had designed it, and nearly six months after he started selling them? Why didn't he send it to the Imperial and Royal Academy of Brussels?

The answer is probably the obvious explanation. Near the end of 1778, Sarton heard of or saw a rotor watch signed by a Parisian maker, perhaps the *Berthoud à Paris* watch. And so he decided to claim the invention of this design in Paris, not for financial gain, but simply to show that he had designed it and not the signatory of the watch.

Second, who made the rotor watches? Sections A5.2 and A5.3 (page 320) examine and compare the five known movements. The evidence supports the view that these movements are almost certainly based on the same calibre.

However, there are differences between the movements which indicate that they were not made in a single batch by the one watchmaker. In addition, there is no evidence to indicate whether the movements were made by one person or several people.

Despite the lack of good evidence, it is reasonable to assume they were made in the Principality of Neuchâtel for Hubert Sarton, for the same reasons that Sarton had watches made by DuBois to Sarton's design (page 196). But who made them is unknown.

The relationship of DuBois with Sarton (Figure 13-18, page 158) suggests that he could have been involved. It is possible that some of the *marchandises* purchased by Sarton at the end of 1777 and early in 1778 consisted of rotor watches made to Sarton's design. If this is correct then it is possible that Perrelet made them.

However, the watch serial number (Figure 15-4, page 184) and the case maker's signature indicate that it is unlikely DuBois was involved in making the rotor watches.

20.6: The Problem of Priority

My opinion is that *what* was invented is much more interesting than *who* or *when*. But other people are interested in the question of priority: Who was the first person to successfully make a self-winding watch?

The evidence presented in this book supports the view that the first successful design was made by Abram Louys Perrelet in 1776. And Breguet, Christin and Sarton independently and simultaneously developed their designs later in 1777, perhaps with some knowledge of Perrelet's work.

21: 1778 to 1779, Final Developments

21.1: The Origins of the Center-Weight Watch

With regard to the center-weight design (Chapter 12, page 139):

> We do not know *who* designed the mechanism.
>
> We do not know *when* the mechanism was designed.
>
> And we do not know who *made* the existing watches, remembering that the designer and makers could be different people.

It is sensible to draw one conclusion: It is very likely that the center-weight mechanism was derived from the rotor and side-weight designs. Someone who had examined both rotor and side-weight watches realised that a better design could be created by using the best features of both:

(a) A weight supported by an equilibrium spring winding a going barrel.

(b) A weight mounted in the center of the movement, and so having a much larger motion (about 120° rather than only about 40°), coupled with bidirectional winding.

If this is correct, then the center-weight design probably dates from about 1778 and, because I believe the development of the self-winding watch occurred in a short period of time, I think this design was created before the end of 1779. But this is admittedly a guess.

It is tempting to suggest that Perrelet created this design. It is possible that someone (Philipe DuBois?) asked Perrelet to make some rotor watches to Sarton's design. And, having already made side-weight watches, he would have been in the position to create center-weight watches.

But there is no evidence, and this is pure speculation. Other people (including, Perret-Jeanneret, Meuron and Sarton) could be responsible for this design.

Sections A5.5 and A5.6 (page 328) examine the center-weight movements. Although they are visually and technically similar, these movements have some significant differences. They are probably based on the same calibre, but it is almost certain that they would have been made separately and it is likely that they were made by different watch makers.

21.2: The Gschwind Center-Weight Movement

The suggestion that the center-weight design was derived from the rotor mechanism appears to be supported by the Gschwind movement; see Section 12.3, page 144. In Section A5.7 (page 331) the Gschwind movement is compared with the rotor and other center-weight movements. It is clear that this movement is not related to the other center-weight movements, because they are based on a completely different calibre. But it is almost certainly related to the rotor movements.

However, it was not made by modifying a rotor movement or rotor ébauche. If it was then the fusee, barrel, escapement and train would have to be discarded, a new barrel, escapement and train made, and some other components adjusted or moved. This is too much work and it would be easier to make a new movement.

Because none of the center-weight movements can be dated accurately, we do not know which was made first, the Gschwind "transitional" movement or the more common design. Indeed, they may be independent developments and unrelated. However, the stop-works on the barrels (see Figure 12-17, page 142, and Figure 12-26, page 145) are almost identical, suggesting that they are related. (They are different. The boss of the center-weight stop-work acts on the arm of the spring that forms the annulus, whereas the boss of the Gschwind movement acts on the annulus itself.)

The most important difference is the way the weight is locked. In Appendix 7.9 (page 377) I discuss the need for instantaneous locking, which is not possible in practice. The center-weight movements have a ratio of about 3.5:1; that is, if the annulus is raised 1 mm then the locking pin will be raised about 3.5 mm (Figure 12-20, page 143). The rotor movements are not as good, having a ratio of about 2:1 (Figure 7-32, page 73). However, the Gschwind movement does not use a lever and its method of locking is poor because the locking pin is raised relatively slowly.

Because of its relationship with the rotor movements, it is likely that the maker of the Gschwind movement had made rotor movements and had seen (or perhaps made) side-weight movements. That is, he understood the advantages and disadvantages of both and decided to make a hybrid prototype.

Because the Gschwind movement is less sophisticated than the center-weight movements, and it shows signs of modification, we can be confident that it was not developed from them. And the most likely scenario is that the same watchmaker went on to improve the design and developed the "ordinary" center-weight watches. In which case we can estimate that the Gschwind movement was made in 1778-1779.

However, it is possible that the Gschwind movement is not related in any way to the other center-weight watches.

21.3: Recordon, Perrelet and Breguet

It has not been possible to examine earlier events by considering each person in isolation. And it is not surprising that we must consider Perrelet, Recordon and Breguet together.

The role of Louis Recordon in this history is explained by the letter in the *Nouveau Journal Helvétique* dated 1 September 1780 (see page 101 and Figure 8-20). Unfortunately, this letter is ambiguous because of the punctuation and the use of the word "he" to refer to two people, Recordon and the master he worked with. However, it is not difficult to clarify the meaning:

> *It has been nearly two years since ...*

That is, the writer is referring to events that occurred about October or November 1778.

> *... a young man, working in watchmaking with one of our best Masters ...*

That is, Recordon was working with a watchmaker in the Principality of Neuchâtel.

> *... who ... arrived, through research, at the [self-winding] mechanism which makes the merit of this work.*

This clearly refers to the master and not Recordon and, because it implies the inventor, the master was probably Abram Louys Perrelet. In addition, the statement of Jeanneret and Bonhôte (see page 43), that Recordon bought self-winding watches from Perrelet, supports this interpretation.

> *This young man ... found the means to remove the secret and withdrew himself to London, where he currently works.*

The writer is inferring that Recordon stole the design, but this is unlikely. There would have been no reason for Perrelet not to freely give the design to Recordon.

> *When he left our mountains, the invention was still in its cradle; he consequently improved it so much ...*

The first "he" refers to Recordon. But whether Recordon or Perrelet improved the design is not clear. Recordon's patent suggests that he did not improve the design and so it is tempting to conclude that the writer is referring to Perrelet. But either way the sentence is dubious. By the end of 1778, Perrelet (and possibly others) had been making side-weight watches for about two years, and the rotor and center-weight watches had been developed. So was the invention still "in its cradle"?

We may assume that Recordon left Geneva not long before these events, with the intention of going to London. So we must ask: Why did he stay in Le Locle and work there? There are two possible explanations:

(a) Recordon was only 22 years old and it is likely that he had very little money. In which case, he may have worked to pay for his trip, stopping in different places to see if he could sell his skills. So it may have been accidental, and very good luck, that he found employment with Perrelet and could see self-winding watches.

(b) While in Geneva, Recordon heard of the self-winding watches being made in Le Locle, and he deliberately went there to find out about them.

Of course, both explanations might be true in part.

It is likely that Recordon had very little money. If he had plenty of money then he would not have needed to work for Perrelet. And, when he arrived in London in late 1778 or early 1779, he would have manufactured self-winding watches himself, instead of getting Spencer & Perkins to make them on his behalf.

Also, lack of money could explain the delay in applying for a patent. At the time, taking out a patent cost a very large amount of money. Earnshaw (1808, pages 4-10) explains why Thomas Wright took out the patent for his spring-detent chronometer escapement. Expressed simply, in 1783 it cost £105 (100 Guineas) to take out the patent and Earnshaw could not afford it. So Wright paid for the patent (and put it in his own name) on condition that each watch made was stamped Wright's Patent and he was paid £1-1-0. In addition taking out a patent was a very complicated process. Although about 60 years earlier, Weiss (1982, pages 289-292) describes the process in detail; at that time the cost was about £98.

It should be noted that the cost of a patent was more than six times the value of a self-winding watch, which was about £16-5 (see page 153).

As we have no indication that the young Louis Recordon was well off, he may have made a similar sort of arrangement with Spencer & Perkins, granting them the right to make watches to his specification.

In which case, it is unlikely that Recordon could afford to buy self-winding watches from Perrelet (assuming he had any to sell), and he probably took drawings with him to London. This is supported by the statement that he "found the means to remove the secret". It is not sensible to suggest that he stole two watches.

Recordon next went to Paris, presumably travelling from Le Locle via Beaune.

According to Chapuis & Jaquet (Section 8.1, page 91), Breguet and Recordon knew each other as early as 1775, although it is more likely that the 28 years old Breguet had a relationship with the family and not the 19 years old Louis in particular. But it is to be expected that at the end of 1778 Louis continued his journey, arrived in Paris, and visited Breguet. It is even possible that he worked with Breguet for a while, to help pay for the rest of his journey.

As Chapuis & Jaquet (1952, page 131; 1956, page 140) put it:

> *... it was due to Recordon that Breguet's attention was drawn to Perrelet's watches, which he admired and improved upon by adopting a more perfected system of pedometer winding. ... Breguet himself, as he never denied, was inspired by one or several earlier systems of self-winding and certainly by Perrelet's invention.*

As noted in Chapter 8 (page 91) Edward Brown stated that Recordon acted as Breguet's agent from 1780.

At the time Breguet had nothing to sell, because he had not yet started making notable watches. And Recordon was not established in London and would have to create a business and contacts from scratch.

So why did Breguet make a 23 or 24 years old person his agent in London?

The most likely explanation is that each person had something to offer the other. Recordon offered Breguet the design of a self-winding watch that was vastly superior to his barrel remontoir system. And in exchange, Breguet offered Recordon the exclusive rights to sell his watches. So they struck a mutually beneficial deal.

In addition, I believe Breguet gave Recordon another design, the verge-fusee design that appears in Recordon's patent. There is no evidence that Recordon was a creative person, and he probably was not interested in watch making. Rather he was a business man aiming to establish a profitable shop in London. This is supported by the fact that, except for his patent and the watches made by Spencer & Perkins, he disappeared from view. Certainly the most important part of his patent was (without much doubt) given to him by Perrelet. But we must note that the patent also included two other mechanisms (Section 8.2, page 91). Whether he invented these or was given them by Breguet or someone else is not clear, but they are very clever designs and are more likely to have come from the brain of Breguet rather than the brain of Recordon. Also, it is possible that Breguet asked Recordon to take out a patent in order to protect Breguet's, and not Recordon's market.

Whether this is correct or not, one consequence cannot be denied. Breguet, realising the advantages of the side-weight design with a going barrel, immediately gave up the barrel remontoir design and started developing his side-weight mechanism.

These events probably happened at the beginning of 1779. Of course it would take some time for Breguet to design and manufacture watches for the London market, probably until 1780. So Recordon astutely filled the gap. When he arrived in London he made a temporary arrangement with Spencer & Perkins to make self-winding watches to "his" design while he was waiting for Breguet to send him watches. And this contract would have been terminated when Breguet became his supplier.

21.4: Forrer and St Martin

Forrer is the second of three mysteries, and he is even more mysterious than Tlustos and Thustas. We do not know his given name, but he also lived in Vienna. We do not know what kind of mechanism he used, and we do not know when he made self-winding watches. Meusel's report of August 1780 (Figure 4-11, page 30) is ambiguous, stating:

> *But I can tell you nevertheless, that here there are watches of this kind that are still working after three years, ...*

Does this mean that Forrer started making self-winding watches in 1777? Or does it mean that other people had been making them and Forrer joined in about 1780?

A late 1777 date is possible. Forrer, like Breguet and Sarton, could have heard of Perrelet's success and designed a watch himself, based on what he had heard, or he could have copied a design. But the only conclusion we can draw is that Forrer may have made a self-winding watch at some time between the beginning of 1778 and 1780, but we cannot be sure until more evidence is found.

Mundschau (2012-2015) notes that in 1779 (Figure 4-10, page 28) Gallmayr stated:

> *But now, by matter of his engraved documentation every approach is possible. ... one may by the post or otherwise send 2 florins and 24 crowns to the house of Mr Gallmayr: after which the inventor will provide the promised instructions, and therefore he gives his guarantee.*

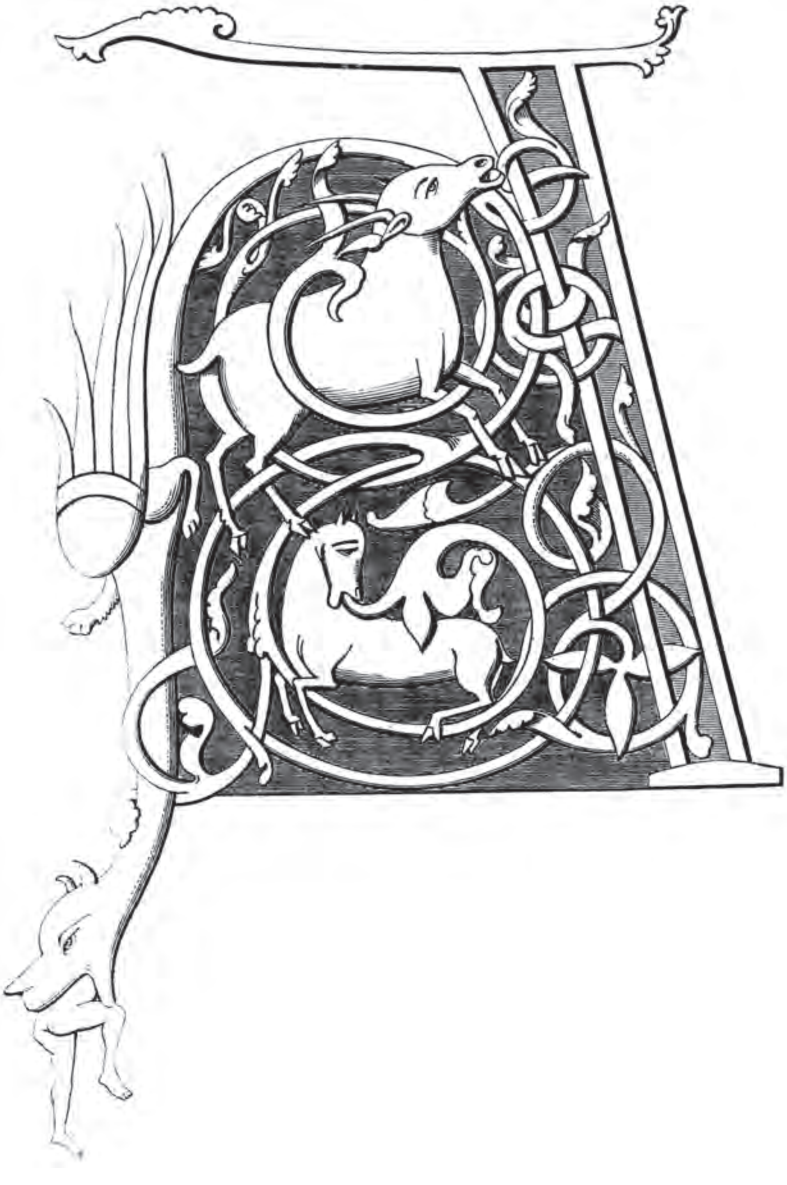
And Mundschau believes that:

> *The old, blind and poor Gallmayr tried to sell a paper copying the plans of Forrer. The text in the Münchner Intelligenzblatt corresponds to the functions we know from Forrer. And Gallmayr, the villain, tried to sell his knowledge!*

This is credible, because I am confident that Gallmayr never made self-winding watches. But he could have copied the design of someone else. At that time Gallmayr stated that he had two watches for sale, but he had never sold a watch to the public (see page 29). Consequently, offering a diagram of "his" watch was unlikely create any interest, and the diagram could have been of some other mechanism than that used by the watches he never sold. Contenders for the source of this engraving would include Perrelet and Christin as well as Forrer.

One statement worth noting is that in Forrer's watch "the pivots run in drilled diamonds" (see page 30). This is not credible. Drilling holes in diamonds is extremely difficult because at that time there was no material to use for the drill which was harder than diamond. So flat diamonds are used as end stones and softer gems, such as ruby, are used for pivot holes.

The last "mystery" is St Martin (Chapter 11, page 137). The only aspect worth noting is that his mechanism can be adapted to ordinary watches, that is, watches with a fusee and verge escapement. This is interesting, but without reliable dates and a description of the mechanism it is impossible to determine if he is significant or irrelevant.



22: Postscript

22.1: From Innovation to Manufacture

It seems that by the end of 1779 all six known designs of self-winding watches had been developed.

Two obvious designs are missing:

(a) There are no early rotor watches with going barrels, and the earliest reference to this design appears to be the 1893 patent of Coviot (see Appendix 4, page 317). However, Sarton's watch did not have a future. Its description was hidden in the minutes of the Paris Académie Royale des Sciences, not to be read for about 178 years. And very few of these watches were made.

(b) There are no center-weight watches with fusees. But if this design was derived from other mechanisms, why would anyone bother creating an unsatisfactory variant?

And so it is not surprising that innovation stopped after these six mechanisms had been created.

At this point the focus changed from innovation to manufacture. Of course the boundary is blurred, but 1780 is a sensible date. By the beginning of that year:

(a) Several Swiss people had started making side-weight mechanisms.

(b) Breguet had begun making his version of the side-weight watch.

(c) And Recordon had arranged for Spencer & Perkins to make these watches in England.

By this date Breguet's barrel remontoir and Sarton's rotor design had passed into history. And, for reasons that I do not understand, the very good center-weight design had appeared only to be ignored.

Just one design, the side-weight with going barrel, remained. And it dominated from 1780 to the advent of the wrist watch. If *dominated* is the right word. At no time were large numbers of these watches made. They were always a minor part of watch making, supplying a few wealthy people intrigued by the idea of an automatic watch.

22.2: The Perrelet Myth

The analysis and interpretation of evidence given in this book has one important feature.

As I have suggested, interpreting evidence can be viewed as the problem of fitting together an incomplete, ambiguous jigsaw puzzle. The history I have presented here has created a coherent picture in which all the pieces fit together: The events, their dates and the people all relate to each other in a credible, satisfying manner.

However, this book is definitely not the last word on the subject:

(a) Other interpretations, other pictures may be possible. Indeed, some people may passionately desire a different view.

(b) New evidence may be found that could agree with or contradict my interpretation of events.

(c) And new books, new tertiary sources, will be written that make some mention of self-winding watches. Some of these will continue to blindly repeat the errors of earlier authors, and some will provide a more realistic view.

But in an ideal world there should be one change. Having presented a rational history here, it should not be possible for people to just state an opinion, a belief. From now on they should justify their views and explain why the evidence supports their version of history as well or better than mine.

The creation of a myth is a simple process.

One or two people, regarded as authorities, reach an incorrect conclusion. Perhaps this is because they did not have access to sufficient evidence. Perhaps it is because they express their beliefs without adequate analysis. Or, as in this history, perhaps it is the result of fictional "facts".

Then other writers copy these sources, repeating these conclusions as though they are real "facts".

And a myth is born. It exists because readers make a fundamental mistake. They assume that if a statement is repeated often enough then it must be true, and frequency replaces logic.

The Perrelet myth is a good example. In 1952 Chapuis & Jaquet made an *almost certain* statement based on a fallacy. And since then many writers have repeated this statement as though it was a fact. But almost no one, including Sabrier, bothered to check the validity of the original statements and reassess the evidence. And so a myth was created, the myth that Perrelet invented the rotor mechanism.

One of the fascinating aspects of this myth is its complete dominance; nearly every writer who mentions self-winding watches comments on the Perrelet myth and nothing else. Even more surprising is that the "expert" books on the subject (by Chapuis & Jaquet and Sabrier) are also satisfied with this one myth and fail to study the other designs and people adequately. Indeed, the book you are reading is the first attempt to create a coherent history.

Unfortunately, I expect many people will ignore my views.

Like most myths, the Perrelet myth will endure. People writing general books on watches and watch making will continue to rely on "experts" and other books for their information, and the overwhelming majority of these people will repeat the Perrelet myth. And so it will be reproduced time and time again.

And advertising will continue to prefer attractive fiction to uninteresting fact. In the history of the brand, Montres Perrelet (2014) make the following statements:

> *History 1729-2014: The inventor of the self-winding watch almost 250 years ago, Perrelet has faithfully cultivated its pioneering, avant-garde spirit ... perpetuating the watchmaking legacy of the brand's legendary founder, Abraham-Louis Perrelet ...*

It appears that the brand Montres Perrelet invented the self-winding watch. But the brand was created about 1995 and there is no link with the past other than using the name Perrelet, which presumably is just a registered trade mark. The history covers 1729-1780 (Abraham-Louis Perrelet), 1781-1834 (the grandson Louis-Frédéric Perrelet), and then skips forward 161 years to 1995. This is not surprising, because there is no evidence for other watchmaking descendants of Abraham-Louis Perrelet in this period. Also, the accompanying portrait is that in Figure 5-15, page 48.

1770: From the 1770s onwards, Abraham-Louis Perrelet applies himself to perfecting a system which, from one single initial impulse, would continue to function indefinitely.

Why perpetual motion is mentioned is a mystery.

It was in 1777 that he develops his completely revolutionary invention – the self-winding or automatic movement.

Montres Perrelet got the date right! Although the type of mechanism is not mentioned, the accompanying photograph is of a rotor watch, which is wrong.

1780: Abraham-Louis Perrelet develops the first podometer ...

There is no evidence that Perrelet ever made a pedometer. And 1780 is too late; for example, Houriet designed a pedometer before or in 1777 (Sabrier, 2006, pages 142-143).

... and also becomes the first person to create watches with a cylinder, duplex, calendar and equation escapements.

Perrelet was not the first person to use cylinder and duplex escapements, which were developed earlier in England and elsewhere. And calendar and equation are not escapements. I don't know why this faux pas was not corrected.

He works on further refining gear trains and improving pinions, gears, the escapement as well as his unique automatic winding mechanism.

Again, there is no evidence that Perrelet did any of these things.

But at least the reader now has an alternative view.

Appendix 1: Documentation

A1.1: Maps

Figure A1-1 shows the main locations in Europe that are mentioned in this book.

Figure A1-2 is a map of Neuchâtel reproduced from Meissner (1838).

A larger map of Neuchâtel and Vallengin is available from Watkins (2014). That map, which consists of four A4 pages, has been reproduced from Bernoulli (1783).

Figure A1-1

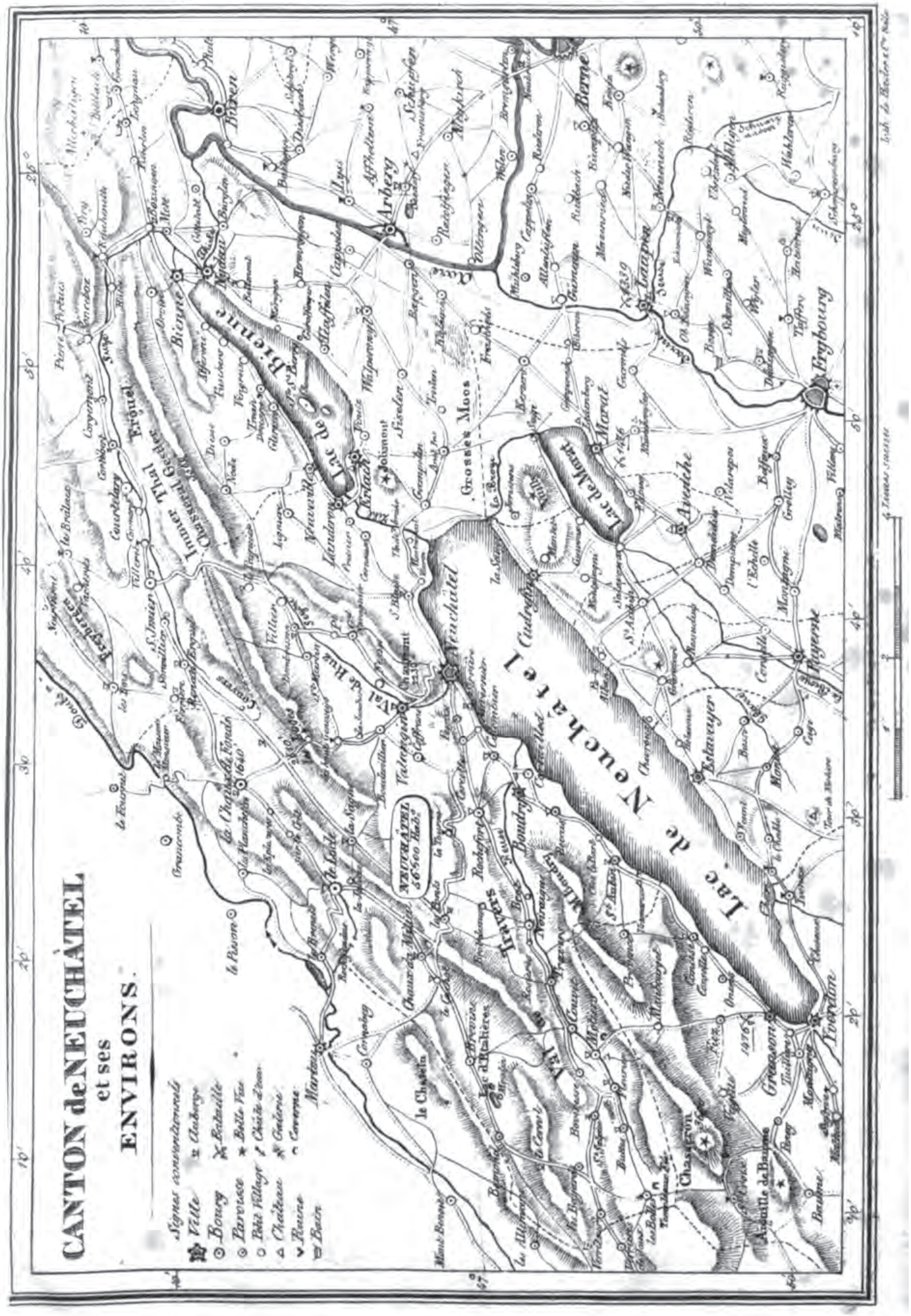

CANTON de NEUCHÂTEL
et ses
ENVIRONS.
Signes conventionnels
Ville
Bourg
Paroisse
Petit Village
Château
Ruine
Bain
Lac de Neuchâtel
Lac de Bienne
Lac de Morat
Neuchâtel
Berne
Fribourg
Yverdon
Bienne
Estavayer
Payerne
Avenche
Morat
Grosses Moos
Travers
Boudry
Grandson
Arberg
Büren
Nidau
Cudrefin

Figure A1-2

A1.2: References

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"... it was in the eighteenth century that the montre à secousses, or jerk-winding watch, made its appearance. ... in recent years, evidence has pointed to Abraham-Louis Perrelet ... as the most probable begetter." Said to have been written by Chapuis and Jaquet. Quotes Jeanneret & Bonhôte (1863).

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"... approximately 1770 with the 'montres perpétuelles', also named "montres à secousse', made by Abraham-Louis Perrelet." "A. L. Perret (sic) is considered the inventor not only of the automatic winding with centrally situated rotor ... but also of the construction with a winding weight positioned at the side of the movement."

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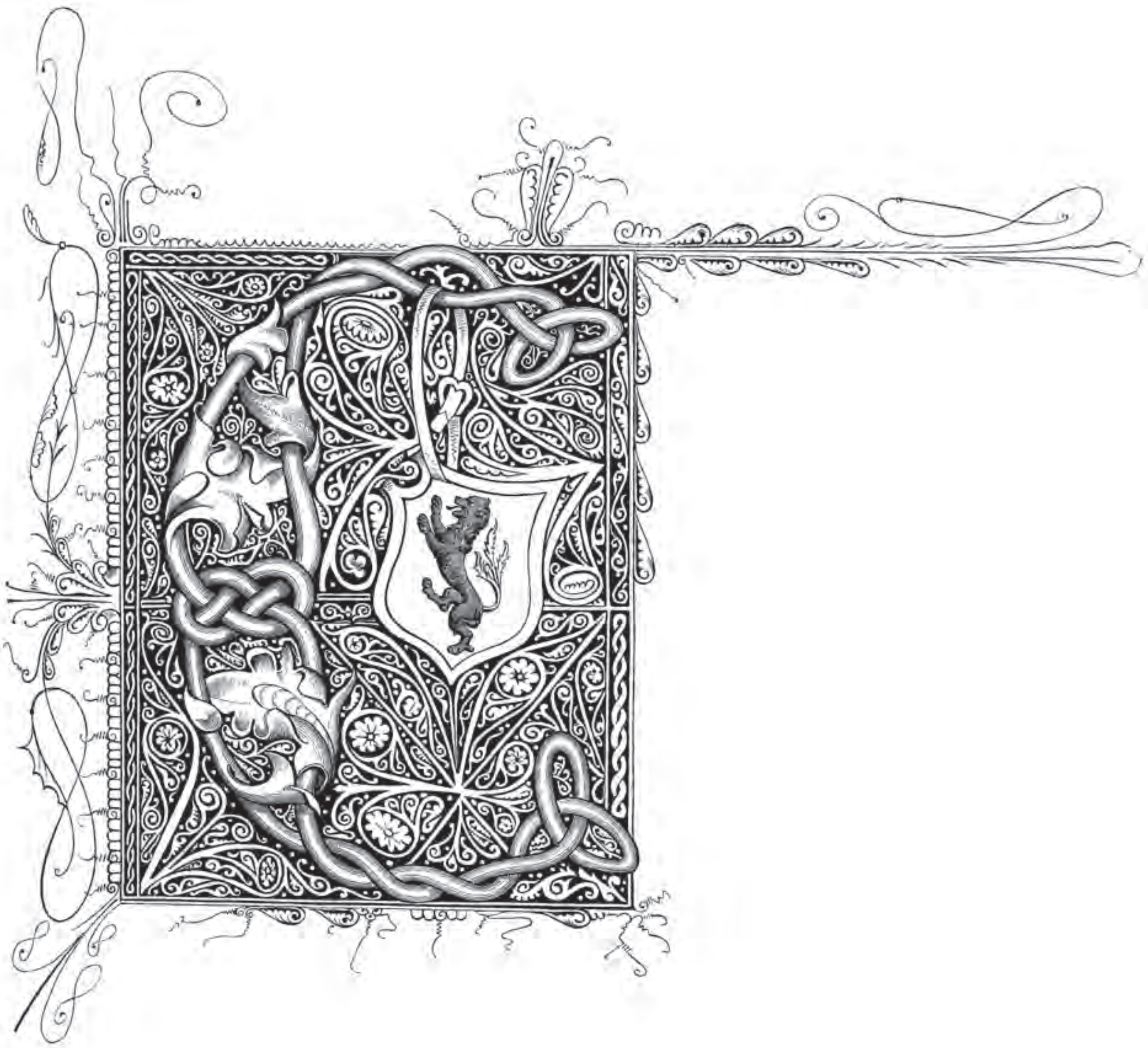


Appendix 2: DuBois Case Makers

A2.1: Available Evidence

The focus of this appendix is on *case signatures*. These signatures are letters, stamped into the cases, which identify the case maker.

As we have pointed out, only a small fragment of the company records remain (DuBois, 1758-1824), and only a few provide information on case making. Although some names of case makers appear elsewhere, the main entries form three distinct groups:

1758 to 1777: *Grand Livre D'horlogerie pour sour Philipe DuBois & Soeur Du Locle* and *No. 1 Grand Livre Pour Philipe DuBois* (Books 1 and 2) include case purchases. These entries often include case signatures as well as names, as in Figure A2-1 (DuBois 1758-1824, *Book 1*, page 21).

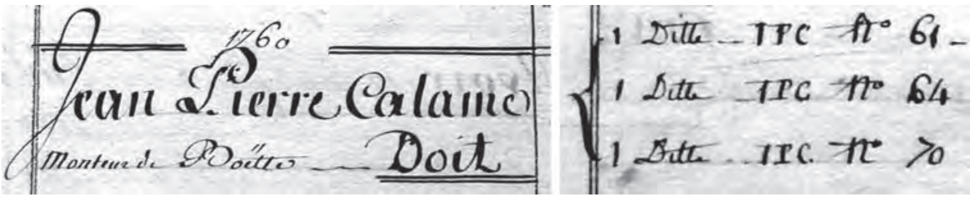


Figure A2-1

1785 to about 1794: *Grande Livre A No 1 Pour Philipe DuBois et Fils* (Book 5) is one of the most valuable, because it contains many purchases of cases. However, only names are given, and there are no case signatures.

Inventories: 1798 to 1823: With one exception (1812) these inventories have many entries giving case signatures without names. These entries are for cases in the houses of workers, who are often named, as in Figure A2-2 (DuBois 1758-1824, *Inventory 1798*, page 64). It is most likely that they are performing additional work, probably engine turning (guillochage), engraving and piercing (for repeaters). However, there may be other reasons, and we believe at least one of these people was probably a watch maker.

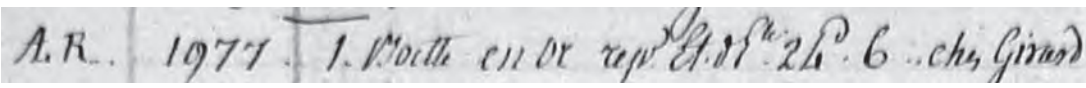


Figure A2-2

In the above example, the case maker's signature is *ALR* with the *A* and *L* joined (Abram Louys Robert), and 1977 is the serial number of the case. It is a gold case for a repeater, weighing *24d 6* (24 deniers, 6 grains) which is in the house of Girard (probably Othenin Girard). The letters *Et d'...* probably refer to an *etuy* (an outer case) of some material.

We believe these letters are case signatures for four reasons:

(a) They are always associated with entries for cases.

(b) The style in which they are written is different from the normal handwriting used in the books and inventories.

(c) Joined letters, such as *ALR* above, only appear in this context.

(d) Three entries, *IPN*, *JPN* and *PHMI*, are written on two lines. Although this may have been done because of a lack of space in the case of *PHMI*, the other two appear to have been written deliberately in this form.

In addition, the 1807, 1809, 1816 and 1819 inventories give signatures instead of names for the workers; for example, Figure A2-3 (DuBois 1758-1824, *Inventory 1807*, page 109).

Figure A2-3

In this instance, the worker *CFM* has 6 cases made by *ALI* (with the A and L joined) in his house. These cases, with serial numbers 6522 to 6527, are silver, English style cases. We know that *CFM* is a *chez* (in the house of) *signature* because the column is headed *chez*.

Most of these entries are for cases, and so it is possible these workers are also case makers and the letters are their case signatures. However there are other entries where the worker has gold dials or case domes (cuvettes), and one strange entry for *CHW*, see Figure A2-4 (DuBois 1758-1824, *Inventory 1819*, page 46). Elsewhere on the same page, *CHW* is listed as having 24 cases made by *JPN* in his house, so why did he also have 11 cylinder escapements?

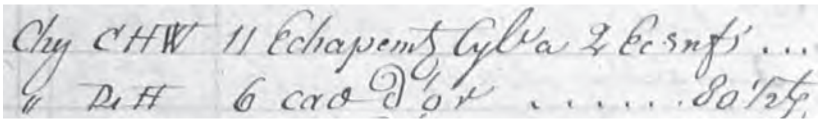


Figure A2-4

So, although we will examine these signatures, they must be treated with care.

Unfortunately, the books covering 1795 to 1824 contain almost no purchases and include very few names of case makers. Of the 210 entries which specify *monteur de boette*, only 10 are dated 1795 or later, and these specify only seven different names, of which three may be irrelevant because they lived too far from Le Locle.

This creates a serious problem, because nearly all the signatures date from 1798 to 1823 when we have no information on case makers.

To fill in part of the following tables, we have included information from Bourdin (2012), marking it with *(B)*. All other information comes from DuBois (1758-1824). Apparently Bourdin did not use the DuBois archives and many names in the following lists do not appear in his book. Indeed, we found only two or three additional names.

A2.2: Case Makers 1758-1824

Table A2-1 lists all case makers mentioned in the DuBois books between 1758 and 1824. Some names are duplicated when there is doubt or a change of location.

Name	Location	Dates
Baillod, David François	Le Locle	1788-1794
Baillod, Leonard	Anvers	1788-1891
Bernier, François	Neuchâtel	1782-1794
Bock, Fredrick	Le Locle	1788-1789
Boillad, Isaac	Le Locle	1793-1794
Boyard, Isaac		1791-1793
Brandt, David	Le Locle	1764-1788
Brandt, Dl Louys		1798
Brandt, Jacob		1785-1787
Brandt, Pierre Louys		1767-1774
Calame	Venise	1801
Calame, Abram	Le Locle (B)	1774-1778
Calame, Jean Pierre		1760-1764
Christin, Louys	Yverdun	1796
Comtesse, David Henry	Le Locle	1786-1793
Constantin	Le Locle (sur le Mont)	1759-61
Courvoisier, Abram Louys		1790
Courvoisier Clement, Jonas	Le Locle (B)	1759-1760
Desrogis	Geneve	1791-1793
Didet		1765
Diedey, Jean	Le Locle	1785-1788
Diedey, Jean	Jaluza	1788-1791
Diedey, Jean	La Cler	1791-1793
Droz, Abram Louys		1778-1785
Droz dit Busset, Abram Louys	Jeanerets	1781
DuBois		1758-1773
DuBois, Abram Louys	Le Locle	1786-1793
DuBois, Abram Louys	Anvers	1788-1790

Table A2-1 a

Name	Location	Dates
DuBois, Charles Fredrich		1793-1794
DuBois, David	Le Locle (B)	1773
DuBois, Jean Charles	Le Locle	1785-1794
DuBois, Pierre	Le Locle (sur le Mont)	1784-1790
DuBois, Samuel	Le Locle	1785-1789
Favre Bulle		1769
Favre Bulle, Charles Fredrich	Le Locle (sur le Mont)	1785-1794
Favre Bulle, Daniel	Le Locle (sur le Mont)	1785-1786
Favre Bulle, Jean Fredrich	Le Locle (sur le Mont)	1773-1789
Gentil, David Guillaume	Replates	1785-1791
Gros Claude, Olivier	Verges	1794
Gros Claude, Samuel	Le Locle	1793-1794
Guinand, Abram Louys	Sernilles Girard	1790-1793
Guinand, Moÿse	Tartelles	1790-1794
Guyot, Daniel	Verges	1771-1791
Hugnin		1769
Hugnin, Abram	Fernayes	1761
Hugnin, Daniel		1764-1765
Hugnin, Les Freres	Jaluza	1759-1761
Hugnin Wirchaux, Abram Louys		1759-1771
Huguenin, Louys	Jaluza	1787-1789
Huguenin, Louys	Anvers	1792-1794
Humberd, B	Auvernies	1790
Jacot, Blaise		1767
Jacot, David Fredrich		1778-1782
Jacot, David Louys		1774-1782
Jacot, Jeanjaques		1767
Jacot des Combes, David Louys	Le Locle (B)	1785-1787
Jeanneret, Daniel		1788-1789
Jeanneret Gris, Abram		1776
Jeanneret Gris, Charles Henry		1789
Jeanneret Gris, Jean Pierre	Le Locle (B)	1776

Table A2-1 b

Name	**Location**	**Dates**
Jeanneret Gris, Jeanjaques		1790-1793
Jeanneret Gris, Pierre *(Fredrich (B)*)		1759-1764
Jeanneret Grosjean, Abram Louys	Renand	1789-1792
Jeanrenaud	La Chaux-de-Fonds	1794
Kniber		1767
L'Huillier Fils	Le Locle (Billodes)	1789-1794
L'Huillier, François	Geneve	1792-1794
Le Roy, Les freres	Le Locle (Cret Vaillant)	1786-1787
Le Sage, Andres	Geneve	1777-1794
Matthey		1769-1771
Matthey, Auguste		1794
Matthey, Daniel	Le Locle (Le Comun)	1793-1794
Matthey, David Fredrich	Le Locle (Cret Vaillant)	1793-1794
Matthey, Jonas Daniel		1794-1795
Matthey & Comtesse	Le Locle	1786-1792
Matthey d'Heuret		1758-1762
Matthey Doret, Charles Philipe		1791-1792
Matthey Doret, Jn Dl		1794
Matthil, Daniel Fredrich	Verges	1785-1794
Matthil, Daniel Fredrich	Le Locle	1798
Matthil, Henry Louys	Le Locle	1791-1793
Oltramare, Jaques	Geneve	1791-1793
Othenin Girard, David Louys	Le Locle (B)	1786
Othenin Girard, Moÿse		1767
Parisse, Jeremie	Le Locle	1785-1788
Perrelet, Abram Louys	Le Locle (Le Comun)	1773-1791
Perrelet, Josue	Le Locle (B)	1773
Perrelet, Samuel		1790-1791
Perrenod		1789
Perrenod & Jacot	Le Locle (sur le Mont)	1787-1789
Perret, Charles Fredrich		1785
Perret, Charles Henry	Eplatures	1801-1803

Table A2-1 c

Name	**Location**	**Dates**
Perret, Jeanjaques	Eplatures	1790-1793
Perret Gentil, Charles Fredrich		1786-1789
Perret Gentil, Jacob	Renfort	1760-1765
Perret Jeanneret, Jacob	Le Locle	1774-1794
Petit Pierre, Jonas Pierre	Le Locle (B)	1759-61
Petit Pierre, Jonas Pierre	Verges	1786
Quartier, Jean David	Brenets	1791-1794
Renand, Jean		1794
Robert, Abram Louys	Eplatures	1791-1794
Robert, Esaye		1759
Roulet, Samuel	La Chaux-de-Fonds	1801-1803
Sabon, Daniel	Geneve	1787
Schraid, Jean Louys	La Chaux-de-Fonds	1787
Spingler	Le Locle	1792-1793
Tissot Daguette (carosse case)		1765
Vincent, Ph Andres	Geneve	1788-1791
Vuagneux, Henry François	Le Locle	1791-1794
Wagneux	Amsterdam	1809-1814

Table A2-1 d

A2.3: Case Production 1758-1794

Table A2-2 lists all known case purchases by Philipe DuBois between 1758 and 1794; there is no information after that date. It is sorted by the first date recorded for each person. Names in this list that do not appear in Table A2-1 may not be case makers.

Explanatory notes are at the end of the table.

