A Myth under Scrutiny

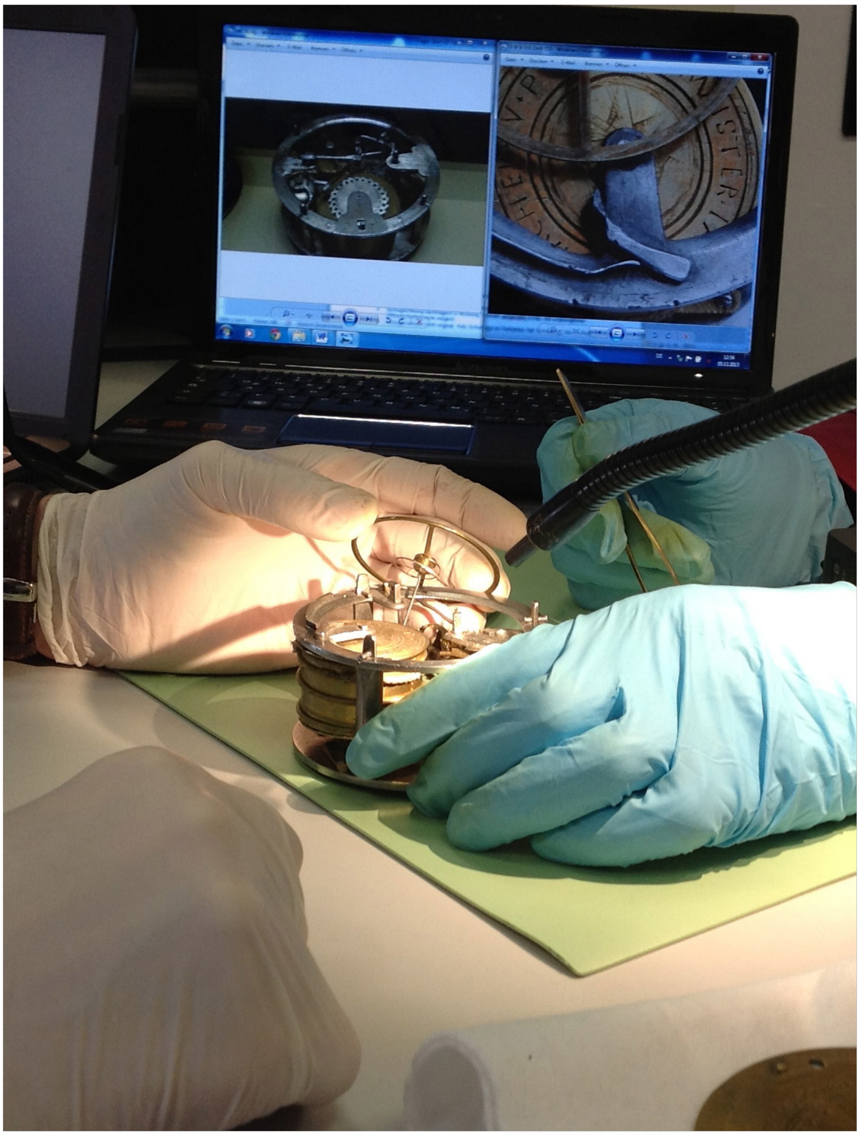
Investigations on the so-called Peter Henlein Clock at the Germanisches Nationalmuseum Nuremberg

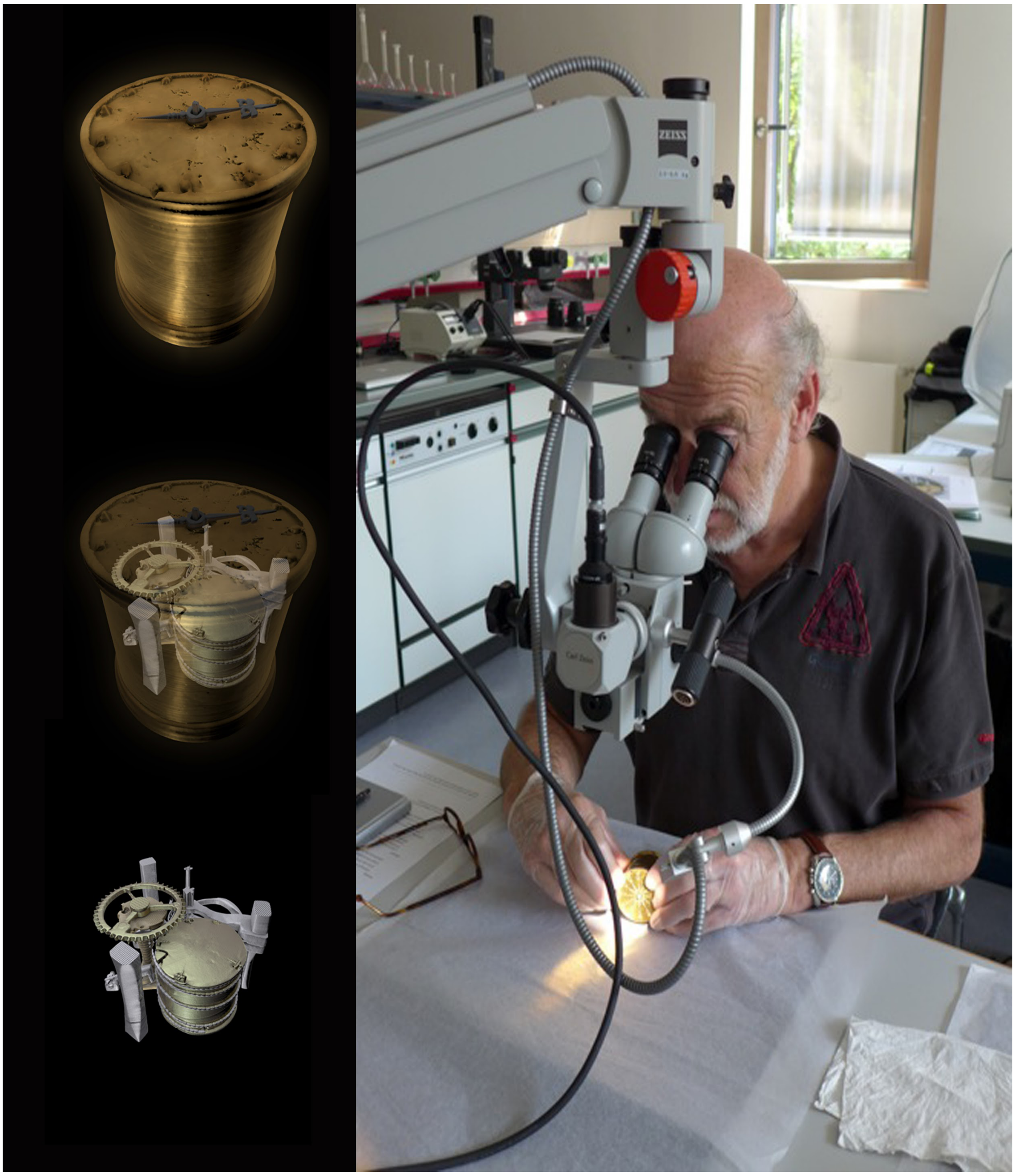
by

Jürgen Ehrt

"If you are looking for an angel and only look at the wings, could bring a goose home."