Dates	**Name**	**Type**	**Number**
1758-59	Matthey d'Heuret	Sim	15
1759-61	DuBois, Freres		140
1759-61	Constantin	Etuys, 1 case	45 + 1
1759-60	Courvoisier Clement, Jonas	Gold, Silv	9
1759-61	Hugnin, Les Freres		24
1759-61	Hugnin Wirchaux, Abram Louys		13
1759-64	Jeanneret Gris, Pierre	Gold, Rep	14
1759-61	Petit Pierre, Jonas Pierre		39
1759	Robert, Esaye		3
1760	Calame, Jean Pierre		4 + 14 (a)
1760-65	Perret Gentil, Jacob	Gold, Silv	28
1761	Ador	Gold	2
1761	Calame, Jean Pierre	Etuy	1
1761	Hugnin, Abram		1
1765	Calame	Silv	10
1765	Didet		21
1765	Didet	Etuy	5
1770-76	Bonnet, George		33
1774-77	Marre, Marc & Fils	Etuy	342
1774-77	Marre, Marc & Fils		53
1775-90	Le Sage, Andres	Sim	321 + 746 (a)
1782-94	Bernier, François	Etuy	41 + 1013 (a)
1785-88	Brand(t), David	Gold	705
1785-87	Brandt, Jacob	Etuy	417 +174 (a)
1785-88	Diedey, Jean	Etuy?	1137 (a)
1785-94	DuBois, Jean Charles	Silv	1077 + 1788 (a)

Table A2-2 a

Dates	Name	Type	Number
1785-87	DuBois, Samuel	Gold	148
1785-91	Gentil, David Guillaume	Silv	23
1785	Jacot, David Louys	Gold	1
1785	Matthil, Les Freres	Gold	13
1785-88	Parisse, Jeremie	Gold	564
1786-90	DuBois, Abram Louys	Silv	13
1786-90	Favre Bulle, Jean Fredrich	Silv	6 (b)
1786	Favre Bulle, Daniel		3
1786-87	Guyot, Daniel		17
1786-91	Perrelet, Abram Louys		109
1787-93	Comtesse, David Henry (e)	Gold	90
1787-88	Favre Bulle, Charles Fredrich		16
1787-89	Huguenin, Louys	Gold	68
1787	Le Roy, Les freres	Gold	3
1787-89	Perrenod & Jacot	Gold	311
1787-89	Perret Gentil, Charles Fredrich	Gold	5
1787	Sabon, Daniel	Silv	13
1787	Schraid, Jean Louys	Silv?	26
1788-94	Baillod, David François	Gold	840 + 191 (a)
1788-90	Baillod, Leonard	Gold	323
1788-89	Bock, Fredrick	Gold	43
1788-91	Diedey, Jean		(f)
1788-90	DuBois, Abram Louys	Gold	345
1788-89	Jeanneret, Daniel	Gold	17
1788-91	Vincent, Ph Andres		767 + 137 (a)
1789	Jeanneret Gris, Charles Henry	Gold	113
1789	Jeanneret Grosjean, Abram Louys		394 (a)
1790-92	DuBois, Abram Louys	Gold	363
1790	Courvoisier, Abram Louys	Silv?	61
1790-92	Desrogis		59 + 670 (a)
1790-93	Guinand, Abram Louys	Silv	27
1790-94	Guinand, Moÿse		68

Table A2-2 b

Dates	Name	Type	Number
1790	Humberd, B	Gold	22
1790-93	Jeanneret Gris, Jeanjaques		(c)
1790-94	L'Huillier	Etuy	2615 (a) (d)
1790-91	Perrelet, Samuel		81
1790-93	Perret, Jeanjaques	Silv	47
1791	Boignard		1 (a)
1791-93	Boyard, Isaac		156
1791-93	Diedey, Jean	Silv?	2642 (a)
1791-92	Matthey Doret, Charles Philipe	Gold	50
1791-93	Matthil, Henry Louys		505
1791-93	Oltramare, Jaques	Sim	135 + 409 (a)
1791-94	Quartier, Jean David		1992 (a)
1791-92	Raisin, Jean Louys	Sim	109
1791-94	Robert, Abram Louis	Gold	571
1791-94	Vuagneux, Henry François	Gold	393
1792-94	L'Huillier, François		115 (a)
1792-94	Matthil, Daniel Fredrich	Gold	912 + 406 (a)
1792	Spingler	Silv	4 (a)
1793-94	Boillad, Isaac	Gold?	174
1793-94	Diedey, Jean	Etuy	853 (a)
1793-94	DuBois, Charles Fredrich		18
1793-94	Gros Claude, Samuel	Gold	402
1793-94	Matthey, David Fredrich		190
1794	Gros Claude, Olivier	Gold?	40
1794	Matthey, Auguste	Gold	41
1794	Matthey, Daniel	Gold	42
1794	Perret Jeanneret, Jacob	Gold	161

Table A2-2 c

Notes for Table A2-2:

(a) Estimated from values using average prices of cases. Because case prices vary significantly, these numbers are only indicative of the magnitude of the work.

(b) *façons de boettes en or*.

(c) *Pour ouvrages*, to the value of £242-4-7 (probably engine turning, guillochage).

(d) Plus *Pour ouvrages*, to the value of £11,770-5-0. The type of work is not known.

(e) Originally Matthey & Comtesse.

(f) *Pour ouvrages*, to the value of £15,782-11-7. The type of work is not known.

(g) Type of work:

Eng: Engine turning (guillochage).

Etuy: Outer protective case.

Rep: Case for repeater.

Sim: Similord (imitation gold) cases including Pinchbeck.

Silv: Silver cases.

The above table lists about 27,179 cases. By 1794 DuBois had produced about 55,600 watches (see Appendix 3). Either half the watches were purchased as complete with cases or, quite likely, many case purchases appeared in books that have been destroyed.

A2.4: Case Signatures

As noted above, the DuBois archives include many entries giving case signatures, and almost all are without names; nearly every name is earlier than 1795 and nearly every signature is after 1795.

These signatures are given in two tables.

Table A2-3 lists signatures and names that are correct, because both name and signature appear in purchases. All of these purchases were made before 1771.

A number of problems should be noted:

(a) Three signatures, *AH*, *IPG and PIG*, appear in the books more than 40 years after the purchase records which link the signatures to the names. It is not clear if the late entries refer to the same person, or perhaps to a son using the same signature. Bourdin (2012) does not list anyone with the name Hugnin and uses the spelling Huguenin. He lists Abram Huguenin as shown in the table.

(b) Of the 13 cases sold by Abram Louys Hugnin Wirchaux, the 12 sold in 1759 have the signature *ALHV*, but the single case sold in 1761 is listed with the signature *ALH*. This might be a mistake.

(a) The signature *IPIG* does not match the name. It may be that DuBois omitted one given name as Bourdin (2012) lists Jean Pierre Jeanneret-Gris. However, DuBois lists Pierre Jeanneret-Gris (1758-1780) *and* Jean Pierre Jeanneret-Gris (1767-1776), both case makers, and they may be two different people.

To add to the confusion, in 1759 DuBois bought 9 cases signed *PIG* from Pierre Jeanneret-Gris, and in 1764 he bought 5 cases signed *IPIG*, apparently from the same Pierre Jeanneret-Gris. But there are no records of case purchases from Jean Pierre Jeanneret-Gris.

(a) The signatures *DLH* and *SDB* do not match the names, and they are probably those of Daniel Hugnin and Samuel DuBois. It appears that, as in England, signatures must be of individual people and not companies.

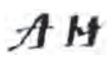
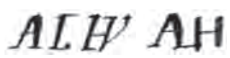
Signature	Initials	Name	Dates
	AH	Abram Hugnin. *Abram Huguenin 1769 (B)*	1761, 1802, 1809
	ALHV	Abram Louys Hugnin Wirchaux. *Huguenin-Virchaux (B)*	1759, 1771
	DB	David Brandt	1764-65
	DLH	Les Freres Hugnin (Daniel Hugnin?)	1759-61
	ER	Esaye Robert	1759
	ICC	Jonas Courvoisier Clement	1759-60
	IIC	Constantin	1759-61, 1771
	IPC	Jean Pierre Calame	1760-61
	IPG	Jacob Perret Genti*l (B)*	1760-61, 1807
	IPIG	*(Jean)* Pierre Jeanneret Gris	1764-65
	IPPP	Jonas Pierre Petit Pierre	1759-61, 1771
	PIG	Pierre Jeanneret Gris	1759, 1802
	SDB	Les Freres DuBois (Samuel DuBois?)	1758-61

Table A2-3

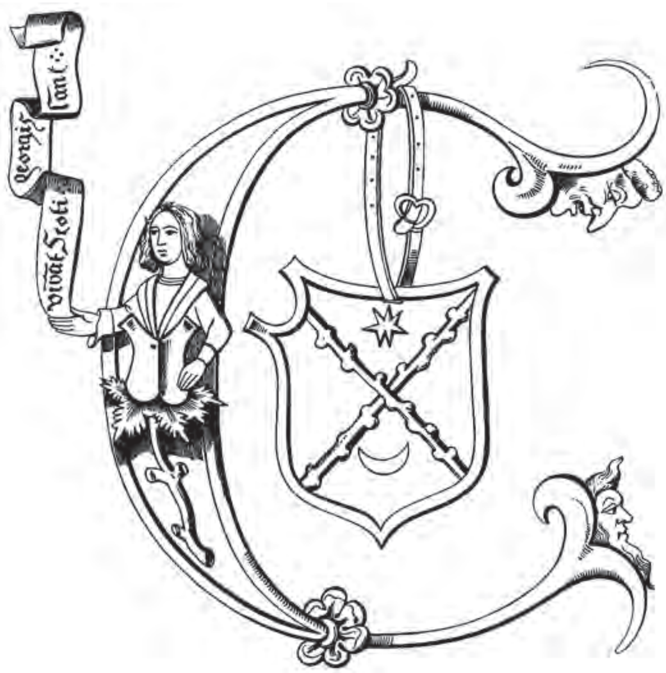


Table A2-4 lists all other case signatures in the DuBois books and inventories between 1758 and 1823. It is sorted by the case initials. By 1823 DuBois had produced over 305,000 watches, about 250,000 of these between 1795 and 1823. Thus there must have been considerable purchases for which we have no evidence, which probably included new case makers not used before, and our only information comes from these signatures.

In addition to providing the signatures, we have attempted to attribute names to them. With regard to these names, Table A2-4 has two types of entries:

(a) Bold text: These names are probably correct, because we have found only one name with appropriately dates, which could be allocated to the signature. These names come from Tables A2-1, Table A2-5, and Bourdin (2012).

(b) Normal text: These names are probably correct, because we have found only one name that could be allocated to the signature, but at different (although possible) dates. These names come from Table A2-1 and Bourdin (2012)

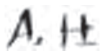
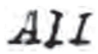
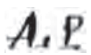
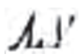
Signature	Initials	Name	Dates
	AC	Abram Calame *(B)*	1804-1807
	ADV		1771
	AeC		1804
	AG		1823
	AH	**Abram Hugnin** (see Table A2-3)	1802-1809
	AI		1771
	AIG	Abram Jeanneret Gris	1761, 1771
	AII		1802
	ALH	Abram Louys Hugnin Wirchaux (see Table A2-3)	1804-1816
	ALI	**Ab L Jaquet** (see Table A2-5)	1804-1816
	ALP	Abram Louys Perrelet	1809-1819
	ALR	Abram Louys Robert	1798, 1801-1804
	ALV		1807

Table A2-4 a

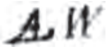
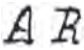
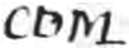
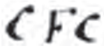
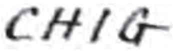
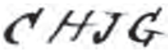
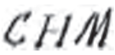
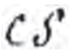
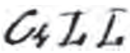
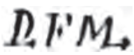
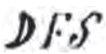
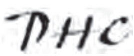
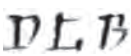
Signature	Initials	Name	Dates
	ALW		1807
	AR	Probably ALR	1802
	CDM		1798-1802
	CDML		1798-1802
	CFC		1809
	CFDB	Charles Fredrich DuBois	1798
	CHIG	Charles Henry Jeanneret Gris	1819
	CHJG	Charles Henry Jeanneret Gris	1819
	CHL		1816-1823
	CHM, CHML		1802-1807
	CL	Charles Lorimier (B)	1798-1823
	CP	Charles Peter (B)	1798
	CPG	Charles Fredrich Perret Gentil?	1809-1816
	CS		1802-1807
	CsLL?		1804-1809
	D&B		1823
	DFB	David François Baillod	1798-1804
	DFM	Daniel Fredrich Matthil	1802-1816
	DLFML?		1798-1809
	DFS		1807
	DHC	David Henry Comtesse	1804-1809
	DLB	Daniel Louys Brandt	1798

Table A2-4 b

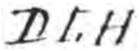
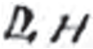
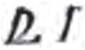
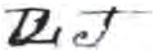
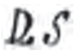
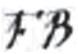
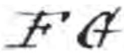
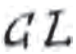
Signature	Initials	Name	Dates
	DLH		1804-1807
	DLH	Daniel Hugnin	1807
	DLI	David Louys Jacot Daniel Jeanneret	1809-1821
	DLJ		1819
	DLS	D L Sandoz D L Savoye (see Table A2-5)	1807
	DPV?		1802
	DR		1802
	EW (FLW?)		1798
	FB	François Bernier Fredrick Bock Frederic Bourquin (B)	1809
	FG		1819
	FHM		1816
	FIG		1802
	FLB		1807-1823
	FLP		1816-1823
	FP		1807
	GB		1798-1823
	GBF		1771
	GL		1802
	GR		1823
	HLBL		1809-1819

Table A2-4 c

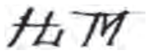
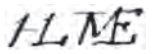
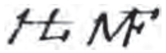
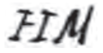
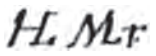
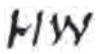
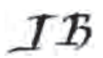
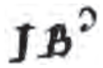
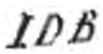
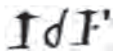
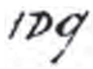
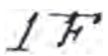
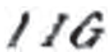
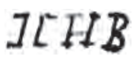
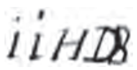
Signature	Initials	Name	Dates
	HLM	Henry Louys Matthil	1819
	HLME		1819
	HLMF		1819
	HLML	Henry Louys Matthil	1802-1819
	HM		1802
	HMr		1809
	HRT		1819-1823
	HW		1798
	IB	Isaac Boillad Isaac Boyard	1798
	IBd	Isaac Boillad Isaac Boyard	1798
	ICDB	Jean Charles DuBois	1802
	ICDB	Jean Charles DuBois	1802-1804
	ID	Jean Diedey	1802-1804
	IDB		1807
	IDD		1804
	IdF		1798
	IDg		1804
	IF		1816-1819
	IIG	Jeanjaques Jeanneret Gris	1802
	IIHB?		1802-1807
	IIHDB?		1802-1804

Table A2-4 d

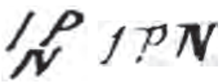
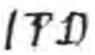
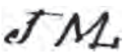
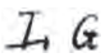
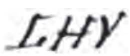
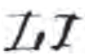
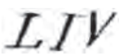
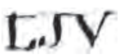
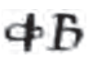
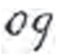
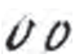
Signature	Initials	Name	Dates
	IML		1821
	IPL?	Josue Perrelet?	1773
	IPD		1798
	IPG	Jacob Perret Gentil	1807
	IPN		1816-1819
	IPTD?		1798
	JF		1819-1823
	JML		1819-1823
	JPN		1819-1823
	LG		1802-1819
	LHV		1804-1807
	LI		1816
	LIV		1821
	LJV		1821-1823
	LR		1819-1823
	NG		1804
	ØB		1798
	Og		1807
	OO		1802
	ØPG		1804-1809
	OQ	Olivier Quartier?	1802-1804

Table A2-4 e

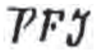
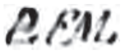
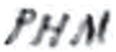
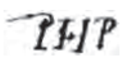
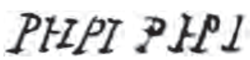
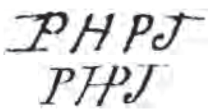
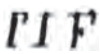
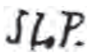
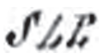
Signature	**Initials**	**Name**	**Dates**
	PFIG	Pierre *(Fredrich (B))* Jeanneret Gris	1804
	PFJ	P F Jeannot	1798
	PFM?		1802
	PG		1804-1809
	PHM		1802
	PHMD		1819-1823
	PHMI		1802-1816
	PHP		1807
	PHPI		1802-1816
	PHPJ		1819-1823
	PI		1798
	PIF		1798
	PIG	Pierre Jeanneret Gris?? (see IPIG)	1802
	PLB		1771
	SGC		1798
	SLP		1802
	SLPL		1802
	THR		1816
	W&F		1816

Table A2-4 f

A2.5: Chez (in the house of) Signatures

As noted above, the DuBois archives include many entries giving case signatures where the cases are in the houses of workers, identified by their names or by signatures. Table A2-5 lists these *chez names*. Table A2-6 lists the *chez signatures* with attributed names from Table A2-5. It is not surprising that there is a good correlation between the two lists.

Name	Date	Name	Date
Bole (Cesar or Samuel?)	1798	Girard, F O (Freres Othenin?, B)	1802
Bourquin, D L	1816	Girod, P	1809
Bourquin, R (Roy, CdF)	1816	Girod Bosset (Pierre)	1804
Brandt, F L	1816	Grandjean, D H	1809
Brandt, J P (Jacob, M, Cdf)	1798	Guinand, Ch Dl (B)	1798, 1804
Calame, B	1809	Guyot, Ab H	1798
Calame, Dl Hy	1809, 1816	Guyot, D P	1809
Carrel, Fs Ls	1798	Huguenin, Dd Fs	1798-1804
Cattin, J	1816	Humberd, Ch (L)	1798
Chevalier (E, V)	1798	Jacot, J H	1816
De La Chaux, D	1816	Jacot, Ph H	1816
De La Chaux, Sim	1809	Jaquet, Ab L	1809
Droz, Ch (Ne)	1798, 1816	Jaquet, C F	1809
Droz, V (Vict), horloger (B)	1804	Jeanneret, Dd F	1804, 1809
Droz dit Busset, Dd, horloger (B)	1804	Jeannot?, Ch Dl	1798
DuBois	1798	Jeannot, Dl Hry	1798-1816
DuBois, A Ls (M)	1809	Jeannot, P F	1804
DuBois, Ph	1809	Matthey, A	1804
DuBois, S P (Samuel, M, L)	1804	Matthey, H F	1809
Favre, Ab & Fils (W, L)	1798-1816	Matthey, Julien	1809
Favre, Amy	1798?, 1809	Matthey?, Ch	1798
Gabus, Ph H	1809	Montandon, Hy	1816
Ginel (Ginnel?), Ch A	1816	Nicolet, Ch	1798
Ginnel, Augte (W)	1809	Othenin Girard, Dl	1804
Ginnel, Ch Hy	1816	Perrelet, A L (M)	1804, 1816
Ginnel, L A	1809	Perret, Ch H (M, Ep)	1804, 1809

Table A2-5 a

Name	Date	Name	Date
Girard	1798, 1801	Perret, Dd Ls & Fils	1804
Perret, F H	1802	Tissot, Dl	1804
Robert, Th?	1809	Vuille, Jh	1804
Sandoz, Aug (Auguste)	1804	Vyss, J F	1804
Sandoz, Dd Ls	1809	Wibelet, Matt	1804
Savoye, D L	1798, 1804	Wuille, Ch H (S)	1816
Savoye, J C	1798	Wuillemin Freres	1798
		Wuillemin, D L	1804

Table A2-5 b

Notes for Table A2-5:

E:	Etuy (outer case) maker	M:	Case maker	W:	Watchmaker
B:	Brenets	CdF:	La Chaux-de-Fonds	Ep:	Eplatures
L:	Le Locle	Ne:	Neuchâtel	S:	La Sagne
V:	Verges				

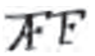
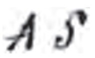
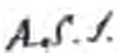
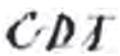
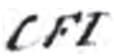
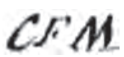
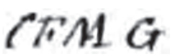
Signature		Name	Location
	AFF	Ab Favre Fils	Le Locle
	ALI	Ab L Jaquet	
	AM	A Matthey	
	AS	Auguste Sandoz	
	ASI?		
	CAG	Ch A Ginel	
	CDI	Ch Dl Jeannot?	
	CFI	C F Jaquet	
	CFM	Ch Matthey?	
	CFMG		
	CHP	Ch H Perret	Eplatures

Table A2-6 a

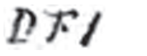
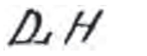
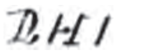
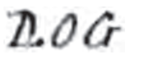
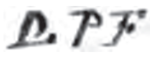
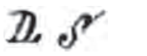
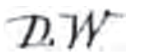
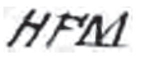
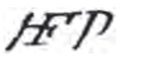
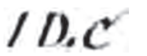
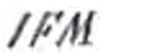
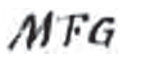
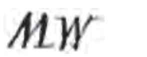
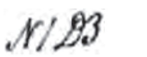
Signature		Name	Location
	CHW	Ch H Wuille	La Sagne
	DFI	Dd F Jeanneret	
	DLH		
	DLHI	Dl Hry Jeannot	
	DLOG	Daniel Othenin Girard David Louis Othenin Girard (B)	
	DLPF		
	DLS	D L Sandoz or D L Savoye	
	DLW	D L Wuillemin	
	FG		
	FOG	Freres Othenin Girard	
	HDB	Hy DuBois	Verges
	HFM	H F Matthey	
	HFP		
	HLB		
	IDLC		
	IFM		
	IM	Julien Matthey	
	MFG		
	MW	Matt Wibelet	
	NIDB		
	OM		
	PDB	Ph DuBois	

Table A2-6 b

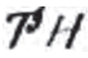
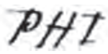
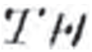
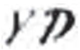
Signature		Name	Location
	PH		
	PHI	Ph H Jacot	
	PHJ	Ph H Jacot	
	TH		
	VD		

Table A2-6 c

Appendix 3: DuBois Serial Numbers

It appears that Philipe DuBois used serial numbers from the start of his business. The existing inventories list watches in stock, either in Le Locle or in the houses of distributors in Frankfurt and elsewhere, and almost all have serial numbers. From these we can estimate total production at the times the inventories were taken.

The following Table A3-1 lists high numbers for watches in the inventories from 1759 to 1823. These give a good estimate of total production at those dates. There is one strange figure; the 1759 inventory lists number 1387, even though that number could not have been used until 1765 or 1766. The low numbers in the inventories are confusing, because we do not have a complete set of inventories. So these numbers are not included as it is not possible to interpret them meaningfully. Certainly many low numbers must be old stock that, for unknown reasons, had not been sold and was carried over for one or more years. (There is some correlation in that the stocks in European cities tend to have low, earlier, numbers. And low numbers are often for special, expensive pieces. But these points have not been investigated.)

A small number of watches listed in the inventories are not given serial numbers. As they do not have any notable characteristics, we do not have an explanation for them.

Inventory	High	Inventory	High
22 Jan 1759	478	14 Dec 1789	35,090
11 Jun 1765	1,368	23 Dec 1793	55,593
2 Jan 1767	1,834	Dec? 1798	110,953
8 Jan 1769	2,219	30 Jan 1801	131,124
1 Jan 1771	2,822	31 Dec 1802	20,585
2 Jan 1773	3,521	31 Dec 1804	41,208
20 Dec 1774	4,612	31 Jan 1807	62,760
13 Dec 1776	5,580	7 Aug 1809	78,598
14 Dec 1778	7,069	1 Jan 1812	89,977
9 Dec 1780	10,200	12 Jan 1816	17,068
9 Dec 1782	14,598	30 Jan 1819	48,053
19 Dec 1785	21,279	4 Jan 1821	61,819
17 Dec 1787	27,103	11 Jan 1823	74,141

Table A3-1: Watch Serial Numbers 1759-1823

Unfortunately, the company did not use a single sequence of serial numbers, and it decided to start a new sequence, probably immediately after the January 30 1801 inventory. The lowest number in the December 1802 inventory is 49, indicating that the new series started from 1.

Then again, sometime after 1812 a new sequence was started, but because of the four-year gap it is difficult to estimate when this happened.

The largest number in the next inventory, 1816, is 100,145 and there are many entries for watches with numbers above 90,000. This figure and the high number in 1801 mean that the numbers cannot form a single sequence with the high order digit omitted, and there are clearly three separate sequences.

Assuming 131,124 is the highest number in the first sequence, and 100,145 is the highest in the second sequence, and that all sequences start at 1, a single production sequence can be created, as in Figure A3-1. This suggests that the third sequence started in January 1815.

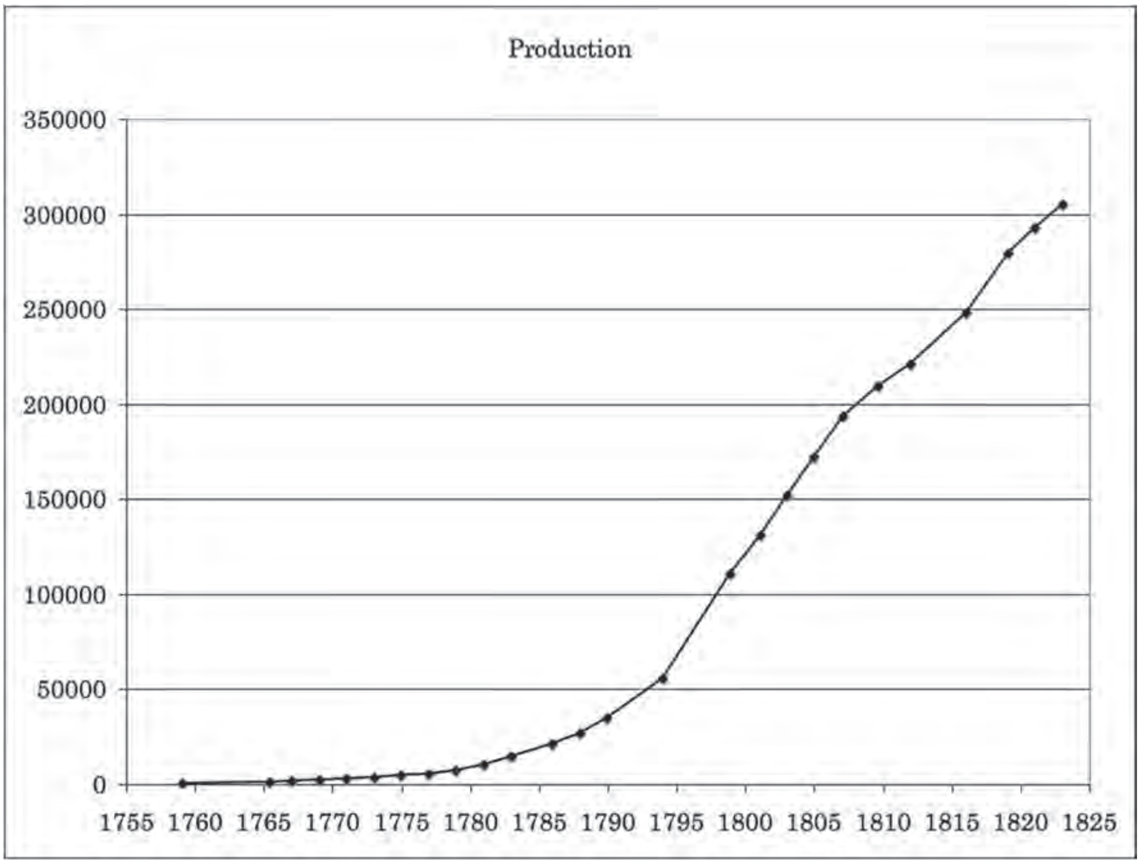


Figure A3-1

The total production between 1759 and 1823 is 305,410 watches. After steady growth from 1759 to 1793, the company stopped expanding and production became roughly constant at about 8,600 watches per year.

Finally, we do not know if DuBois signed movements in addition to giving them serial numbers. If so, and the signatures changed, it might be possible to use them to distinguish watches belonging to different sequences.

The production of the company in the years 1777 and 1778 was about 750 watches per year, or about 63 watches per month. Ignoring case and dial making, DuBois must have used about 60 workers to produce these watches (see Section 5.7, page 53).

Appendix 4: The History of a History Revisited

Although events after 1779 are not directly relevant to this book, two additional aspects of the "History of a History" in Section 1.1 need to be considered.

A4.1: The Leroy Letters

In 1993 Philippe Leroy, son of Léon Leroy, put the *Leroy watch* into an auction at Antiquorum, the sale of 25 April (Antiquorum, 1993a, lot 168, pages 88-89). The Patek Philippe museum bought it for 100,000 CHF, to the dismay of the museum in Le Locle that had only 60,000 CHF.

After the sale of the *Leroy watch*, copies of 13 (edited) letters written to and by Léon Leroy relating to the watch were distributed to several people. Most of these letters were written by Pierre Huguenin. Huguenin was a watchmaker at Neuchâtel, and a friend of Leroy. He examined the *Leroy watch* and helped getting the article by Leroy republished in *La Suisse Horlogère* in December 1949 (Leroy & Huguenin, 1949). He also contributed much information to Chapuis and Jaquet's book. The typed letters have been edited, removing some of the original text that presumably was not relevant.

The full list of letters is:

(a) Leroy to and from Gardon (omitted from this book): 5 letters from 1 March 1949 to 16 March 1949 arranging the purchase of the *Leroy watch*.

(b) Huguenin to Leroy 20 May 1949, Figure A4-1.

(c) Huguenin to Leroy 15 June 1949 (omitted from this book): Pierre Huguenin had read the article published in May (Leroy, 1949) and repeated his suggestion to publish in Switzerland with 4 lines of introduction by Huguenin.

(d) Huguenin to Leroy 5 July 1949, Figures A4-2 and A4-3.

(e) Huguenin to Leroy 5 August 1949 (omitted from this book): Huguenin comments on references to self-winding watches in the catalogue of the Musée Conservatoire National des Arts et Métiers (see Arts & Métiers, 1949, in the tertiary sources Appendix A1-3) and Encyclopédie Méthodique (referring to Saint Martin; see Chapter 11, page 137)

(f) Huguenin to Leroy 23 February 1950, Figure A4-6.

(g) Leroy to Chapuis 15 March 1950 (except for two paragraphs, the letter is omitted from this book): This is the reply to a letter from Chapuis of 8 March. Leroy comments on dating the case to the late 18th century (in reply to something Chapuis wrote?) and states that Chapuis can use his article (Leroy & Huguenin, 1949) and photographs of the watch in the book being prepared by Chapuis and Jaquet.

(h) Huguenin to Leroy 4 October 1950, Figure A4-8.

(i) Chapuis to Leroy 11 November 1950, Figure A4-9.

The five important letters are discussed here.

The first letter, Figure A4-1, begins a recurring theme, the problem of the hallmarks on the case.

> *20 May 1949*
>
> *From Monsieur Pierre Huguenin, Beauregard 3, Serrières Neuchâtel*
>
> *Automatic watch in your collection. I should note the mark of the master in the case back next to the remains of the hallmark. From checking my records I see that I do not know the marks of the masters of Locle earlier than 1819, when regulation made the hallmark obligatory in either of the two offices of Le Locle and La Chaux de Fonds, the only ones in Switzerland at the time with that of Geneva. But there is a chance of finding that which is in the case back of the watch in the list of the marks of masters filed in 1819, because the marks were not invented at the opening of the office, they were mandatory long before. I do not know what date in the 17th or 18th century. Thus many marks in 1819 were very old and in use in the community for a long time. If we can identify the mark of the master, it will not mean that the maker of the movement will be known - [unless] we find some other index on disassembling?*
>
> *A schematic sketch below shows how the hallmark was made, about half of which remains in the case back next to the number. At the time the masters often fashioned these hallmarks themselves, although the regulation stated that they must provide them to the magistrate. So in the beginning the offices only had to verify the accuracy of the titles, the punching was the job of the master. That changed immediately after the organization of offices.*
>
> *And the article, the design of the movement? Is it you who will write it or another? Or someone from your people? If not and you are embarrassed that you want me to do it. It is sufficient to give me the watch for a few days and the opportunity. You could then make an announcement in one of the French watchmakers' journals while simultaneously I could send a similar text to the Suisse Horlogère. This combination may suit you.*
>
> *Schematic indicating the form of the old 18 K hallmark of Neuchâtel. It seems that it remains in the right half of the automatic watch case. There was no line bordering the edge of the punch in the 18th century. The line only came later about 1850.*

Huguenin was probably too late to offer help with the first article, which was published in May (Leroy, 1949); this article by Leroy describes the mechanism, but it does not mention the case.

To avoid confusion, the first paragraph refers to the signature of the case maker; it does not refer to the chevrons, the hallmark. At that time the case maker was unknown and Huguenin stated that he probably could not help with an 18th century maker, because his information was too late. In contrast, the second and last paragraphs refer to the hallmark, the chevrons. These are two independent problems when attempting to date the case.

The drawing of the chevrons is fascinating. Huguenin is quite clear, stating that the chevrons with a border is a late form of the hallmark (but not as late as the date he indicates, about 1850). And although he is not explicit, the letter seems to suggest that he thinks the case might be much later than desired when he writes "… the hallmark … about half of which remains …". However, he is vague. We can be sure that he thought the movement was made in the 18th century, creating serious problems with the case, and almost certainly he thought he was wrong about the hallmark, because he suggests looking for an 18th century case maker.

du 20 Mai 1949

de Monsieur Pierre HUGUENIN
Beauregard 3
Serrières Neuchatel

....

Montre à secousse de ta collection - J'aurais du relever la marque de maitre insculpée dans le fond à coté des restes de la marque de controle . Venant de vérifier mes fiches je constate que je ne connais les marques de maitre locloises que dès I8I9, moment ou une règlementation rendit le controle obligatoire dans l'un ou l'autre des deux bureaux du Locle et de la Chaux de Fonds, les seuls en Suisse à l'époque avec celui de Genève . Mais il y a cependant quelque chance de trouver dans la liste des dites marques de maitres déposées en I8I9 celle qui se trouve dans le fond de la montre car on n'invente pas les marques à l'ouverture des bureaux. elles étaient obligatoires bien avant depuis je ne sais quelle date du I7ème ou I8ème siècle. Il se trouve donc que nombre de marques déposées en I8I9 étaient fort anciennes et en usage dans la localité depuis longtemps. Si on réussit à identifier la marque de maitre, il n'en résultera pas que l'horloger constructeur de mouvement sera connu - trouverait-on quelques autre indice endémontant?

Un croquis schématique ci dessous fait voir comment était constitué la marque de controle, dont il reste environ moitié dans le fond à coté du numéro . A l'époque les maitres façonnaient souvent ces marques de controles eux mêmes , quoique le règlement prévoyait qu'ils devaient se les procure chez le magistrat - Au début les bureaux n'eurent donc qu'à vérifier l'exactitude des titres, le poinçonnement étant l'affaire du maitre ... Cela changea immédiatement après l'organisation des bureaux.

Et l'étude, le dessin du mouvement ? Estce toi qui va faire l'un et l'autre ? Ou quelqu'un de tes gens ? Sinon et que tu sois embarrassé veux tu que je m'en charge - Il suf - firait de me confier la montre pour quelques jours et par une occasion - Tu pourrais faire ensuite une communication dans un des journaux horlogers deFrance tandis que simultanément je ferais passer le texte analogue dans la Suisse Horlo gère - Cette combinaison peut elle te convenir.

Ici schématiquement indiqué la forme de l'ancien poinçon I8 K. neuchatelois Il semble qu'il en resta la moitié de droite sur la boite montre secousse. Il n'y avait pas de filet limitrophe au bord du poinçon au I8ème siècle . Le filet est venu plus tard vers I850 environ seu - lement.

Figure A4 -1

The second letter (Figures A4-2 and A4-3 following) is the most interesting. The translation of this letter is interspersed with a commentary on its significance.

> *Letter from Mr Pierre Huguenin of 5 July 1949*
>
> *To Mr Leroy*
>
> *Thank you so much for sending your latest photos of automatic watches. On reflection, I have given them to Mr Chapuis, because his project to publish something on automatic watches is just postponed and his fame in horological publications will give to the lines he is going to devote to the Leroy watches a far wider impact than if I speak first.*

Given the penchant of Chapuis to write historical fiction, this is to be regretted.

> *The events relating to "automatic watches" multiply. It is like a detective novel, with successive new ideas, changes of situations, the unexpected, and the passion that surrounds "the affair". As there was "L'affaire du collier" (the affair of the necklace), "L'affaire Dreyfus" (the Dreyfus affair) and many others, there is now the affair of the automatic watches. You write that you have received some letters? Is there another episode to add?? How am I going to manage to describe the ins and outs of this affair in one page?*
>
> *I - The detail that touches you closely is your discovery of the watch with the weight placed in the center of the movement. Messers Jaquet and Wilsdorf have contacted the Swiss Chamber so that the article that you have written in the Revue Française des Horlogers et Bijoutiers of May 1949 is not reproduced, as I have asked the editorial staff of the "Suisse Horlogère" to do. The matter is in abeyance. The article will probably be printed soon, and under your signature, as is appropriate, because I took the liberty of adding only 4 lines of introduction, the aim of which is to make clear that the decision to publish in France and Switzerland predates the discussions of Wilsdorf-Jaquet-Chapuis.*

Hans Wilsdorf was the founder and owner of Rolex, and Eugène Jaquet, author and president of some important organizations in the Swiss watchmaking industry, was a very good friend of Wilsdorf. It is not clear why they wanted to suppress publication of information about the *Leroy watch*, considering that it was only delayed until December.

A possible reason, indicated later in the letter, is that Wilsdorf had already financed the work by Chapuis and Jaquet with the aim of publishing something. So perhaps Wilsdorf and Jaquet wanted this work published first; but it took another three years to reach the printer. It is unlikely that Wilsdorf was worried about a challenge to the Rolex patent, because that patent would last only a few years before it entered the public domain.

When the article was published in *La Suisse Horlogère* in December 1949, Huguenin's "4 lines of introduction" had expanded dramatically. Instead of a mention of Wilsdorf-Chapuis-Jaquet, he provided a discussion of the watch and its case. It is this text that is the source of most of the text on the watch in Chapuis & Jaquet (1952, pages 50-52; 1956, pages 51-53). Also, the drawings of the watch and its case come from these two articles.

> *II - My researches at the State Archives to identify the maker's mark inside the case have not yet ended. Here I note that your article refers to the absence of a corporation mark. There have never been corporations in the mountains near Neuchâtel. People have worked under a system of absolute freedom, under the old regime. Besides, this has changed (and how) in the modern time. Until further information, your watch can thus be French, or Swiss, or another origin and for me, the only visible evidence on the outside concerning the origin is this half-punch of*

guarantee of title, which seems to be the remainder of the mark of Neuchâtel. But??? It is more than half-worn. As to the date, I would not be surprised if your estimate is some years older than it is. The dial, the hands, the use of the various types have been perpetuated on several occasions…

As I have noted, the date of the *Leroy watch* case is a recurring theme in the letters and Huguenin was well aware of the problem. But more than 60 years later this problem has not been resolved.

Twice Huguenin wrote about the chevrons stating "half of which remains" and "it is more than half worn". But the inside of the case dome is protected and not subject to wear. So either someone deliberately abraded the dome or the chevrons were badly punched. The latter is more likely.

III - In short, Messrs Jaquet and Chapuis attribute the origin of various types of automatic watches to the elder Perrelet (Abraham-Louis 1729-1826).

Public knowledge has long accepted this argument. Perrelet was the creator of these watches and because he had been the apprenticeship or improvement master for Breguet, we can wonder if he was not also a supplier for Breguet.

As noted on page 47, Breguet was not a student of Perrelet.

IV - Let us make a digression here - Where can one find information about Perrelet concerning automatic watches? First the story has been well known. While I was an apprentice we sometimes amused ourselves with some old watches with weights that we took out of a showcase in the museum of the school. We knew that the elder Perrelet made them, but where can one find a written testimony that confirms (or establishes) this well-known opinion? Within the Biographies Neuchâteloises, published in 1863, that is to say 34 years after the death of Perrelet. The author takes as the source for his article Henri Ernest Sandoz, an expert on local history. Where did Sandoz get his statements from? A mystery for now. His papers have been in the possession of Pierre Huguenin for years and years.

I do not know where the watches looked at by the apprentices are now. But they should be found and examined. However, it is certain that none of these watches has a rotor mechanism. If Huguenin had evidence for attributing the watches to Perrelet, then it would give additional support to the conclusion that Perrelet made a side-weight mechanism.

VI - To search? Within a great half a cubic meter of old letters and notes often on scrap paper. Because Henri Ernest Sandoz took whatever paper was at hand, tore an end off it and entrusted his notes to it. And then, there is still another obstacle. I have deposited these papers in the national archives. And nobody can access them before the year 2000, apart from me. This seems baroque. One must, to understand these provisions, know that I put in the boxes all the papers of a family from 1770 to about 1930, perhaps. There are love letters, full of innocence, announcements of deaths, letters of condolences, inventories, shares of inheritance, household budgets taken to extreme rigor, and tax slips. At most there is no notice in that about what the revenue services lost. I did not want this complete picture of the life of a family to be lost. Result: the public will know all of this when we are dead. There are some old ladies still live who would be upset by seeing everybody going through the family documents, although they burned the most intimate ones before I put all into the boxes. Thus, for lack of time, I will not begin soon to hunt for the origins of automatic watches within these respectable old things. And Mr Chapuis, who suggests discretely that I could open the files, will not be satisfied.

To the best of my knowledge, no one has examined these archives. To do so would be very tedious and time consuming. And without much hope of success, because it is possible that Sandoz handed over his notes to Jeanneret and Bonhôte, and they may have never been returned. But we will not know until someone investigates.

> *VII - But all the above is a line of research that we do not know for sure where it will lead, because Ernest Henry could have thrown his notes and documents into the waste paper basket. On the other hand, Mr Chapuis has something more solid and immediately usable. Why then, does he not use it immediately? This is still one of the acts of the comedy playing out.*
>
> *Some years ago, Mr Wilsdorf proposed to Mr Chapuis that he should make some investigations into the origins of automatic watches. Mr Chapuis suggested that the archives of Breguet must be consulted and that the presence of a competent watchmaker knowing the business would be indispensable. Mr Wilsdorf offered the trip to Mr Jaquet accompanied by Mr Chapuis. The result of their investigations was about zero. But later, about two years ago, the Library of Neuchâtel bought the remaining archives of the Société d'édition??? of Neuchâtel which, during the French revolution, published many political texts, forbidden by the French censure and which were smuggled into Paris. This society, under the direction of the Banneret Osterwald even sent some watches to its clients. And some automatics among them.*
>
> *An abbot of Versailles exchanged a lot of letters with the editors. Recordon in London, more or less the agent of Breguet in England, joined in the discussion. In my hands I have the essential parts of these documents or at least on cards.*

The desire of Chapuis to have a watchmaker with him on the trip to Paris supports my view of him; see page 182. It is not clear what Huguenin knew in 1949. The statement that "Mr Chapuis has something more solid and immediately usable" probably refers to the letters written to Osterwald (Section 5.1, pages 35-36). So at that time he may have known nothing about Saussure's diary and the following report (pages 33-34).

> *And Mr Chapuis himself puts the question: Having been sponsored by Mr Wilsdorf who now opposes publication, am I right if I go ahead? We have decided provisionally in our last conversation that he should put his cards on the table at Rolex and ask if he could be considered as free from any obligation.*

It is clear that "Mr Chapuis, who suggests discretely" and "in our last conversation" shows that Huguenin and Chapuis had a relationship and a reasonable amount of contact. Indeed, it seems that Chapuis wanted Huguenin's advice.

What *obligation*?

As noted above, Wilsdorf paid for Chapuis and Jaquet to visit Paris. But sponsoring probably means considerably more. Certainly the English edition of Chapuis & Jaquet (1956) was at least partly (but possibly completely) funded by Wilsdorf; although Griffon in Neuchâtel published some copies, Rolex published 2020 copies.

What publication did Wilsdorf oppose? Surely not the article (Leroy & Huguenin, 1949), because Chapuis had nothing to do with it. But possibly the book, because the idea of a publication arose "some years ago". But why oppose the publication of a book he had sponsored?

The letter of 5 July 1949 specifically refers to Wilsdorf and not to Rolex. Certainly Wilsdorf owned and ran Rolex, but there is no reason to suppose his actions were directly linked to the company.

At the time, Rolex was renowned for its self-winding watches using a rotor and the company, supported by its patents, claimed to have invented the mechanism. But this was secondary. Rolex watches have always been regarded as special because of the oyster case, and it is this case, more than anything else, that distinguishes the company from all others. So the discovery that Rolex had merely reinvented the rotor mechanism design might have been a pity, but it was of no great consequence. After all, very few people read serious books and articles on horology, and it would be paranoia for someone to suggest that any of these publications could have damaged the sales, let alone the reputation of Rolex. And the possibility that the 18th century design might impact on the patents of Rolex is extremely unlikely, because the Rolex design is significantly different.

Similarly, the origins of the oyster case do not matter. Aaron Dennison's English patent, number 356 of 3 February 1872 (Patents for Inventions, 1979), describes a case with screwed on bezel and screwed on back. And in 1915 his grandson took out the English patent number 1390 of 28 January 1915 for a screw-down crown (Patents for Inventions, 1979). Thus the main features of the oyster case had been created many years before Rolex developed it. But it is unlikely that the customers of Rolex either know or care.

So I suspect Wilsdorf was acting on his own account. In this case we must assume that Wilsdorf wanted a book that supported his opinions and would not support Chapuis if he decided to write something contrary to his views.

> *Basically, all this trust of Mr Chapuis, who puts his precious papers into my hands, is nothing more than a friendly little manoeuvre to obtain my confidence and to make me open the Sandoz files. I will not do anything for the more or less sentimental reasons mentioned above.*

This cynical view of Chapuis is surprising. But perhaps not, because I am equally or more cynical. At the start of this book, in Section 1.1, I suggest that Chapuis had no understanding of watch and watchmaking technology. My view is influenced by Jaquet and Chapuis (1953). When I read that book (Watkins, 2011a) I decided that it was a too long, sophisticated advertisement for Swiss watches. And I assume the order of the names of the authors was determined by the title and not the quantity of their respective contributions; it is hard to imagine that Jaquet, a competent watchmaker, could have written what is best described as an historical novel. But a geographer interested in magic and with no knowledge of technology could have written it.

> *Let us wait for the matter to run its course and see the parade of descriptions and other documents, each in turn. Light will eventually illuminate this segment of history - funny history.*
>
> *I hope I have not romanticized too much.*

The next important event, in December 1949 about five months after the above letter, was that the second article was published, Leroy & Huguenin (1949). As noted above, it was quoted extensively by Chapuis & Jaquet. In the article and the book (Chapuis & Jaquet, 1952, page 51; 1956, page 52), Huguenin states that the case has:

> *l'ancien poinçon de garantie du titre, légal dans la Principauté de Neuchâtel dès le XVIIIe et jusque tard dans le XIXe, soit les chevrons.*
>
> *the old hallmark of guarantee, official in the Principality of Neuchâtel from the XIIIth to the [late] XIXth centuries, i.e. the chevrons.*

The word "late" appears in the French edition but not the English edition. Chapuis & Jaquet (1952, page 52; 1956, page 53) also cite a book on the Neuchâtel goldsmiths trade that states *the small shield with chevrons made its appearance* as early as 1780 and *remained unchanged until 1881*.

The article included a drawing of the inscriptions on the case that shows a well-defined border around the chevrons when compared to the photograph of the case, Figure A4-4. What was

Huguenin thinking! We must conclude that he was forced (by his own integrity) to illustrate the hallmark correctly, and to express some doubt about when this form (with a border) was used. By doing this he could avoid antagonising some people.

Although not important, Huguenin changed the positions of the inscriptions and omitted one punch that is beside the letters ALR (Figure 15-5, page 186). The only useful photograph we have of the case back (Figure A4-5) is poor, but the correct positions are highlighted.

Figure A4 -4

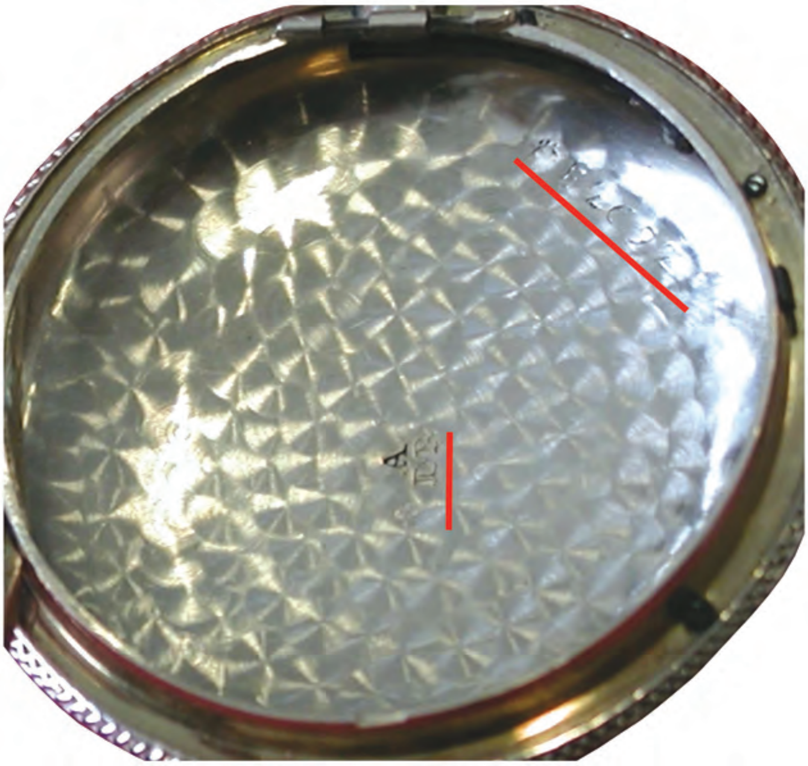


Figure A4-5

Lettre de Monsieur Pierre HUGUENIN du :5 Juillet 1949

à Monsieur LEROY

Merci mille fois pour ton dernier envoi de photos de montres automatiques. Réflexion faite je les ai remises à Mr CHAPUIS, car son projet de publier quelque chose sur les montres automatiques n'est que renvoyé et sa notoriété dans les publications horlogères donnera aux lignes qu'il consacrera aux automatiques LEROY une portée bien autrement large que si c'est moi qui parle le premier.

Les péripéties du sujet " Montres automatiques " se multiplient - Cela tient du roman policier, avec des trouvailles successives, des situations retournées, des imprévus, et la passion qui entoure ' l'affaire " Comme il y eut l'affaire du collier, l'affaire Dreyfus et bien d'autres - il y a donc l'affaire des montres automatiques - Tu as reçu des lettres m'écris tu ? est-il encore une épisode à ajouter ?? Comment vais je m'en tirer pour exposer les détours de l'affaire dans une page ?

I - Le détail qui te touche de près est donc ta trouvaille de la montre à masse axée sur le centre du mouvement MM. JAQUET et WILSDORF ont interpellé la Chambre Suisse pour que l'article que tu as écrit dans la Revue Française des Horlogers et Bijoutiers de mai 49 ne soit pas reproduit, comme je l'ai demandé à la Rédaction de la Suisse Horlogère. L'affaire est en suspens. Probablement que l'article sera imprimé prochainement, et sous ta signature comme il convient, puisque je ne me suis permis d'ajouter que 4 lignes d'introduction destinées à faire apparaître que la décision de publier en France et en Suisse est antérieure aux discussions Wilsdorf - Jaquet Chapuis.

II Mes recherches aux Archives de l'Etat pour identifier la marque de maître dans la boite n'ont pas encore abouti. Ici, je remarque que ton article évoque l'absence d'une marque de corporation .. Il n'y eut jamais de corporations dans les Montagnes Neuchateloises - On y a travaillé sous le régime de la liberté absolue sous l'ancien régime. Cela a d'ailleurs changé (et comment) dans le temps moderne. Jusqu'à plus ample informé ta montre peut donc être d'origine française ou Suisse ou autre, et pour moi, le seul indice d'origine visible extérieurement est ce demi-poinçon de garantie du titre, qui paraît être le reste du poinçon Neuchatelois. Mais ??? il est plus qu'à demi usé. En ce qui concerne la date, je ne serais pas étonné que tu la voies vieille de quelques annéesde plus que le compte. Le cadran, les aiguilles, - ~~On a perpétué~~ - On a perpétué l'emploi des genres en maintes occasions ... Bref, Messieurs JAQUET et

III CHAPUIS voient l'origine des montres automatiques en diverses éxécutions chez l'ancien PERRELET (Avraham Louis 1729-1826)

La notoriété publique a admis cette thèse depuis longtemps - Perrelet fut le créateur de ces montres et comme il fut maître d'apprentissage, ou de perfectionnement, de Breguet, on peut se demander s'il ne fut pas aussi fournisseur de Breguet.

IV - Ouvrons ici une parenthèse - Ou trouve t'on les renseignements sur le travail de Perrelet en matière de montres automatiques - D'abord l'affaire est restée notoire. Lorsque j'étais apprenti, nous jouions quelque fois avec des vieilles tocantes à masses, prises dans une vitrine faisant Musée de l'Ecole. On savait que c'était la fabrication de l'ancien Perrelet mais ou se trouve un écrit confirmant (ou établissant) cette certitude notoire ?Dans les Biographies Neuchateloises publiées en 1863, soit 34 ans après le décès de Perrelet. L'auteur a recouru pour rédiger son article à Henri Ernest Sandoz, connaisseur de l'histoire locale. Ou Sandoz a t'il puisé ses dires ? Mystère pour le moment. Ses paperasses sont entre les mains de Pierre Huguenin depuis des années et des années.

Figure A4-2

VI Chercher ? Dans un gros demi mètre cube de vieilles lettres et notes sur des déchets de papier souvent. Car Henri Ernest Sandoz prenait le papier qui lui tombait sous la main en déchirait un bout et lui confiait ses notes. Et puis il y a encore un autre obstacle - j'ai déposé aux Archives de l'Etat ces paperasses - Personne jusqu'en l'an 2000 n'a le droit de les consulter si ce n'est moi . Ca paraît baroque. Il faut, pour comprendre ~~ces~~ ces dis - positions, dire que j'ai mis dans les coffres tous les papiers d'une famille depuis I770 environ à I930 peut être. Il y a des lettres d'amour touchantes dans leur naîveté, des faire part de décès, des lettres de condoléances . Des états de fortune , inventaires, partages de successions, comptes de ména - ges poussés jusqu'à la dernière rigueur et bordereaux d'impôts . Tout au plus y manque t'il le compté exact de ce que le fisc y a perdu - Je n'ai rien voulu perdre de ce tableau complet de la vie d'une famille. Résultat , les étrangers prendront connaissance lorsque nous serons morts . Il y a là des vieilles demoiselles qui s'éffaroucheraient encore de voir des mains étran - gères tripoter les papiers de famille, malgré qu'elles aient brûlé le plus intime avant que je ferme les caisses . Donc, faute de temps, je n'irai pas de sitôt faire la chasse aux inventions automatiques dans ces vieilleries respectables . Et Monsieur CHAPUIS qui suggère délicatement que je pourrais entrouvrir les dossiers ne sera pas satisfait dans ses désirs.

VII - Mais tout ce qui précéde n'est qu'une piste de recherche dont on ne sait pas de façon certaine ou elle mênera parce qu'Henri Ernest peut avoir mis à la corbeille ses documents et ses notes. Par contre Monsieur CHAPUIS a du plus solide et immédiatement utilisable. Pourquoi donc ne l'utilise t'il pas immédiatement . C'est encore un des actes de la comédie qui se joue ces temps Il y a quelques années Monsieur WILSDORF proposa à Mr CHAPUIS de faire des recherches sur les premières origines des automatiques - Mr CHAPUIS suggèra qu'il faudrait consulter les archives Breguet et que la présence d'un hotlo- ger connaissant le métier était indispensable , Mr Wildsdorf offrit le voyage à Mr Jaquet en même temps qu'à Mr Chapuis. Le résultat des investigations fut à peu près nul. Mais plus tard, il y a deux ans environ, la Bibliothèque de Neuchatel acheta le solde des archives de la Société d'édition ??? à Neuchatel ou, avant la révolution française, on imprimait force ouvrages poli- tiques défendus par la censure française. et qu'on faisait passer encontrebande à Paris . Cette Société sous la direction du Banneret Osterwald expédiait aussi parfois des montres à ses Clients - Et parmi celles ci des automatiques.

Un abbé de Versailles s'en entretient abondamment avec les éditeurs. Recordon à Londres plus ou moins agent de Breguet en Angleterre s'en mêle aussi . Ma serviette contient l'essentiel de ces documents ou du moins des fiches . Et Monsieur Chapuis se pose la question : Ayant été subven- tionné par Monsieur Wilsdorf qui aujourd'hui s'oppose à une publication ais-je le droit d'aller de l'avant - nous avons conclu provisoirement lors de notre dernière conversation, qu'il profiterait de son prochain séjour à Genève pour mettre cartes sur table chez Rolex et demander si oui ou non il peut se considérer comme libéré de toute obligation.

Au fond toute cette confiance de Monsieur Chapuis, qui dépose dans ma serviette ses précieux documents n'est qu'une gentille petite manoeuvre pour me mettre en confiance et m'obliger à ouvrir les dossiers Sandoz - On ne mordera pas pour les raisons plus ou moins senti- mentales dites plus haut.

Laissons la représentation suivre son cours et les tableaux et actes défiler, chacun à son tour. La lumière finira bien par apparaitre sur ce point d'histoire - histoire drôle -

J'espère n'avoir pas trop romancé.

Figure A4-3

On 23 February 1950 Huguenin again wrote to Leroy, Figure A4-6 following.

> *The objections to the publication of the automatic watch article, as well as the eagerness of Messers Dubois and Wolfrath, have calmed down themselves and each other. I think all these gentlemen could not now say why they were troubled. Great energy without substantial grounds which eventually burst, just wait a little while to see the balloon deflate itself. So the article was published in December 1949, in the weekly edition No. 51 of Suisse horlogère. And Mr Gagnebin must have sent you a copy.*

The objectors were Wilsdorf and Jaquet, but who were Dubois and Wolfrath and why were they eager?

> *Mr A. Chapuis has done some digging in the business papers of Philip Dubois in Locle. I asked him to look for the name of a gold case maker corresponding to the ALR mark. He found Abram Louis Robert in 1792. The researches of Mr Chapuis will continue .... He will see if he can find the same case maker earlier; he may well be the one who made your case. Mr Chapuis is also attentive in his research for the possibility of orders placed by Dubois with Abram Louis Perrelet ... In fact he has already found orders to the latter, but they do not involve automatic watches.*

As I have stated, Chapuis did not (and could not) find any early information about Abram Louis Robert (see page 186) or any useful information about Abram Louis Perrelet (see page 155).

> *I have made Mr Chapuis aware of a fact. Dubois when he ordered movements from an établisseur supplier ordered the cases himself and had them delivered to the person who made the movement. It was a regular custom in the Dubois house of which I have proof by many letters in my own collection of documents. In these examples it happens that the case was numbered (that of Dubois) and movement by another (that of Zuberbuhler in the examples provided by my own documents). But do not see work done by people who are currently unknown. Dubois advised his movement supplier that he passed the order for the case to ..... and he had to go to to the latter for the details of execution ... Or on other occasions the matter had been previously discussed between Dubois and the movement établisseur. Dubois ordered a case, and when finished and ready to be put on the "hinge" he sent it to an établisseur. In both instances two different numbers. When watch cases and movements are made under the financial responsibility of the one man they usually have the same number in both places. I believe the above was the rule in the 18th century (and even later) in the Mountains.*

The name Zuberbuhler appears in the DuBois books (DuBois, 1758-1824) from 1804 to 1823, but all entries are for financial transactions. There are no records of purchases or sales, and none of the entries provide occupations or locations. In 1804 DuBois refers to Henriette Zuberbuhler and the sisters Zuberbuhler. Of the remaining 31 entries from 1806, 29 refer to Jaquet Zuberbuhler. Huguenin implies that he was a movement maker.

The suggestion that DuBois numbered the cases is wrong. For example, in Figure A4-7 (DuBois, 1758-1824, *Inventory 1798*, page 66) it is obvious that there is no overall sequence of numbers, which we would expect if DuBois numbered the cases. But the numbers for each case maker are sequences, and it is clear that the case makers numbered their own cases.

Also, in Appendix 3 I showed that movements were given serial numbers by DuBois. But no one has examined enough watches to confirm this view. This does not preclude Zuberbuhler from adding his own numbers.

lettre de M. Pierre HUGUENIN
à Serrieres-Neuchatel
du 23 février 1950

Les oppositions à la publication de l'article montre automatique, de même que les impatiences de M.M. Dubois et Wolfrath se sont calmées d'elles mêmes les unes et les autres. Je pense que tous ces Messieurs ne sauraient plus dire maintenant pour - quoi ils se sont agités. Les grands élans d'énergie sans motifs sérieux finissent ainsi , il suffit d'attendre un peu de temps pour voir le ballon se dégonfler tout seul. Donc, l'article a paru dans le N° 51 en decembre 1949, edition hebdomadaire de la Suisse horlogere . Et Monsieur Gagnebin a dû te faire parvenir un numero.

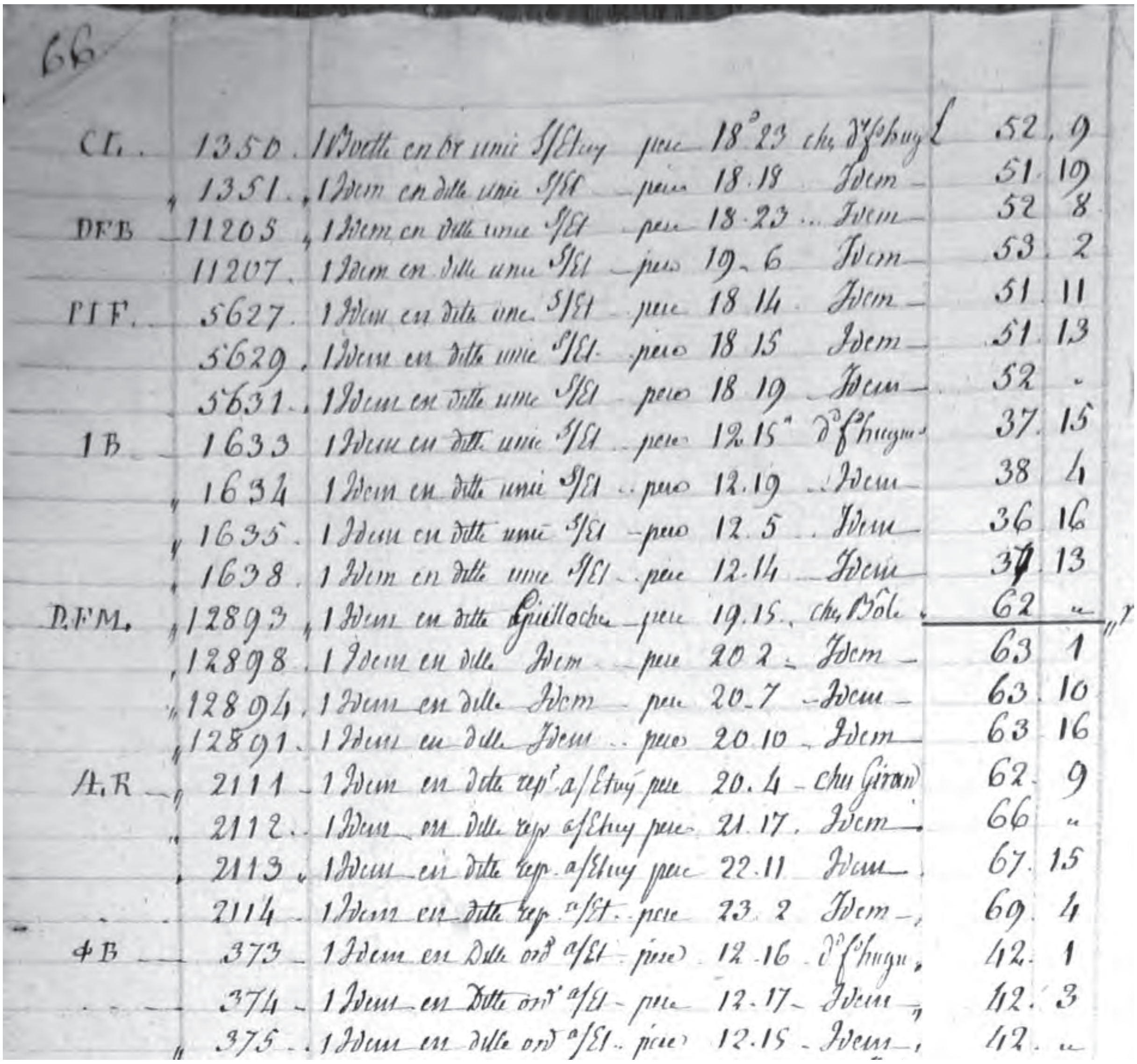
Mr A. CHAPUIS devait aller faire des fouilles dans les papiers d'affaires de Philippe Dubois au Locle. Je l'ai prié d'y chercher le nom d'un monteur de boites d'or correspondant à la marque A L R . Il a trouvé Abram Louis Robert en 1792 Les recherches de Mr Chapuis continuent .... il verra s'il retrouve encore le même monteur de boites plus anciennement. Ce pourrait bien être celui qui fit ta boite. Mr Chapuis est aussi attentif dans ses recherches a la presence eventuelle de commandes passées par Dubois a Abram Louis Perrelet ... En fait il a déja repairé des commandes a ce dernier, mais elles ne concernaient pas des mo tres automatiques.

J'ai encore rendu Mr Chapuis attentif a un fait, Dubois lors qu'il commandait des mouvements a un fournisseur établisseur commandait lui même les boites et les faisait livrer a celui qui entreprenait le mouvement. Ce fut coutume constante chez Dubois j'en ai la preuve par maintes lettres de mes propres fonds de documents . Dans ces cas il arrivait donc que la boite portait un numero (celui de Dubois) et le mouvement un autre (celui de Zuberbuhler dans les cas donnés par mes propres documents . Ne voyons cependant pas un travail fait par des gens qui s'ignor mutuellement . Dubois avisait son fournisseur de mouvement qu'il passait commande de la boite chez ... et qu'il fallait aller s'entendre chez ce dernier pour le détail d'exécution .. Ou bien d'autres fois l'affaire ayant été préalablement discutée entre Dubois et l'établisseur du mouvement, Dubois faisait monter une boite et lorsque finie et prête a être mise " en charnière " il l'envoyait a son établisseur . Dans les deux cas deux numérotations différentes . Tandis que les montres , boites et mouve- sont faites sous la responsabilité financière du même homme portent généralement le même numero aux deux endroits . Je crois bien que ce qui précede fut la règle au 18eme siècle (et plus ta encore) aux Montagnes.

De ce qui précède on peut tirer l'hypothèse suivant Abram Louis Robert peut bien être l'auteur de ta boite. 2° ,il n'est pas exclu que la montre ait été faite pour un marchand prob blement Loclois ou de la Chaux de Fonds , lequel suivait la mode de l'époque et n'y a mis aucune marque sur mouvement et cadran

Cela n'ajoute pas des certitudes aux constations faites jusqu'ici - Ce sont néanmoins des indices qui peuvent conduire plus loin une fois ou l'autre.

Figure A4-6



66

CL.	1350	1 Boëtte en or unie S/Etuy	pese	18.23	chez D. Hugu.	52	9
	1351	1 Idem en ditto unie S/Et	pese	18.18	Idem	51	10
DFB	11205	1 Idem en ditto unie S/Et	pese	18.23	Idem	52	8
	11207	1 Idem en ditto unie S/Et	pese	19.6	Idem	53	2
PIF.	5627	1 Idem en ditto unie S/Et	pese	18.14	Idem	51	11
	5629	1 Idem en ditto unie S/Et	pese	18.15	Idem	51	13
	5631	1 Idem en ditto unie S/Et	pese	18.19	Idem	52	"
1B	1633	1 Idem en ditto unie S/Et	pese	12.15	D. Hugu.	37	15
	1634	1 Idem en ditto unie S/Et	pese	12.19	Idem	38	4
	1635	1 Idem en ditto unie S/Et	pese	12.5	Idem	36	16
	1638	1 Idem en ditto unie S/Et	pese	12.14	Idem	37	13
D.F.M.	12893	1 Idem en ditto Guilloché	pese	19.15	chez Bol.	62	"
	12898	1 Idem en ditto Idem	pese	20.2	Idem	63	1
	12894	1 Idem en ditto Idem	pese	20.7	Idem	63	10
	12891	1 Idem en ditto Idem	pese	20.10	Idem	63	16
A.R	2111	1 Idem en ditto rep. a/Etuy	pese	20.4	chez Girard	62	9
	2112	1 Idem en ditto rep. a/Etuy	pese	21.17	Idem	66	"
	2113	1 Idem en ditto rep. a/Etuy	pese	22.11	Idem	67	15
	2114	1 Idem en ditto rep. a/Et	pese	23.2	Idem	69	4
4B	373	1 Idem en ditto ord a/Et	pese	12.16	D. Hugu.	42	1
	374	1 Idem en ditto ord a/Et	pese	12.17	Idem	42	3
	375	1 Idem en ditto ord a/Et	pese	12.15	Idem	42	"

Figure A4-7

From the above we can draw the following hypotheses: Abram Louis Robert may well be the maker of your case. 2, it is not excluded that the watch was made for a merchant probably in Le Locle or La Chaux-de-Fonds who followed the fashion of the time and there is no mark on the movement and dial.

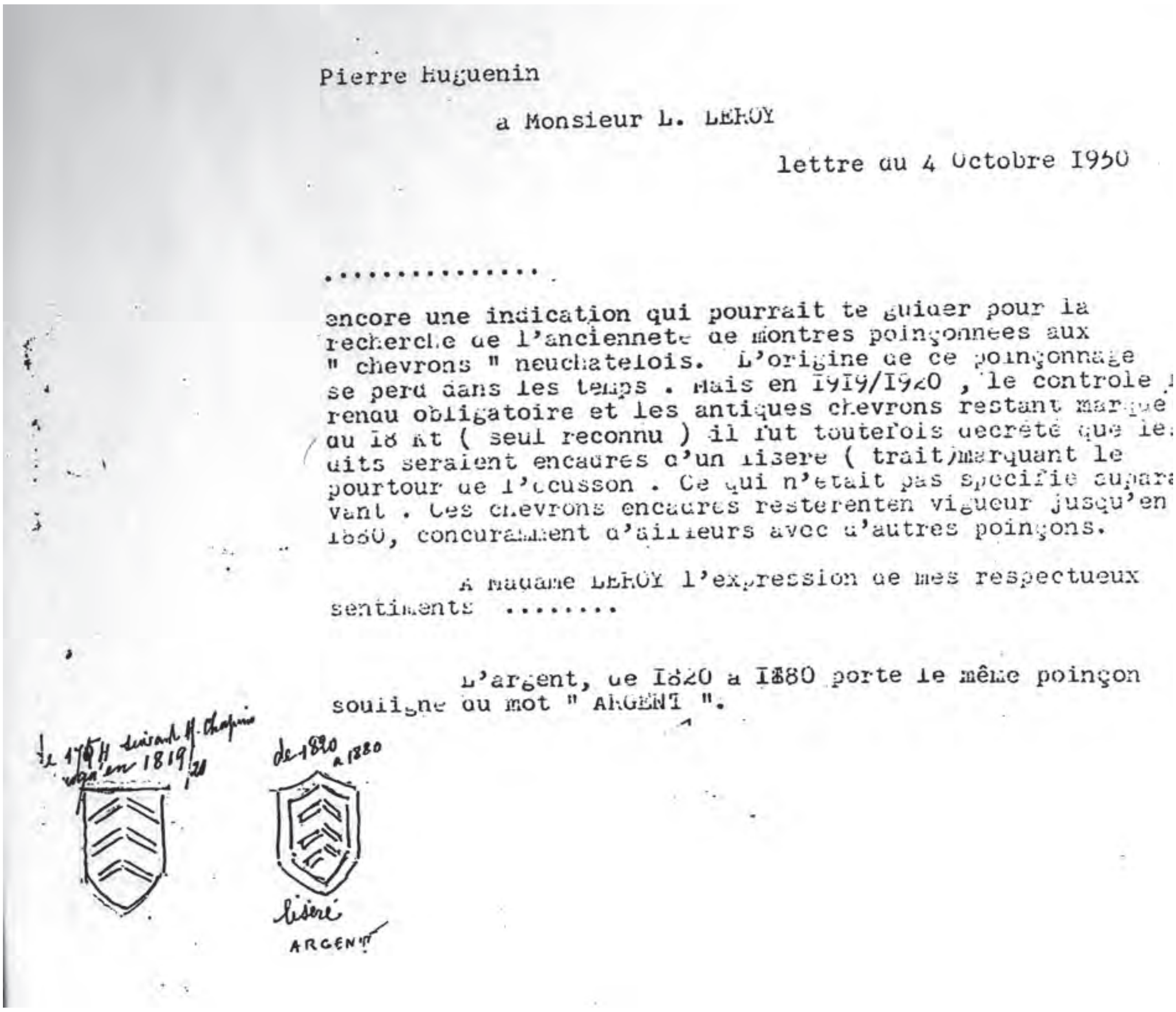
These do not add certainty to the findings made so far. Nevertheless, they are clues that can lead further one day or another.

In the next letter of 4 October 1950, Figure A4-8, Huguenin wrote:

Another indication that could guide you in the search for the age of the watches stamped with the "chevrons" of Neuchâtel. The origin of this punch is lost in time. But in 1819/1820, control was made mandatory and the ancient chevrons remained the mark for 18 Kt (only recognized) but it was decreed that they would framed by a border (line marking the edge of the shield). This was not specified before. These framed chevrons remained in force until 1880, also concurrently with other punches.

Give my respects to Madame Leroy.

The silver, from 1820 to 1880 has the same punch emphasising the word "SILVER".



Pierre Huguenin

a Monsieur L. LEROY

lettre du 4 Octobre 1950

....

encore une indication qui pourrait te guider pour la recherche de l'anciennete de montres poinçonnees aux " chevrons " neuchatelois. L'origine de ce poinçonnage se perd dans les temps . Mais en 1919/1920 , le controle [illegible] rendu obligatoire et les antiques chevrons restant marque au 18 Kt (seul reconnu) il fut toutefois decrete que le[illegible] uits seraient encadres d'un lisere (trait) marquant le pourtour de l'ecusson . Ce qui n'etait pas specifie auparavant . Les chevrons encadres resterenten vigueur jusqu'en 1880, concuramment d'ailleurs avec d'autres poinçons.

A Madame LEROY l'expression de mes respectueux sentiments ....

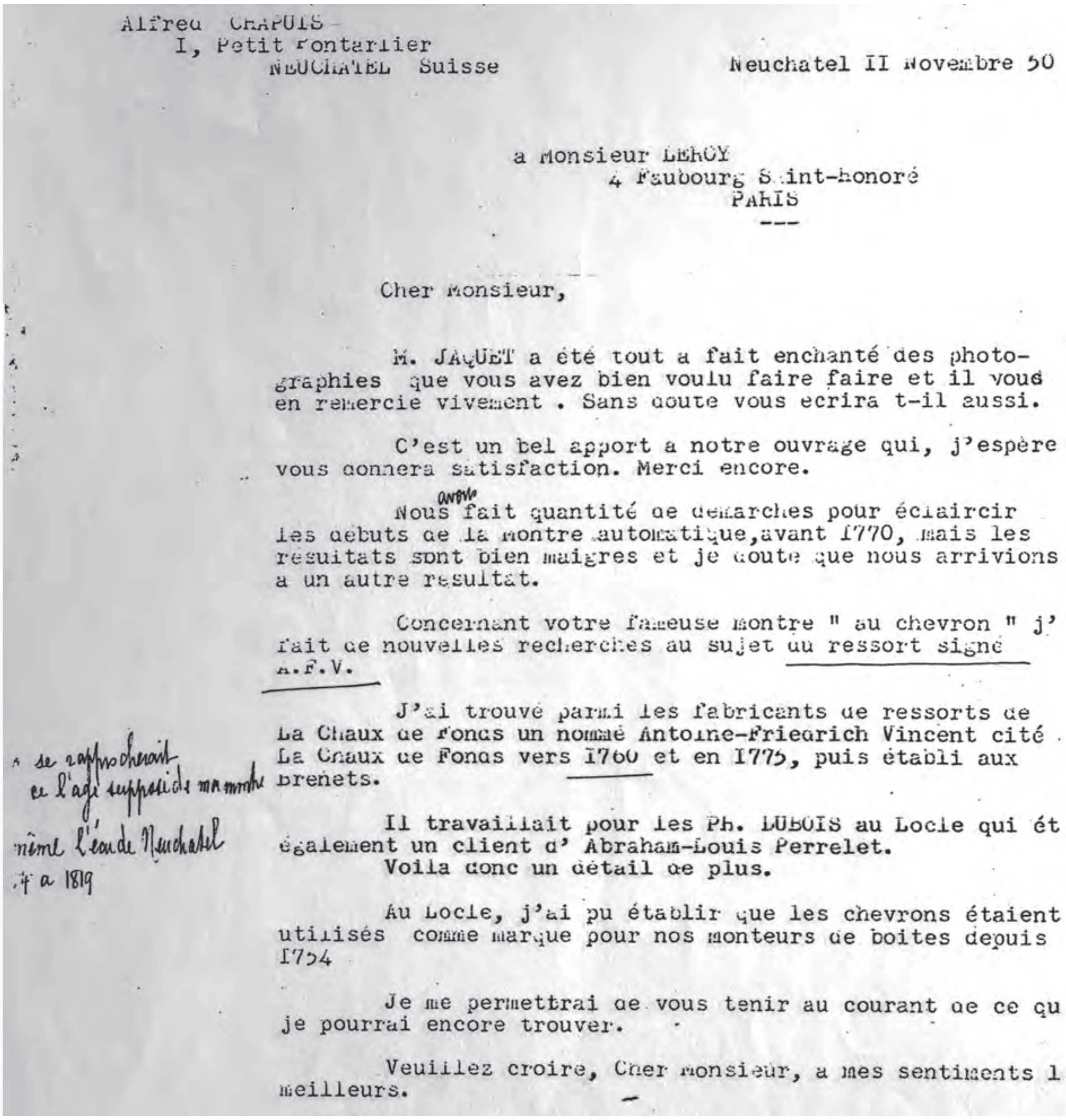
L'argent, de 1820 a 1880 porte le même poinçon souligne du mot " ARGENT ".

Figure A4-8

The handwritten note on the left-hand drawing reads "from 1754 according to A. Chapuis up to 1819/20". (From the handwriting, this was written by Leroy.) But this is directly contradicted by the letter! Although I will not give the whole letter, two sentences from the 15 mars 1950 letter from Leroy to Chapuis are relevant:

> *I acknowledge receipt of your kind letter of the 8th instant, and thank you kindly let me know your painstaking research.*
>
> *The manufacturer of the case in the late 18th century has an importance that might lead you to find some artist who could have conceived of making my movement. This is the matter that takes precedence, because he may be modest but he was a genius.*

It is clear that Chapuis (and Leroy) wanted the case to date from the 18th century. But Huguenin contradicted this desire. And the wording of the handwritten note indicates that Leroy was not sure who to believe. The vague statements of Huguenin in the December 1949 article must have perplexed Leroy! But there is no doubt that Huguenin had handled the watch and, as suggested earlier, it seems he was trying to avoid any conflict.



Alfred CHAPUIS
I, Petit Pontarlier
NEUCHATEL Suisse

Neuchatel II Novembre 50

a Monsieur LEROY
4 Faubourg Saint-honoré
PARIS

Cher Monsieur,

M. JAQUET a été tout a fait enchanté des photographies que vous avez bien voulu faire faire et il vous en remercie vivement . Sans doute vous ecrira t-il aussi.

C'est un bel apport a notre ouvrage qui, j'espère vous donnera satisfaction. Merci encore.

Nous avons fait quantité de demarches pour éclaircir les debuts de la montre automatique,avant 1770, mais les resultats sont bien maigres et je doute que nous arrivions a un autre resultat.

Concernant votre fameuse montre " au chevron " j'ai fait de nouvelles recherches au sujet du ressort signé A.F.V.

J'ai trouvé parmi les fabricants de ressorts de La Chaux de Fonds un nommé Antoine-Friedrich Vincent cité La Chaux de Fonds vers 1760 et en 1775, puis établi aux Brenets.

Il travaillait pour les Ph. DUBOIS au Locle qui ét également un client d'Abraham-Louis Perrelet.
Voila donc un détail de plus.

Au Locle, j'ai pu établir que les chevrons étaient utilisés comme marque pour nos monteurs de boites depuis 1754

Je me permettrai de vous tenir au courant de ce qu je pourrai encore trouver.

Veuillez croire, Cher Monsieur, a mes sentiments l meilleurs.

se rapprocherait
de l'âge supposé de ma montre
même l'écu de Neuchatel
a 1819

Figure A4-9

The final letter in this collection was written by Chapuis to Leroy on 11 November 1950, Figure A4-9:

> *Mr. Jaquet was very pleased with the photographs you were good enough to make and sincerely thanks you. No doubt he will write too.*
>
> *This is a very nice contribution to our work, which I hope will give you satisfaction. Thank you again.*
>
> *We have made many efforts to clarify the beginning of the automatic watch, before 1770, but the results are meagre and I doubt if we get a different result.*
>
> *About your famous watch "with chevron" I did more research on the spring signed A.F.V.*
>
> *I found among the manufacturers of springs of La Chaux de Fonds one named Antoine-Friedrich Vincent mentioned in La Chaux de Fonds in 1760 and in 1775, established at Brenets.*

He worked for Ph. Dubois at Locle who also had Abraham-Louis Perrelet as a client.

So here is another detail.

At Locle, I was able to establish that the chevrons were used as a hallmark for our case makers since 1754.

Allow me to keep you informed of what I can find.

Please accept, dear sir, my best feelings.

First, the most important words are

Concernant votre fameuse montre «au chevron» ...

It is certain that Chapuis wrote these words because Huguenin (or Leroy) had raised concerns about the chevrons and the date of the case. Otherwise the chevrons would not be mentioned, and definitely not in such a prominent way. And Chapuis is able to write

the chevrons were used as a hallmark ... since 1754

because that is true. But he has avoided mentioning that the chevrons were used, *but not the frame*. It would not be surprising if Leroy was confused! In this context, the incomplete handwritten note is important:

... se rapprocherait ce l'âge supposé de ma montre

... même l'écu de Neuchâtel ...4 a 1819

The missing words are important, but a possible interpretation is:

would approach that of the supposed age of my watch

even the shield of Neuchâtel from 1754 to 1819

What Leroy was thinking is unknown, but what is known is that he was unsure.

Second, Chapuis should have known, but does not mention, that Vincent the spring maker is mentioned by DuBois from 1759 until 1786. That is, the mainspring in the watch could have been made many years after the desired dates of 1775 or earlier.

The main problem with these letters is that three separate problems are intertwined: The date of the movement, the date of the case, and the designer of the rotor mechanism.

I do not know anyone who would dispute the date of the movement to be about 1777. The date of the case is irrelevant. Of course it would be better if it was contemporary and not a replacement made more than 40 years later. But it does not, and cannot change the dating and importance of the movement. And it does not, and cannot change the fact that it has no influence on who *designed* the movement.

It is clear that Huguenin had researched the Neuchâtel hallmarks and he eventually provided the correct dates (as given by Clerc, 1993; see page 189). Three times Huguenin mentioned the chevrons (May 1949, December 1949 and now October 1950), but he never made a definitive statement about the *Leroy watch* case. But it is not important. The origin of the case can never tell us who *designed* the movement. And that is the only question that needs to be answered. Was it Perrelet? Was it Sarton? Was it someone else? Nothing in these letters answers that question.

Because my opinions may not be acceptable to some people, I must make one final point. In Chapter 1 I have listed six major faults in Chapuis & Jaquet (1952; 1956). That is, with regard to the early history the book is bad. Why? Was Chapuis incompetent, which is possible? Certainly Jaquet & Chapuis (1953) might support that conclusion. Or was Chapuis forced to distort history? Although we do not know, it is tempting to decide that the very bad sections of the book were the result of interference by Wilsdorf. If the rotor watch was going to be included, as it must be, then it was essential that there was no doubt that it was a Swiss invention.

A4.2: The Rolex Hypothesis

The second aspect of "The History of a History" that deserves consideration can be called *The Rolex Hypothesis*. This is a little misleading, because Wilsdorf and Rolex had nothing to do with it; other people unrelated to the company have suggested it. The following discussion should be viewed as both serious and tongue-in-cheek.

One aspect of the vigorous debate concerning the designer of the rotor mechanism has always puzzled me: Why has this design created so much controversy?

Certainly it is an elegant and effective solution to the problem of self-winding. But being based on the verge-fusee watch it was doomed to have a short life and it appears possible that no one other than Sarton was interested in it.

The only explanation I can give is the Rolex hypothesis:

> *The Rolex self-winding wristwatch was derived from the 18th century rotor watch.*

Chapuis & Jaquet (1952, page 61; 1956, page 62) hinted at this possibility when they wrote:

> *The watch we have described [the Leroy rotor watch] would certainly have brought its maker a fortune had the wristlet been in existence at the time, as this automatic winding system would then have become, in some sort, universal or at least served as a prototype to be gradually perfected.*

Sabrier & Imbert (1974) were more definite:

> *[It is] the system with "rotor" which was adopted by Rolex for the first automatic wrist watches and which is always used today.*

Then, more recently:

> *The historical importance of the invention comes from the fact that the inventor of a [rotor] system is the forefather of the modern self-winding wristwatch that is also based on a center-mounted rotor. (Philip Poniz, 2012.)*
>
> *[The rotor watch] is the design adopted by all of today's horological industry. ... [The side-weight watch] is no longer in use.* (Flores, 2012c, page 654.)

Such statements are vague, and it seems no one has actually put forward the Rolex hypothesis. But there is an implied link.

Self-winding wrist watches were not developed until about 46 years after they were first worn. Cummins (2010, page 236) shows a circa 1870 photograph of a woman wearing what may be a wrist watch.