Georg Christoph Lichtenberg (1741-1799) - mathematician, mathematicia, physicist





IMPRESSUM

2nd edition 2024

Front cover: photomontage of Peter Henlein clock

Back cover: Image of Peter Henlein clock

Photo: Germanisches Nationalmuseum (GNM): R. Schewe, G. Janßen

CONTENTS

Preface

Is it the oldest pocket watch in the world or not? To make it clear from the outset: No, it is not. As Dr. G. Ulrich Großmann[1], the director-general of the Germanisches National-museum, writes in the preface of the exhibition catalog excellently curated by Dr. Thomas Eser.

"In conclusion, the clock turns out to be a construct predominantly assembled in the 19th century from older or supplementary components, claiming to be a clock by Peter Henlein.".[2]

Here, Dr. Großmann succinctly summarizes the results of the investigation we conducted over a period of 10 months on the so-called Henlein clock. This statement leaves no room for authors, whether intentionally or unintentionally, who want to revive the old myth through rhetorical devices, suggesting that this is still a Peter Henlein clock or at least partially preserved…

While Ulrich Großmann captures the essence of the result with his statement, the topic is much more subtle and needs further differentiation from a scientific and technical perspective.

To emphasize once again: **The so-called Henlein clock is a <u>construct</u>, a <u>conglomerate</u> of clock parts from various eras and origins.** It was disassembled by my colleague Johannes Eulitz (Mathematisch-Physikalischer Salon Dresden) and me.

Through months of meticulous research, analyzing the documentary images we captured, and the 3D micro-computed tomography images created at the Fraunhofer Institute Fürth, we arrived at our conclusion, which I will delve into in this report.

After the Rembrandt Research Project conducted in Amsterdam around the Rembrandt painting "The Man with the Golden Helmet" in 1968, one cannot entirely shake off the feeling of déjà vu.

Both exhibits not only share the same year, 1897, in their provenance; they were independently acquired in this year. While experts still disagree on the Rembrandt painting, there is no room for hypotheses and interpretations allowing attribution to the

---

[1] Im Verlauf der wissenschaftlichen Ausarbeitung wird das Germanische Nationalmuseum Nürnberg des Öfteren mit GNM abgekürzt

[2] Vgl. Germanisches Nationalmuseum Nürnberg, Die älteste Taschenuhr der Welt?, Vorwort von G.U. Großmann, S. 6.

Nuremberg clockmaker Peter Henlein from the first half of the 16th century in the so-called Henlein clock at the Germanisches National Museum.
In 2014, the GNM Nuremberg also called for a correction of the previous statements regarding the age and authenticity of the Henlein clock.
at this point, special mention should be made of Dr. Thomas Eser, who courageously took the unique step of addressing a topic that is generally considered in the museum community as not opportune. Subjecting questionable artifacts from one's own collection to verification is one thing, officially presenting the results to a broad audience is another. Thomas Eser went even further. He initiated the extensive investigation, culminating in an exhibition known as the Henlein Clock Controversy under the auspices of the Germanisches National Museum Nuremberg. He deserves recognition for this.

The examination of the so-called Henlein clock unfolded similarly to the Berlin painting "The Man with the Golden Helmet," in a controversial manner. However, in Nuremberg, the adversaries were more on the periphery than within the investigation committee. The challenge was to defend old, cherished, traditional views as well as previously asserted statements.
As an observer and consultant not directly involved in the examination of the Henlein clock, Peter Dziemba, the specialist advisor for Renaissance clocks of the Deutsche Gesellschaft für Chronometrie, was present. He had already examined the so-called Henlein clock in 1985, measuring it in great technical detail, yet without reaching a conclusion that questioned the authenticity of the exhibit as an original from the 16th century. He has replicated copies of the so-called Henlein clock multiple times for collectors and museums. Peter Dziemba has distanced himself from the examination results of the expert team.
For the near future, I have begun evaluating and providing comments on the other clocks that were part of this project.
The current scientific work on the authenticity of the Henlein clock is also available for download on my website http://www.uhrenrestaurator.de. This allows for an enlarged view of the images.

Dresden-Meißen, 2020 July

Jürgen Ehrt

I. The investigation of the so-called Peter Henlein clock in 2014

I.1 The investigation team

The investigation team was composed as follows:

Dr. Thomas Eser Project leader, head of the collection “Scientific instruments and medical history, weapons and hunting culture”

Experts investigating the watch:

Roland Schewe M.A. Restorer, Institute for Art Technology and Conservation (IKK)

Markus Raquet Restorer, Institute for Art Technology and Conservation (IKK)

Jürgen Ehrt, Restorer, publicly appointed and sworn expert for historical clocks, Dresden

Johannes Eulitz, Restorer, Mathematical-Physical Salon, Staatliche Kunstsammlungen Dresden

As observers not involved in the investigation of the Henlein clock:

Dr. Dietrich Matthes, Qatar, private clock historian

Dipl.-Ing. Peter Dziemba, Bad Nauheim-Wisselsheim, member of the German Society for Chronometry

Cooperation partners carrying out the technical logistics:

Dr. rer. biol. hum. Dipl. Phys. Theobald Fuchs, Fraunhofer Institute for Integrated Circuits (IIS) Development Center for X-ray Technology (EZRT)

Prof. Dr. Stefan Röttger, Technical University of Nuremberg Georg Simon Ohm, Faculty of Electrical Engineering, Precision Engineering, Information Technology

Scientific infrastructure:

Oliver Mack, Institute for Art Technology and Conservation (IKK)

Dr. Andrea Langer, Science Management and Marketing

I.2 Documentation and examination

Drum clock by Peter Henlein, GNM Nuremberg, Inv. - No. WI 1256

The cooperation partners of the Henlein project, the Fraunhofer Institute for Integrated Circuits (IIS) Development Center X-ray Technology (EZRT) in Fürth and the Technical University of Nuremberg Georg Simon Ohm, Faculty of Electrical Engineering, Precision Engineering, Information Technology, provided us with the necessary technical equipment for evaluating the 3D Micro computed tomography data are available, consisting of a 3D visualization tool in the form of a viewer specially developed for our project and computer software for evaluating tomograms obtained from the CT.

So, we were and are able to do research at our professional locations over a longer period of time.

The use of three-dimensional imaging processes, which allow us to non-invasively examine technical artifacts, such as clocks in the present case, is a milestone in the development of modern examination methods for historical clocks. Forgers, who in the past sometimes went to work with ingenious sophistication and believed that, due to their knowledge of the object, they were undermining the investigative methods and investigation parameters of the experts, whose crimes can also be unmasked with the help of these new procedures.

Adequate reference objects had to be procured for the exploration of the so-called Henlein clock, which was to be carried out based on comparative investigations.

National and international lenders supported the project in a grateful manner.

The exhibits listed below were included in the investigation canon.