Figure A4-10

And the photograph in Figure A4-10 is from the first Afghan war and is dated 1879 (National Army Museum, 2015). The wrist watch may be a converted pocket watch.

With regard to the wrist watch, the following is a list of the most significant early events in the development of self-winding wrist watches; it is derived from Chapuis & Jaquet (1956) and Sabrier (2012a):

1896: N. Thomas jeune patent (actually for a pocket watch). Because the weight is in the case band, this must be a center-weight system, where the weight cannot rotate 360°. Also, the weight must be much less than a semi-circle or it could not be put into the case (see page 342). Apparently no watches were made to this design. The patent also refers to a winding weight consisting of a mercury-filled tube, reminiscent of Thustas.

1922: Léon Leroy, a side-weight system.

1923: Harwood, a center-weight system (invented ca 1917). Sabrier (2012a, page 249) notes that "the brass weight hit too sharply against the banking pins as it pivoted." Thus the problem of such watches being *à secousse* (with jerks) re-appeared 140 years after the Abbé Desprades reported it (see Figure 5-4, page 36).

1925: Driva Watch Co, a side-weight system.

1930: Eugène Meylan, a center-weight system.

1930: Léon Hatot, *Rolls*, where the whole movement moves sideways. This is not quite original, because Charles and Joseph Oudin made watches where the whole movement oscillates in the case (Sabrier, 2012a, pages 109 and 111).

1931: Louis Müller, *Wig-Wag*, where the whole movement moves sideways.

1931: Rolex, a rotor system with unidirectional winding (see Flores, 2010).

We can be confident that some of the designs were influenced by self-winding pocket watches. In particular, the side weight systems of Leroy and the Driva Watch Company were probably derived from Breguet, Recordon, Loehr's 1878 patent, Lange & Söhne (Sabrier, 2012a, pages 223-226) and others. But the rotor mechanism?

The Rolex design was created about 18 years before the publication of a description of the rotor watch (Leroy, 1949), and 25 years before the publication of the 1778 report. So we can conclude that, as the 18th century rotor watch was unknown at the time, it cannot have influenced any of these wristwatch designs. In other words, the Rolex rotor mechanism was probably an independent re-invention. This is supported by the fact that the Rolex design uses unidirectional winding and other aspects of it are different.

However, it is possible that the designers at Rolex had discovered the 1778 report or had seen an 18th century rotor watch. But this seems unlikely.

This view is compromised by a French patent not discussed by other writers, that of Coviot, number 227487, 30 January 1893 (Flores, 2000b, 2013). It is listed in Paris (1895, page 491) as:

> *227487. Brevet de quinze ans, 30 janvier 1893, Coviot, à Nueil (Maine et Loire) Montre dite la perpétuelle.*

This patent, from which Figures A4-11 and A4-12 are taken, describes a center-weight watch (see Chapter 12, page 139) from which the cock for the weight and the equilibrium spring have been removed, so that the weight can rotate 360°. Thus it has a bidirectional rotor mechanism that is basically identical to that of the 1778 report. It only differs by using a going barrel and there is no mention of stop-work; presumably it used a slipping mainspring.

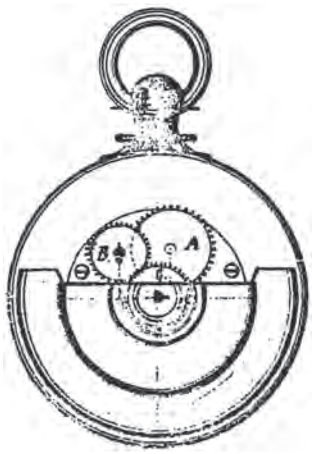


Figure A4 -11

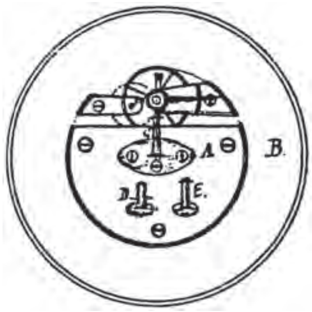


Figure A4 -12

In an article on a center-weight watch, Sabrier & Imbert (1974) stated:

> *The process of winding of this [center-weight] watch is so clever that it was "reinvented" by a person called Coviot who patented it in 1893. However, the reader will notice that, although copied exactly from that of the old watch, the system of bi-directional winding that Coviot adapted to a vulgar cylinder movement is hardly of interest for a pocket watch. The Coviot system, indeed, does not have a recoil spring for the weight, so that it remains hopelessly*

> *motionless unless the carrier is particularly active. In addition, the Coviot system does not envisage locking of the weight when spring is sufficiently wound.*

Sabrier & Imbert are confusing the two similar, but different designs of the rotor and center-weight mechanisms. Their suggestion that the mechanism would not work without an equilibrium spring is contradicted by Huguenin, who stated that "This self-winding system works well" (see page 83 and my tests in Appendix 6, page 352).

The above might be interesting, but it does not explain the vigorous debate concerning the designer of the rotor mechanism, and so a different hypothesis is needed:

> *There is a very strong desire for the rotor watch to be a Swiss invention.*

Despite dominating the industry, one feature of Swiss watchmaking is that it has not been particularly creative. Indeed, if we look at the main developments, none of them are Swiss. For example:

> England: Cylinder, spring detent and lever escapements; repeaters; overcoil balance springs (Arnold, modified by Breguet); chronograph heart cams.
>
> France: Lepine calibre; tourbillon; chronographs; invar.
>
> USA: Machine based watchmaking (David, 1992 and 2003; Watkins, 2009).

But Switzerland? Certainly the Swiss can claim Breguet, Berthoud and Guillaume, because they were born in Switzerland. But it is probable that none of these people would have been successful if they had not moved to Paris. And although Switzerland can claim the Roskopf and Rolex watches, unfortunately both Roskopf and Wilsdorf were born in Germany and the Rolex company was created in England.

It seems the Swiss were content to manufacture watches rather than create new designs. As Moinet (1853, Volume 1, page 11) put it:

> *La Suisse, cette nation industrieuse, active et d'un sens droit, a beaucoup contribué a répandre les produits de l'Art de l'Horlogerie, plus à la vérité sous le rapport commercial que sous celui du perfectionnement; cependant on a vu souvent sortir de ses fabriques de très-beaux et bons ouvrages.*
>
> *Switzerland, this industrious nation, active and in a right way, has contributed much to spread the products of Art of Watchmaking, more in truth in the commercial relationship than from development, but very beautiful and good works are often seen out of its factories.*

Of course I believe Switzerland can claim the first, practical self-winding watch. But, sadly, it had the wrong mechanism.

The problem is that the word *invention* is infused with emotional values and so *reinvention* does not have the same glory associated with it. No matter how important the Rolex mechanism is, it can never achieve the fame associated with Hubert Sarton.

If this argument is correct, the desire of the Swiss to claim the rotor mechanism makes sense. Or does it? If we use the neutral word *design* and recognise the fact that Sarton's mechanism was not important in the history of the 18th century, its country of origin really does not matter.

Appendix 5: Comparisons of Rotor and Center-Weight Movements

A5.1: Comparison Methods

Ideally, comparisons of movements should be made by measuring the actual watches, but this option was not available to me. Instead I had to use photographs of variable quality.

Almost all of the photographs have been made when the camera was not perpendicular to the movement plates and not centered over the center of the movement. The result is that the photographs show the plates as ellipses, not circles, and determining the exact position of points, such as the center of the movement, is very difficult.

To improve the comparison, each photograph was altered using the Photoshop scale and warp transformations. Then the center was found by measuring distances from the edge of the plates. But errors in the photographs and the measurements taken from them mean the results are far from exact.

Two methods were used to compare movements:

(a) *Angular relationships*: The angles between pivots are indicated by lines from the center to those pivots.

To compare the angles, lines were marked on one movement and then copied to the other movements so that the lines are identical and the relative positions of the pivots can be compared. The photographs were scaled and rotated as necessary.

(b) *Distances*: The distances between pivots were measured on each photograph and the differences between corresponding measurements of different movements were compared.

This method requires all movements to be scaled so that the measurement comparison is meaningful. The initial assumption is that the rotor movements use the same *calibre*, and the method of scaling was to assume that all rotor movements have the same plate diameters. This scaling was done separately for the center-weight movements.

In this context a calibre means that the movement uses wheels and pinions with the same numbers of teeth and leaves (the trains are identical) and the positions of them relative to each other are the same. Such a calibre could be made any size and considered to be identical. That is, the actual diameters of the movements are not important because changing their size will not change the inter-relationships of the component parts. Figures A5-1 and A5-2 illustrate part of the calibre of a rotor movement.

Figure A5-1:

(a) Draw a circle the same radius as the plate, ***PD***. Draw an arc from the center which is the radius of the third wheel to center distance, ***3C***, and choose a point on this arc to be the 3rd wheel pivot, ***3rd***.

(b) Draw a second arc from the center which is the radius of the fourth wheel to center distance, ***4C.***

(c) Finally, draw a third arc ***34*** using the third wheel pivot ***3rd*** as the center and which is the radius of the third to fourth wheel distance. Where these arcs intersect is the position of the fourth wheel pivot ***4th***.

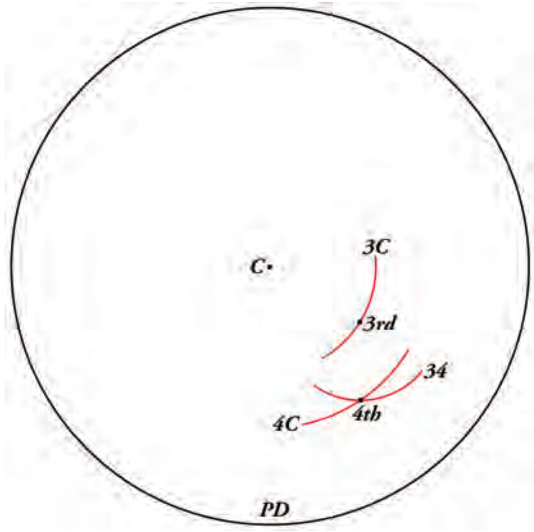


Figure A5-1

Although this diagram defines the positions of the 3rd and 4th wheels relative to each other, it does not define the gear ratio between them. For example, dividing the distance ***3C*** in the ratio 4:1 we can use a center wheel with 32 teeth and a third pinion with 8 leaves. Alternatively, dividing the distance ***3C*** in the ratio 5:1 we can use a center wheel with 40 teeth and a third pinion with 8 leaves.

Figure A5-2:

(a) Continuing with Figure A5-2, draw an arc from the center which is the radius of the fusee to center distance, ***FC.***

(b) Draw a second arc ***F3*** using the third wheel pivot ***3rd*** as the center and which is the radius of the fusee to third wheel distance. Where these arcs intersect is the position of the fusee pivot ***FC3***.

(c) Finally, draw a third arc ***F4*** using the fourth wheel pivot ***4th*** as the center and which is the radius of the fusee to fourth wheel distance. Where these arcs intersect is the position of the fusee pivot ***FC4***.

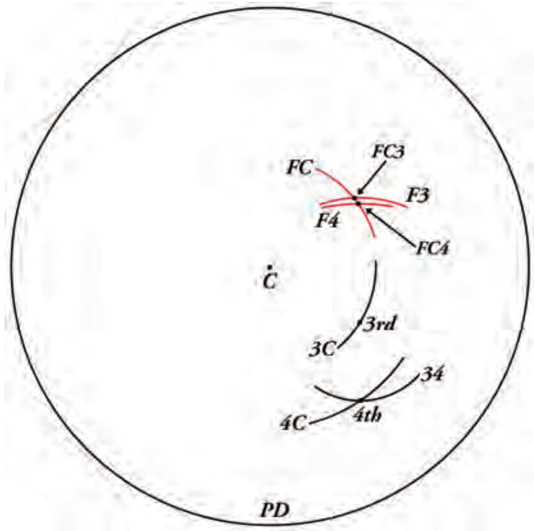


Figure A5-2

If the measurements were perfect, the points ***FC3*** and ***FC4*** would be in exactly the same position. But they are not, and we do not know precisely where the fusee is located. And we do not know how much of this error is due to the photographs and how much is due to the measurement.

A5.2: Top Plate Comparisons of Rotor Movements

Four rotor movements (Figures 7-48 to 7-51, page 86) were used. These are identified by the names *Leroy*, *Klokken*, *Berthoud* and *Mazzi*.

The angular relationships are shown in Figures A5-3 to A5-6. Ten lines were drawn on the *Berthoud* movement and transferred to the other four movements.

The high degree of similarity, especially of the positions of the driving wheel ***D***, the intermediate wheel ***I***, the fusee ***F*** and the stop-work ***S***, indicates that these movements are based on the same calibre.

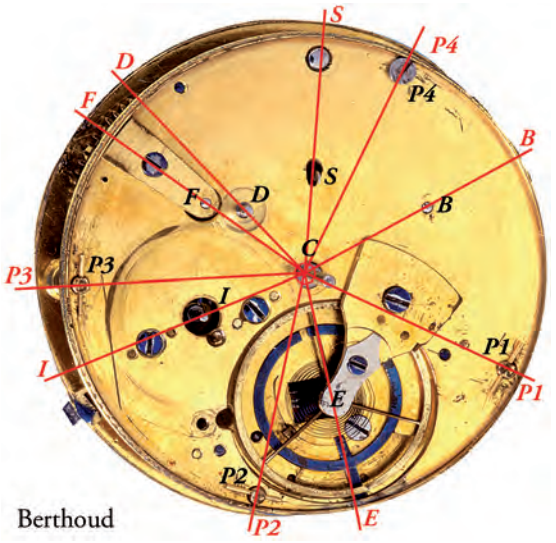


Figure A5-3

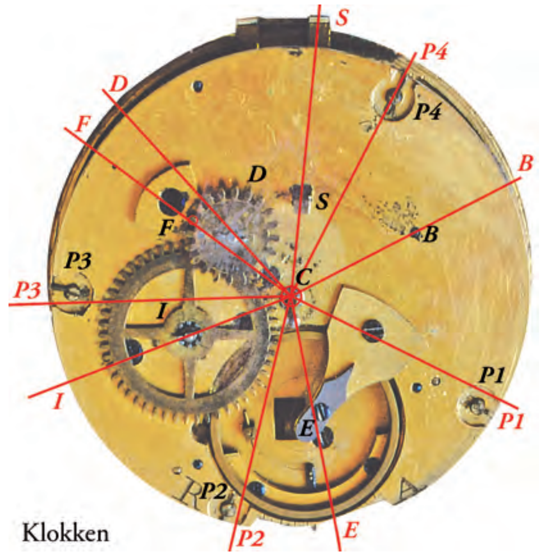


Figure A5-4

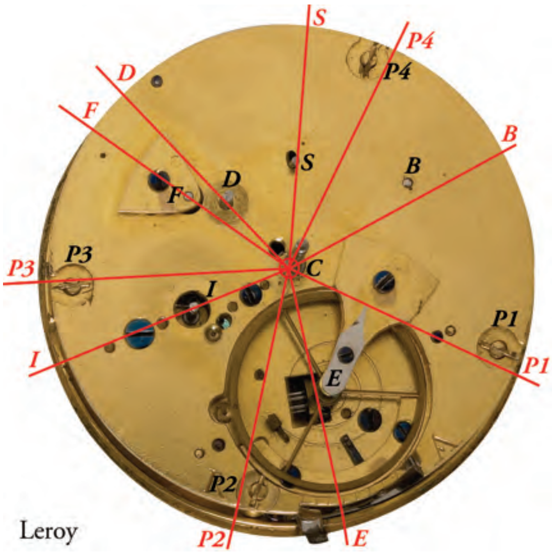


Figure A5-5

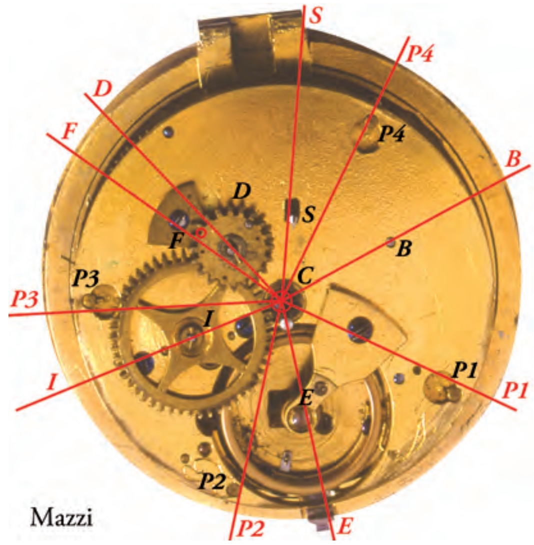


Figure A5-6

The *Egidius Link* movement, in Figures 7-47, 7-52 and A5-7, is interesting because it appears to be the same calibre, but the positions of the pillars are completely different. This change may be a consequence of it having a repeater mechanism under the dial.

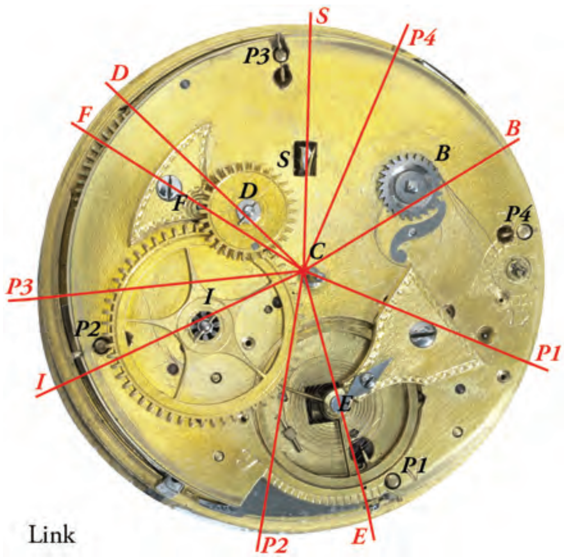


Figure A5-7

The method of calculating distances uses the 11 different pivots shown in Figures A5-3 to A5-6:

(a) Movement: Balance staff ***E***, barrel ***B*** and fusee ***F***.

(b) Self-winding mechanism: Center ***C***, driving wheel ***D***, intermediate wheel ***I***, and stop-work ***S***.

(c) Pillars ***P1***, ***P2***, ***P3***, and ***P4***.

In addition the diameter of the top plate, ***TD***, was measured to scale the data.

23 different distances were measured between these pivots. It must be noted that the positions of the pillars are arbitrary and they are only limited by the need to place them so that they do not interfere with other parts and by convention. In addition, in a fusee movement the position of the fusee is limited because it must mesh with the center wheel. But the position of the barrel is arbitrary, and only limited because it must not touch other parts.

The measurements were scaled so that the four movements have the same top plate diameter of 37.2 mm; this is the diameter of the Berthoud and Mazzi movements (See Table A6.1, page 347). Table A5-1 illustrates this scaling:

	Berthoud	Klokken	Berthoud scaled	Klokken scaled	Difference
D to C	18.6	17.3	6.95	6.49	0.47
D to I	23.8	22.1	8.90	8.29	0.61
D to E	44.3	42.1	16.56	15.79	0.77
TD	99.5	99.2	37.20	37.20	0.00

Table A5-1

The raw data in column 2, for the *Berthoud* movement, was multiplied by $^{37.2}/_{99.5}$ to scale the data to a top plate diameter (***TD***) of 37.2 mm, as in column 4. And the data for the *Klokken* movement in column 3 was multiplied by $^{37.2}/_{99.2}$, as in column 5. Then the *Klokken* scaled data was subtracted from the *Berthoud* scaled data.

Table A5-1 shows the comparison of the *Klokken* movement with the *Berthoud* movement. If we compared the *Berthoud* movement with the *Klokken* movement we get the same results except the signs of the numbers are reversed.

Table A5-2 gives all measurements (except pillar positions) of the *Klokken*, *Leroy* and *Mazzi* movements compared to the *Berthoud* movement, the *Leroy* and *Mazzi* movements compared to the *Klokken* movement, and the *Mazzi* movement compared to the *Leroy* movement. This set includes all possible combinations.

To make the comparison simpler, the results are classified into four groups:

(a) Green: The difference is 0.00 to 0.50 mm. This range is within the accuracy of the photographs and the measurements. Green entries are considered to be identical.

(b) Yellow: The difference is 0.51 to 0.75 mm. This range is probably within the variations caused by hand watch making and the measurements.

(c) Red: The difference is 0.76 to 1.00 mm. This range probably indicates a real, but small, variation.

(d) White: The difference is greater than 1.00 mm. This range almost certainly indicates that the movements are different with respect to that measurement.

The last two rows of the table give the percentage of measurements that are a "perfect" match and the percentage that are "excellent".

	Klokken (Berthoud)	Leroy (Berthoud)	Mazzi (Berthoud)	Leroy (Klokken)	Mazzi (Klokken)	Mazzi (Leroy)
D to C	0.47	-0.26	-0.38	-0.73	-0.84	-0.11
D to I	0.61	0.41	0.32	-0.20	-0.29	-0.09
D to S	-0.43	-0.08	-0.14	0.35	0.29	-0.05
D to F	0.37	0.10	-0.01	-0.27	-0.37	-0.10
D to B	0.41	0.68	0.44	0.28	0.04	-0.24
I to C	0.31	0.55	-0.08	0.24	-0.39	-0.63
I to S	0.18	0.40	0.49	0.22	0.31	0.09
I to F	0.42	0.08	0.06	-0.35	-0.36	-0.02
I to B	0.43	0.66	0.31	0.23	-0.12	-0.35
S to C	0.39	0.16	0.86	-0.23	0.47	0.70
S to F	0.69	0.60	0.37	-0.09	-0.31	-0.22
S to B	0.23	0.46	0.54	0.22	0.31	0.08
F to C	0.53	-0.26	-0.54	-0.79	-1.08	-0.29
F to B	0.85	0.72	0.38	-0.12	-0.47	-0.34
E to D	0.77	0.41	0.32	-0.37	-0.45	-0.08
E to I	0.71	0.27	0.33	-0.44	-0.39	0.06
E to C	-0.22	0.76	0.20	0.98	0.42	-0.55
E to S	-0.54	0.45	0.20	0.99	0.74	-0.25
E to F	0.51	0.13	-0.08	-0.37	-0.59	-0.22
E to B	-0.69	0.11	-0.53	0.80	0.16	-0.64
C to B	0.08	-0.04	0.29	-0.12	0.21	0.33
< 0.51	57.1%	71.4%	72.6%	76.2%	81.0%	81.0%
< 0.76	90.5%	95.2%	95.2%	81.0%	90.5%	100%

Table A5-2

The obvious conclusion is that all four movements were made to the same calibre using the same ébauche.

Finally, Table A5-3 compares the *Link* movement with the other four rotor movements.

It is clear that there are significant differences, but the *Link* movement is probably related to the others. Again, it is not known if these changes are the result of moving pieces to accommodate the repeater mechanism.

	Berthoud	Klokken	Leroy	Mazzi
D to C	-0.18	0.28	-0.45	-0.56
D to I	0.69	1.30	1.10	1.01
D to S	-0.31	-0.74	-0.39	-0.44
D to F	0.79	1.15	0.89	0.78
D to B	-1.60	-1.20	-0.92	-1.16
I to C	-0.08	0.23	0.47	-0.16
I to S	0.58	0.76	0.98	1.07
I to F	0.50	0.92	0.58	0.56
I to B	-0.14	0.28	0.51	0.16
S to C	0.29	0.68	0.45	1.15
S to F	-0.23	0.46	0.37	0.14
S to B	-0.83	-0.60	-0.37	-0.29
F to C	0.35	0.89	0.10	-0.19
F to B	-0.91	-0.07	-0.19	-0.53
E to D	0.17	0.94	0.58	0.49
E to I	-0.26	0.45	0.01	0.07
E to C	0.13	-0.09	0.89	0.34
E to S	1.10	0.56	1.55	1.30
E to F	0.51	1.02	0.65	0.43
E to B	1.28	0.59	1.39	0.75
C to B	0.05	0.13	0.01	0.34
< 0.51	57.1%	38.1%	47.6%	52.4%
< 0.76	71.4%	57.1%	66.7%	71.4%

Table A5-3

A5.3: Pillar Plate Comparisons of Rotor Movements

The measurements used are defined in Figure A5-8. By using the pillar plate eleven different points can be compared:

(a) Five pivots, center ***C***, third wheel ***3***, fourth wheel ***4***, fusee ***F*** and barrel ***B***. Estimating the center of the movement was very difficult because of the cannon pinion (and the hour wheel) together with the angle of the photograph.

(b) The three screws holding the fusee cock and the bridge, ***FS***, ***BS1*** and ***BS2***.

(c) Three dial feet holes ***D1***, ***D2*** and ***D3***. An indication of the distortion of the photograph is indicated by measuring the distance between these holes and the center of the movement. These holes appear to be equidistant from the center, except for one on the *Berthoud* movement.

The angular relationships are shown in Figures A5-8 to A5-11. With the exception of the positions of the dial feet holes, they show that the movements are very similar, perhaps identical. The dial feet holes of the *Mazzi* movement have not been used because of the modifications made to it.

Sixteen measurements between these points were taken. In addition, the diameter of the pillar plate ***PD*** was measured to scale the data.

It must be noted that the positions of the dial feet holes and the screws are arbitrary. In addition, in a fusee movement the position of the fusee is limited because it must mesh with the center wheel. But the position of the barrel is arbitrary, only limited because it must not touch other parts.

As before the measurements are scaled, as described above, so that the movements can be compared and all four movements have the same pillar plate diameter. The diameter of the Berthoud movement, 38.6 mm, was used. (The Mazzi movement has the same diameter.)

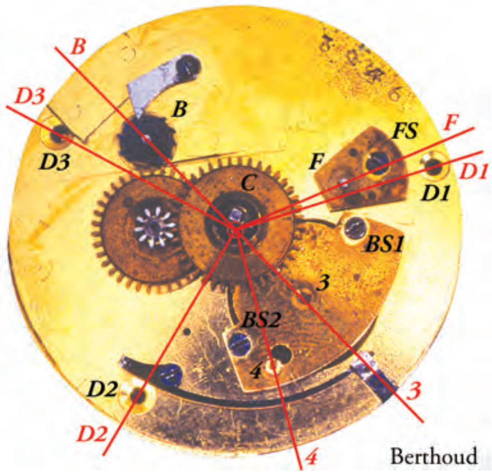


Figure A5-8

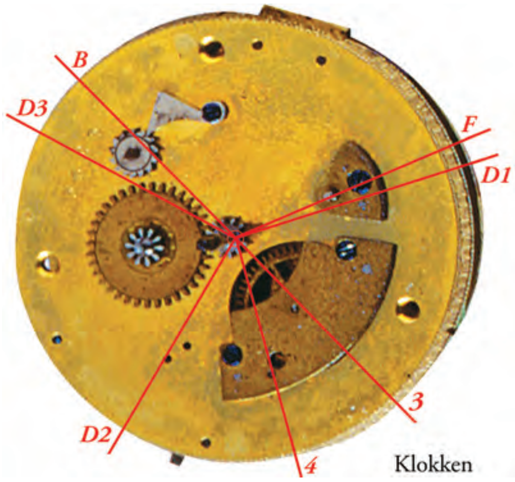


Figure A5-9

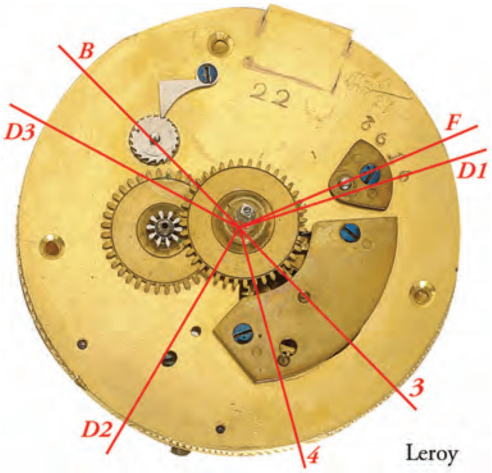


Figure A5-10

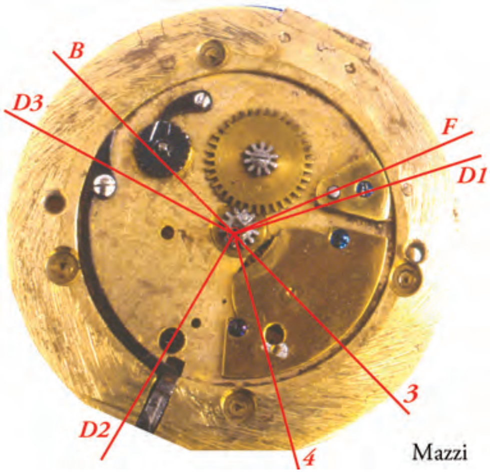


Figure A5-11

The fusee, barrel and center pivots appear on both sides of the movement, and these pivots can be used to compare the top plate and pillar plate measurements; the pillars also appear on both sides, but they cannot be seen on the pillar plate views because of the gilding. Table A5-4 provides a comparison of these top plate and pillar plate measurements.

Ideally we would expect the distances from both photographs to be the same. This is true of the *Berthoud*, *Leroy* and *Mazzi* movements, and the differences give an indication of the errors in measurements. The *Klokken* movement has large differences, but these may be due to the very bad photographs of that movement and the manipulation in Photoshop that was necessary.

	Klokken (Berthoud)	Leroy (Berthoud)	Mazzi (Berthoud)	Leroy (Klokken)	Mazzi (Klokken)	Leroy (Mazzi)
F to C	0.32	0.30	-0.08	-0.02	-0.41	0.39
B to C	-0.88	-0.04	-0.04	0.84	0.84	0.00
B to F	-1.38	-0.50	-0.11	0.88	1.27	-0.40

Table A5-4

Table A5-5 shows the differences in all measurements. Again, to make the comparison simpler, the results are classified into the four groups described above. The screws and dial feet have been included, but their positions are arbitrary and large differences are not significant.

The three columns involving the *Klokken* movement should be regarded as inaccurate. The *Link* movement is not included because the repeater mechanism hides most of the pivots.

	Klokken (Berthoud)	Leroy (Berthoud)	Mazzi (Berthoud)	Leroy (Klokken)	Mazzi (Klokken)	Leroy (Mazzi)
3rd to C	0.12	0.02	0.40	-0.10	0.28	-0.38
4th to C	-0.18	0.04	0.49	0.22	0.67	-0.45
3rd to 4th	0.28	0.41	0.67	0.13	0.39	-0.27
F to C	0.86	0.05	-0.06	-0.81	-0.91	0.10
F to 3rd	-0.10	-0.09	0.18	0.00	0.28	-0.27
F to 4th	0.05	0.41	0.86	0.35	0.80	-0.45
B to C	-0.80	-0.08	0.23	0.72	0.93	-0.31
B to 3rd	-0.59	0.00	0.70	0.59	1.22	-0.69
B to 4th	-0.58	-0.19	0.37	0.39	0.89	-0.56
B to F	-0.54	0.22	0.67	0.75	1.11	-0.45
C to BS 1	0.50	0.62	0.24	0.12	-0.25	0.37
C to BS 2	-0.50	0.61	0.98	1.11	1.48	-0.36
C to FS	1.51	0.99	0.37	-0.51	-1.14	0.63
C to D1	1.28	0.74		-0.54		
C to D2	0.11	-0.12		-0.22		
C to D3	0.48	0.93		0.45		

Table A5-5

Again we can conclude that all four movements were made to the same calibre using the same ébauche.

A5.4: Five Different Makers?

Although the five rotor movements are very similar, differences between them make it very likely that they were not made by one person as a batch.

First, the variations in the shapes of the cocks and the bridges (Figures A5-3 to A5-7 and Figures A5-8 to A5-11) preclude them being made in a batch simultaneously.

Second, the pinned ends of the pillars are different. As shown in Figures A5-3 to A5-7:

(a) The Klokken and Leroy movements have the pillars sunk in concentric recesses.

(b) The Mazzi movement has deliberately eccentric recesses for three pillars, but the fourth does not have a recess and its pin protrudes into the sink for the balance.

(c) The Link movement has separate holes to access the ends of the pins.

(d) The *Berthoud* movement does not have recesses and the pins are above the level of the plate. (One pillar must have split because the pin has been replaced by a modern screw).

The purpose of the recesses is to allow the tops of the pillars to be set in the plate, so that the outside of the weight can be closer to the plate. The pins holding the pillars are in holes drilled through the thickness of the plate and the recesses expose the ends of the pins so that they can be removed. (The weight is recessed to provide space for the balance cock.).

Third, Joseph Flores has pointed out that the arms of the wheels in the movements are different. Figure A5-12 shows the intermediate wheels of the five movements and it is clear that the crossing-out (the process of creating the arms from a disk) varies significantly. Other wheels in each of the movements consistently show the same styles.

These variations support my opinion that these movements were not made in a batch. And the differences in crossing-out suggest the five movements were made by five different people, although the similarity of the Klokken and Leroy movements suggests that they may have been made together by one person.

A likely explanation is that an order was placed for several watches (probably by Sarton) and the movements were made simultaneously by different makers to avoid a long delay in filling the order.

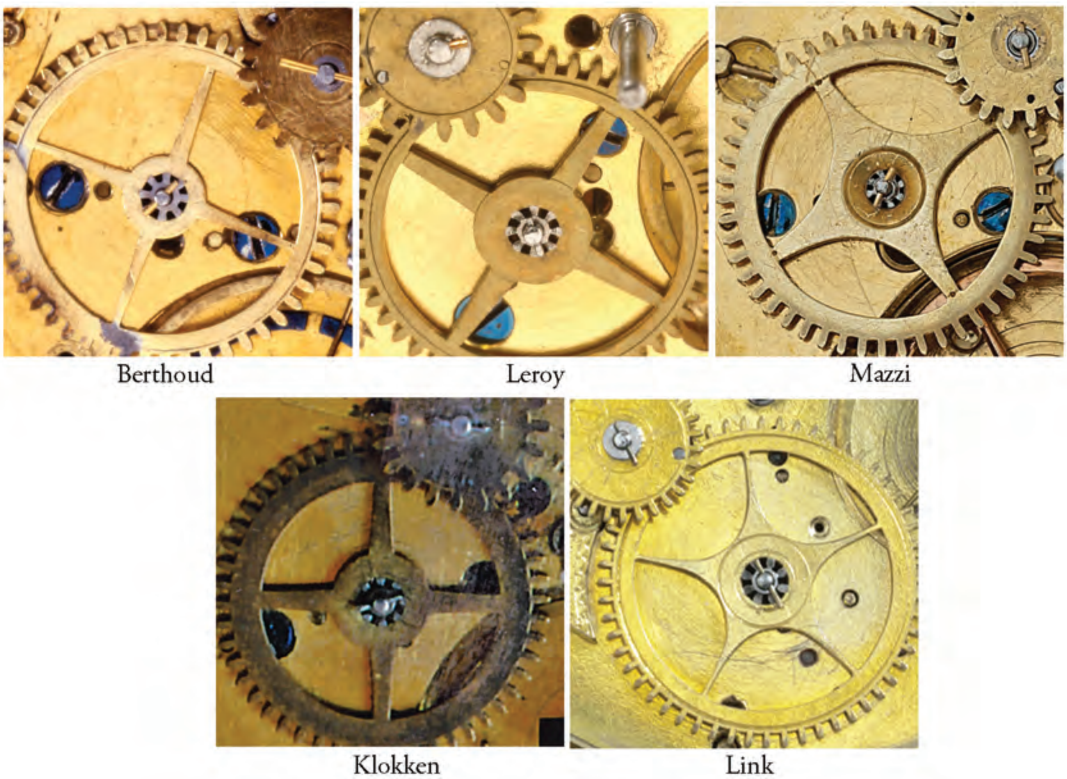


Figure A5-12

A5.5: Pillar Plate Comparisons of Center-Weight Movements

Only the *Le Locle*, *Meuron* and *Private* movements have pillar plate views, Figures 12-2, 12-4 and 12-8 (page 139), and the photograph of the *Private* movement is too distorted to be useful. Figures A5-13 and A5-14 show the angular relationships for the *Le Locle* and *Meuron* movements, with lines from the center to the intermediate wheels ***I1*** and ***I2***, the barrel ***B*** and the balance ***E***. They are almost identical.

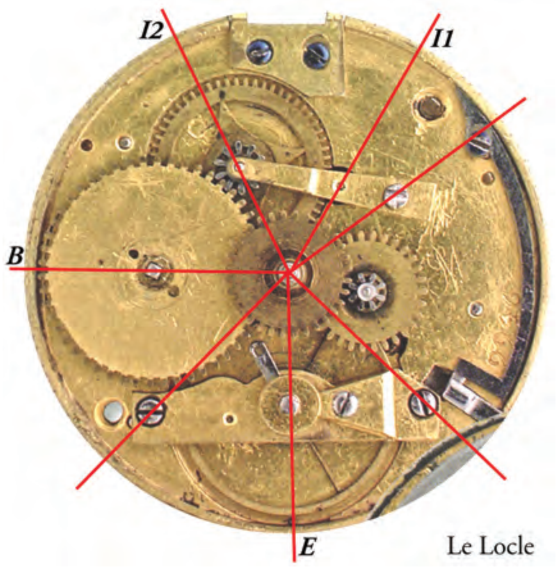


Figure A5-13

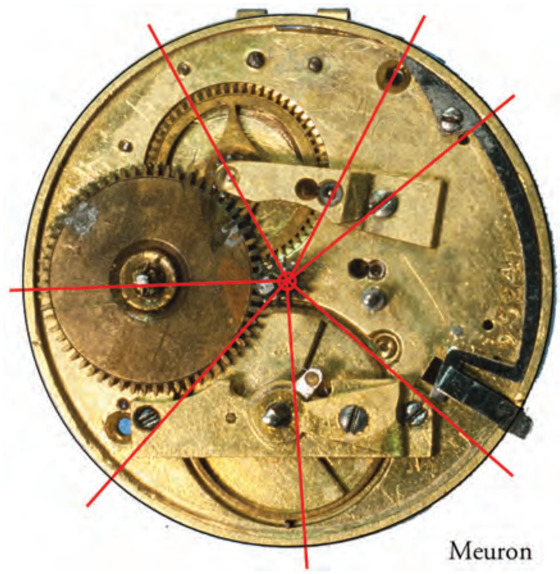


Figure A5-14

The distances between these four pivots and the center are given in Table A5-6, scaling the pillar plate to an arbitrary size of 40 mm.

	Le Locle	Meuron	Difference
C to I1	7.73	7.33	0.40
C to I2	8.93	8.84	0.09
C to B	10.31	10.27	0.04
C to E	10.04	10.00	0.04
I1 to I2	7.82	7.60	0.22
I1 to B	15.60	15.07	0.53
I1 to E	17.16	17.02	0.13
I2 to B	10.22	9.87	0.36
I2 to E	18.44	18.22	0.22
B to E	14.53	14.13	0.40

Table A5-6

It is obvious that the two movements are identical.

Although the *Private* movement has not been compared, the visual similarity suggests that it is also based on the same design and it is probably very similar or even identical to the *Le Locle* and *Meuron* movements.

A5.6: Top Plate Comparisons of Center-Weight Movements

The angular relationships between the top plate pivots are given in Figures A5-15 to A5-20; they are based on the *Le Locle* movement. The six movements are identical within the expected errors.

Measuring the movements was difficult, because the diameters of the top plates appear to vary, making scaling the data difficult. Instead, the diameters of the pillar plates were used and scaled to 40 mm, as in the pillar plate comparison.

The results, comparing five movements with the *Le Locle* movement, are given in Table A5-7.

	Choisy	Crott	Furtwangen	Meuron	Private	Choisy 50 mm	Furtwangen 45 mm
C to D	1.80	0.60	0.70	0.13	-2.40	-0.07	-0.38
C to B	2.57	0.27	0.70	-0.03	-0.80	0.57	-0.53
D to B	2.17	0.67	0.60	0.03	-1.00	0.03	-0.66
C to E	2.43	0.30	2.93	0.67	-0.50	0.37	1.96
C to 4	1.47	0.03	0.53	0.67	-0.63	-0.60	-0.62
C to 5	2.40	0.40	1.43	0.60	-0.37	0.28	0.25
E to 4	1.53	-0.03	1.47	0.20	-1.60	-0.41	0.49
E to 5	0.60	-0.03	0.17	0.20	-0.60	-0.30	-0.34
4 to 5	1.20	0.07	0.90	-0.10	-1.00	0.08	0.30
D to 4	3.40	0.57	1.33	0.83	-2.70	-0.36	-0.80
B to E	3.27	0.60	2.43	0.53	-1.50	0.29	0.84

Table A5-7

The disastrous results for the *Choisy* movement illustrate the problem with assuming all movements have the same pillar plate diameter.

If the *Le Locle* movement has a diameter of 40 mm and the *Choisy* movement diameter is increased to 50 mm, then there is a nearly perfect match between the two. And the match of the *Furtwangen* movement is improved, but still not perfect, if its diameter is increased to 45 mm.

This table highlights the problems that can occur when making arbitrary decisions so that the data can be scaled for comparison. In particular, is this scaling meaningless? That is, has the data been modified so that the results are good but the method of comparison is bad? The answer is no. Eleven separate measurements were made to produce Table A5-7 and *only one* measurement was scaled for each table. That is, the *ratios* between the measurements have not been altered; every measurement is enlarged or reduced by the same amount, the plate diameter of 40 mm. The only consequence of this scaling is that the differences are also scaled. For example, if Table A5-7 was scaled to 200 mm (the size of a clock) then the differences would be 5 times larger; similarly they would be one half for a wrist watch. That is, the choice of 0.50 mm, 0.75 mm and 1.00 mm to classify the distances has been chosen for a time-piece the size of a pocket watch and may not be suitable for clocks or wrist watches.

However, arbitrarily changing the *Choisy* movement diameter to 50 mm and the Furtwangen movement to 45 mm is probably be unacceptable manipulation of the data.