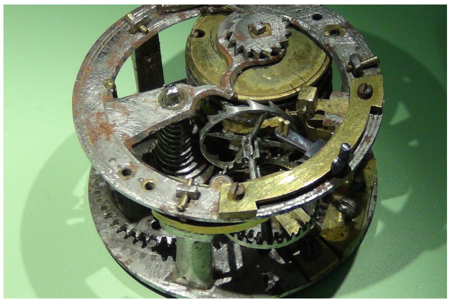
1. So-called "Early Walters Clock",
Walters Art Museum Baltimore,
Can clock 1st half of the 16th century.
INV no. 56.68
Photo: R. Schewe, G. Janßen (GNM)

2. So-called "Melanchthon clock", Walters Art Museum Baltimore, Muskrat clock at 3:30 p.m. INV no. 58.17

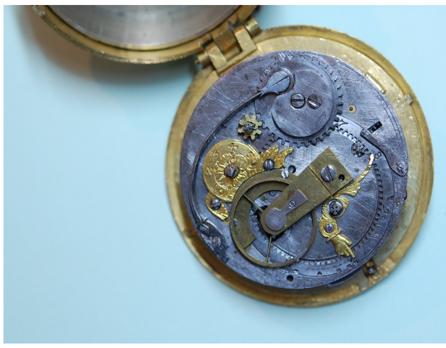
3. So-called "Culemann clock",
Kestner Museum Hannover,
Can clock 1st half of the 16th century.
INV no. 3731 CUL III.60
Photo: Kestner Museum Hannover

4. So-called “Jacob Zech-Uhr”, Prague, Mathematical and physical salon Dresden, Can clock 1527 INV no. DIV b 153
Photo: R. Schewe, G. Janßen (GNM)

5. So-called "Clemens clock", Museum of Applied Arts Cologne, Can clock 1st half of the 16th century INV no. KGM K 313
Photo: Restoration studio J. Ehrt



6. So-called "Pfinzing clock", Private Lender, Neck clock from the middle of the 16th century INV no. without
Photo: Restoration studio J. Ehrt



At the outset, the challenge was to coordinate with all lenders to encourage them to provide their exhibits for two examination sessions scheduled for August and December 2013.

The necessary logistics were expertly managed by the project leader, Dr. Thomas Eser, along with the IKK team members Roland Schewe and Markus Raquet, demonstrating unwavering commitment. Especially in December, a tight schedule had to be met by the examination team, as the clocks from the USA were available for only two days.

All six clocks were scanned using two- and three-dimensional imaging techniques and subsequently subjected to a visual examination by the team. Groups were formed to independently document their findings, which were later discussed in a group session.

The examination of the so-called Henlein clock, however, <u>was the sole responsibility of the four authorized experts and expert restorers.</u>

In the group discussion, experts Ehrt, Eulitz, Raquet, and Schewe presented their findings to the team.

<u>This first stage of the project</u>, involving the so-called Henlein clock and two other clocks contributed by a private collector, took place in August 2013 at the GNM premises and marked the beginning of an extensive, ongoing examination of wearable, spring-driven clocks from the early 16th century.

<u>The second stage of the examination</u> of exhibits 1 to 6 took place in December 2013 at the GNM premises. These were non-invasive observations that prohibited any interference with the complexity of the clocks.
However, this report explicitly focuses on the so-called Henlein clock of the GNM-Nuremberg. The insights gained from the other clocks will be presented in a separate report by me.

<u>The third stage of the project</u>, conducted in the second week of February 2014 at the GNM premises, provided crucial insights for a final assessment of the so-called Henlein clock.
During this week, my colleague Eulitz and I disassembled the clock with inventory number WI 1256 into its individual parts in the workshops of the IKK at the GNM. Restorers Schewe and Raquet, based on their professional specialization, focused on examining the clock case. At the end of the week, we orally presented our jointly developed preliminary findings to the team leader Dr. Eser and indicated our subsequent written final report for May 2014

"The final report prepared for the Germanisches Nationalmuseum in May 2014 by the experts involved in the examination, Ehrt and Eulitz."

Final report drum clock Peter Henlein GNM Nuremberg Inv. - No. WI 1256

"The following report is based on the joint examination of the so-called Henlein clock with my colleague Johannes Eulitz, an expert in Renaissance small clocks, master watchmaker, and restorer at the Mathematisch-Physikalischer Salon / Staatliche Kunstsammlungen Dresden. During our collaborative investigations spanning several months on clocks from the Henlein era, we evaluated our findings through close contact and professional exchange of opinions. It is sensible to consider our reports as interconnected. The technical examination results, especially the evaluations, insights, records, and attributions resulting from the investigations, are part of this final report. They are summarized in a separate investigation protocol with visual material and computer tomographic scans. These are available to authorized individuals at the GNM through the experts.

The aim of the examination was to use modern, completely non-invasive methods such as CT, RTI, and RFA to conduct investigations that would better explain the technical history of the object and provide reference values for subsequent examinations of comparable exhibits.

It was also to be clarified whether so-called 'secret signatures' such as the letters P and H or word formations like Henlein or P Henlein could be found on components of the exhibit.

We unanimously concluded that such signatures are not present on the clock at the GNM Nuremberg with inventory number WI 1256.

For the dating, attribution, and authentication of a technical artifact, as the so-called Henlein clock represents, besides stylistic features, provenance, materials, and their characteristics, the transitory changes such as modifications, additions, repairs, and component losses of the exhibit are of considerable importance.

After the computed tomographic evaluation raised significant doubts about authenticity, we decided to conduct an invasive examination of the exhibit.

In February of the year, we disassembled exhibit WI 1256 into its individual parts in the restoration workshop of the GNM, including a written and photographically secured documentation. In this exploration, focused on maximum reversibility, we also examined the corresponding components for the presence of coherence."

The present colleagues Roland Schewe and Markus Raquet, GNM Nuremberg, reported significant doubts about the authenticity after a closer examination of the drum-shaped clock case. They identified machining traces on the surface, which, in their opinion, indicated a subtractive change in the original surface texture. They also noticed traces of regilding of this already worked surface, which had also been machined again.

The undersigned confirm these findings and additionally doubt the original coherence of the movement and the case. Not only are the expected signs of wear from the mechanical transitions from the movement to the case and the earliest made hand in the late 17th century missing, but the inadequate fixing of the movement in the case lacks the signature corresponding to the technology of that time. Significantly, the undisputed forged signature on the lid of the case is also noteworthy. An opening groove with very strong signs of use, which was intended to detach the lid engraved with the dial, appears illogical and inexplicable in this context.

The placement of two separate mainsprings in the barrel, noted with surprise in the computed tomographic evaluation, turned out to be the implantation of two pocket watch mainsprings from the 18th/19th century with corresponding modifications and additions to the mainspring core and the barrel in particular.

The barrel, constructed from forged sheet iron in cylindrical form, is closed on the lower side by hard soldering. The upper, also circular, lid-shaped closure is secured by pegs with locking pins protruding from the cylindrical wall.

The undersigned, Eulitz and Ehrt, hereinafter referred to as experts, are of the opinion that this is the creation of a barrel involving components from different clocks.

The examination revealed that the wedge that concludes the barrel is a new creation. This includes a shortening of the barrel wall. The spring plate riveted to this wedge serves solely to lock the wedge in the barrel wall and has neither a stabilizing character nor a technical function. It is plausible that the apparent benefit is to give the barrel the style and architectural character of a barrel from the first half of the 16th century. This is supported, among other things, by the spring core tailored to the dimensional requirements of the barrel abor.