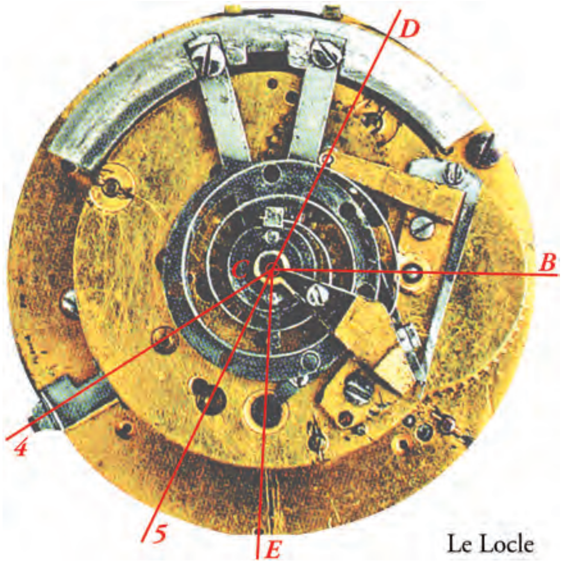


Figure A5-15

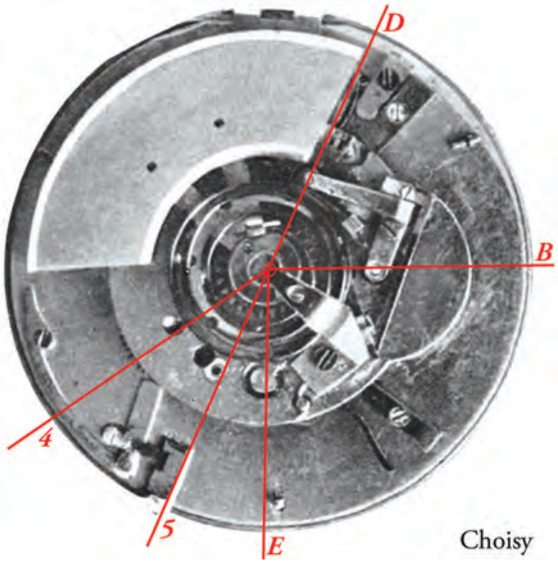


Figure A5-16

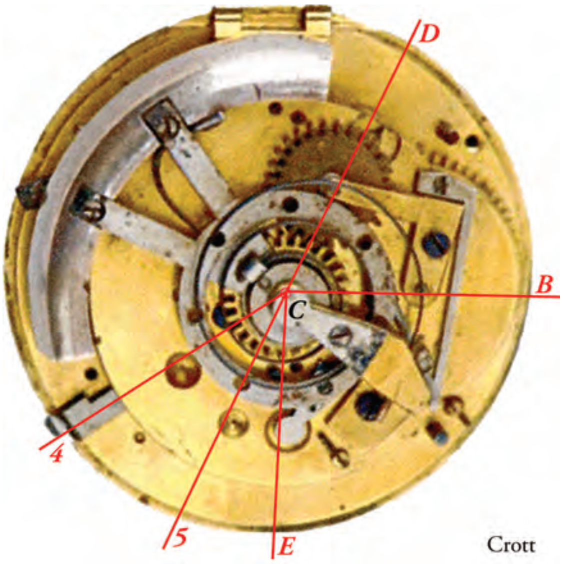


Figure A5-17

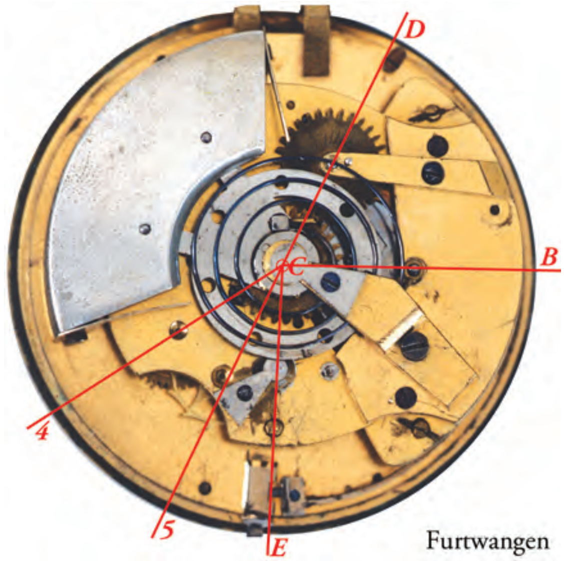


Figure A5-18

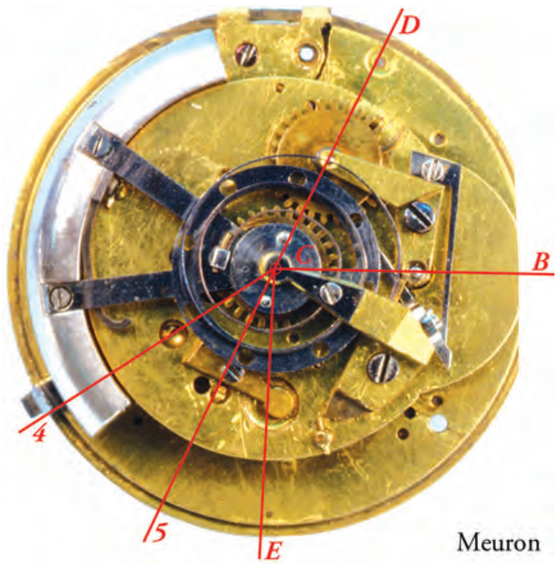


Figure A5-19

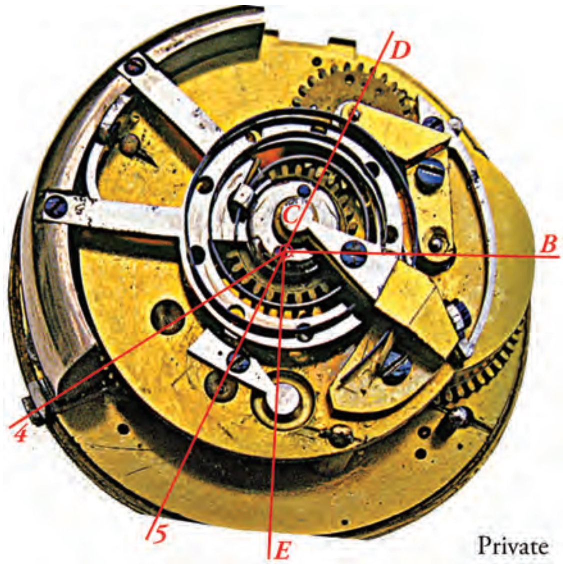


Figure A5-20

Therefore, although the approach is sensible, it is not clear if the center-weight movements are the same or different calibres. And that can only be resolved by examining and measuring the movements themselves.

However, an important point is that the *Choisy* and *Furtwangen* movements have weights that are obviously different from the weights used by the other movements. And the *Furtwangen* movement has a different weight locking mechanism (see page 143). These features suggest that they have been made to a different calibre.

Because of the bad results for the *Choisy* movement, a different method was tried where the distance ***C*** to ***D*** was scaled so that it is the same for all six movements, 9.30 mm (this is the ***C*** to ***D*** distance of the *Le Locle* movement when the data is scaled to a plate diameter of 40 mm). The results, again comparing five movements with the *Le Locle* movement, are given in Table A5-8. Now the results are excellent, but the *Private* movement is disastrous. This is probably because the photographs of it are so bad that it cannot be scaled and measured correctly.

	Choisy	Crott	Furtwangen	Meuron	Private
C to B	0.65	-0.44	-0.10	-0.19	1.53
D to B	0.12	-0.03	-0.22	-0.12	1.40
C to E	0.45	-0.42	2.30	0.52	1.80
C to 4	-0.52	-0.64	-0.22	0.53	1.49
C to 5	0.36	-0.32	0.66	0.45	1.94
E to 4	-0.33	-0.68	0.83	0.07	0.64
E to 5	-0.26	-0.33	-0.16	0.14	0.38
4 to 5	0.12	-0.32	0.51	-0.18	0.37
D to 4	-0.21	-0.67	-0.06	0.58	1.64
B to E	0.41	-0.40	1.40	0.32	1.92
PD	-0.96	-0.28	-0.33	-0.06	0.82

Table A5-8

Again Table A5-8 is valid because *only one* measurement was scaled for it. That is, the *ratios* between the measurements have not been altered; every measurement is enlarged or reduced by the ***C*** to ***D*** distance of the *Le Locle* movement when that data is scaled to a plate diameter of 40 mm.

Therefore, although the approach is sensible, it is not clear if the center-weight movements use the same or different calibres. And that can only be resolved by examining and measuring the movements themselves.

A5.7: The Gschwind Center-Weight Movement

The description and photographs of the Gschwind movement in Chapter 12 (page 144) suggest that it may be a modified rotor movement or a modified center-weight movement. So the questions that need to be answered are:

Is the Gschwind movement a modified rotor movement or a modified center-weight movement?

Or is it unique?

The first comparisons are the angular relationships, Figures A5-21 and A5-22.

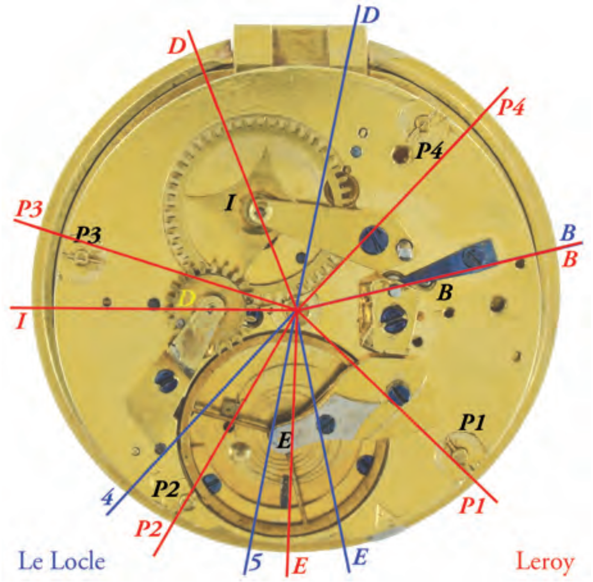


Figure A5-21

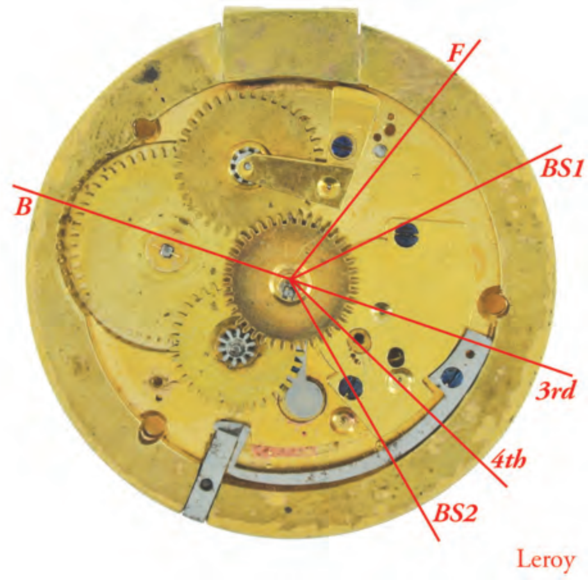


Figure A5-22

In the top plate comparison, Figure A5-21, the lines have been oriented using the position of the barrel ***B***:

(a) Red lines, the Leroy rotor movement: Barrel ***B***, balance ***E***, intermediate wheel ***I***, driving wheel ***D***, and pillars ***P1***, ***P2***, ***P3*** and ***P4***.

(b) Blue lines, the Le Locle center-weight movement: Driving wheel ***D***, barrel ***B***, balance ***E*** 5th (escape) wheel ***5*** and 4th wheel ***4***. The blue line for the barrel is hidden under the red line for the Leroy movement.

The Gschwind movement has a very similar layout to the Leroy rotor movement, except that the driving wheel (yellow ***D***) and intermediate wheel have swapped places. But there is nothing similar when compared with the Le Locle center-weight movement. Note that the positions of the driving wheel ***D*** are completely different in all three movements. This is to be expected in the case of the rotor movements, because ***D*** must move from the position to mesh with wheels connected to the fusee to wheels connected to the barrel.

The consequence is that based on this evidence alone the Gschwind movement seems to be a modified rotor movement.

The pillar plate comparison, Figure A5-22, only includes the Leroy rotor movement, and we can see that the layout of the two movements is almost identical. Again, it seems that the Gschwind movement is a modified rotor movement.

The differences in the positions of the driving wheel ***D*** in the above photographs can be understood from the layout of the self-winding mechanisms. Figures A5-23 to A5-25 show the mechanisms from the dial, pillar plate side of the movements. They are "transparent" views which give the approximate locations and sizes of wheels and pinions on the top plate and between the plates as well as the "visible" wheels on the pillar plate.

The winding mechanism of the Gschwind movement, Figure A5-23, consists of:

(a) The pinions of the driving wheels ***D1*** and ***D2*** (red) mesh with the intermediate wheel ***I1*** that is under the top plate.

(b) The arbor of ***I1*** passes through the movement and is supported by the cock ***C*** on the pillar plate.

(c) Between the cock ***C*** and the plate is the pinion for ***I1***, and it meshes with the second intermediate wheel ***I2*** that is supported by an extension of the cock ***C***.

(d) The pinion of ***I2*** meshes with the winding wheel ***W***, which is squared onto the barrel arbor.

Figure A5-23

The mechanism used by rotor movements, Figure A5-24, is different because it acts on the fusee instead of the barrel and has only one intermediate wheel:

(a) The pinions of the driving wheels ***D1*** and ***D2*** (red) mesh with the intermediate wheel ***I1*** (blue) which is above the top plate.

(b) The pinion of ***I1***, which is in a hole below the top plate, meshes with the winding wheel W (blue), which is on the top of the fusee and squared onto the fusee arbor.

Figure A5-24

Only one intermediate wheel is needed because the planetary gears in the fusee cause a 4:1 reduction (see page 75 and Section 7.6 page 83).

The mechanism used by the center-weight movements, Figure A5-25, uses two intermediate wheels:

(a) The pinions of the driving wheels ***D1*** and ***D2*** (red) mesh with the intermediate wheel ***I1*** (blue) which is under the top plate.

(b) The arbor of ***I1*** passes through the movement and the pinion for ***I1***, on the outside of the pillar plate, meshes with the second intermediate wheel ***I2*** (black) which is supported by the same cock.

(c) The pinion of ***I2*** meshes with the winding wheel ***W***, which is squared onto the barrel arbor.

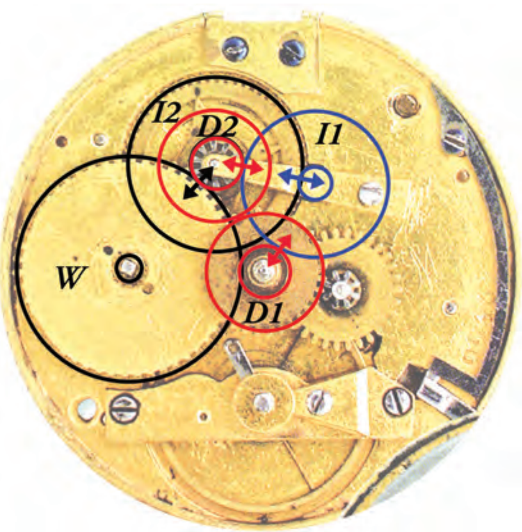


Figure A5-25

Except for the position of the driving wheel ***D2***, the arrangement for the Gschwind movement is very similar to that used by the other center-weight movements. In contrast, the rotor movements use a completely different mechanism.

Table A5-9 compares the Gschwind movement pillar plate to the four rotor movements; as before, the Link movement is omitted because the pivots are hidden by the repeater mechanism. This table assumes all movements have a pillar plate diameter of 38.6 mm, the diameter of the Berthoud plate. Although measurements of the photographs were inconsistent, the Gschwind movement pillar plate probably has the same diameter. The fusee holes are not included because the corresponding holes in the Gschwind movement are definitely not for a fusee.

	Berthoud	Klokken	Leroy	Mazzi
3rd to C	-1.14	-1.02	-1.12	-0.74
4th to C	-1.28	-1.46	-1.24	-0.79
3rd to 4th	-1.03	-0.75	-0.62	-0.36
B to C	-1.21	-2.01	-1.29	-0.98
B to 3rd	-2.52	-3.10	-2.51	-1.82
B to 4th	-2.36	-2.94	-2.56	-1.99
C to BS 1	-1.17	-0.67	-0.55	-0.93
C to BS 2	-0.72	-1.22	-0.11	0.25

Table A5-9

There appears to be no relationship between the Gschwind movement and three of the four rotor movements. However, the table is misleading. Only the watch train is being compared and, because the movements have different escapements, large variations are to be expected.

A top plate comparison of the Gschwind movement with the rotor movements is given in Table A5-10; the symbols are those used for the rotor movement comparisons above and it uses the known top plate diameters of 37.2 mm for the rotor movements and 37.6 mm for the Gschwind movement. Two important features of this table are:

	Berthoud	Klokken	Leroy	Link	Mazzi
C to D	-0.15	0.20	-0.43	-0.04	-0.79
C to I	-0.73	-0.48	-0.27	-0.80	-1.02
C to B	-0.55	-0.55	-0.80	-0.45	-0.41
C to E	-0.04	-0.33	0.54	-0.36	0.08
D to I	-0.35	0.20	0.34	-1.11	-0.19
D to B	2.36	2.66	2.86	3.98	2.53
D to E	-5.04	-4.38	-4.77	-5.31	-5.06
I to B	-5.52	-5.23	-5.16	-5.52	-5.54
I to E	5.43	6.06	5.64	5.46	5.59
B to E	-0.16	-0.96	-0.21	-1.38	-0.90
C to P1	-0.35	0.45	0.18	-0.46	0.13
C to P2	-0.65	-0.08	-0.06	0.09	-0.39
C to P3	-0.46	0.04	0.22	-0.23	-0.25
C to P4	-0.16	-0.04	0.16	-0.05	-0.13
C to ES1	-0.11	0.17	0.20	-2.59	0.52
C to ES2	0.10	0.54	0.77	4.77	0.31
ES1 to ES2	0.43	1.37	0.75	0.33	0.79

Table A5-10

First, the Gschwind movement has the driver wheel ***D*** and the intermediate wheel ***I*** in different positions, and so the four rows measuring these wheels to the barrel ***B*** and the balance ***E*** have very large values. If the positions of ***D*** and ***I*** are swapped the differences are much smaller, but still too large, and it is certain that positions of these two wheels are not related to the rotor movement positions.

Second, two additional measurements are ***ES1*** and ***ES2***, the screws holding the *balance plate*.

Four of the five rotor movements have a *balance plate* screwed to the inside of the top plate, as in Figure A5-26. The purpose of the plate is to enable the balance to be placed in the thickness of the top plate instead of above it, so that the balance does not interfere with the weight. In addition, the components of the verge escapement are attached to the underside of the balance plate instead of the underside of the top plate where they normally are; ***a*** is the potence carrying the bottom pivot of the balance staff, ***b*** the counter potence and ***c*** the contrate wheel pivot. The Link movement probably uses this design.

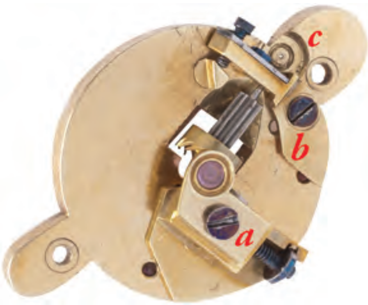


Figure A5-26

This design has an important feature. The common arrangement for a verge escapement, Figure A5-27, has the escape wheel mounted between the potence ***a*** and the counter potence ***b*** at the edge of the plate. As a result, the contrate wheel ***c*** pivots beside the escape wheel arbor and its teeth mesh with the escape wheel at an angle, the yellow line. Berthoud described this problem:

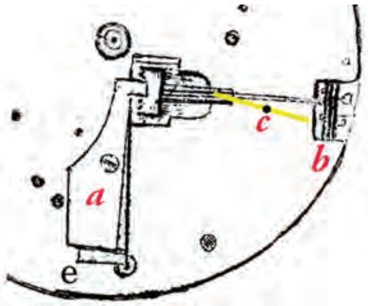


Figure A5-27

> *To decrease the friction which affects the pivot on the outer end of the escape wheel, it is necessary, instead of placing the counter-potence on the edge of the plate and having the arbor pass beside that of the contrate, to place the counter-potence inside, between the contrate arbor and the potence, as it is shown in Figure A5-28 where b represents the counter-potence. From this it will result that: 1, the two escape wheel pivots will experience an equal pressure, which will allow these pivots to be smaller than would be the case without this provision; 2, the engagement with the contrate wheel will be better; and 3, the hole in the nose of potence, in which the inner pivot of the wheel runs, will not wear oval, as happens from the bad arrangement that is given to this part.* (Berthoud, 1786, volume 2, page 359; Berthoud & Auch, 2007, page 18.)

The Gschwind movement also has a balance plate to lower the balance, Figure A5-29, and it has the holes for the 4th and escape wheel upper pivots, ***c*** and ***b*** respectively. The lower pivots of these wheels and the balance staff ***a*** are in the pillar plate as normal.

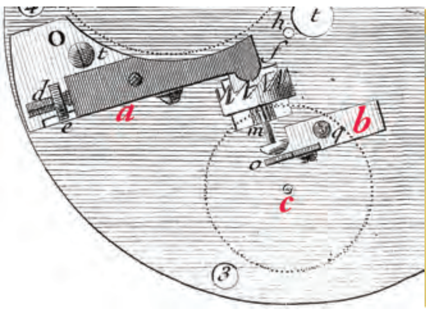


Figure A5-28

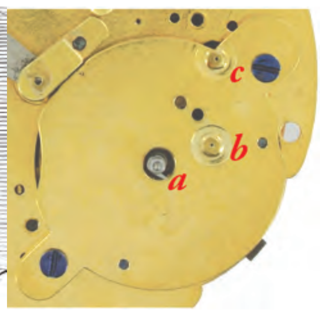


Figure A5-29

In conclusion, Table A5-10 strongly suggests that the Gschwind movement is based on the rotor movement design.

Comparing the Gschwind movement with the other center-weight movements shows that the two designs are not related. Tables A5-11 and A5-12 compare the Gschwind movement pillar and top plates by assuming the pillar plates have the same diameter of 38.6 mm; it is obvious that the top plates are completely different and cannot be compared.

	Locle	Meuron
C to I1	-0.31	0.08
C to I2	0.05	0.14
C to B	-0.69	-0.64
C to E	-0.64	-0.59
I1 to I2	-1.46	-1.25
I1 to B	-2.35	-1.83
I1 to E	-0.85	-0.72
I2 to B	-1.31	-0.97
I2 to E	-0.25	-0.04
B to E	0.73	1.12

Table A5-11

	Choisy	Crott	Furtwangen	Locle	Meuron	Private
C to B	2.49	-1.02	-0.12	-0.05	-0.18	-0.82
C to D	-0.50	-0.88	-2.26	-2.59	-2.43	-4.23
C to 4	4.13	2.49	3.96	2.84	3.64	2.16
C to 5	4.22	1.07	3.96	2.23	2.77	1.46
B to D	8.62	7.11	7.04	6.53	6.59	5.69
B to 4	6.20	3.17	3.69	2.63	3.14	1.05
B to 5	6.17	3.21	3.89	2.53	2.28	1.15
E to 4	0.27	-0.98	0.37	-1.08	-1.24	-2.56
E to 5	0.31	-0.33	-0.14	-0.20	-0.59	-0.81
4 to 5	1.31	0.66	1.21	0.34	1.60	-0.75

Table A5-12

Other than the escapements, there is no relationship between the Gschwind movement and the other center-weight movements.

Finally, there are three sets of empty holes in the pillar plate, Figure A5-30:

(a) Top right, red: There are two steady pin holes, a screw hole for a cock (with a broken screw in it?), and a pivot hole.

But, because the first wheel under the fusee must mesh with the center wheel pinion, the fusee must extend outside the edge of the plate as shown. This is impossible and the holes cannot be for a fusee.

A possible explanation for these holes is that they were for a cock supporting the intermediate wheels, and it has been replaced by the cock beside the holes.

(b) Bottom right, green: This might be a screw hole that has been damaged, but the marks next to it appear to be punch marks and not holes for steady pins. The large hole cannot be for a pivot.

Figure A5-31 shows the arrangement of the train, which is the normal design. Because the center wheel must pass under the barrel and the fusee, it is placed in a recess cut into the pillar plate. To enable the 3rd wheel to mesh with the center wheel, a large hole is cut in the plate and a bridge is placed on the outside. Both the 3rd and 4th wheel pivots run in this bridge so that their pinions can mesh with the preceding wheel.

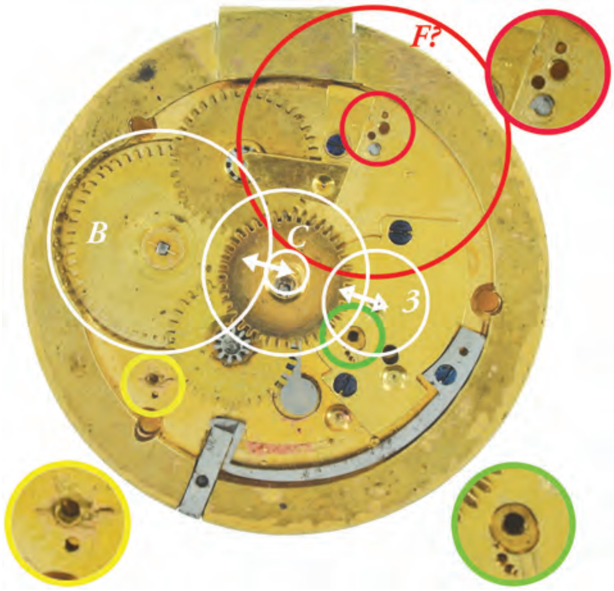


Figure A5-30

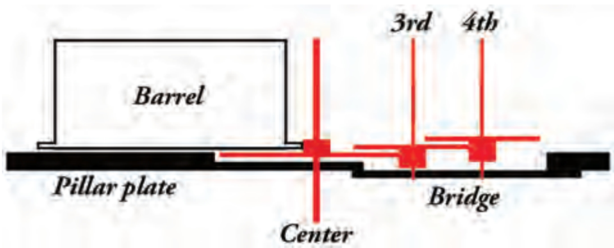


Figure A5-31

From Figure A5-30 it is clear that the unused holes lie inside the space occupied by the 3rd wheel, and may also be inside the space occupied by the center wheel (the diagrams are not accurate). Therefore, the unused holes cannot be for anything mounted on the inside of the bridge, and anything on the outside of the bridge cannot have a useful purpose.

There are two other possibilities. First, the empty hole is a peep hole, like that near the 4th wheel pivot that is used by the watchmaker to check the depthing of the 4th and escape wheels. But because of its location nothing can be observed through the empty hole. Second, the empty hole could have been the original position of the 3rd wheel pivot. But there is no reason to use a layout different from the normal one (where the 3rd wheel is located) and no reason to bore out the hole.

Again, there is no explanation for these holes.

(c) Bottom left, yellow: Here there is a screw hole and a steady pin hole.

There is no explanation for these holes. Certainly there is nothing that they can hold on the top of or underneath the pillar plate.

These deductions are confirmed by Figure A5-32; it shows the same holes from the inside of the pillar plate. Most importantly, there is nothing near the holes that could explain their purposes. In particular, it is obvious that the bottom right (now bottom left) hole cannot be a peep hole and nothing can be attached to it.

Figure A5-32

A5.8: Conclusions

The tables and illustrations given above allow us to reach some tentative conclusions:

(a) *Rotor movements*: The evidence indicates that these five movements are based on the same calibre.

There are differences between the movements which indicate that they were not made in a batch by the one watchmaker. In addition, there is some evidence that suggests the movements were made by several people.

(b) *Center-weight movements*: Although visually and technically similar, there are significant differences, the most obvious being the shape of the weight and the banking springs. Although they are probably based on the same calibre, it is almost certain that they would have been made separately and it is possible that they were made by different watch makers.

(c) *The Gschwind movement*: This movement is not related to the other center-weight movements, because they are based on a completely different calibre.

The evidence supports the opinion that this movement is based on the rotor movement calibre.

The empty holes indicate that the movement has been modified, but from what, how and why is unknown. This work suggests that the Gschwind movement is probably a prototype.

The most important comparison is that of the self-winding trains, which are different in each type of movement. But that can be misleading, because the position and arrangement of the train is restricted by the need to wind either the barrel or the fusee. Also, the position and arrangement of the watch train is also restricted, and similarities must be expected.

The most likely explanation for the Gschwind movement is that it and the rotor movements were constructed using the same design.

Finally, to state the obvious, no definite conclusions are possible until all the rotor and center-weight movements have been examined, measured and photographed correctly.

Appendix 6: The Mazzi à Locarno Watch

A6.1: A Comment on Values

Recently I have watched some episodes of the British TV series *The Antiques Roadshow*, in which people bring pieces to be examined and valued by "experts". These people have encyclopaedic knowledge in their areas of expertise, but often they are vague when suggesting values.

Common methods of valuation are: "An auction estimate for me is about ...". "If you bought this at a good shop you would have to pay about ..." (sometimes this is expressed as "The insurance replacement value should be ...".

But none of the experts comment on the difference between auction and retail prices.

For example, assume a piece sells at auction for £5,000. The seller must pay a commission to the auction house and will actually get about £4,000. The buyer also pays fees to the auction house and the piece will cost about £6,000.

The buyer then puts the piece in his or her superior shop and will sell it for between £9,000 and £12,000; the latter is more likely. This markup is not all profit, the dealer having to pay for rent on the shop, electricity, insurance, staff, and so on.

So the retail or insurance value is about three times the amount the seller gets at auction.

Some experts on *The Antiques Roadshow* state: "I think this is worth ...". That is clearly a useless valuation, because what a piece is worth depends on what method of valuation is being used.

Auction "estimates" are misleading. Sometimes a piece will sell for less, but often the actual bid price is much greater than the estimate; usually this occurs when two or more people desperately desire a piece and each has enough money in a bank to be able to bid endlessly. And the aim of the auction house is to maximise bids. As Antiquorum (2001, page 21) states:

> *The chronology chosen for the auction catalogue is aimed at arousing and maintaining high public interest throughout the sale, with a variety of different types of watches, some affordable by all, others destined for only a handful of collectors.*

Where there are previous sales of a piece, auction estimates are probably a good guide, but valuations of unique pieces are likely to be wrong. And that is the problem with rotor watches.

One of the main factors controlling values is "perfect condition". Both experts and "serious" collectors regard flaws as fatal, and a piece worth £5,000 could be reduced to £500 if it has a small crack or other blemish.

The Leroy watch has been sold twice.

In 1949, Léon Leroy purchased the watch for 21,000 AFR (old French Francs), Figure A6-1. At the time he knew nothing about it. He had never seen a rotor watch before, it was not signed and the

9 Mars :
Offert pour la montre 28g50 .... 17.000 Frs
" pour le cachet .... 4.000 "
21.000 "

Détail : 28,50 x 550 = 15.675
pour la curiosité
du mouvement 1.325

au total .... 17.000 Frs

Figure A6-1

maker was unknown, and when and where it was made were also unknown. How could he value the watch? So he offered the seller 15,675 AFR for the weight of the gold in the case, and 1325 AFR for "the curiosity of the movement". It was only after he had bought the watch that its significance became known.

No data is available for 1949, but in 1953 the case was worth 192 CHF (Swiss Francs) and the movement was valued at 17 CHF (Fxtop, 2015).

The watch remained with the Leroy family until 1993 when it sold at auction for 100,000 CHF (Antiquorum, 1993a, lot 168, pages 88-89). Even allowing for inflation over the previous fourteen years, this is an astounding increase in value (inflation would have only raised the value to about 4,000 CHF). In 1993 the gold value of the case was only 517 CHF (Only Gold, 2015) and so the "the curiosity of the movement" had risen to about 99,000 CHF! And this was 60,000 to 70,000 CHF more than the auction estimate of between 30,000 and 40,000 CHF. Clearly two or more people desperately wanted the watch.

Three factors would have influenced the price.

First, the watch was described as "attributed to Abraham Louis Perrelet" and this would have significantly increased that value of the unsigned movement.

Second, the watch was "highly important and almost unique". That is, although at least one other rotor movement must have been known to exist, the bidders probably thought that this was their one and only chance to own such a watch.

Third, what is the value of perfection? The watch is complete, in very good condition and probably in its original form. That is, in 1949 the watch was interesting, but in 1993 it was perfect and worth ten times more, or about 40,000 CHF. So the auction estimate might have been sensible, although I think the final price reflects desperation and possibly more money than common sense.

A little is known about the "Mazzi à Locarno" watch. It had been in the collection of a Swiss industrialist. Then in 1996 his descendants sold the watch to a watchmaker, Jean-Louis Fabris (Fabris, 2015). About 2002 Fabris cleaned and oiled the movement and signed the mainspring, Figure A6-2. He then sold the watch to Jean-Claude Sabrier. After Sabrier died his collection was auctioned, and on 6 May 2015 I purchased it for the hammer price of 7200 EUR, about 7470 CHF (Chayette & Cheval, 2015, lot 128, page 59). The auction estimate was 2,000 to 3,000 EUR and two or more people must have wanted the watch. Was this a sensible price?

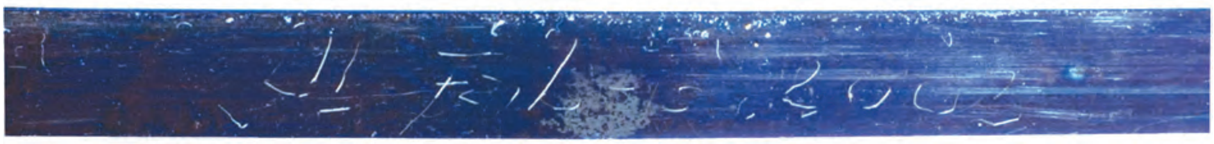


Figure A6-2

First, it is unique in the sense that it is the only known rotor movement that is not in a museum, and again the bidders may have thought that this was their one and only chance to own such a watch; I certainly did.

Second, the movement has been re-cased and it is not in original condition. Indeed, my bid was only for the movement because I regard the case, dial and hands to be worthless, and they only serve to protect the movement.

Third, the movement is not in "very good" condition; it is only "good" as we will see later.

The catalogue is surprisingly vague. The watch is described as "system attributed to Abraham Louis Perrelet", but there is no photograph of the movement and it is stated to be "enigmatic". The condition is not mentioned, nor the "uniqueness".

So what is the only rotor watch not in a museum worth? Probably 7,200 EUR! Because if it had been in its original gold case and in better condition it should have been worth about 72,000 EUR or 75,000 CHF, which compares well with the price of the Leroy watch.

However, an interesting question that needs to be answered is: *What do people collect?*

Unlike many objects, watches have an important feature in that they are made up of four different components: the case, the dial, the hands, and the movement. In contrast, snuff boxes, paintings and (sometimes) porcelain consist of a single piece. And some collectors are only interested in a specific component. For example, a Huaud painted enamel case may be worth a lot of money even though it houses an uninteresting movement. Indeed the case, like a painted enamel snuff box, could be empty without detracting too much from it. Likewise, an exceptional movement in an ordinary silver case may be very valuable.

What is important about a rotor watch? Obviously the movement. The Leroy watch case is very well made, but it is just a plain gold case, no better and no worse than thousands of other 18th century gold cases. What makes the watch valuable is the movement. And what makes the "Mazzi à Locarno" watch valuable is the movement. A movement of which only five examples are known and four of those examples are in museums.

So I am pleased that experts and serious collectors want perfection, whereas I am only interested in watch movements. It enabled me to own something very special. (Since writing this, the watch has been sold to the Musée international d'horlogerie, La Chaux-de-Fonds, Switzerland.)

A6.2: A Polygamous Marriage

Before the "Mazzi à Locarno" watch was sent to me in Australia, it was disassembled, examined and photographed by Joseph Flores. Most of the photographs and measurements in this section were made by him. In addition, I have examined some parts of the watch with a stereo microscope, using 20x magnification.

It is obvious that the "Mazzi à Locarno" watch has been constructed using parts from four different sources:

First, the movement: This movement, like the other four, was almost certainly made in 1777 or 1778, and most measurements of it and the *Berthoud* movement are identical or nearly identical; see Table A6-1, page 347.

Second, the case, dial and hands: The case and the dial come from the same source. The diameter of the dial is 45.5 mm and the internal diameter of the bezel is about 45.3 mm; they are a perfect match. The photograph in Sabrier (2012a, page 42) and Figure A6-10 suggest the dial is too small for the case, because its edge is visible on the right. However, this is because the movement is not centered in the case. The hands are also a very good match with the dial, being the correct length and curved to follow the shape of the dial.

Figure A6-3

Figure A6-4

Third, the weight extension, Figure A6-3: This is a substantial piece of brass that is 7.2 mm high with a maximum width of 2.3 mm, and attached to the weight by a pin and two screws. Clearly it cannot have been part of the watch that was originally in the case.

Also, it cannot have been part of the rotor movement. For a hinged movement to be lifted out of the case, which is necessary to adjust the regulator, the top plate must be smaller than the pillar plate; this is called *embichetage* (see Berthoud, 1786, volume 2, page 354; Auch, 1827, page 80; Berthoud and Auch, 2007, pages 16 and 93). In Figure A6-4 the movement is hinged at the left (green circle) and the top plate must be inside the green arc or it will hit the movement seat (black). The embichetage of the Mazzi and Berthoud rotor movements is 1.4 mm; the diameters of the plates are 38.6 mm and 37.2 mm in both watches.

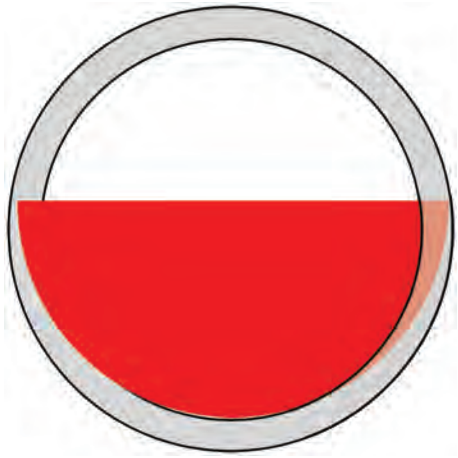


Figure A6-5

The weight attached to the top plate is a semi-circle and to lift the movement out of the case it can be placed near the hinge, and then the only limitation is that the diameter of the weight must be smaller than the diameter of the movement seat. Assuming, with the aid of prayer and magic, it is possible to get the Mazzi movement into its original case, it would be impossible to lift the movement out of the case because the diameter of the extension to the weight is greater than the diameter of the movement seat.

Figure A6-6

Most importantly the reverse is also true, and it would be impossible get the movement into the case when the watch was first assembled. Figure A6-5 shows the weight and its extension (red) with one end inserted into the case, and it is obvious that the other end cannot be put under the movement seat.

Fourth, the annulus, Figure A6-6: This part was made from a brass disk at least 3.2 mm thick, and it is too thick to have been a watch plate. In Figure A6-7 the edge of the dial

Figure A6-7

has been cut back to make room for the hinge and this appears to be original. That is, the hinge attached to the annulus was made for the dial and the case.

An important question is: *When was the movement adapted to fit into its new case?*

Sabrier (2012a, page 37) states that:

> *... the watch made by Mazzi, and completed circa 1795 ... in accordance with the new fashion for large watches, the dial plate was set into a gilt brass ring and its weight enlarged in the same manner. Sold by Mazzi in Locarno, its dial bears his signature.*

And on pages 41-42 of that book, he states that this watch:

> *... was constructed from an unfinished movement from the Revolutionary period and completed in the early 19th century. ... [it] was enlarged with a brass ring so that it could be fit with a larger dial and housed in one of the large-diameter [silver] cases then fashionable. The winding weight was also enlarged ...*

This second statement appears to be supported by a feature that Sabrier might have been told about. As shown in Figure A6-8, the mainspring is signed *E Bethmann 1809*, and so the mainspring was replaced about 1810.

Figure A6-8

If the movement was put into the case at that time then:

> *The workmanship should be of the same standard produced by other circa 1800 watchmakers, as described by Berthoud (1786), Vigniaux (1802) and Auch (1827).*

But it is not. To avoid confusion I will refer to the *rotor movement*, the movement in the case at present, and the *Mazzi movement*, the movement that may have been in the case before it was exchanged for the rotor movement.

First, let us assume that Sabrier never saw the watch disassembled, and he based his opinion on what can be seen from the outside. Being an expert watch assessor, he should have noted four problems:

(a) The hands: As shown in Figure A6-9, the hole in the minute hand is too large for the square on the canon pinion. Even though the hand has been squashed, it is still loose and will foul the hour hand or fall off; the watch cannot run with the minute hand on it. In contrast, the hour hand is a reasonably good (but not perfect) fit on the pipe of the hour wheel. Although I am not sure, the hole in the hour hand may have been enlarged slightly with a file.

Figure A6-9

It is possible that the hands are modern replacements for the original hands which have been lost. However, this is unlikely because they match the dial perfectly; that is, the hands belong to the Mazzi movement.

(b) The dial is off center. With respect to the *case*, Figure A6-10, the dial is off center in the direction of the red arrow. With respect to the *movement* it is off center in the direction of the green arrow, as shown in Figure A6-11. Sabrier may not have known about this latter error if he did not remove the hands.

Figure A6-10

The error with respect to the case could be caused by the movement hinge (riveted to the annulus) being in the wrong position. It is not caused by looseness, because there is no play when the movement is locked in the case.

The error with respect to the movement could be caused by the dial feet holes being drilled in the wrong positions in the annulus. However, the dial has two feet at 12 minutes and 42 minutes, and the foot at 12 minutes was bent towards 13 minutes. Most of these errors disappeared after I straightened the dial feet. But the dial was still off center with respect to the case and the movement, and trying to improve either would cause the other to become worse.

Figure A6-11

(c) The weight extension, Figure A6-12, is well made but far from perfect. There are variations in the gap between it and the weight. The width varies erratically and the widest part is not in the middle, as we would expect, but to the left. The right end is thinner than the left end. And finally, the width of the engraving is uniform and so part of it has been removed where both ends taper.

Figure A6-12

(d) The chain guard screw, Figure A6-13, appears to be a tall, modern dial-foot screw; but it has a coarse thread and the screwdriver slot is wide, suggesting it is an old screw. (In contrast, the Leroy movement has a short, normal screw.)

Figure A6-13

As shown in Figure A6-14, the Berthoud movement also has a tall screw, and so it is possible for both screws to be original. However, the Berthoud movement has been re-cased and repaired, including a screw used to hold one pillar (see Figure 7-50, page 86), and both screws might be modern replacements.

Figure A6-14

These problems should have rung alarm bells. They suggest, but do not prove, that the work was done in the 20th century and not circa 1800. But when the dial is removed ...

Figure A6-15 shows the surface of the annulus under the dial. The Mazzi à Locarno dial is domed and about 3.7 mm deep. The canon pinion square and hour wheel pipe must protrude through the dial to attach the hands, and to achieve this the annulus has been filed into a wide bevel.

This is obviously not circa 1800 work.

First, the coarse file marks remain and the surface is very rough because of them. Second, on the inside there is a flat surface that has not been filed, but this varies in width.

A watchmaker working in 1800 would have filed or turned the bevel uniformly and then smoothed and polished it, leaving no traces of file marks.

Figure A6-15

The pillar plate, Figure A6-16, displays further evidence of 20th century work. As shown in the enlargement, Figure A6-17, the holes for the pillars have been crudely notched, and then the pillars riveted using a triangular punch, probably from a staking set. The punch has not been centered correctly.

Figure A6-16

In contrast, circa 1800 the pillars would have been riveted using the method in Figure A6-18. The pillar is placed in a countersunk hole ***a*** and a hammer used to form the rivet ***b***. Then in ***c***, the end of the pillar is filed flush with the plate, the plate smoothed and gilded (yellow). As a result the ends of the pillars are normally invisible. Figures 7-48 to 7-50 (page 86) show the pillar plates of three rotor movements and illustrate this work. Only one of the 12 pillars is visible; in Figure 7-50 (the Berthoud movement) the gilding around the left pillar has cracked.