The experts believe that this barrel, for various reasons, is a unit inserted separately into the work of the exhibit, not least because of the lack of running tracks on the pegs and the non-coherent adaptation of its elements.

The examination of the fusee and the fusee-wheel, especially in the context of an expected authentic interaction of the building components as an early portable clock from the 16th century, also raises considerable doubts.

The square for winding the clock is, for example, supplemented with its immediately underlying running surface for the pinhole provided in the movement plate. It is inserted with a dovetail connection without visible soldering. Since both the winding square and the pivot pin show almost no usage-related traces, which should also be in relation to other usage traces in the exhibit, one can also assume that this was made later. The 3D micro-computer-supported tomography provides us with the possibility of assessing usage traces in the interior of the fusee. Here, too, expected signs of wear are not present. The diametrical pivot placement of the winding square in the extension of the adapted fusee wheel also shows no relevant usage traces.

The dimensioning of the fusee fundamentally precludes reliable use between the fastening points of the clock. It was modified by means of an extension bearing for use in the movement. In summary, this means that the fusee, with its applied fusee wheel, is too short. The fusee wheel, with its unusual module that also questions its originality and the fusee lock attached to it, is the subject of a detailed discussion in the examination protocol.

The experts consider the fusee, along with its associated fusee wheel, to be incompatible with the other components, also due to the significant brute processing traces on the fusee turns and the absence of running tracks for a chain on these turns. The chain attached to the clock is in its construction similar to the chains of key-wound pocket watches from the early 19th century. Further blatant changes and modifications to the fusee can also be found in the examination protocol.

The synthesis of exploration on the object and the evaluation of 3D micro-computer tomography raised further questions that absolutely questioned the coherence of the components. The examination protocol deals extensively in words and pictures with the disclosure of the connections from a technical perspective.

The undersigned consider the examined so-called Henlein clock at the GNM Nuremberg to be non-homogeneous in its complexity and coherence of components. When considering the findings gained on the watch case by colleagues Schewe and Raquet, who postulate a marriage between the watch case and the movement, and summarizing the results of the specialist group, one must inevitably come to the conclusion that the movement is a conglomerate of clock components of different origins and ages.

Hude and Dresden, May 7, 2014

Jürgen Ehrt and Johannes Eulitz

II. Evaluation

"The following documentation about the physical structure and the insights gained by the expert team regarding the so-called Henlein clock is intended to enable non-expert observers to recognize and understand the connections. For experts among us, it can serve as an invitation to engage in a professional discourse.

The non-invasive approach to the exhibit **in the initial phase of the examination** was initiated through 3D computer tomography (CT). Another analysis method frequently used in museum exploration, Reflectance Transformation Imaging (RTI), was used to assess surface structures and their homogeneity.

For the evaluation and assessment of introduced materials and material combinations, as well as their adhesive and cohesive bonding structures, we used X-ray fluorescence analysis.

The disassembly of the so-called Henlein clock and the on-site examination confirmed our expected findings and axiomatically aligned them with the results of the computer-assisted analyses from the initial examination phase.

Subsequently, for better understanding and standardization of the terms used in the documentation, a description of the technical clockwork structure of the so-called Peter Henlein clock will be provided."

II.1 The description of the technical clockwork structure

"The so-called Henlein clock corresponds in its technical and architectural structure to the requirements of clockwork construction in the early 16th century.

The fundamental physical requirements to be met in the construction of a portable clock at that time included the functional areas of the energy source, energy storage, pinions, escapement, oscillator, and display.

Translated into the mechanical terminology of clockmaking, these are analogous to:

- A winding mechanism operated by hand with a clock key and a mainspring as the force storage, which is transmitted through a mathematically designed system of pinions and trains to the escapement (in our case, a spindle escapement).

- A crown wheel escapement, which is used as the oscillating system in the Henlein clock. It regulates the operation of the mechanical pinions to ultimately rotate at a speed that allows a hand attached to the hour wheel to display the time on a dial.

The following listed components are the essential parts of the so-called Henlein clock. We will not go into further detail on components that connect, stabilize, and guide parts."

Bauteile der sogenannten Henlein - Uhr

© Layout und Texte: Restaurierungsatelier Jürgen Ehrt
Foto: GNM - Roland Schewe

1 = Untere Platine
2 = Obere Platine
3 = Zifferblatt
4 = Federhaus
5 = Hemmrad- und Kronrad-Kloben
6 = Beisatzrad-Kloben
7 = Unterer Spindellager-Kloben
8 = Oberer Spindellager-Kloben
9 = Federhausdeckel
10 = Wechselrad
11 = Antriebsrad
12 = Hemmrad
13 = Kronrad
14 = Radunrast
15 = Schnecke
16 = Welle mit Federkern
17 = Stundenrad
18 = Zeiger
19 = Andruckfeder Stundenrad
20 = Sperrrad Federhaus
21 = Zugfeder 1
22 = Trennscheibe
23 = Zugfeder 2

"Components of the so-called Henlein clock"
© Layout: Restoration studio Jürgen. Ehrt
Photo: R. Schewe, G. Janßen (GNM)

II.1.1 The winding mechanism

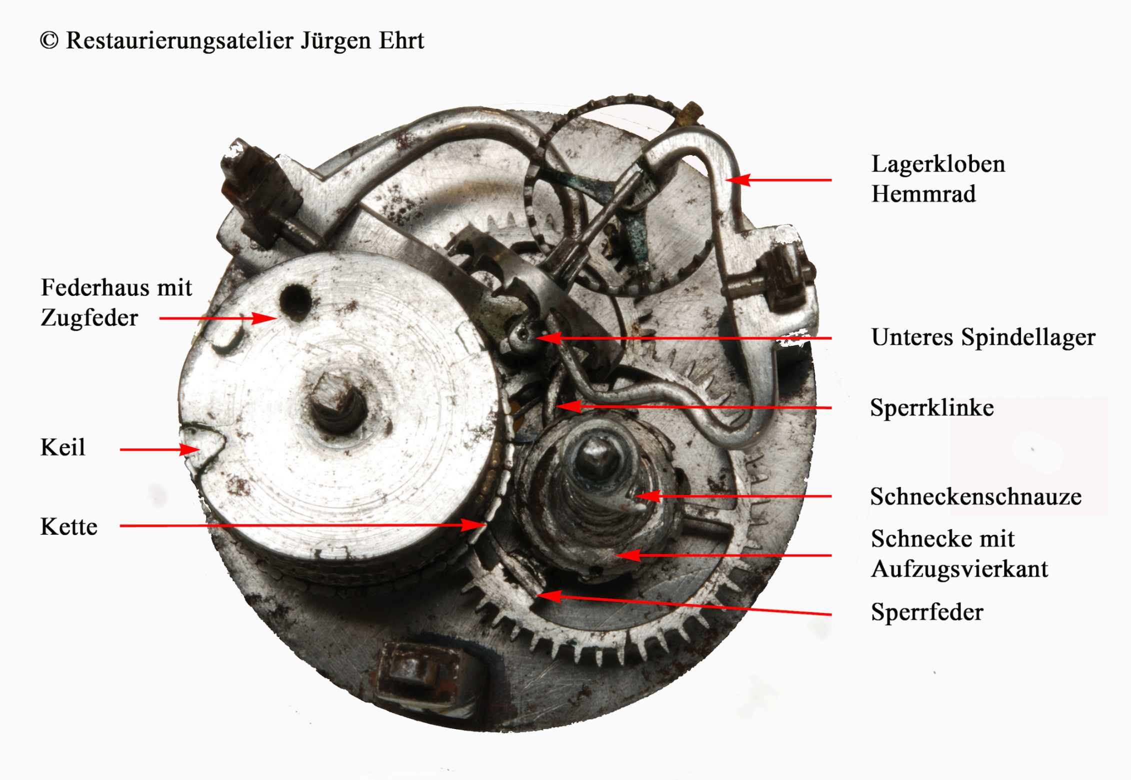
The winding mechanism consists of:

- Fusee with a square drive
- Chain
- Barrel with (two) tension springs
- innerspring and shaft
- Lever for mainspring tension

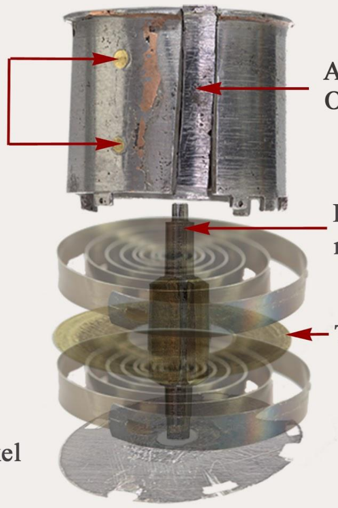
"The attached winding key is turned counterclockwise. Thus, the chain winds onto the coils of the fusee until it is stopped by the fusee stop. The now wound chain has turned the mainspring barrel counterclockwise. The tensioned but rigid mainspring core has pull springs attached to its outer end, each with an eyelet hole. The pull springs could potentially be attached and tensioned against the inner mainspring barrel wall. As the clockwork runs and operates, the spring relaxes again."

II.1.2 The mainspring barrel with pull springs

The mainspring barrel of the so-called Henlein clock has inside it, instead of a spring, two pull springs from 19th-century industrial production, arranged one above the other by a separating disc, in approximately the width of the mainspring barrel.


© Restaurierungsatelier Jürgen Ehrt
Lagerkloben Hemmrad
Federhaus mit Zugfeder
Unteres Spindellager
Sperrklinke
Keil
Schneckenschnauze
Kette
Schnecke mit Aufzugsvierkant
Sperrfeder

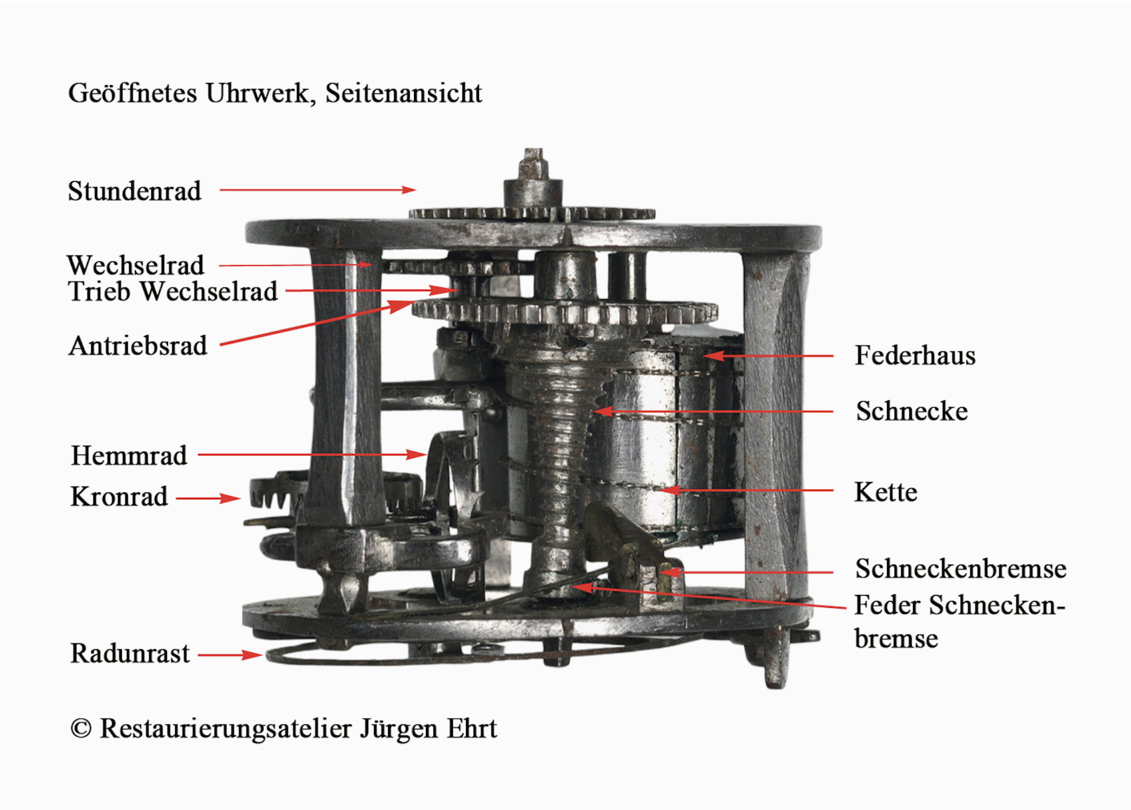
Aufbau Federhaus



II.1.3 The gear train

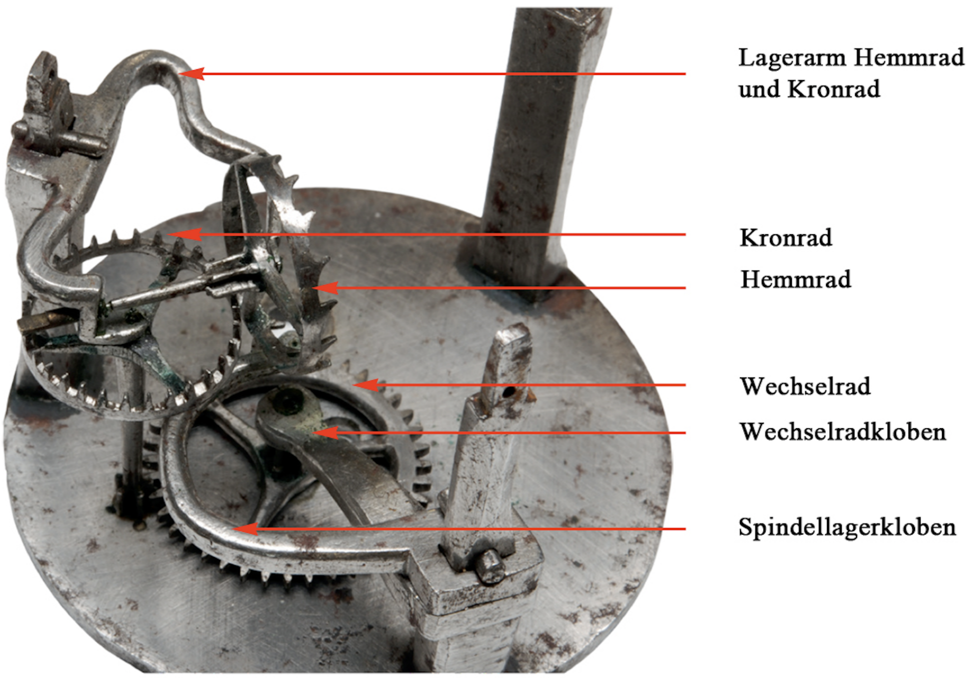
During the unwinding of the mainspring barrel, the fusee with its attached driving wheel is brought back in the opposite direction of rotation. The driving wheel engages with the pinion of the intermediate wheel, which drives the pinion of the crown wheel. The horizontally toothed crown wheel engages with the pinion of the escapement wheel, which, in turn, controlled by the pallets of the spindle shaft with the attached escape wheel, runs in the rhythm of its changing frequency.