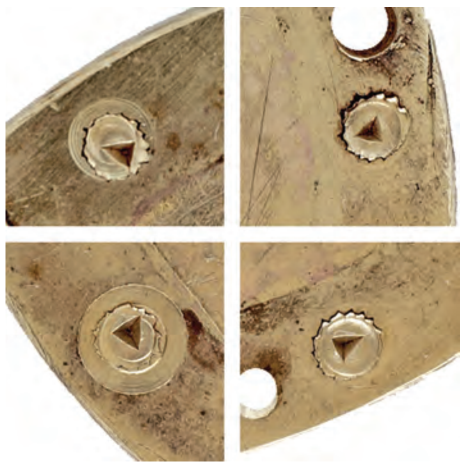


Figure A6-17

We can now be very confident that some time in the 20th century the rotor movement did not have a case. The movement of the Mazzi watch was removed and scrapped (it was probably uninteresting or damaged) leaving the case, dial and hands. Then the annulus was made and riveted to the rotor movement. To do this, the original hinge on the pillar plate was cut back, Figure A6-19, creating space for a new hinge (probably taken from the Mazzi movement). We can also be confident that the rotor movement would have had a gold case that, like many gold cases, was removed and sold for its scrap value some years before the movement was put in the Mazzi case.

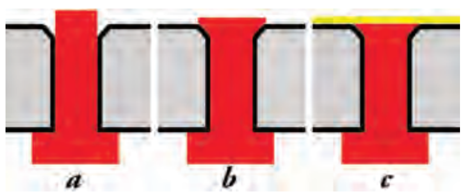


Figure A6-18

But this does not explain three important features. First, it is possible, in an 18th century movement, for one pillar to be loose, *but not all four pillars*. Second, the ends of the two pillars on the left side in Figure A6-17 have been countersunk into the plate. That is, they are *shorter* than they were originally. Third, as Figure A6-20 shows four holes have been drilled through the annulus to expose the riveted ends of the pillars.

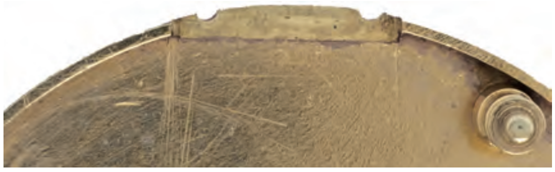


Figure A6-19

Why?

Watch movements are quite robust, and it would take considerable force to damage the pillars. Also, if the movement was assembled when the damage was done, then we would expect catastrophic damage within the movement. The pivots of the 3rd and 4th wheels would break or be badly bent, and other damage to the train and pivot holes would occur. It is probable that the movement could not be repaired.

Figure A6-20

Although we will never know, it seems likely that the pillars were damaged when the movement was disassembled and the annulus was attached to the pillar plate. Perhaps the two left side pillars were badly damaged and had to be shortened?

As shown in Figure A6-21, there are six holes around the edge of the pillar plate, two new holes for the feet of the Mazzi dial (red) and four holes for the rivets that attach the annulus (yellow). Because there are no spare holes, three of the rivet holes must be the original holes for the rotor movement dial feet. The fourth rivet hole, one of the two at the bottom, was probably added because the annulus has split beside the movement catch, Figure A6-22.

Figure A6-21

Why was the annulus not finished, and why were the four holes drilled through to reveal the ends of the pillars? A possible explanation is that the person who re-cased the rotor movement wanted it to be obvious that the work was done in the 20th century and not circa 1800. The watch looks finished and all the external surfaces are polished. It is only when the dial is removed that the “modern” features become visible.

Figure A6-22

Although not relevant to the above discussion, the fusee of this movement is different from the other rotor movements. The other fusees have 6¾ steps that provide a power reserve of 81 hours. In contrast, the Mazzi fusee has only 3¾ steps that provide a power reserve of 45 hours, Figure A6-23. But the mainspring and barrel are the same sizes as those in the Berthoud movement and have sufficient turns and strength to run the watch for 81 hours.

Figure A6-23

Except for a repair and the holes needed to attach the annulus and dial, the movement appears to be unchanged from when it was first made. The only obvious damage, shown in Figure A6-24, is that the driver wheel has a bent tooth (arrow) and the click spring has been replaced; the empty holes in the driver wheel were used to pin the original click spring.

Figure A6-24

The teeth of the two wheels are shaped so that they mesh correctly. The wheel attached to the weight, Figure A6-24 left, acts as a pinion and its teeth are formed accordingly (as the English would say, they are shaped like a bay leaf). And the driver wheel beside it has teeth shaped for a meshing wheel (as the English would say, they are shaped like a thumb).

There is no evidence that the fusee has been modified, and I presume the maker decided that a power reserve of 1⅞ days was sufficient.

Two other features of the watch support my belief that the rotor movement was put in the Mazzi case some time during the 20th century before 1996:

(a) The Mazzi à Locarno dial has two feet and one foot is too close to the fusee, requiring the pin to be short so that it does not touch and interfere with the first wheel. A circa 1800 dial maker would have placed the dial foot further from the fusee.

(b) The screws attaching the weight extension have fine treads and appear to be modern. In addition, the internal diameter of the weight extension is too large and it has not been curved to match the weight; the diameter of the weight is 37.6 mm and that of the weight extansion is 39.6 mm. It is drawn in closer to the weight by the two screws.

A6.3: Comparison of the Berthoud and Mazzi Movements

The data in Table A6-1 has been provided by Joseph Flores. Although there are a few differences, it is clear that the two movements are based on the same calibre.

	Berthoud à Paris	Mazzi à Locarno
Movement size		
Pillar plate diameter	38.6 mm	38.6 mm
Top plate diameter	37.2 mm	37.2 mm
Height of movement including weight	15.5 mm	15.5 mm
Annulus diameter		44.4 mm
Weight diameter	38.2 mm	37.6 mm
Barrel		
External diameter	15 mm	15.5 mm
Internal diameter	14.4 mm	14.6 mm
Height	4 mm	4 mm

Table A6-1a

	Berthoud à Paris		Mazzi à Locarno	
Mainspring				
Length	500 mm		500 mm	
Height	2.8 mm		2.6 mm	
Thickness	0.17 mm		0.17 to 0.19 mm	
Fusee				
Height	3.8 mm		3.8 mm	
Diameter of 1st wheel	18 mm		~17.6 mm	
Winding wheel on arbor	60 teeth		60 teeth	
Annular wheel	30 teeth		30 teeth	
Sun wheel	10 teeth		10 teeth	
Planet wheel	10 teeth		10 teeth	
Number of steps	6¾		3¾	
Watch train				
1st wheel	72 teeth		72 teeth	
Center wheel	60 teeth	8 leaves	60 teeth	8 leaves
3rd wheel	50 teeth	6 leaves	50 teeth	6 leaves
Contrate wheel	48 teeth	6 leaves	46 teeth	6 leaves
Escape wheel	13 teeth	6 leaves	15 teeth	7 leaves
Escapement frequency	17,333 ⅓ bph		16,428 4/7 bph	
Power reserve	81 hours		45 hours	

Table A6-1b

A6.4: Re-Casing, Dial Plate or Annulus?

The re-casing of movements in cases that do not fit the movement perfectly (and are usually of the wrong date) is a modern phenomenon. Although this might have happened towards the end of the eighteenth century, most re-casing has been done in the twentieth century. It has occurred because interesting movements have been found where the original gold cases have been removed and scrapped for their gold value. Later, substitute cases are found to preserve the movement.

However, in the absence evidence supporting a 20th century date, it may not be possible to decide when a movement was re-cased. As noted above, Sabrier thought that the Mazzi movement had been re-cased in the early 19th century. Indeed he suggested that the existing case was the first (and so original) case. However the remains of the original case hinge (Figure A6-19) show that the movement was intended to be put in a smaller case.

In this context, the 13 known rotor and center-weight movements are fascinating:

(a) 4 movements are bare movements without cases.

(b) 5 movements have been re-cased, and at least some of these were re-cased in the 20th century.

(c) 2 movements have probably been re-cased, but information about them is not available.

(d) 1, perhaps 2, movements are in their original cases, the Leroy rotor movement and the Choisy center-weight movement. Chapuis & Jaquet (1952, page 202; 1956, page 212) date the latter watch to circa 1850 and this suggests they dated the case to this time. If so, it has been re-cased.

That is, it is likely that between 9 and 12 of these movements have been separated from their original cases.

We can be sure that the original cases were not damaged beyond repair, because such damage would inevitably result in catastrophic damage to the movements. So it is likely that all 13 watches originally had gold cases and at least 9 of them have had the cases removed and scrapped; silver is not sufficiently valuable to justify scrapping a silver case. In two instances, the Berthoud and Mazzi movements, we know that replacement cases have been used to protect the movements. The *Berthoud à Paris* movement, Figures 7-45 and 7-50 (see page 85), has been put in a English case hallmarked London 1768 (Figure 7-54, page 87); the re-casing is not perfect because the original hinge had to be replaced.

Before discussing re-casing, two terms need to be explained.

Dial Plate: The purpose of a dial plate is to *create space* between the pillar plate and the dial for motion work and other under-dial work. A dial plate has four important features:

(a) The dial is pinned or screwed to the dial plate.

(b) The dial plate is pinned or screwed to the pillar plate so that it can be removed from the movement.

(c) The case hinge is attached to the dial plate instead of the pillar plate.

(d) The dial plate rests on the movement seat in the case instead of the pillar plate, and so the dial plate has a slightly larger diameter than the pillar plate to which it is attached.

Figures A6-25 to A6-27 show three dial plates. In Figures A6-25 and A6-26 the dial is attached by three pinned feet ***a*** and there are three feet ***b*** to attach the dial plate to the pillar plate. The center is cut out to suit the requirements of the under-dial work. Figure A6-27 is the dial plate from a circa 1740 English repeater. The dial has four pinned feet ***a*** and the dial plate is attached to the pillar plate by a screw. It is about 3.5 mm deep to create the space needed for the quarter repeater mechanism.

Many watches do not have dial plates because the dial is domed enough to provide the necessary space. Or the pillar plate is made with a raised rim for the dial to sit on; for example, the three center-weight movements in Figures 12-2, 12-4 and 12-8, page 139.

Figure A6-25

Figure A6-26

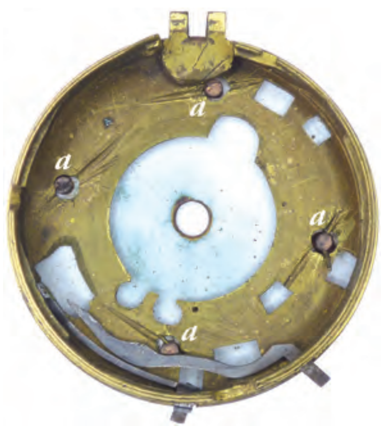


Figure A6-27

Annulus: The purpose of an annulus is to *increase the diameter* of a movement so that it can be put into a case where the diameter of the movement seat is too large for the pillar plate or dial plate. It has five features:

(a) The dial is not pinned to the annulus; it is attached to the pillar plate, or the dial plate if there is one.

(b) The annulus is not meant to be removed from the movement. Unlike a dial plate, which normally has to be removed to access under-dial work, an annulus covers nothing and can be riveted or soldered to the movement.

(c) The case hinge is attached to the annulus instead of the pillar plate or dial plate. Because of the change in diameter of the case, it must be a new hinge and not the original hinge.

(d) The annulus rests on the movement seat in the case instead of the pillar plate or dial plate, and so the annulus can have a much larger diameter than the pillar plate or dial plate.

(e) Unless the new case is only just larger (and the annulus is very small) an original dial will be too small for the opening in the bezel and part of the annulus will be visible.

As an example of these points, the following illustrations are from a *Freres Esquivillon & De Choudens* quarter repeater made between 1776 and 1790 (Patrizzi, 1998). It is housed in an English silver case hallmarked Chester 1909, and so it was re-cased after 1909. It has been used because it has both an annulus and a dial plate.

By a stroke of luck, a case was found where the bezel, with an internal diameter of 41.9 mm, was nearly perfect for the dial, which has a diameter of 42.2 mm, Figure A6-28. However, the diameter of the movement seat was too large for the dial plate and the hinge could not reach the tubes in the case. So a very thin annulus was made, Figures A6-29 ***a*** and A6-30 ***a***, and a different hinge used, ***b***; both figures have the same labels. The annulus and hinge may have come from the movement that had been in the case, the pillar plate being cut down to a thin annulus with the internal diameter being the same as the diameter of the repeater's dial plate.

In this watch the dial is attached by a screw just under the 12 that enters the block ***d*** on the dial plate ***g***. The dial also has two feet, but these are not pinned and are used to align the dial by entering two holes ***e*** in the dial plate. The dial plate ***g*** is fixed to the pillar plate ***h*** by two dog screws ***f***.

Figure A6-28

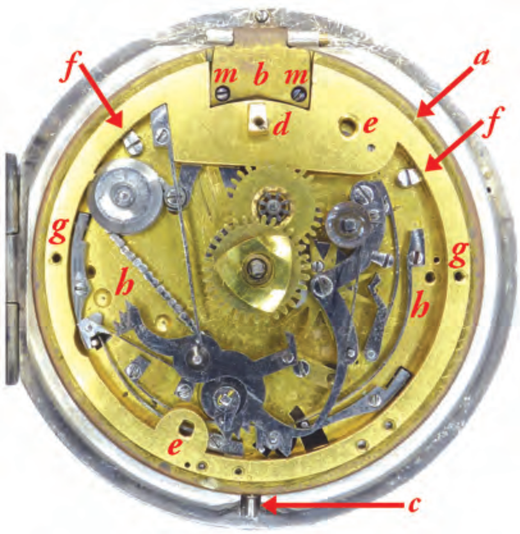


Figure A6-29

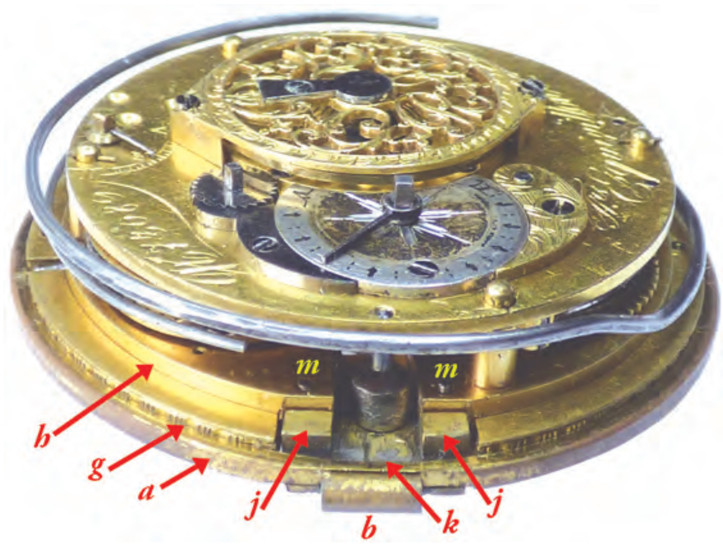


Figure A6-30

Some modifications to the repeater and the case were necessary:

(a) The original hinge, Figure A6-30 ***j***, had to be filed back so that it would fit inside the annulus ***a***.

(b) The new hinge ***b*** is very thin and, because the annulus is also very thin, there is very little metal to attach it. So the hinge is soldered to the annulus (just visible at ***k***) and two screws ***m*** attach it to the pillar plate.

(c) Because there is no space for the catch to lock the movement into the case, the original catch has been removed and it has been replaced by a dial screw ***c***.

(d) Originally the repeater would have been activated by a plunger which formed part of the case pendant, but the replacement case is from an ordinary movement and does not have this feature. To overcome this problem, the pendant has been bored out and a plain rod inserted to act as the plunger. This also required replacing the bow. Because this movement winds through the dial, the winding hole in the back of the case has been filled with silver.

This watch has been described in detail because it illustrates two points:

First, the different functions of the dial plate and annulus are clearly displayed.

And second, the workmanship is excellent, and the person who re-cased the movement has done it carefully and precisely.

It can be difficult to decide when an annulus has been added to a movement and the movement put into a larger case. It is obvious in the above example that the movement was re-cased after 1909. But if the case is contemporary and cannot be dated accurately there must be some doubt, as shown by the Mazzi movement.

The annulus on the Mazzi movement is used to fit the movement into a larger case. It is not a "dial plate" used to create space for the parts under the dial as is shown by three rotor watches; they do not even have a raised rim on the pillar plate, because there is enough space under the dial for the simple motion work and other parts (see page 86). The Link movement has a raised rim on the pillar plate to make the space necessary for the repeater mechanism. Although the Mazzi movement might have been cased in the early 19th century, the evidence presented above makes it very likely that it was *re-cased* in the 20th century. Certainly, the remains of the original hinge, Figure A6-19, make it clear that originally the movement was put in a smaller case and with a smaller dial.

A6.5: Walking with Mazzi and Gryphon

As noted in Section 7.6 (page 83) there are two contradictory views of the performance of rotor watches. Huguenin tested the Leroy watch and found it performed well when carried in a pocket. But Sabrier and Imbert stated that the weight remained hopelessly motionless unless the carrier was particularly active; however, they do not tell us if that was just an opinion or if they actually tested a watch. Certainly a self-winding watch must have some movement to wind it, and that movement depends on how the watch was worn and the activity of the wearer. Except for the watches made by Breguet, it appears that none of the 18th century self-winding watches have an up-down indicator, and the owner can only know if the watch is running by listening to the escapement or seeing the minute hand move. And so the owner needs to be reasonably active every day.

Other than Cummins (2010) there is little information about wearing watches in the late 18th century. Cummins (2010, page 19) writes:

> *The watch was contained in the fob pocket (a small concealed pocket in the band of the breeches). It was only the watch attachment in the form of a chain and breloques (trinkets) that was on display. The watch would be produced for viewing with a flourish ... The word fob has its origins of meaning in deception and secrecy and this pocket was a more hidden site than the previous pockets of the earlier coats.*

Cummins (2010, plate 82) shows a fob pocket in breeches. The pocket opening is level with the waist and the pocket itself is below the waist.

Wikipedia (2015b) includes two useful illustrations:

(a) Portrait of Johann Christian Fischer (1733–1800), German composer, by Thomas Gainsborough, circa 1780; see Figure A6-31.

(b) Portrait of Francisco Cabarrús (1752-1810), by Francisco Goya, 1788; see Figure A6-32.

Figure A6-31

Figure A6-32

Both have chains on their right hand sides, presumably for watches. The second portrait shows what may be an exposed watch on the left hand side.

An important question is: *How would the person produce his watch with a flourish, when the waistcoats are long, quite tight and buttoned down to the waist?* It would be very difficult to access the fob pocket in the breeches underneath a very long waistcoat that opened in a *V* beneath the stomach. But it would be possible if raising the flap of the waistcoat exposed the fob pocket, and so we can be confident that the pocket must have been below the waist.

The way women wore watches is also relevant, because Joseph Gallmayr sold a self-winding watch to Her Highness Mecklenburg-Schwerin (see page 29). Cummins (2010) points out that in the 18th century women usually wore watches on chatelaines where they were exposed and loose. But a loose self-winding watch would perform badly. An example of the problem is the behaviour of a pendulum clock mounted on a flimsy stand or in a flimsy case. The motion of the pendulum will cause the clock and its case to oscillate in sympathy, damping the movement of the pendulum, and it will stop quite quickly. Similarly, a self-winding watch on a chatelaine is free to move and the weight will move only a little or not at all.

A second important question is: *Did the sellers of self-winding watches give advice on wearing them?* The buyers of these watches were a select group of wealthy people, and at that time clothes were made by tailors to fit perfectly and satisfy the requirements of these people. So we can expect that the watch sellers made suggestions on how to wear these watches and, if necessary, clothes would be made or adapted to be appropriate for this purpose. Thus it may be that a "self-winding watch pocket" was included, assuming none of the normal pockets were suitable.

The Victoria and Albert Museum has a diagram of breeches showing the location of pockets in men's breeches in England, between 1770 and 1780 (V&A, 2015a). It illustrates three pockets, but again, accessing the fob pocket is very difficult.

However, V&A (2015b) shows breeches, circa 1760, with "a pocket and pocket flap on each side, a watch pocket in the front of the right waistband, and a pocket in the right side seam". Figure A6-33 shows the positions of these pockets, the fob pocket ***w***, the two waist band pockets, ***a*** and ***b***, and the pocket in the right seam ***l***. (Figure A6-33 is a watercolour of Beau Brummell by Richard Dighton, from Wikipedia, 2015c. The clothing dates from 1805 and is significantly different from fashions in 1780, but it has been used because the breeches are exposed to view.) The seam pocket is very similar to a modern pocket. Most importantly, because the opening runs vertically down the seam, the bottom of the pocket must be about the middle of the thigh or lower. However, in the 1770s, the bump made by a watch in it would probably be hidden by the long waistcoat and outer coat. Another pair of breeches in the V&A collection, circa 1750, has six pockets (V&A, 2015c).

Figure A6-33

Before discussing the performance of the Mazzi watch, we must remember that the movement in it is about 237 years old and the mainspring is 206 years old. Consequently, although the movement is in fairly good condition there are signs of wear. Most importantly, sometimes the weight does not rotate freely and occasionally locks, probably due to excessive friction caused by too much freedom of the weight on its pivot. And, according to Joseph Flores, the escapement has considerable wear. These problems mean that we cannot expect the watch to perform as well as when it was new, and the watch needs to be fully restored.

As I do not own any 18th century clothes, the following tests used modern pockets.

The first test was a walk to buy a newspaper. Gryphon, Figure A6-34, is a silky terrier cross. In the tradition of Emma (Watkins 2015) Gryphon takes me for walks and usually I follow her. Unlike Emma, her walks are best described as bizarre as she zigzags everywhere, repeatedly crossing roads to read the "pee-mails" left by other dogs and to say hello to cats. As a result I have no idea where we are going or how long the walks will last. Except when buying a newspaper; then we follow a regular route from home, through a park to a supermarket, and back along the same route.

Figure A6-34

Table A6-2 has the results for four of nine tests. In each case the Mazzi watch was set to the current time, shaken a few times to start it running and then taken for a walk with Gryphon. The times of the walks were measured using a Longines wristwatch chronograph and the distances walked were calculated using Google Maps. The total time of the 9 tests was 3.86 hours. After each walk, the Mazzi watch was left until it stopped. While it was running its time was checked against the actual time to determine the rate of the watch, fast or slow.

The power reserve achieved on each walk was calculated by adjusting the total time for the rate of the watch and subtracting the duration of the walk. All results were rounded, but are accurate to about 5 minutes. From these measurements I calculated how much the watch was wound for each meter walked, and the time to fully wind the watch. Table A6-2 lists the results of 4 of the 9 tests.

Test	Distance meters	Total power reserve hours	Power reserve minutes per meter	Minutes walking for 45 hours reserve	Minutes walking for 24 hours reserve
1	920	27.7	1.8	30	16
4	1250	14.5	0.7	94	50
7	1450	10.0	0.4	165	88
9	920	0	0	∞	∞

Table A6-2

For these tests I put the Mazzi watch into a pocket where it was outside my thigh and about 26 cm below my waist; this position is similar to, but perhaps lower than the seam pocket ***l*** shown in Figure A6-33. I walked normally (a gentle stroll at a bit less than 3 km per hour) and did nothing special that might affect the winding of the watch. The performance of the wristwatch chronograph was poor because it has unidirectional winding and I did not move my arm enough. In one test it stopped completely, so for the rest of the tests I carried it in a pocket to ensure it wound satisfactorily.

With regard to the results:

(a) It is clear that the weight did not remain hopelessly motionless. One 360° rotation of the weight winds the watch for 4.8 minutes running (see page 84), and in the first test the average movement of the weight was 135° per meter.

(b) The watch did not jerk when in a pocket and the movement of the weight could not be felt.

The rapid decline in the performance of the Mazzi watch was surprising, but up to test 8 it was satisfactory because it could be fully wound in a reasonable time. Until test 9 when it stopped winding. I removed the weight and the driving wheel and I found that the click of the driving wheel, made from soft steel, had been filed away by the hard steel ratchet until it ceased to work.

In fact, most of this damage had occurred before I got the watch and tested it. Figure A6-35 shows the state of the click when I received the watch from France, the arrow highlighting the wear.

Figure A6-35

Throughout the tests the weight oscillated and its movement was insufficient for it to rotate 360°. Figure A6-36 illustrates the mechanism when the driving wheel click ***d'*** no longer functions. When the weight turns anti-clockwise the click ***d*** will cause the intermediate wheel to turn clockwise and wind the watch. However, when the weight returns, rotating clockwise, both clicks ***d*** and ***d'*** are inactive and the mainspring forces the intermediate wheel to rotate anti-clockwise, unwinding the watch. As the two parts of the oscillation are approximately the same, the watch cannot be wound.

The weight must be moving for this to happen. If it is stationary and the force of the mainspring tries to rotate the intermediate wheel anti-clockwise, the ratchet ***B*** has to rotate clockwise. But the stationary click ***d*** stops it from turning. (The watch can be wound and will run if the weight rotates 360°, only turning anti-clockwise.)

The results in Table A6-2 now make sense. During the tests the click was abraded and became less and less effective. Because the ratchet teeth are not identical, it is likely that the click worked with some teeth and not with other teeth, and the winding became intermittent.

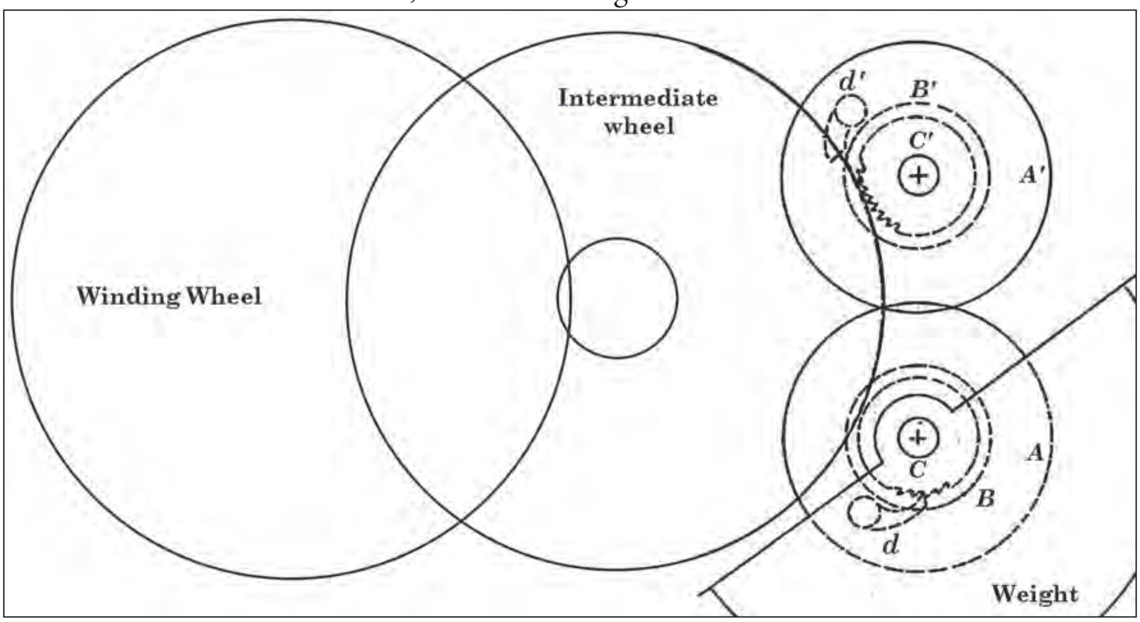


Figure A6-36

Figure A6-37 shows the ratchet under the driver wheel with two teeth (yellow arrows) that are not shaped correctly. These may have caused the wear on the click. When the click is active, rotating the ratchet against the force of the mainspring, these teeth may have forced the click outwards, cutting into it.

Figure A6-37

Also, the teeth are very small. This ratchet is about 4 mm in diameter and has 41 teeth. The depth of the teeth is only about 0.17 mm and the click must be carefully shaped to enter and hold the teeth. Also note that one tooth (green arrow) is much wider than the others, and all the teeth vary in shape and size.

Figure A6-38 is the ratchet under the weight. It has 27 teeth that are about the same depth as the teeth in Figure A6-37, and the click is shaped so that its tip fits into the ratchet teeth. One tooth (yellow arrow) is narrow and very small; the click slides over it.

Figure A6-38

Making these small ratchets from steel disks must have been very difficult. They are about 4 mm in diameter and the ten holes at the base of the leaves are about 0.3 x 0.5 mm; they are essential to create space for a file to shape the leaves. The differences between them suggests they were made by two different people; perhaps a master made the ratchet in Figure A6-38 and his apprentice made the ratchet in Figure A6-37.

The most likely cause of failure is the click spring (Figure A6-24, page 347). It is bent (and too long?) and probably exerts too much pressure on the click. In which case, when the ratchet rotates anti-clockwise its teeth abrade the click until it no longer funtions.

The click was replaced by a Hobart watchmaker, Glen Nutting. As expected, the new click was also abraded rapidly, but a few important tests were made; Table A6-3. The distance in all these tests was 920 meters.

Test	Pocket	Total power reserve hours	Power reserve minutes per meter	Minutes walking for 45 hours reserve	Minutes walking for 24 hours reserve
1	Low	43.3	2.82	20	11
2	Fob	10.1	0.66	88	47
3	Low	19.7	1.26	35	19

Table A6-3

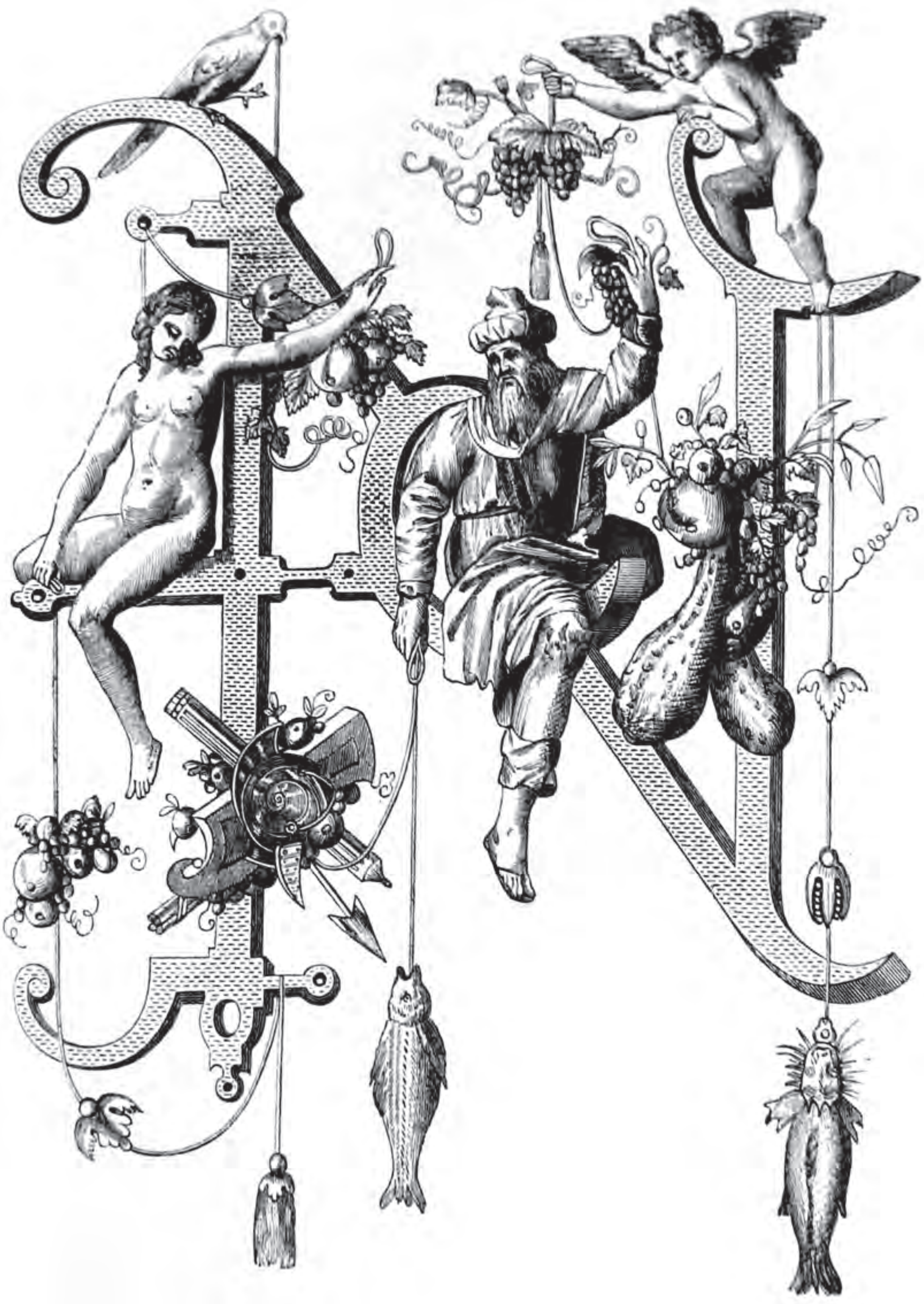
(a) Test 1 was the first walk with the new click. The watch was carried close to the seam and about 20 cm below my waist. In this test the average movement of the weight was an extraordinary 211.5° per meter, and the watch may have been fully wound.

(b) Test 2, with the watch in a fob pocket shows that the watch performed adequately, even though it was in a poor position. Also, because the click has started abrading, the reserve is lower than would be achieved with a new click, when the reserve would be 15 hours or more.

(c) Test 3 confirms the above point. In this test the watch was carried close to the seam and about 15 cm below my waist. The performance is about 45% of that in test 1, much too low to be attributed to the change in position.

It is now obvious that the rotor mechanism is a very good, practical design, even when carried in a fob pocket. Because winding is bidirectional, it is equivalent to the performance of the side-weight mechanism with unidirectional winding.

These tests raise an interesting question. Although Huguenin does not explain how the Leroy watch was tested, it achieved a reserve of about 60 hours after being carried for 12 hours (page 83). However, even when carried in a fob pocket the Mazzi watch could achieve a 60 hour reserve in about 1 hour and 20 minutes. So had the clicks in the Leroy watch also abraded?



Appendix 7: Going Barrel Weight Locking

A7.1: Principles

This section examines the weight locking mechanisms that have been used in side-weight, going barrel watches. These watches were made by many people over a considerable period of time and, unlike the other designs, there are many variations. The information has been put in this appendix because most of these designs date from after 1779 and are not directly relevant to the main purposes of this book. However, they are interesting enough to deserve inclusion.

It was not possible to obtain and disassemble the many watches showing design variations, and this examination is based on photographs in books, primarily Chapuis & Jaquet (1952), Daniels (1975) and Sabrier (2012a). Although far from ideal, this approach was satisfactory because the mechanisms have distinct features that are often visible in photographs, and other features can be deduced from the purposes of them. Naturally there are also many photographs which are ambiguous because defining features are not visible. But often sensible deductions can be made.

In watches with going barrels, the mainspring is wound by turning the barrel arbor clockwise (when viewed from the back of the watch). Then the mainspring unwinds by turning the barrel clockwise and driving the watch train.

Therefore, the state of the mainspring depends on relative motion of the barrel and its arbor.

When the mainspring is fully wound and runs the watch, some of the first turns provide excessive power and some of the last turns provide insufficient power, Figure A7-1.

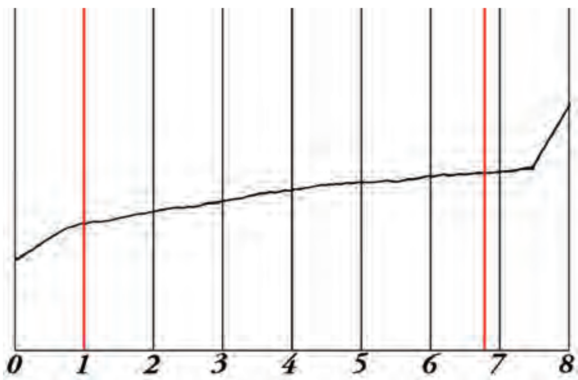


Figure A7-1

To avoid using these turns there must be some way to know the state of the mainspring that is hidden inside the barrel.

The primary purpose of *stop-work* is to prevent these turns being used to run the watch. It has *two stops*, one to prevent the first turns being used and one to prevent the last turns being used. In self-winding watches the stop-work is modified so that it locks the weight when the mainspring is "fully" wound. But this *weight locking mechanism* is an *addition* to the stop-work mechanism.

Four different types of stop-work will be described:

(a) Geneva and Maltese Cross stop-work.

(b) Breguet's stop-work.

(c) Differential screws.

A7.2: Geneva and Maltese Cross Stop-Work

Geneva stop-work, Figure A7-2 consists of two wheels: An *arbor wheel* ***a*** squared onto the barrel arbor; it has only one tooth and is often called the *finger*. And a *barrel wheel* ***b*** attached to the barrel or barrel cover, using a shoulder screw so that it is free to rotate. Part of ***b*** has teeth and the rest is uncut. The following illustrations represent an "ordinary" watch, where the barrel meshes directly with the center pinion. So, viewed from the back (the top plate), the barrel rotates clockwise to run the watch and the barrel arbor rotates clockwise to wind the mainspring.

Figure A7-2 shows the position of the stop-work when the mainspring has run down. The barrel cannot rotate clockwise to drive the train because the finger ***a*** stops the barrel wheel ***b*** from moving. When the watch is assembled, the mainspring is *set up*, turning it before putting on the stop-work so that some of the last turns cannot be used.

When the mainspring is wound by turning the barrel arbor clockwise, the finger ***a*** repeatedly enters the spaces between the teeth on ***b*** and rotates ***b*** anti-clockwise around its center, Figure A7-3. This continues until the finger meets the uncut part of ***b*** and cannot rotate, Figure A7-4. At this point the mainspring has been wound about 5 ¾ turns and the mainspring can be set up 1 turn while the last 1¼ turn is not used. Note that the barrel arbor must also have a ratchet and click to stop the arbor rotating anti-clockwise and unwinding the mainspring. In other words, the stop-work *limits* winding, but it does not *control* winding.

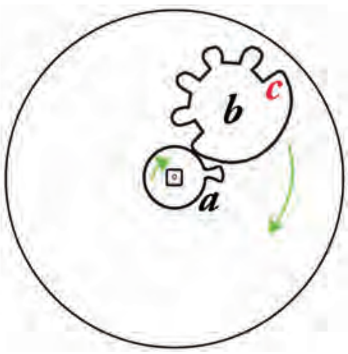


Figure A7-2

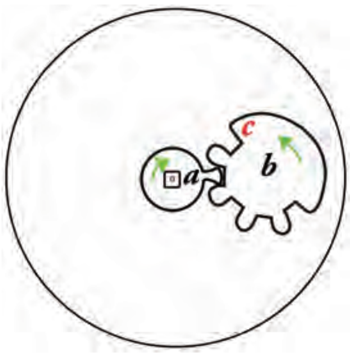


Figure A7-3

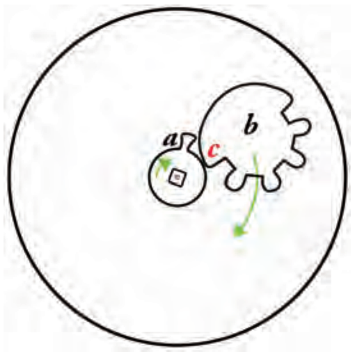


Figure A7-4

As the watch runs, the barrel rotates clockwise and the barrel wheel ***b*** pirouettes around the arbor with it. Whenever ***b*** passes the finger ***a*** it rotates clockwise on its axis.

In self-winding watches with going barrels, the state of the mainspring can be determined by modified Geneva stop-work where there is a boss ***c*** on the barrel wheel ***b***, as shown in the above illustrations.

During winding, Figure A7-5, starting from the position in Figure A7-2, the boss ***c*** moves closer to the center of the barrel; the illustration shows the path taken by ***c*** in red. When the mainspring is "fully" wound ***c*** raises the annulus (green circle) to lock the weight.

This diagram is close to reality. The certificate for Breguet watch No 160 (Roobaert, 2015) states "it is sufficient that the person carrying the watch walks for quarter of an hour to wind it for 50 hours."

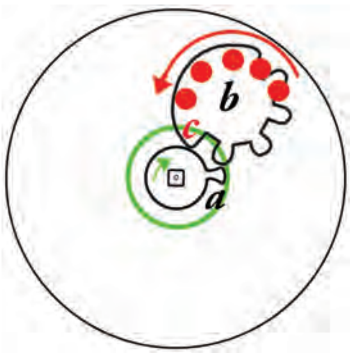


Figure A7-5

Although it depends on the barrel to center pinion gear ratio, in 15 minutes we would expect the barrel to rotate only about 7.5° as it runs the watch, and this causes the path taken by the boss ***c*** to spread out a negligible amount.

During running, Figure A7-6, the barrel wheel ***b*** pirouettes clockwise around the center of the barrel and when it meshes with the finger it rotates clockwise around its center. So the boss c moves away from the center of the barrel, following the path shown in red, and allowing the lever to drop and release the weight. This is the mechanism described by Recordon in Figure 8-2 (page 93) and used in the barrel remontoir watches (page 114).

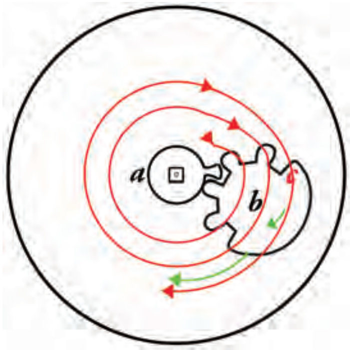


Figure A7-6

Depending on the barrel to center wheel gear train, Figure A7-6 covers a period of about 40 to 60 hours and it assumes no winding takes place during this time. This is unrealistic for a self-winding watch, and in practice the path taken by ***c*** will be much more complex.

Geneva stop-work with a boss has two features:

(a) The mainspring is "fully wound" when ***c*** raises the lever. But, as in Figure A7-5, this occurs about ¾ turn earlier than when the watch is key wound, and the stop-work allows only 5 turns of the mainspring.

(b) The locking mechanism must work irrespective of the position of ***c***. When the mainspring is "fully wound", ***c*** can be in any position on the green circle in Figure A7-5, depending on the position of ***b*** when winding starts. Consequently, as in the Recordon and Breguet watches, the lever that locks the weight must have a raised annulus corresponding to the green circle. Because the wheel and its boss repeatedly pass under the lever when the watch runs, except for the raised annulus it must be high enough not to touch the boss.

Geneva stop-work has a serious problem. Figure A7-7 shows the position of the stop-work some time after the position in Figure A7-6. Because the barrel wheel ***b*** is loose under a shoulder screw it can accidentally rotate and change the relationship of the stop-work with the mainspring.