In addition to the escapement wheel, the mainspring also drives the hour hand via the fusee wheel. The fusee wheel has a shaft passing through the plate with three attached drive pegs. These three drive pegs move the hour wheel with the attached hour hand.



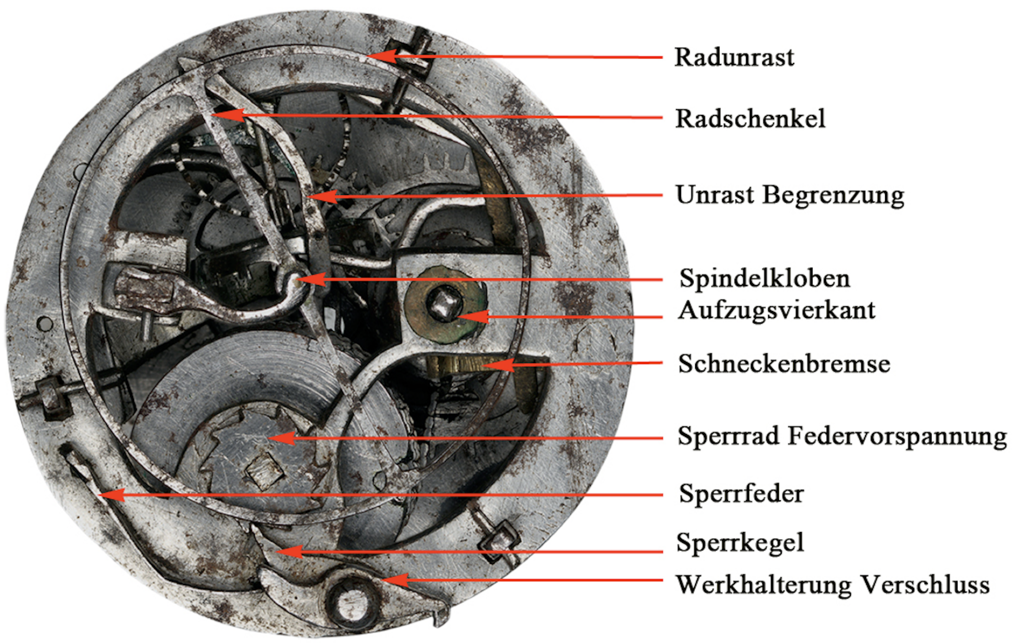
I.1.4 The escapement

The oscillating *Radunrast* receives a triggering impulse transmitted through the spindle shaft by the elevation of the spindle lobes. The amplitude of the *Radunrast* was limited by two opposing pig bristles inserted into a movable regulating arm riveted on the plate (no longer present in the so-called Henlein clock, replaced by metal pins). The arms of the *Radunrast* originally rebounded from the bristles and consequently followed a returning path. By shifting the lever and thus changing the distances between the arms and the pig bristles in one direction or the other, the speed of the gear train changes proportionally to the distance. As a result, the regulation of the clock's advance or delay is achieved through the hour wheel and the attached hand.

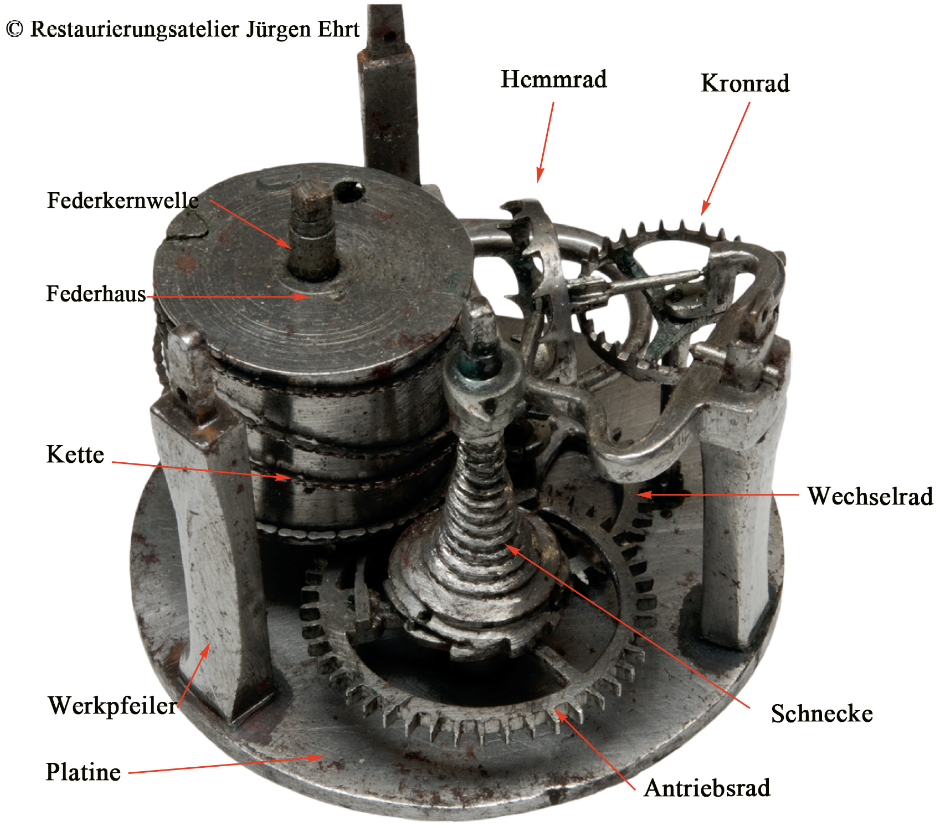


II.1.5 The functional scheme of the fusee

Unlike weight-driven clocks, the force in spring-driven clocks does not run constantly and linearly. The mainspring undergoes a force cycle from the tensioned state to its relaxation, which, rapidly decreasing, only vaguely assumes linearity in the middle. The strong spring tension at the beginning leads to a rapid clock movement, causing the clock to "advance." Subsequently, the force curve is approximately linearly decreasing for a while, while at the end, the force of the spring tension decreases significantly, causing the clock to "retard."



To mitigate this significant issue and achieve the most constant movement of the gear train, the principle of the fusee and gut line (later chain) was also employed in clocks from Peter Henlein's time. As described in the explanations of the winding mechanism, the chain is wound on the mainspring barrel. By winding the clock, the chain is wound onto the guiding turns of the fusee. The winding of the chain begins at the largest diameter of the conical fusee and ends at the cone's tip with the smallest diameter. During the backward movement of the chain from the fusee during the clock's operation, the spring relaxes. As the tension of the mainspring decreases, the radius of the fusee increases. This helps to keep the force applied to the gear train largely constant.



II.2 Analyse

The following analysis consists of exploring and interpreting the insights gained from the so-called Henlein clock through technical know-how and expert knowledge.

As Thomas Eser already stated in his publication in DGC 2015[3], the moral-legal interpretation of the creation of the construct wrongly attributed to Peter Henlein should not be the subject of the investigation.

I will therefore limit myself to the facts that exclude an attribution of the artifact to the 16th century.

An attribution to the clockmaker Peter Henlein is obsolete anyway, as there is still no clock worldwide that can be scientifically attributed to him.

My colleague Johannes Eulitz writes:

"In the box clock, in addition to understandable repairs, significant changes have been made to components that, among other things, resulted in the loss of their secure function. They suggest that at the time of the conversion, the clock did not possess anything close to the status it later achieved and that the interventions did not primarily aim for functionality or higher accuracy. Were the original components in the clock altered or were secondary parts adapted to create a supposedly correct original?"[4]

In the core statement, I align with my colleague, but to avoid misinterpretations, I want to emphasize clearly that we are dealing with a construct created from old and new clock parts.

This means that, taking the statement: "*In the drum clock, in addition to understandable repairs, significant changes have been made to components...*" - it should be assumed that at the time of the conversion, it was not a drum clock, but at best the fragment of one. The experts unanimously concluded that the clockwork and the case originally did not belong together. From this fact alone, it is evident that the *Kompilator*, as Thomas Eser calls him, had a specific intention – to create a clock from fragments of no longer complete clocks, representing a clock from Henlein's time.

[3] Vgl. Deutsche Gesellschaft für Chronometrie - Jahresschrift 2015, Band 54, S.25 ff. Thomas Eser: Die Henlein-Ausstellung im Germanischen Nationalmuseum / Rückblick, Ausblick, neue Befunde.
[4] Vgl. Deutsche Gesellschaft für Chronometrie - Jahresschrift 2019, Band 58, S.99 ff. Die Henlein-Uhr. Befund ihrer technischen Untersuchung - Autorengemeinschaft Jürgen Ehrt, Thomas Eser, Johannes Eulitz, Markus Raquet, Roland Schewe.

The motivations of the so-called *Kompilatur* cannot be explained with the help of our acquired knowledge and are not the subject of the investigation.

I cannot fully endorse the statement[5] made by Thomas Eser in his conclusion, *"....the so-called Henlein-Uhr proves to be a* ***probable*** *forgery*," especially considering the inscription on the lid of the clock.

The engraved inscription on the lid, **"Petrus Hele me f(ecit) Norimb. 1510,"** implies the intention to attribute this construct to the legendary 16th-century clockmaker Peter Henlein from Nuremberg. Given this, along with the purchase in 1897 by the museum for a significant sum, the term **forgery** is indeed applicable to the so-called Henlein-Uhr.

Photo: R.Schewe, G. Janßen (GNM)

For this reason alone, the interpretation of the acquired insights into the examined so-called Henlein-Uhr must be conducted rigorously and unambiguously.

---

[5] Vgl. Deutsche Gesellschaft für Chronometrie - Jahresschrift 2019, Band 58, S.108. Die Henlein-Uhr. Befund ihrer technischen Untersuchung - Autorengemeinschaft Jürgen Ehrt, Thomas Eser, Johannes Eulitz, Markus Raquet, Roland Schewe.

At this point, let's refer to the old adage:

**"There is no debate about the value or worthlessness of a forgery!
A forgery remains a forgery, regardless of whether it is well or poorly executed!"**

II.2.1 The Movement Frame

The movement frame of the examined exhibit is to be considered as the base. It consists of the lower and upper plates connected by three pillars.

These components, made of iron, including the base plate, upper plate, and movement pillars, are joined together through hard soldering and pinning.

The examination results will demonstrate that we are dealing with a movement frame used as the base for the reconstruction of the so-called Henlein clock.