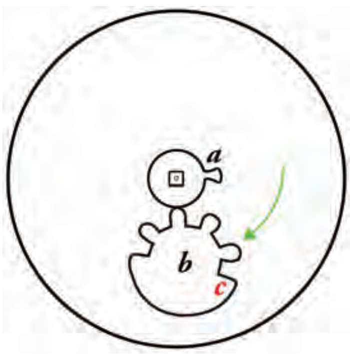


Figure A7-7

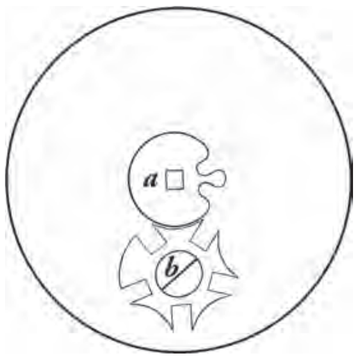


Figure A7-8

Maltese cross stop-work was developed to overcome this problem. Figure A7-8 shows the position equivalent to the Geneva stop-work in Figure A7-7. The concave faces of the barrel wheel ***b*** fit into the convex surface of the arbor wheel ***a*** and the wheel cannot rotate unless it is acted on by the finger. One segment of the wheel has a convex surface which acts like the uncut part of the Geneva stop-work wheel and only four turns of the mainspring can be used.

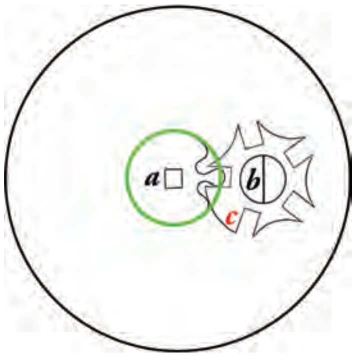


Figure A7-9

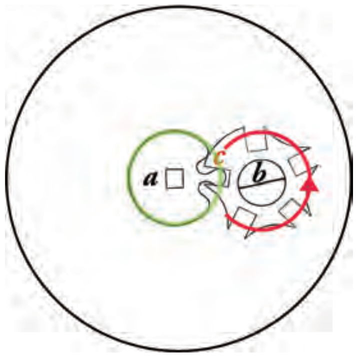


Figure A7-10

Figures A7-9 and A7-10 show Maltese cross stop-work unwound and fully wound, and the path taken by the boss ***c*** as the mainspring is wound; the green circle is the annulus. During winding and unwinding ***c*** moves away from and then towards the center of the barrel. When the watch runs and ***b*** pirouettes around the barrel ***c*** moves in concentric circles, similar to Figure A7-6, with the circles first moving away from the center and then towards it.

It is very important that the boss ***c*** does not touch the annulus when the watch is unwound. If it did, the weight would be locked and the barrel arbor could not turn. At the same time, the barrel cannot turn and the watch could not wind or run until it is disassembled and fixed.

Animations of Geneva and Maltese Cross stop-work are available from Watkins (2016).

A7.3: Breguet's Stop-Work

Breguet created his own designs for stop-work using crown wheels. Like Maltese cross stop-work, these stop the barrel wheel from accidentally rotating.

Information about Breguet's use of different designs is very limited. The vast majority of photographs, particularly those in Daniels (1975), are poor quality and often necessary detail cannot be seen. And the few good photographs often do not show the relevant parts, they being hidden under other pieces. However 42 photographs of self-winding watches show enough detail for us to draw some conclusions; these photographs come from Antiquorum (1991), Breguet (1997), Daniels (1975), Daniels & Markarian (2009) and Sabrier (2012a).

(a) 25 watches definitely and 12 watches probably use Breguet's stop-work described below.

(b) 2 watches use Maltese cross stop-work.

(c) 2 watches use an unknown form of stop-work that may be a modification of Geneva stop-work.

(d) 1 watch uses a differential screw; this is the undated watch No 9 (Sabrier, 2012a, page 71). There is a completely different watch No 9 illustrated by Daniels (1975).

(e) 40 watches have two mainspring barrels and 2 watches have only 1 barrel (numbers 9 and 630 (Sabrier, 2012a, page 107).

(e) 39 watches have power reserve indications on their dials; numbers 9, 28 (Sabrier, 2012a, page 91) and 630 do not.

The watches with numbers 9 and 630 are so different from the others that I think it is likely that Breguet did not make them.

Through the generosity of the Musée international d'horlogerie, the following photographs and description refer to Breguet's watch No. 28 that is in the collection of that museum, Figure A7-11. Jean-Michel Piguet (2012-2016) arranged to have the movement partially disassembled and then sent photographs of the weight locking mechanism.

There are apparently *three* watches with the number 28; the MIH watch illustrated here, circa 1791, Sabrier (2012a, page 91), circa 1784, and Daniels (1975, page 146), circa 1791. All have obvious differences.

The MIH watch uses the mechanism described in Section 9.4 (page 120) and it has two mainspring barrels. The barrel arbors rotate anti-clockwise to wind the mainsprings, and the barrels rotate anti-clockwise to run the watch. This is the reverse to that in ordinary watches.

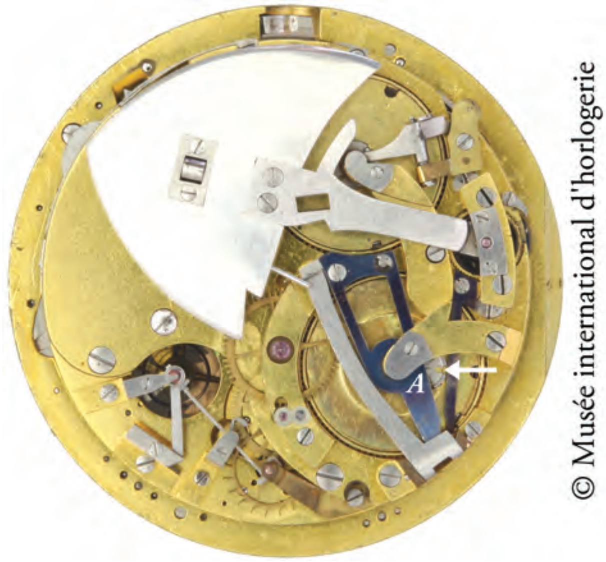


Figure A7-11

Figure A7-12

Figure A7-12 shows the arbor wheel ***a***, the barrel wheel ***b*** and how they mesh. The black circle on ***a*** corresponds to the "finger" underneath the arbor wheel.

Both wheels are crown wheels, as seen in Figure A7-13, with the arbor wheel inverted over the barrel wheel. Three features are important:

(a) The arbor and barrel wheels have the same diameter. Part of the barrel wheel is visible in Figure A7-14 (at the red arrow) and it shows the relative sizes of the barrel wheel and the spring ***A***. From this the relative sizes of the arbor wheel and the annulus can be calculated.

(b) The finger ***f*** is part of the original crown of ***a*** and is in the form of a pin that enters the slots in the base of the barrel wheel.

(c) The boss ***c***, used to lock the weight, is at the right-hand (clockwise) end of a segment. The whole of this segment is inclined and part of its left-hand (anti-clockwise) end is low enough to fit under the part ***d*** of the arbor wheel.

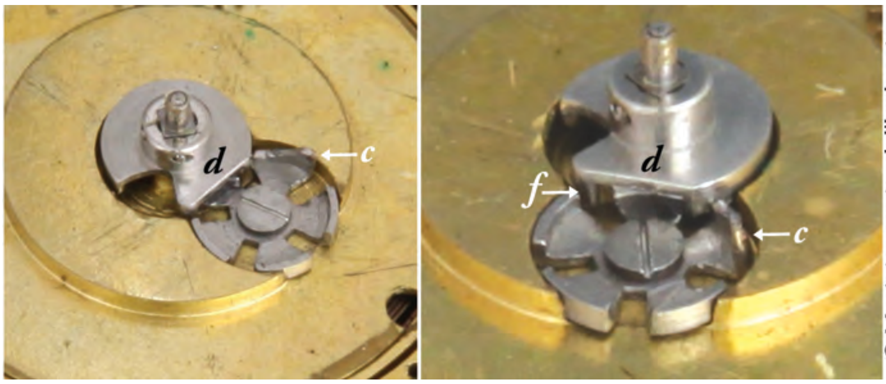


Figure A7-13

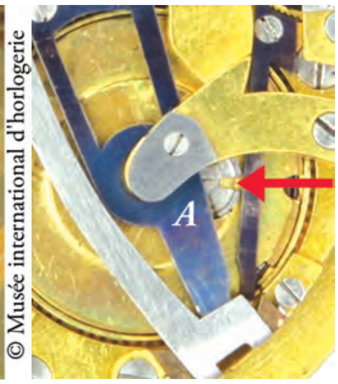


Figure A7-14

Underneath, Figure A7-15, the spring is shaped to form the raised annulus. Using Figure A7-11, the annulus was scaled to the same relative size.

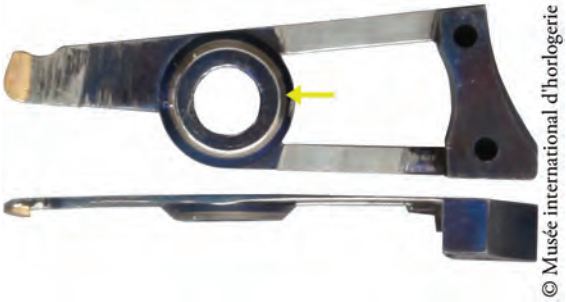


Figure A7-15

Figures A7-16 and A7-17 show the position of the stop-work when the mainspring is "fully" unwound (actually at this point the mainspring is still set up a turn or more). Both are identical except that the green annulus is not shown in the second figure. If the barrel tries to rotate anti-clockwise to run the watch (red arrow) the finger will try to rotate the barrel wheel anti-clockwise. But this is impossible because the segment with the boss (shown in red) is blocked by the arbor wheel. However, the barrel arbor can rotate anti-clockwise to wind the mainspring (white arrow) because the weight is unlocked. As it rotates the finger turns the barrel wheel clockwise until the finger leaves slot 4, Figure A7-18. At the same time, the crown of the arbor wheel enters slot 3 of the barrel wheel and, like Maltese Cross stop-work, the barrel wheel cannot accidentally rotate.

Figure A7-16

Figure A7-17

Figure A7-18

In the sequence in Figures A7-19 to A7-21, the arbor wheel continues to rotate until the finger enters slot 3. Then the finger again turns the barrel wheel clockwise until it leaves slot 3 and the arbor wheel crown enters slot 2. The mainspring has now been wound a little more than 1 turn, and the barrel wheel has rotated ⅕th turn.

This sequence is repeated and in Figure A7-22 the mainspring has been wound a little more than 2 turns, and the barrel wheel has rotated ⅖th turn.

Figure A7-19

Figure A7-20

Figure A7-21

Figure A7-22

Figure A7-23

Figure A7-24

Again the sequence is repeated until the wheels are in the position shown in Figure A7-23. Then, as the arbor wheel rotates, the barrel wheel rotates until the boss (red) moves under the annulus and locks the weight; Figure A7-24 shows the boss above the annulus to make clear how far it has moved. At this point the mainspring has been wound a little more than 3 turns, and the barrel wheel has rotated ⅗th turn. An animation of this sequence is available from Watkins (2016).

A number of points must be made:

(a) In Figure A7-13 the segment with the boss has a small step, after which it slopes up to the boss itself. Although it is not clear from the photographs, because this incline could raise the annulus when the mainspring is unwound, I presume that it is the step that butts against the arbor wheel, as in Figures A7-16 and A7-17. Indeed, the shape of the boss with its incline is not sensible and a better design would have two distinct steps.

(b) The situation in Figure A7-24 depends critically on the diameter of the annulus. If it is smaller, Figure A7-25, then the weight will not be locked until the arbor wheel has rotated another ⅘th turn, the finger has entered slot 0 and the barrel wheel has rotated enough to bring the boss under the annulus; then the mainspring has been wound about 4 turns, and the barrel wheel has rotated ⅘th turn.

It also depends on the amount of freedom in the locking mechanism; if in Figure A7-24 the annulus has not been raised sufficiently the extra rotation could occur. Note that, as shown in Figure A7-11, this watch does not have any adjustment between the spring and the locking lever, whereas the design illustrated by Daniels, Figure A7-57 page 377, has an adjustment screw. Even though, the spring, Figure A7-15, presses lightly on the arbor wheel, freedom between it and the lever might be sufficient to allow the extra turn. However, the diameter of the annulus makes this effectively impossible.

Figure A7-25

(c) It is essential that part of the crown of the arbor wheel is removed to allow it to enter into the space occupied by the barrel wheel. However, the very deep cut-out (yellow arrow and Figure A7-12 left) serves no purpose because the boss cannot enter it. It can only be useful if the annulus is very much smaller (Watkins, 2016) when the stop-work definitely allows four turns.

Appendix 7: Going Barrel Weight Locking

The description of Breguet's stop-work given by Daniels is wrong because his diagram has the barrels and arbors rotating clockwise (see Section 9.4, page 120). Also, as shown in Figure A7-26, it impossible for the weight to be locked with the finger on the line of centers between the two wheels unless the annulus is much too small; a huge annulus with the finger in slot 1 is not possible.

Figure A7-26

In addition, Daniels states the mainspring has 4 turns; it might be possible, but it is very unlikely because he has drawn a large annulus similar to that in the above description.

A more serious error is the description of the mechanism when the mainspring has unwound:

> *In order that [the boss] will not raise [the annulus] in the unwound position its segment is slightly longer than the other four, and the flange [crown] of [the arbor wheel] will not be able to enter the slot.*

Daniels is correct because the segment between slots 0 and 4 is longer than the other segments. But he is obviously wrong because, as shown in Figures A7-16 and A7-17, the crown of the arbor wheel is nowhere near the barrel wheel when the mainspring is unwound. So why is one segment wider than the others?

Figure A7-27

Figure A7-28

Figure A7-29

Figures A7-27 to A7-29 show what happens when all five segments are equally long. Figure A7-27 is the same position as in Figure A7-17 and the sequence to Figure A7-28 is the same as in Figures A7-18 to A7-20. However, as the arbor wheel continues to rotate its crown butts against the crown of the barrel wheel and stops winding, Figure A7-29. This happens because the segment between slots 2 and 3 has been made longer. In addition, the weight is free and will continue to oscillate, with catastrophic results.

Note that the long segment does not cause any problems. As can be seen in the animations (Watkins, 2016) the finger and crown of the arbor wheel span two adjacent slots, as in Figure A7-27 where the finger is in slot 4 and the crown is about to enter slot 3. But the pair of slots 0 and 4 is *never* used. If these slots were used then the same problem of butting would occur.

Actually, the long segment between slots 0 and 4 is essential to compensate for an important design fault: *The arbor and barrel wheels have the same diameter*. As we will see, if the arbor wheel is made smaller then equal slots work correctly.

Breguet provided a detailed description of a later design (Chapuis & Jaquet, 1952, pages 102-103; Chapuis & Jaquet, 1956, pages 107-108; Sabrier, 2012a, pages 84-85). Instead of quoting his complete words, which are precise, I will explain the mechanism using Figure A7-30; it shows the position when the mainspring is fully wound.

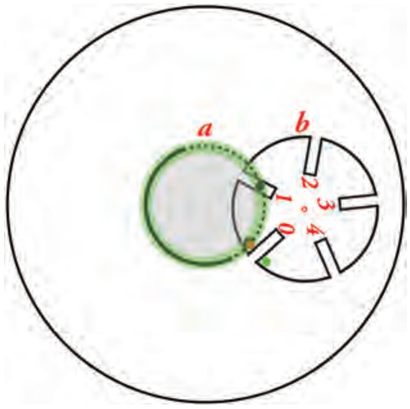


Figure A7-30

(a) The barrel wheel ***b*** is a crown wheel with five equidistant slots. The diameters of the arbor wheel ***a*** and the barrel wheel ***b*** are in the ratio 4:5. This is close to the correct ratio of $5 \tan(36^\circ)$ or 3.63:5.

(b) The barrel wheel has two pins on either side of slot 0. The red pin is the "boss" that stops *winding* and it extends above the arbor wheel to raise the annulus. The green pin stops *unwinding* and its top is level with the outside of the arbor wheel.

Breguet is a bit vague regarding the positions of these two pins, writing *this barrel wheel carries a strong steel pin inserted in the bottom and quite near to its crown* (the red boss pin) and *there is another, lower pin, placed a little in front of the long one and which alone stops the bottom of the spring*. Placing them on either side of the slot fits this description.

(c) The annulus, the transparent green circle, is slightly larger than the arbor wheel. It and the arbor wheel are transparent so that the barrel wheel and the two pins are visible.

(d) The arbor wheel is a crown wheel. Its base is not cut and forms a complete circle. About half of its crown is removed but leaving a small piece for the finger that, as before, reaches into the slots of the barrel wheel. The solid part of the circumference of ***a*** is the section that has the crown. And, except for the finger, the dotted part of the circumference of ***a*** is the section that has the crown removed.

Breguet actually specifies this design, writing *one part of the crown* [not the surface] *of the smaller, upper wheel is cut away*, and *this pin* [the boss] *butts against the circumference of the small arbor wheel.*

(e) Breguet notes that when the red pin butts against the arbor wheel *it even half penetrates it through a slot made for this purpose*; Figure A7-30 shows this slot and the boss in it.

This feature is essential. Without it the boss can only reach the outermost part of the annulus and it is possible that the weight will not be locked. With it, more of the annulus is accessible.

(f) Breguet states that the five slots allow the arbor wheel to make four revolutions while the barrel wheel makes only ⅗th of a revolution. He is correct regarding the latter, but wrong regarding the former.

The barrel wheel must makes ⅕th turn for every turn of the arbor wheel and this design allows only three turns of the mainspring. To achieve four turns requires a different design where the barrel wheel has 6 slots and, because the segments are smaller, the mainspring develops about 4⅕ turns.

The illustrations of Breguet's watch number 28 show how the mainspring is wound. The following explanation of this 2-pin design shows the watch running. It starts in the fully wound position, as in Figure A7-30, but the annulus is not shown.

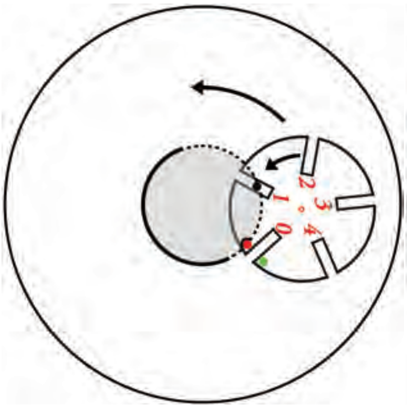


Figure A7-31

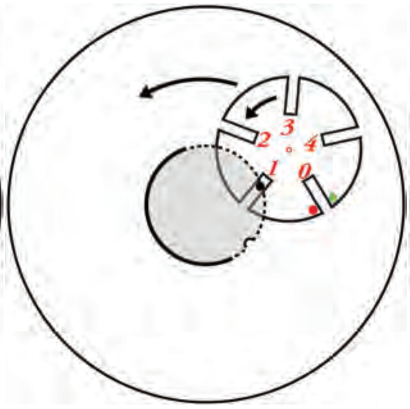


Figure A7-32

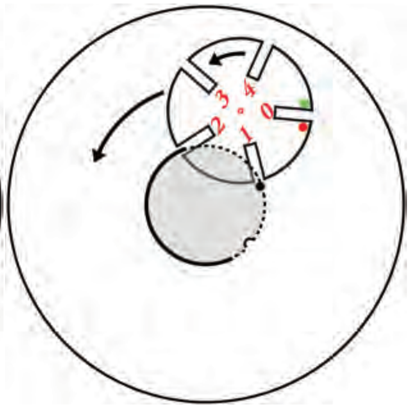


Figure A7-33

Starting with Figure A7-31, the mainspring provides power to the watch by rotating the barrel anti-clockwise. The finger on the arbor wheel forces the barrel wheel to rotate anti-clockwise around its center and move the red locking pin away from the annulus, Figure A7-32. This continues until, Figure A7-33, the barrel and barrel wheel have rotated sufficiently far to be free of the finger.

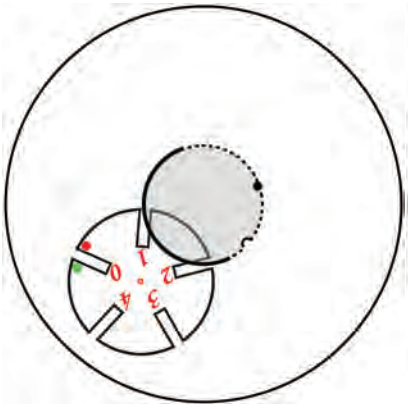


Figure A7-34

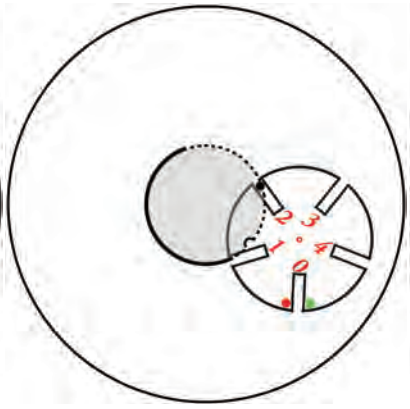


Figure A7-35

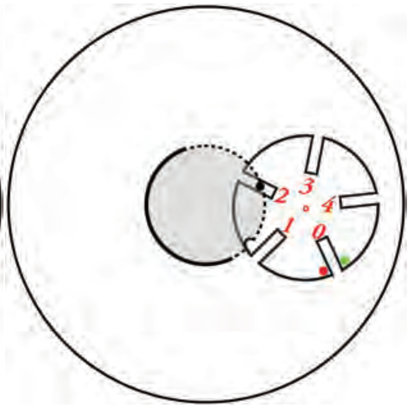


Figure A7-36

As the barrel and barrel wheel rotate, Figures A7-34 and A7-35, the crown of the arbor wheel enters the slots in the barrel wheel and prevents it from turning around its center. This continues until the finger enters a slot and starts to rotate the barrel wheel. After one complete turn of the mainspring, Figure A7-36, the wheels return to their original position in Figure A7-31, except that the barrel wheel has rotated ⅕th turn.

This occurs two more times, Figures A7-37 and A7-38. Each time the mainspring unwinds one turn and the barrel wheel rotates 1/5th turn, making a total of 3 turns and 3/5th turns respectively.

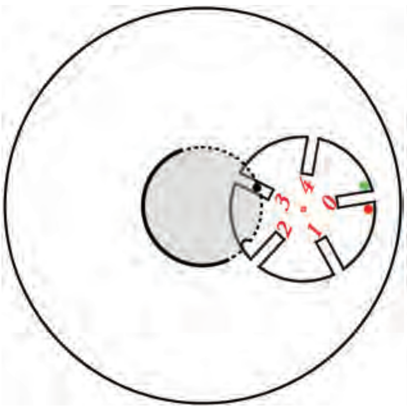


Figure A7-37

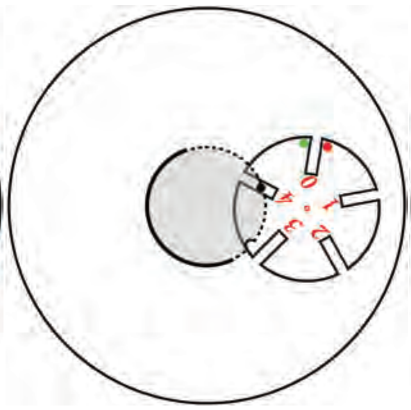


Figure A7-38

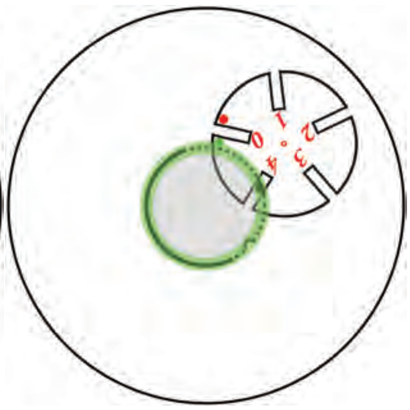


Figure A7-39

Finally, Figure A7-39, the barrel continues to rotate anti-clockwise and the barrel wheel also rotates anti-clockwise until the green pin butts against arbor wheel, preventing any more movement of the barrel. At this point the green pin is under the annulus, but it is too short to raise it, and the red pin is too far away to raise the annulus. And the mainspring has unwound about 3⅕ turns.

Almost all of Breguet's self-winding watches have up-down indicators showing the number of hours the watch will run without winding. Frequently this is 60 hours, but other watches have significantly less reserve.

How many turns of the mainspring are required to achieve these reserves depends critically on the barrel to center wheel train. Breguet specified this in his description of self-winding watches (Chapuis & Jaquet, 1952, pages 95-96; Chapuis & Jaquet, 1956, page 101; Sabrier, 2012a, page 76); see Figure A7-40. This train gives a barrel to center wheel ratio of 1:13.5; that is, one turn of the barrel will run the watch for 13.5 hours.

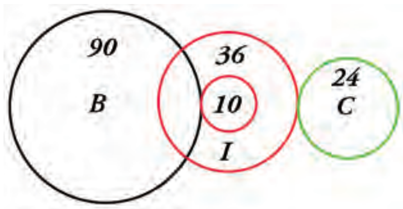


Figure A7-40

Breguet varied this train. Daniels (1975, page 344) indirectly specifies a 1:15 ratio, and drawings by Moinet in Chapuis & Jaquet (1952; 1956) and Sabrier, (2012a) have different (but obscure) teeth counts. However, in the absence of specific information the 1:13.5 ratio will be used.

Photographs of 12 watches are clear enough to know both the reserve indicated on the dial and the number of segments in the stop-work.

Three of these watches have *dummy barrels*, Figure A7-41. These watches have a normal barrel ***B*** connected to the center wheel. Beside it is the dummy barrel ***D***, consisting of two wheels and an arbor. The arbor is squared onto the bottom wheel, which meshes with the barrel ***B***. And the top wheel meshes with a wheel squared onto the arbor of ***B***. This dummy barrel has the stop-work mounted on it, and there is a 6:4 ratio between it and the barrel.

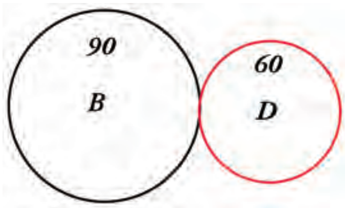


Figure A7-41

Table A7-2 summarises the information about these 12 watches.

Breguet No	Stop-work segments	Reserve	Estimated reserve	Comments
5	5	60	43.9	Low
15	6	60	56.7	
19	6	60	56.7	Uncertain
28	5	60	43.9	Low
46	6	60	56.7	
157	6	60	56.7	
1670	6	45	37.8	Dummy barrel, low
2781	5	48	43.9	Uncertain
2783	5	48	43.9	
4220	5	45	43.9	
4548	6	40	37.8	Dummy barrel
4973	6	40	37.8	Dummy barrel, uncertain

Table A7-2

(a) Three watches are "uncertain", meaning that there is some doubt about the number of segments.

(b) Nine watches have estimated reserves that agree with the display on the dial. Three watches have estimated reserves that are too low, but it is not known if they use the 1:13.5 train or a different one. For example, if the center pinion has 18 leaves instead of 24, one turn of the barrel would run the watch for 18 hours and stop-work with 5 segments would provide a power reserve of about 57.6 hours. And the 1:15 ratio given by Daniels will provide a power reserve of about 48 hours.

The correlation between the displayed reserve and the estimated reserve is very good.

As an aside, both Chapuis & Jaquet (1956, page 104) and Sabrier (2012a, page 81) translate "roue de cuivre" as "copper wheel". This is wrong. The word *cuivre* was used for brass and *cuivre rouge* for copper; for example see Berthoud & Auch (2007, page 14)

A7.4: Differential Screw Stop-Work

Several self-winding watches, including the Breguet No 9 mentioned above, use the very simple differential screw stop-work.

In Figure A7-42 the barrel arbor (yellow) has a right-hand thread on which is the internally threaded stop disk (green). There are two posts (red) mounted on the barrel which pass through holes in the stop disk and prevent it from rotating freely. The action is simple:

(a) As the barrel arbor rotates clockwise to wind the watch, the stop disk moves up, away from the barrel. This movement is limited by the number of turns of the mainspring.

(b) As the barrel rotates clockwise to run the watch, the posts force the stop disk to rotate with it and the stop disk moves down towards the barrel. When it presses against the barrel, the barrel and its arbor cannot turn, allowing the mainspring to be set up.

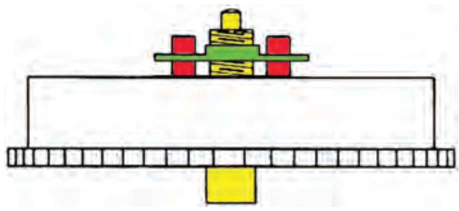


Figure A7-42

As shown in the diagram, the mechanism has a fault: there is no stop for when the mainspring is "fully" wound.

It is clear that the movement of the stop disk can be used to move a lever vertically. It can also move a lever sideways, either by making the stop disk conical or using an appropriate lever, as in the Le Coultre calibre 497 wristwatch (Humbert, 1956, pages 86-91). Most wristwatches use a slipping mainspring and the weight is not locked. But this watch uses an ordinary mainspring and has a weight locking mechanism. The lever has a pin and the weight has a spring with a hook at the end. Normally when the weight oscillates this hook is not impeded by the pin. But when the watch is fully wound the stop disk moves the lever so that its pin is in the path of the hook, which then goes over the pin and locks the weight. A similar design is shown in Figure A7-52 below.

Although a very simple, very good mechanism, it has the disadvantage of taking up vertical space and so reducing the barrel height or increasing the thickness of the watch.

A7.5: Weight Arm Locking

Some self-winding watches have the weight attached to the end of an arm, and the *lock-work*, operated by the *stop-work*, acts on this arm.

The first system to be described is locking using *weight arm holes*, as in Figure A7-43. Here the lock lever ***l*** has a pin (or block) which fits into a corresponding hole in the arm. When the mainspring is wound the stop-work raises the lock lever and the pin enters the hole. This system has three important features:

(a) The locking is *bidirectional*. That is, when locked the weight cannot rotate in either direction.

(b) As drawn, *false locking* can occur. In Figures A7-44 and A7-45 the stop-work has raised the lock lever ***l*** so that the weight is free to oscillate between the lever's red pin and the buffer spring, continuing to wind the mainspring beyond the "fully" wound state. What happens then depends on the particular design, but it will be catastrophic.

To overcome this, the weight arm must have two wings, as in Figure A7-46, that prevent the lock lever rising except into the hole.

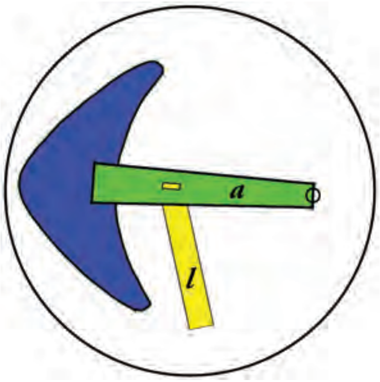


Figure A7-43

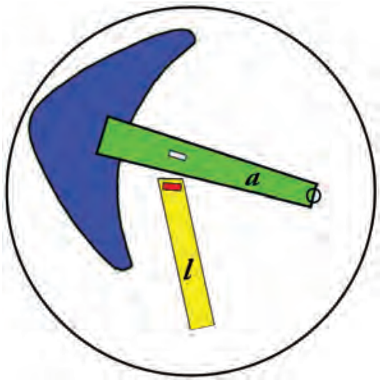


Figure A7-44

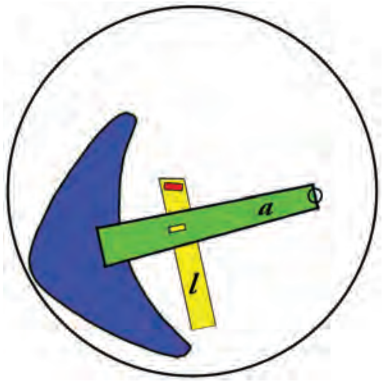


Figure A7-45

(c) The at-rest position of the weight is controlled by the equilibrium spring. If the at-rest position is that shown in Figures A7-44 or A7-45, the weight can make small oscillations without the pin ever entering the hole on the weight arm and, because of the wings, the weight will not be locked; again catastrophic. Consequently the position of the hole in the weight arm must be at the at-rest point of the weight, because the weight always passes through that point.

If the watch was disassembled to clean or repair it, the equilibrium spring might not be set up correctly so that the weight has the same at-rest point. In which case, this problem may re-appear.

This may be why Breguet frequently used two or three weight arm holes.

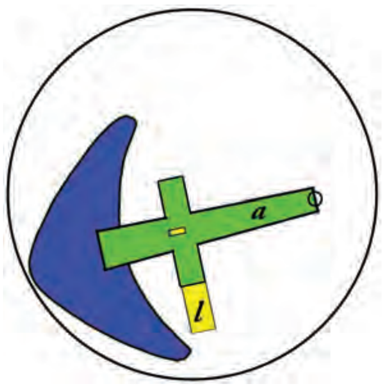


Figure A7-46

I have seen 47 photographs of watches with weight arm holes, of which 41 are watches made by Breguet, 5 are watches made by Breguet's students, and 1 watch is signed Le Roy.

Table A7-3 classifies the Breguet watches according the types of wings on the weight arms.

It is interesting that all except two are unique, although the differences in some watches are small. Often the differences do not reflect changes in design and they seem to be arbitrary. I have read somewhere that Breguet continually changed his designs to incorporate improvements, but this is not relevant. I suspect that some differences have egotistic origin. Imagine a count surrounded by princes and other notable people. He shows his Breguet watch to someone only to be told "Oh, I have one of them." How embarrassing! How deflating! Perhaps Breguet made unique watches to avoid this situation.

Type	Number of watches	Similarity
1 hole, asymmetric wings	5	all unique
1 hole, symmetric wings	16	all unique
2 holes, asymmetric wings	5	Nos 4548 and 4973 identical
2 holes, symmetric wings	5	all unique
3 holes, asymmetric wings	2	all unique
3 holes, symmetric wings	7	all unique
5 holes, asymmetric wings	1	unique

Table A7-3

Two Breguet watches are unusual.

First, watch number 148 (Daniels, 1975, page 161) has a small bar screwed to the weight. It does not appear to serve any useful purpose, but it may have been added to extend the upper wing if it had been made too short.

Second, watch number 28, in the Musée international d'horlogerie, has a rod attached to the weight, Figure A7-47, red arrow; it acts like a wing and holds down the locking lever ***a***. Without it the stop-work could raise the lever in the position shown, and then the weight would not be locked and would continue to oscillate between the buffer spring and the weight arm (white arrow). This rod is always above the lever ***a***, but it only acts near the end of ***a*** because the lever is tilted, the end that locks the weight being higher than the other end. For comparison Figure A7-48 shows the lower wing that would be necessary if the rod did not exist.

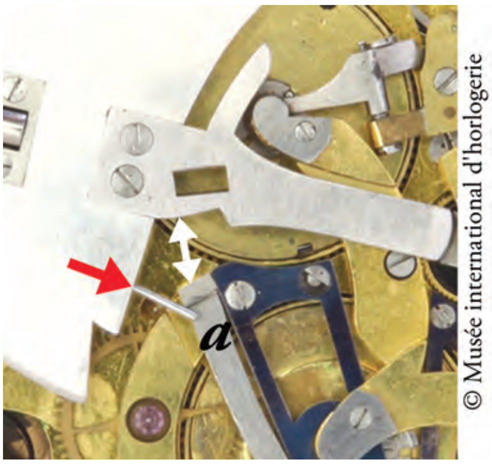


Figure A7-47

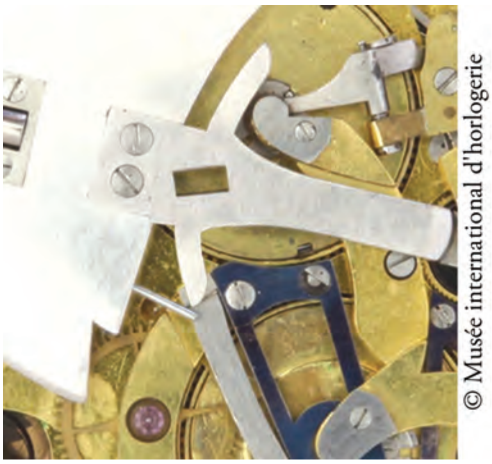


Figure A7-48

Four other methods have been used to lock the weight arm:

(a) *Weight arm impeding*: Figure A7-49 is a diagram of the mechanism used in the Breguet No 9 watch (Sabrier, 2012a, page 71). The lock lever ***l*** is held down by a spring. The stop-work ***s*** is a differential screw. When the lock lever rises it blocks the movement of the weight arm. This is unidirectional locking and the at-rest position of the weight is with it against the top buffer spring.

If a repairer set the equilibrium point with the weight horizontal, then it is very likely that the weight will oscillate without it being locked.

I have seen 44 photographs of Breguet perpetuelles and this is the only one that does not use weight arm holes.

Several other watches use arm impeding; for example, a watch by Jaquet Droz (Sabrier, 2012a, page 145) and an unsigned watch (Sabrier, 2012a, page 152).

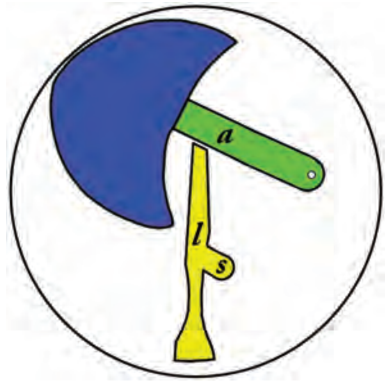


Figure A7-49

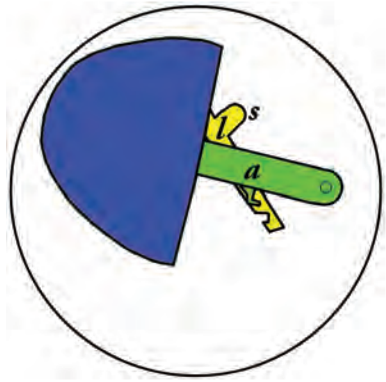


Figure A7-50

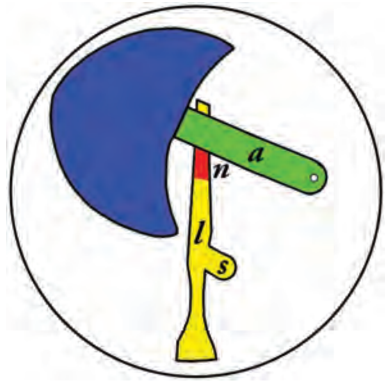


Figure A7-51

(b) *Weight arm hook*: In Figure A7-50, the weight arm ***a*** has a hook attached to it. The lock lever ***l*** is raised by a differential screw ***s***. At its end there is a notch that fits around the hook. This is bidirectional locking.

(c) *Lock lever notch*: In Figure A7-51, the lock lever ***l*** extends past the weight arm to prevent incorrect locking. It has a notch ***n*** (red). When the stop-work raises this lever the weight arm is held in the notch, which provides bidirectional locking. See Sabrier (2012a, page 153).

(d) *Weight arm pin*: This is the reverse of the first design. Instead of a pin on the lock lever and one or more holes in the weight arm, there is a pin underneath the weight arm which fits into a hole in the lock lever, providing bidirectional locking. See Sabrier (2012a, page 196) where there are five holes in the lock lever.

A7.6: Weight Locking

The most common method used to lock the weight, as opposed to the weight arm, is locking with *weight holes*. It is the same in principle as locking with weight arm holes and is exemplified by Recordon, Figure 8.1, page 93, and Breguet, page 115. The lock lever has a pin that enters a hole underneath the weight. The weight takes the role of the wings to prevent incorrect locking.

As before, it is necessary that locking occurs at or very near to the at-rest position of the weight.

The second method uses a *weight detent*, Figure A7-52. The lock lever is in two parts, ***l*** and ***m***, and at the extremity of ***m*** there is a hook ***h*** near the detent ***d*** attached to the weight. The two parts of the lock lever meet at ***w*** and the ends of the levers form wedges.

Normally, when the weight is free and winding the watch, the hook and the detent do not touch. However, as shown in the diagram, when the lock lever ***l*** rises, the wedge at its end rises. This allows the wedge on ***m*** to move sideways to the left under the pressure of a spring. And so ***m*** rotates anti-clockwise bringing its hook ***h*** into the path of the detent ***d*** and locking the weight. As the watch runs, the lock lever ***l*** drops under the pressure of a spring and forces ***m*** to rotate clockwise, releasing the detent and allowing the weight to resume winding the mainspring.

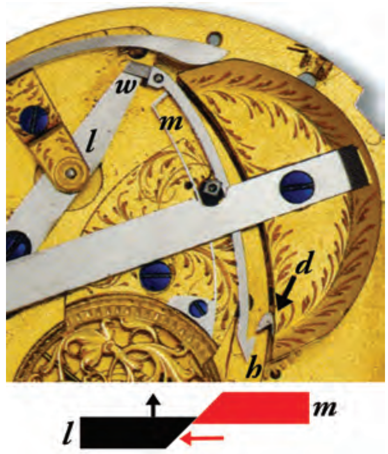


Figure A7-52

There are a few other designs, including one where the whole movement oscillates (Sabrier, 2012a, pages 109-111), but the photographs do not show enough detail to enable their mechanisms to be deduced.

A7.7: Up-Down Indicators

Knowing the state of the mainspring is very important for the owner of a self-winding watch. But, with the exception of Breguet this complication was rarely, if ever, included in early self-winding watches by other makers.

Breguet used differential screws for this purpose, that had either a cylindrical or conical stop disk and moved a lever vertically or horizontally (Daniels, 1975, pages 344-346).

Frequently more modern watches have up-down mechanisms that use *differential gears*, which are a type of planetary gear (Section 7.4, page 74), to determine the relative motion of the barrel and its arbor. Figure A7-53 illustrates the principle.

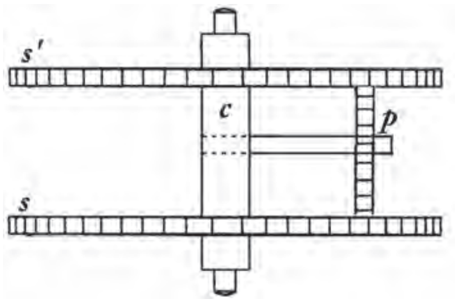


Figure A7-53

Unlike planetary gears, differential gears are not in a plane. Here the gears have been "folded" so that the planet gear ***p*** is vertical and the annular gear ***s'*** is horizontal and above the sun gear ***s***. To do this, the annular gear must be changed into an ordinary gear and the carrier is in the form of an arbor ***c*** around which ***s*** and ***s'*** are free to move. This carrier supports the planetary gear ***p*** by a transverse arbor on which ***p*** turns freely.

Because ***s*** and ***s'*** must mesh with the barrel and its arbor, the planetary gear runs between contrate teeth on these wheels. For this to work, the contrate gears must be identical, with the same number of teeth, and often the annular gear ***s'*** is called the second sun gear. That is, in the formula for planetary gears $Na = Ns' = Ns$ and so:

$$NsTs' + NsTs = (Ns + Ns)\ Tc$$

or:

$$Tc = \tfrac{1}{2}\ (Ts' + Ts)$$

On page 79 I mentioned that Massotéau had designed a ship's capstan. His illustration, Figure A7-54, and text described the arrangement in Figure A7-55.

The sailors turned the carrier c using four long poles attached to it, and this was meant to turn the sun gear s that was attached to the capstan around which the rope or cable was wrapped. Unfortunately this is impossible, because turning the carrier will cause the planet gear to rotate without moving the sun gear! It is clear that Massotéau actually designed the differential gears in Figure A7-53 but he omitted the essential annular gear s'. In his system s' is locked (rigidly attached to the ceiling of the room) and then with $Ts' = 0$ the above formula becomes:

$$2\ Tc = Ts$$

As Massotéau stated, when the sailors walked once around the carrier the capstan turned twice. However he also stated that the planet wheel must be the same size as the sun wheel. Clearly this is not correct and the planet gear can be any convenient size.

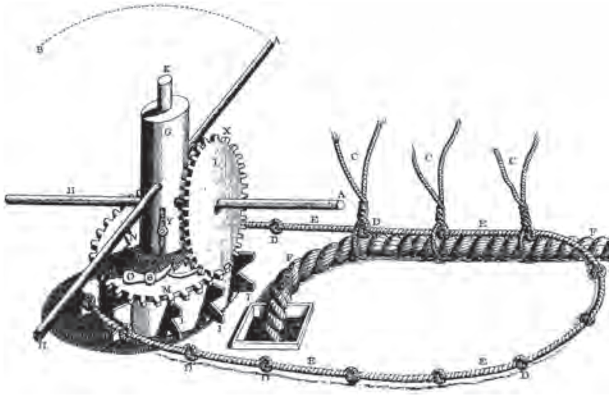


Figure A7-54

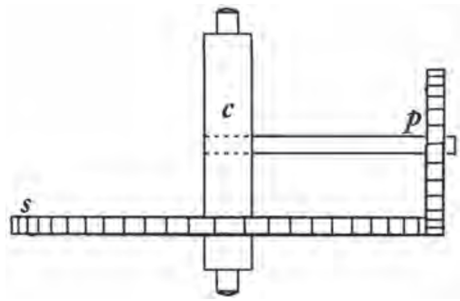


Figure A7-55

A simple arrangement for an up-down indicator is shown in Figure A7-56 (see Humbert, 1956, pages 84-85). The barrel b meshes with the sun wheel s. As the barrel rotates clockwise to run the watch s and c rotate anti-clockwise. The barrel arbor a meshes with the annular wheel s' through an intermediate wheel i. As the barrel arbor rotates clockwise to wind the watch s' and c rotate clockwise. That is, c counts the difference in the number of turns of the barrel and the barrel arbor and, with appropriate gears, it can be used to drive an up-down indicator.

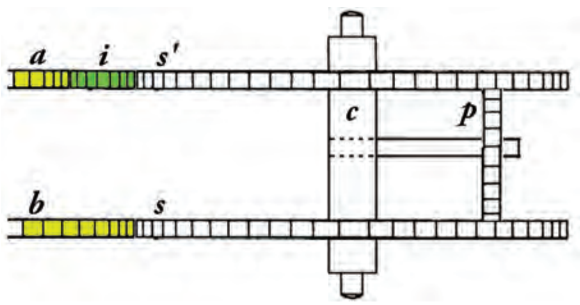


Figure A7-56

In principle, this mechanism could also drive stop-work and a weight locking mechanism by limiting the rotation of the arbor c and using that rotation to move a lever either vertically or horizontally. However, differential gears are much more complicated than other stop-work, and it is not a good solution to the problem.

A7.8: Lock-Work Failure

First, consider an ordinary going barrel watch without stop-work. When the watch is wound, turning the barrel arbor clockwise, there is no limitation on rotating the mainspring. The only control is that the barrel arbor has a ratchet and click to prevent the arbor anti-clockwise and unwinding the spring. In this case the mainspring can be "over-wound" by trying to turn the key or the crown after all of the mainspring has wrapped tightly around the barrel arbor. Forcing the key or the crown will lead to serious damage. There are five possibilities:

(a) The mainspring barrel hook breaks: The force is transmitted by the mainspring to the barrel through the hook. The hook on the barrel arbor is unlikely to break, because most of the force will taken by the coiled spring.

(b) The mainspring breaks: Spring breakages are unpredictable, but failure at the barrel hook is most likely.

(c) Wheel teeth bend or break: If the mainspring does not break, the brass teeth of the first wheel on the barrel or the center wheel could be damaged. If the mainspring breaks there is a sudden shock that is transmitted through the train and damage to some or all of the wheels can occur.

(d) The rivet attaching a wheel to its pinion breaks: I once had a watch where the winding was very stiff. I turned the crown with some force, only to see the hands rotate at high speed! The rivet joining the center wheel to its pinion had failed and the pinion, together with the canon pinion and motion work, could rotate without the center wheel and the train rotating.

(e) A pinion breaks: Although unlikely, a pinion with thin leaves could fail before the meshing teeth fail.

An ordinary going barrel watch with stop-work behaves differently. When the watch is "fully" wound, the stop-work on the barrel prevents the mainspring from being fully wound around the barrel arbor, and there is usually a turn of the spring that is unused. At this point, for example, Figure A7-4, page 360, the stop-work locks the barrel arbor and barrel together. And so attempting to rotate the barrel arbor will transmit the force to the barrel and its first wheel through the stop-work and not through the mainspring. As a result (a) and (b) above are very unlikely consequences. However, a sixth failure can occur:

(f) The stop-work breaks: The attachment of the stop-work wheel to the barrel cover must be strong enough to resist a high lateral force from the finger, as in Figure A7-4. Unless care is taken, the shoulder screw holding the wheel can be forced out of its threaded hole and winding continue. That could then leads to one of the failures in (a) and (b) above.

All lock-work mechanisms in self-winding watches have a serious problem. If locking takes place during vigorous exercise, such as horse riding, the weight will attempt to move equally vigorously, and the force may be sufficient to damage the locking detent.

For example, as discussed above, weight arm locking using a pin on the lever and a hole in the arm can fail because the pin and/or the hole are damaged. Instead of having square, sharp edges, they are rounded and, together with bending or movement of the arm, the weight will continue to oscillate and try to turn the barrel arbor. What happens depends on the both the stop-work and the lock-work and, most importantly, how far the locking mechanism can move. That is, if the stop-work boss or the differential screw raises the lock lever only just enough for the pin to enter the hole in the arm, any damage to the pin and the hole will allow the weight to oscillate without any restriction. If this happens, then the stop-work will not function correctly, the mainspring will continue to be wound, and any of the catastrophic failures listed above can occur.

A7.9: The Speed of Locking and Vincent's Safety Lock

The main problem with all weight locking mechanisms is that the locking levers move *continuously* and there is no *discrete, sudden* change from the weight being unlocked to being locked.

The problems caused by using continuous motion to change discrete states is most obvious in repeater mechanisms. In a minute repeater, for example, striking must change from sounding 32 times to sounding just once in the space of one second, from 12 hours 59 minutes 59 seconds to 1 hour (see Watkins, 2011b).

A similar problem occurs in self-winding watches. In most watches the stop-work lifts a lever relatively slowly and continuously while the mainspring is being wound. And so there must always be a moment when the two parts of the detent that lock the weight have only just met and locking relies on the sharp corners to hold the weight. But freedom in the pivots, flexing of the weight arm and the force of the weight make this locking very unsafe. Not only can the weight continue to oscillate, the sharp corners can be rounded making it even easier for the weight to continue to oscillate.

Also, when locked the weight tries to move in reaction to the motion of the wearer of the watch. Consequently, the closer the locking hole is to the pivot point of the weight the greater the force exerted by the weight on the detent, and if the two parts of the detent that lock the weight have only just met, damage to it can be expected.

Ideally there should be a *large, instantaneous* movement of the locking pin so that it fully enters the hole and provides a strong lock. Unfortunately this is almost impossible to achieve and locking is usually very fragile.

Most designs use a single lever where the stop-work is between the lever hinge and the locking detent as, for example in Figures A7-49 and A7-51. These levers provide an advantage of about 2.5:1; that is, if the stop-work raises the lever 0.5 mm then the detent will rise 1.25 mm. Rotor watches are about the same (see Figure 7-32, page 73) and the barrel remontoir design has a ratio of about 8:1 (see Figure 9-13, page 115).

Breguet's design, Figure A7-57, is significantly better. The annulus is in the middle of ***D*** and the end under the hinge ***F*** will rise about twice as far as the annulus. And when ***D*** lifts the lever ***E*** there is about a 10:1 ratio between the lifting point and the pin that locks the weight; a total of about 20:1. That is, if the boss lifts the annulus 0.2 mm then the pin will rise about 4 mm. This has two effects:

First, provided there is not too much freedom (which can be adjusted by the screw on ***E***) the weight will be locked when the boss has just started to move under the annulus. So the design used in watch number 28 can only wind the mainspring three turns.

Second, frequently the pin will press against a wing before it enters the hole in the arm.

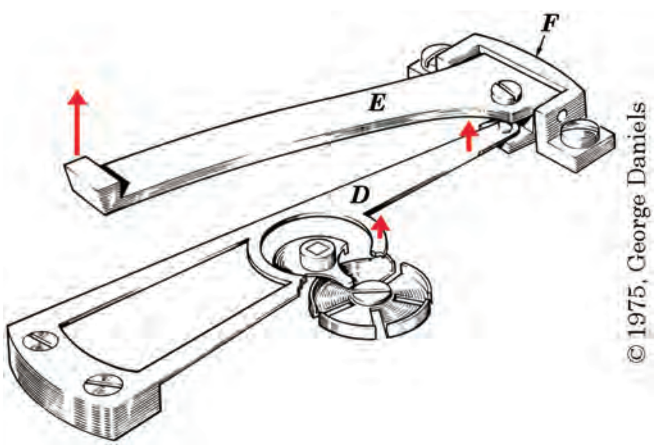


Figure A7-57

This is why ***D*** is a spring. The annulus will try to lift ***E*** but it cannot, so ***D*** bends until the pin meets the hole and it snaps rapidly into the hole; not quite instantaneous, but very good. Of course there will still be times when the pin just enters the hole and damage can still occur. And there remains the problem of small oscillations where, if the arm hole is not at the rest point of the weight, the mainspring will continue to be wound. As Sabrier & Imbert (1972 and 1974) stated:

> *... the system with "oscillating weight" of the Breguet type, ... was so effective, that too often it broke the fragile system of locking the weight, which, almost inevitably involved the rupture of the mainspring of the watch.*

Breguet used three different designs with compound levers. However, numbers 9 and 630 use a single lever, reinforcing my opinion that these two watches were probably not made by Breguet. And number 8 10/83 also appears to use a single lever.

This appendix concludes with a mystery. On 6 May 1791, a report was submitted to the *Société Nationale des inventions et découvertes* describing a self-winding watch made by Vincent at Montmartre, Paris (Paris, 1791). The original report, provided by Jean-Michel Piguet (2012-2016), is given in Figures A7-65 to A7-68 at the end of this section. Vincent might be Jean-Gédéon Vincent or Abraham-Aimé Charles Vincent (a student of Ferdinand Berthoud), however their addresses are different; see Tardy (1972).

This watch had a special safety lock-work to prevent damage to the watch caused by excessive movement.

Here is a translation of the report:

> *The National Society of inventions and discoveries have asked us to examine several inventions of Monsieur Vincent watchmaker at Paris. We went to his home, Rue de Rochechouard fb Montmartre. Mr Baradelle the elder* [probably Jacques]*, Mr Ruelle* [Abram?]*, Mr Denivernois* [Jean Henri] *and Robin* [Robert?]; see Tardy (1972).
>
> *Mr. Vincent first showed us an à sécousse watch for which he has invented a stop-work, giving the watches of this construction the ability to withstand major shocks.*
>
> *To understand the merit, it is necessary to say a word on the stop-work ordinarily employed in watches of this construction.*
>
> *In order to perpetuate the movement of these watches, by the shaking the watch receives in the pocket while walking, there is a second train, composed of the necessary numbers, so that the turns of the spring unwinding for thirty six hours, are rewound by this second train, using a counterweight which is held balanced on the axis of the last mobile by a spiral spring, which allows it the freedom to move from right to left more or less, as its shaking is greater or smaller. The axis of this weight carries a ratchet, whose teeth meet a click which is placed on the last wheel of the gear train. It is seen that by this provision, when the weight goes right* [anti-clockwise] *the click receives no resistance; but as soon as it returns* [clockwise]*, the click engages in the teeth of the ratchet, it is forced to rotate with the weight, and this movement winds a portion of the mainspring of the watch, which is retained by a second click when the weight returns to the other side.*
>
> *Thus, in a watch of this nature, and well made, the weight has to move for around two hours so that the watch is fully wound for 36 hours, for its ordinary running. We will not give more detail on the construction of à secousse watches, whose invention is not that of Mr Vincent, and we believe it should be placed forty years before the date of this invention.*

Several watchmakers gave an earlier idea to Mr Requaud, horloger at Nancy. [He is not listed in Tardy.]

But this invention is clearly acknowledged to Mr Perlet, watchmaker at Chaux-de-Fonds, in 1750, so we will say that for 40 years these watches have been in general use.

First, because this invention does not add anything to the art of measuring time, and that it doubles the price of a watch of equal quality.

Second, because large shocks have always caused considerable damage, especially on horseback. By demonstrating the effect of winding, one sees that in two hours the mainspring is fully wound, and without stop-work the weight, that is more powerful than the mainspring, would break all the pinions (that is what happens when the stop-work fails to operate). So different methods have been used to fix or anchor the weight when the spring is wound, but this provides locking that is sometimes more, sometimes less [secure?]. *It happens that great shocks were causing the weight to escape from the detent and by escaping the sharp angle of the detent is blunted, the weight still moved a little, and broke the pinions.*

It is essential to remedy this defect, so Mr Vincent designed a lever or rocking lever, which moves up and down in the same way as the lever that produces the ordinary detent, but the lever is constructed so that it can operate only when a great shock carries the weight further and requires it to bend a spring placed so that the weight does not strike the case. This spring bends enough for the lever that we talked of to fall on one side of the weight arm and it can make absolutely no movement until the mainspring is unwound by a turn, and what perfectly assures the effect of this lever is a surprise that supports it and in an instant it engages the arm of the weight by a good half line, and thus prevents the detent being blunted, as we have said above. [In this context *surprise* refers to the instantaneous action of the surprise piece in repeaters (see Watkins, 2011b).]

We then examined a repeater mechanism in which Mr. Vincent invented a ratchet mounted on the axis of the quarter rack to promptly operate the release of the gathering pallet so the hammer should no longer sound.

We then examined a lathe for the easy fabrication of the pivots of watches and clocks, and a lever to break the resistance of friction of the sides of the pivots relative to the wheels which they carry.

From the review we have just done, we believe should be concluded:

First, the invention of Mr Vincent for locking the weight of à secousse watches, is very well combined to ensure the effect of the weight, for use in the accidents that happen very frequently, and that is the most fortunate invention until now so that these watches can withstand big tremors.

Second, the repeater work of Mr. Vincent insures its effects, and has the property to occupy a very small space in a watch.

Third, the pivot lathe can only facilitate the proper execution of pivots, and discourage the risk of breaking them during polishing. And finally his balance and other objects advertise Mr Vincent's inventive genius.

Paris 23 April 1791

Appendix 7: Going Barrel Weight Locking

The report is vague and obscure, because the reporters fail to explain the mechanisms and give only a brief outline of them. But some features can be deduced:

(a) We are told that the safety locking mechanism *"is constructed so that it can operate only when a great shock carries the weight further"*. That is, there are two, separate weight locking mechanisms; an ordinary mechanism that operates in normal use, and a safety mechanism for when the watch experiences large shocks.

That is, the safety locking only acts when the ordinary locking mechanism can be damaged, and so it is only activated when the watch is nearly fully wound.

(b) The first part of the report describes a side-weight, going barrel watch but, despite writing that they will do so, the reporters do not describe the stop-work ordinarily employed in self-winding watches.

However, the weight has an arm, and we are told that *"the sharp angle of the detent"* can be *"blunted"* when the weight fails to lock. That is, the watch might have had a weight-arm locking mechanism using one or more holes in the arm.

(c) When the safety locking is activated *"the weight arm … can make absolutely no movement until the mainspring is unwound by a turn"*. From this we can deduce that the watch had differential screw stop-work, because the other forms of stop-work release the locking lever in a small fraction of a turn and they cannot indicate a full turn of the mainspring.

(d) The safety locking lever falls *"on one side of the weight arm"* and this is unidirectional locking at one of the two extreme positions of the weight.

Despite these deductions, the absence of diagrams makes understanding Vincent's mechanism almost impossible. However, the following mechanism might be what he invented. And it might not be what he invented.

Figure A7-58 shows the position when the mainspring is fully wound, but the safety lock has not been activated. One end of the safety locking lever ***k***, that pivots at ***p***, is above the buffer spring ***b***. The other end of the lever has a raised end, but it is under the weight arm. The spring ***s*** presses down on the lever, trying to raise the end under the weight arm, but the buffer spring prevents this movement.

In Figure A7-59 the weight has moved forcefully down, pushing the buffer spring in the direction of the blue arrow. This movement releases the end of the locking lever and it rotates under the force of ***s***, lifting the other end of the lever into the path of the weight, locking it. At the same time, the end of the locking lever blocks the buffer spring and it remains in its new position.

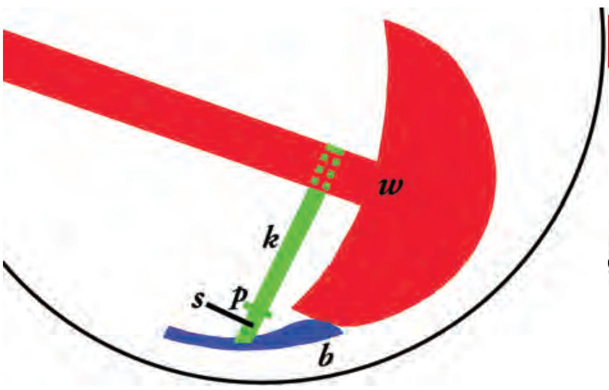


Figure A7-58

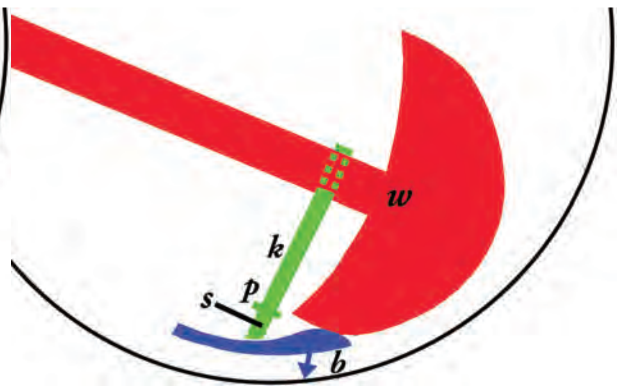


Figure A7-59

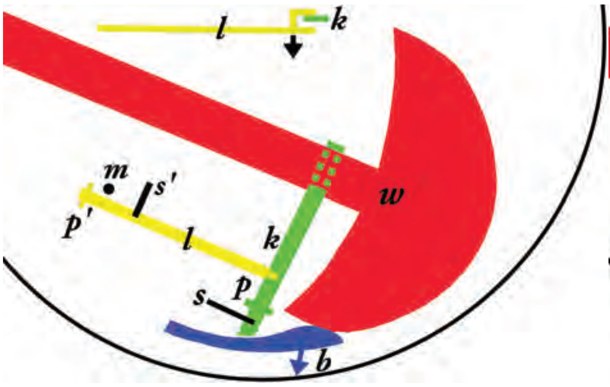


Figure A7-60

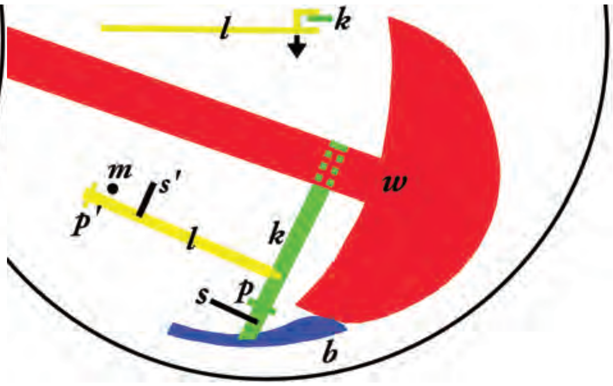


Figure A7-61

The mechanism described above will lock the weight, but there is no mechanism to *unlock* it. Figure A7-60 adds this feature.

The lever ***l***, pivoting at ***p'***, is moved by the differential screw on the barrel arbor ***m*** and the spring ***s'*** holds ***l*** against the differential screw. The end of ***l*** forms a hook that surrounds the lever ***k***, as shown in the elevation at the top of the illustration. ***s'*** is stronger than ***s***. The position of the parts is the same as in Figure A7-59, with the mainspring fully wound and the safety locking activated.

As the watch runs, the differential screw rotates and ***l*** drops, forcing ***k*** to drop with it. After one turn of the mainspring, ***k*** unlocks the weight and, because its other end is now above the buffer spring ***b***, the buffer spring returns to its normal position and locks ***k***, Figure A7-61. Now the weight is free and can resume winding the mainspring.

As the mainspring unwinds further, the levers ***l*** and ***k*** drop together and there is now space between ***k*** and the buffer spring ***b***.

When the weight rewinds the mainspring, the lever ***l*** is raised and the lever ***k*** rises with it, held against the top of the hook by its spring ***s***, Figure A7-62. Then they rise together until ***k*** meets the buffer spring ***b*** and can rise no further. During this time, the end of ***k*** is above the buffer spring ***b*** and a large movement of the weight that hits the buffer spring will have no effect.

When the weight continues to rewind the mainspring, the lever ***l*** rises by itself, because the lever ***k*** is held in place by the buffer spring, Figure A7-63. This continues until the lever ***k*** is pressed against the bottom of the hook. At this point the mainspring is "fully" wound because ***k*** stops ***l*** from rising further.

In Figure A7-58, unless there is a large shock to unlock ***k***, the weight is free to oscillate even though the mainspring is fully wound. That is, as noted in the report, there must also be an ordinary weight

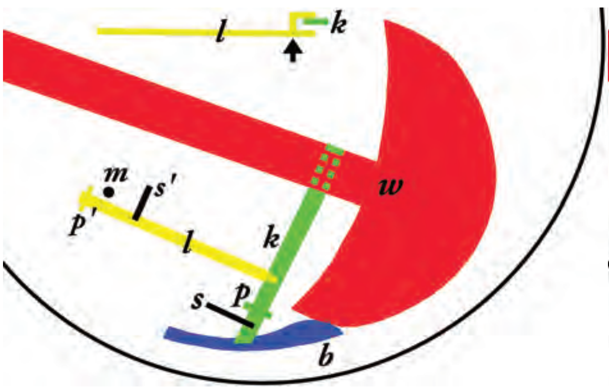


Figure A7-62

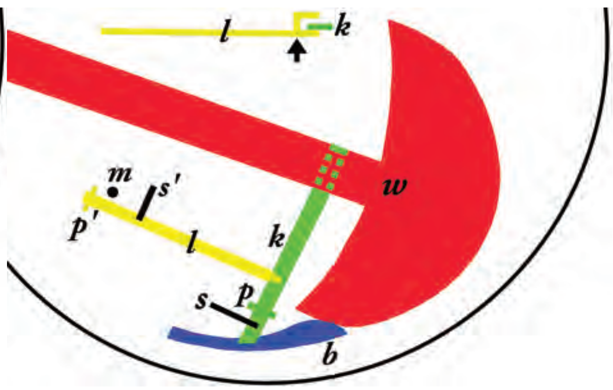


Figure A7-63

locking system to lock the weight when its oscillations are too small to activate the safety locking. Because we do not know the type of mechanism, Figure A7-64 only indicates that another lever ***j*** must exist to lock the weight arm. The exact position of ***j*** and the mechanism it acts on is unknown.

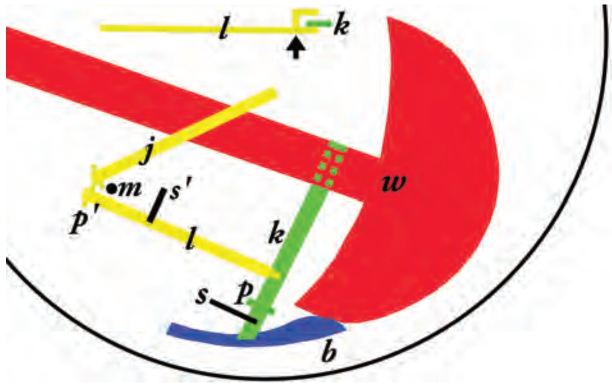


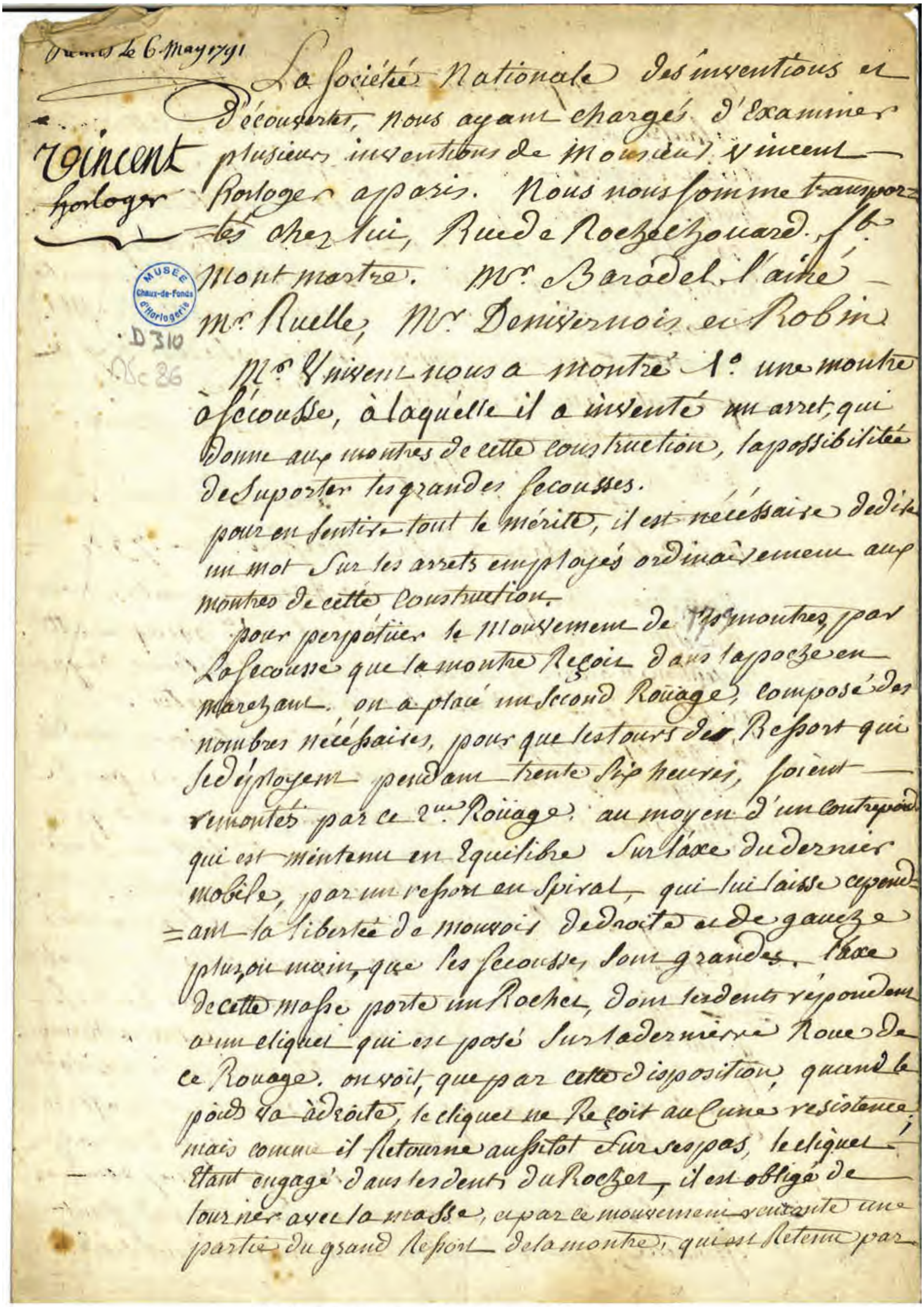
Figure A7-64

Finally, Vincent's safety lock-work is not perfect.

As the mainspring is wound, there is a slow transition from the state in Figure A7-62 to the state in Figure A7-63. During this time the lever ***k*** rests on the banking spring, and a large shock will release the lever and it will rise up until its end rests against the top of the hook on lever ***l*** and the weight will be locked. If this occurs just after ***l*** has begun rising by itself, ***k*** will move a very small distance and only the corner of its raised end will hold the weight. As the weight will rebound from the banking spring with considerable momentum, it is likely that the detent will be damaged and/or the lever ***k*** will be bent. However, this may not be catastrophic, because the mainspring is not full wound and, if the following movements of the weight are small, the only effect will be some small damage to the detent. Unless there are several large shocks in succession, which might cause much more severe damage.

Unlocking the weight also has problems. When the mainspring has unwound nearly one turn and the weight is still locked, the continuous motion of the lever ***l*** means that the detent formed by the lever ***k*** and the weight arm relies on the sharp edges of both. And then, if the watch is jerked suddenly, the weight can move, resulting in similar damage.

The design used by Vincent is unknown and it could be very different from that described above; although I cannot think of an alternative design that might work. But no matter what he used, the same problem would occur: An inherent property in all stop-work and lock-work is the need to convert the continuous motion of the mainspring into the discrete motion required for weight locking and unlocking. And nothing we have seen achieves this satisfactorily.



Vendredi le 6 May 1791

Vincent horloger

MUSÉE Chaux-de-Fonds d'Horlogerie

D 310

Ac 86

La société Nationale des inventions et découvertes, nous ayant chargés d'examiner plusieurs inventions de Monsieur Vincent horloger a paris. Nous nous sommes transportés chez lui, Rue de Rochechouard. fb. Montmartre. Mr Baradel l'ainé Mr Ruelle, Mr Denisvernois et Robin

Mr Vinsent nous a montré 1° une montre à secousse, à laquelle il a inventé un arret, qui donne aux montres de cette construction, la possibilitée de supporter les grandes secousses.

pour en sentir tout le mérite, il est nécessaire de dire un mot sur les arrets employés ordinairement aux montres de cette construction.

pour perpétuer le mouvement de ces montres, par la secousse que la montre Reçoit dans la poche en marchant. on a placé un second Rouage, composé des nombres nécessaires, pour que les tours du Ressort qui se déployent pendant trente six heures, soient remontés par ce 2me Rouage, au moyen d'un contrepoids qui est maintenu en équilibre sur l'axe du dernier mobile, par un ressort en spiral, qui lui laisse cependant la liberté de mouvoir de droite et de gauche plus ou moins, que les secousses sont grandes. l'axe de cette masse porte un Rochet, dont les dents répondent a un cliquet qui est posé sur la dernière Roue de ce Rouage. on voit, que par cette disposition, quand le poids va à droite, le cliquet ne Reçoit aucune resistance; mais comme il Retourne aussitôt sur ses pas, le cliquet étant engagé dans les dents du Rochet, il est obligé de tourner avec la masse, et par ce mouvement remonte une partie du grand Ressort de la montre, qui est Retenu par

Figure A7-65

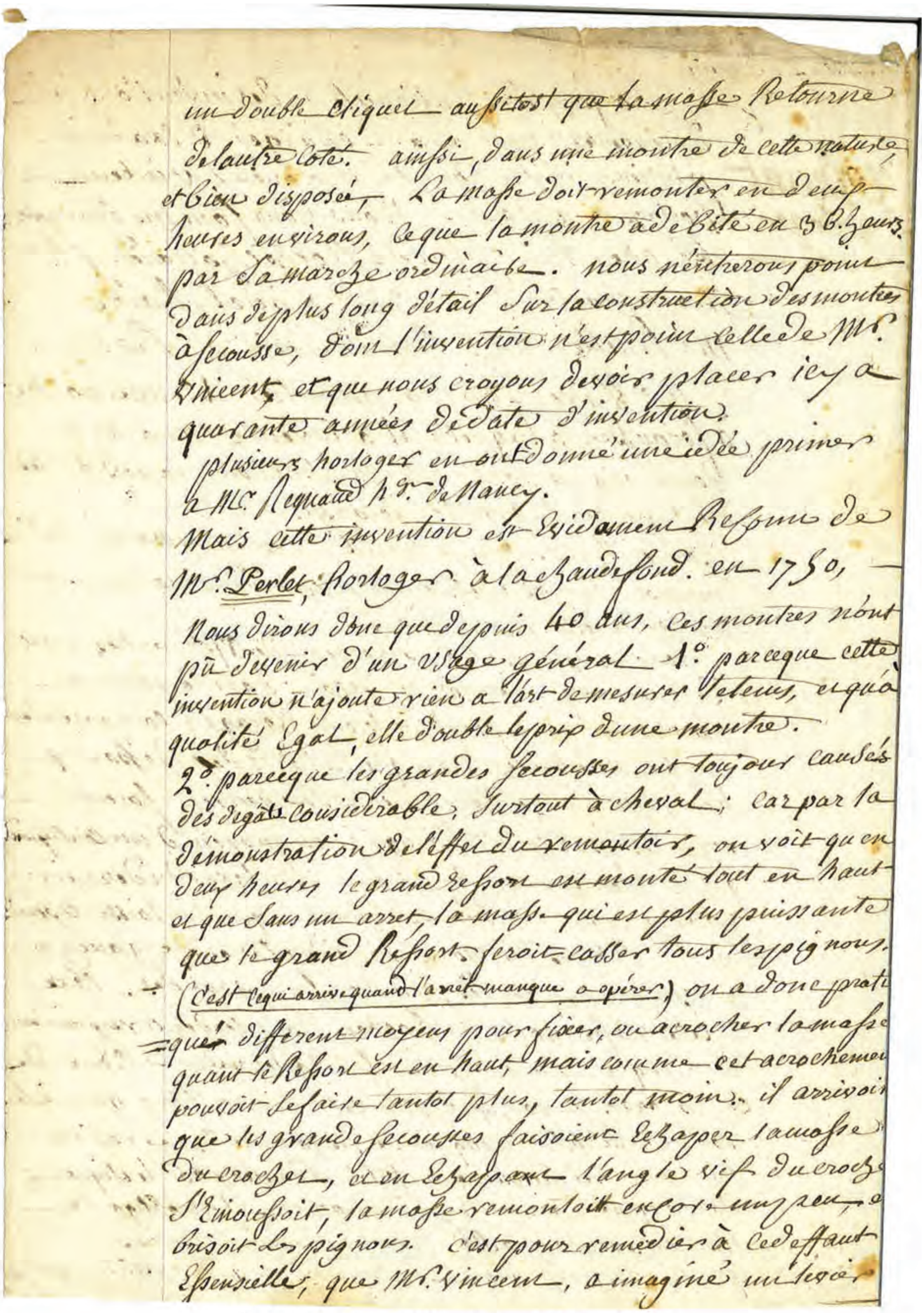
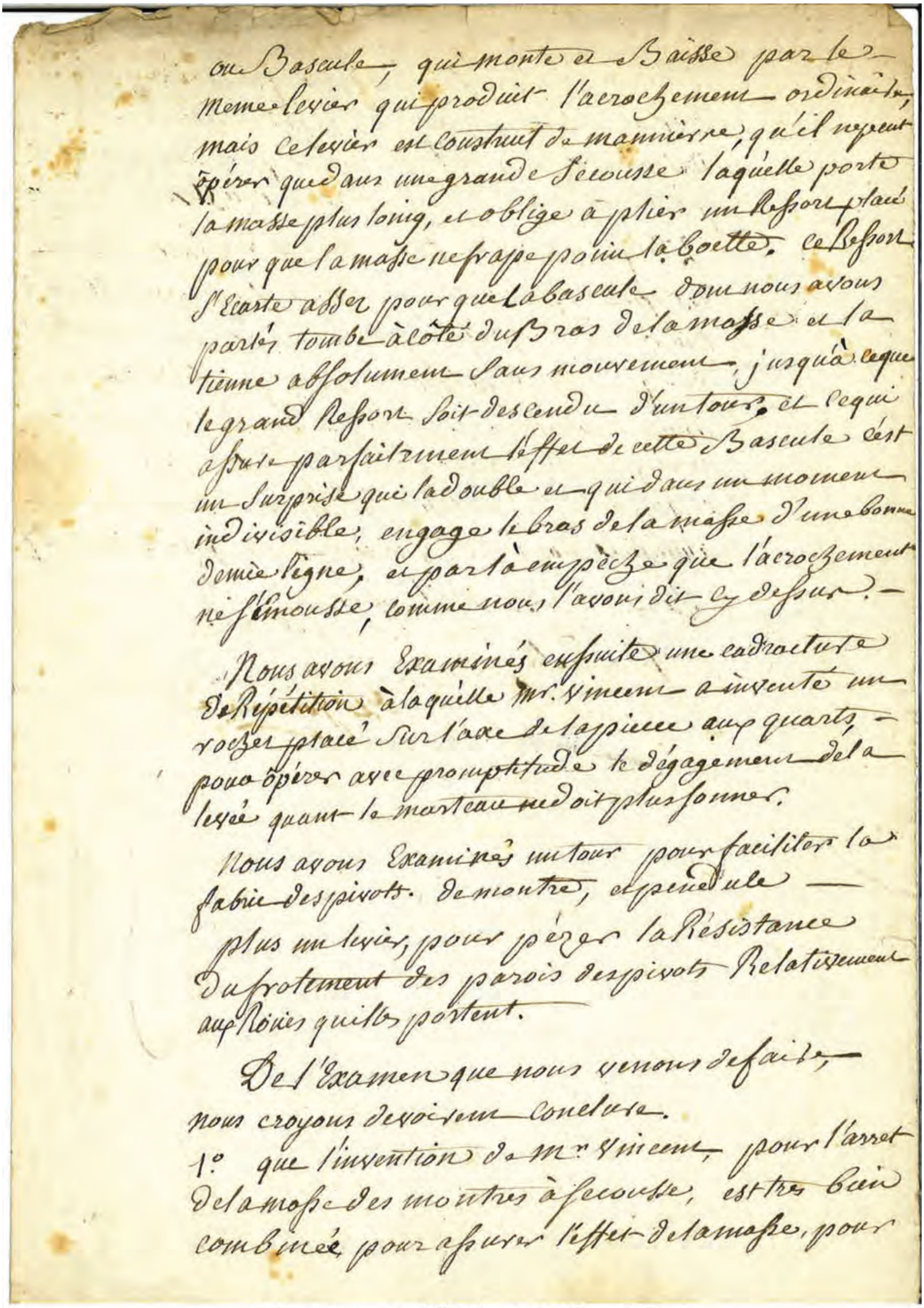

un double cliquet aussitost que la masse Retourne
de l'autre coté. ainsi, dans une montre de cette nature,
et bien disposé, la masse doit remonter en deux
heures environs, ce que la montre a debité en 36 heures
par sa marche ordinaire. nous n'entrerons point
dans de plus long détail sur la construction des montres
à secousse, dont l'invention n'est point celle de Mr.
Vincent, et que nous croyons devoir placer icy a
quarante années de date d'invention.
plusieurs horloger en ont donné une idée primer
le Mr. Requard hr. de Nancy.
Mais cette invention est evidament Reforme de
Mr. Perlet, horloger à la chaudefond. en 1750,
Nous dirons donc que depuis 40 ans, ces montres n'ont
pû devenir d'un usage général 1° parceque cette
invention n'ajoute rien a l'art de mesurer le tems, et qu'à
qualité égal, elle double le prix d'une montre.
2° parceque les grandes secousses ont toujour causés
des dégats considerable, surtout à cheval; car par la
démonstration de l'effet du remontoir, on voit qu'en
deux heures le grand ressort est monté tout en haut
et que sans un arret, la masse qui est plus puissante
que le grand Ressort feroit casser tous les pignons.
(C'est ce qui arrive quand l'arret manque a opérer) on a donc prati
qué different moyens pour fixer, ou acrocher la masse
quand le Ressort est en haut, mais comme cet acrochement
pouvoit se faire tantot plus, tantot moin. il arrivoit
que les grandes secousses faisoient échaper la masse
du crochet, et en échapant l'angle vif du crochet
s'émoussoit, la masse remontoit encore un peu, et
brisoit les pignons. c'est pour remedier à ce deffaut
essentielle, que Mr. Vincent, a imaginé un tirer

Figure A7-66



ou Bascule, qui monte et Baisse par le
meme levier qui produit l'acrochement ordinaire,
mais ce levier est construit de manierre, qu'il ne peut
opérer que dans une grande secousse laquelle porte
la masse plus loing, et oblige à plier un Ressort placé
pour que la masse ne frappe point la boette. ce Ressort
s'écarte assez pour que la bascule dont nous avons
parlés tombe à coté du Bras de la masse et la
tienne absolument sans mouvement, jusqu'à ce que
le grand Ressort soit descendu d'un tour, et ce qui
assure parfaitement l'effet de cette Bascule c'est
un surprise qui la double et qui dans un moment
indivisible, engage le bras de la masse d'une bonne
demie ligne, et par là empêche que l'acrochement
ne s'émousse, comme nous l'avons dit cy dessus. —

Nous avons Examinés ensuite une cadracture
de Répétition à laquelle Mr. Vincent a inventé un
rocher placé sur l'axe de la pièce aux quarts, —
pour opérer avec promptitude le dégagement de la
levée quant le marteau ne doit plus sonner.

Nous avons Examinés un tour pour faciliter la
fabric des pivots. de montre, et pendule —
plus un levier, pour pézer la Résistance
du frotement des parois des pivots Relativement
aux Roües quils portent.

De l'Examen que nous venons de faire,
nous croyons devoir en conclure.
1° que l'invention de Mr. Vincent, pour l'arret
de la masse des montres à secousse, est très bien
combinée pour assurer l'effet de la masse, pour

Figure A7-67

pour empecher les accidens qui arrivent tres
frequament, et que c'est la plus heureuse —
invention jusqua lors, pour que ces montres
puissent supporter les grandes secousses.

2° que la cadracture de Mr. Vincent a
des effets assurés, et quelle a la propriété de
tenir une tres petite place dans une montre.

3° que le tour a pivot ne peut que faciliter la
bonne Exécution des pivots, et empecher quon
ne risque de les casser en les polissant.

et quenfin la balance et les autres objets —
annoncés dans Mr. Vincent un genie inventif.

Paris Le 23. avril 1791. Robin

Baradelle l'ainé

C. L. Goerwoix

[illegible] Neulle

Rapport pour Mr. Vin[illegible]

Figure A7-68

joseph flores aout 2009

About the Author

Richard Watkins was born in Australia and studied computer science and mathematics at the University of Melbourne, where he obtained his PhD in 1972. After retiring from teaching at the University of Tasmania, he took up the study of watches, building an extensive library on the subject. His publications include 19 translations, 3 monographs, and a 1300 page bibliography on watches and watchmaking. Most of Richard's work can be downloaded from his web site www.watkinsr.id.au. In 2010 Richard was made a Fellow of the National Association of Watch and Clock Collectors for his work in research and education.