Image: Lower Plate

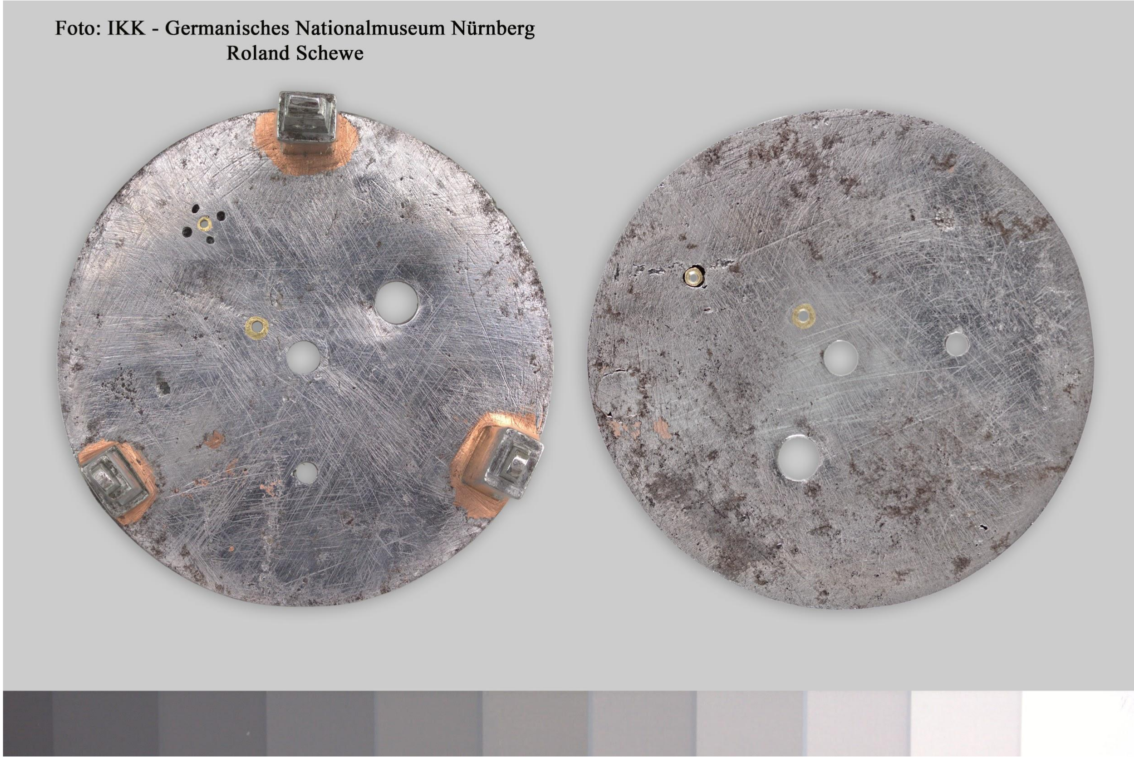
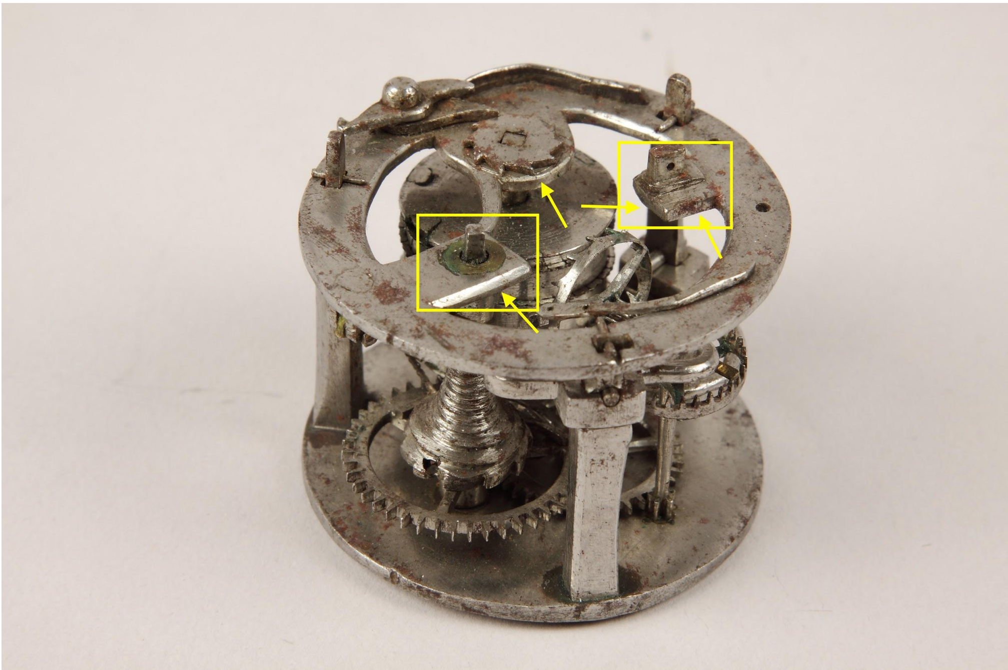
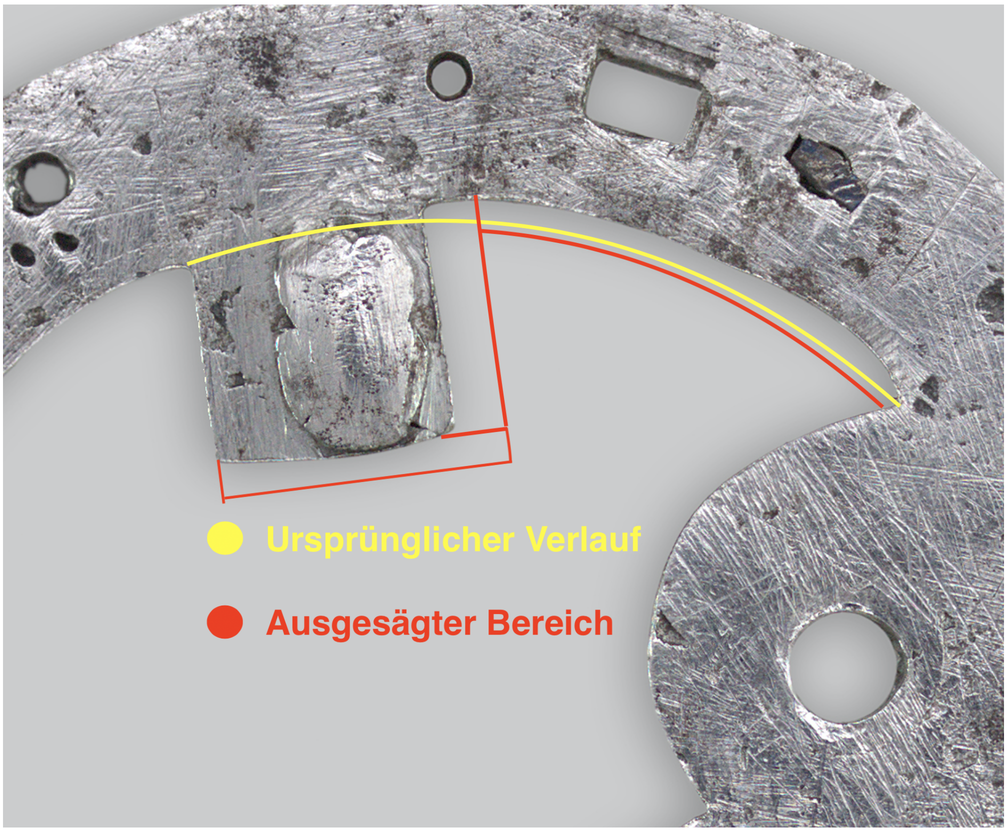


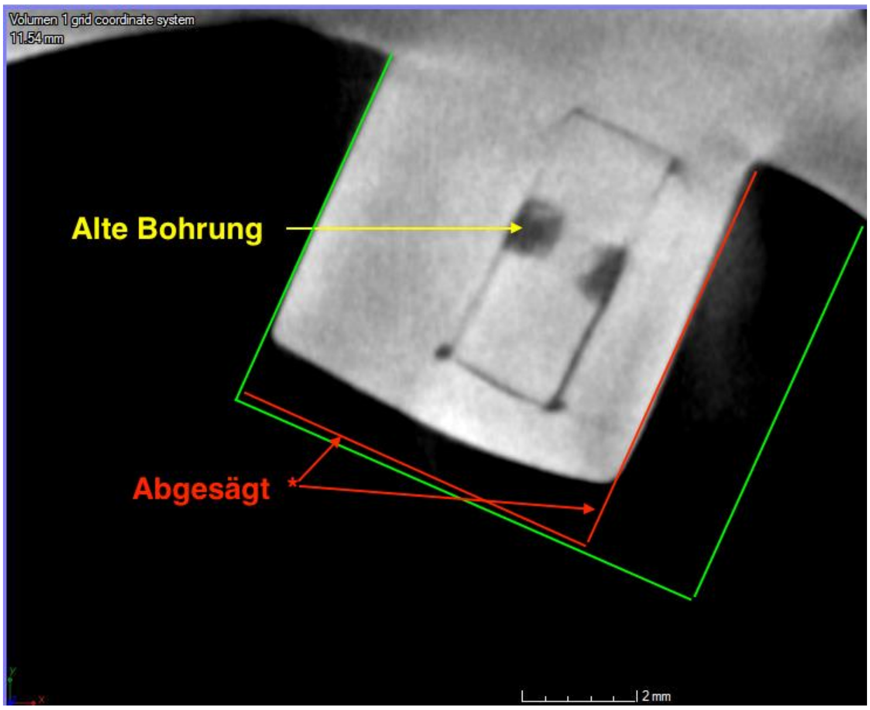
Image: The upper plate inclined toward the dial

The chamfered edges - see yellow markings - as opposed to the sawn edges on the lower spindle bearing bracket support the finding that the movement cage was modified for a new construction.




Ursprünglicher Verlauf
Ausgesägter Bereich

The plateau for accommodating the lower verge bearing bracket was sawn in width and length to create a clearance space for the barrel and escapement wheel. Consequently, in this movement cage, before this modification was carried out, neither the existing barrel nor the installed escapement wheel could have been present. In the tomography, an old transverse hole can be seen through the riveted plateau pin, which serves to accommodate the lower spindle bearing bracket. This unused transverse hole originally had the plateau pin riveted under a different plate, which, however, cannot be identical to the one used here. Thus, this plateau pin cannot belong to the examined exhibit.

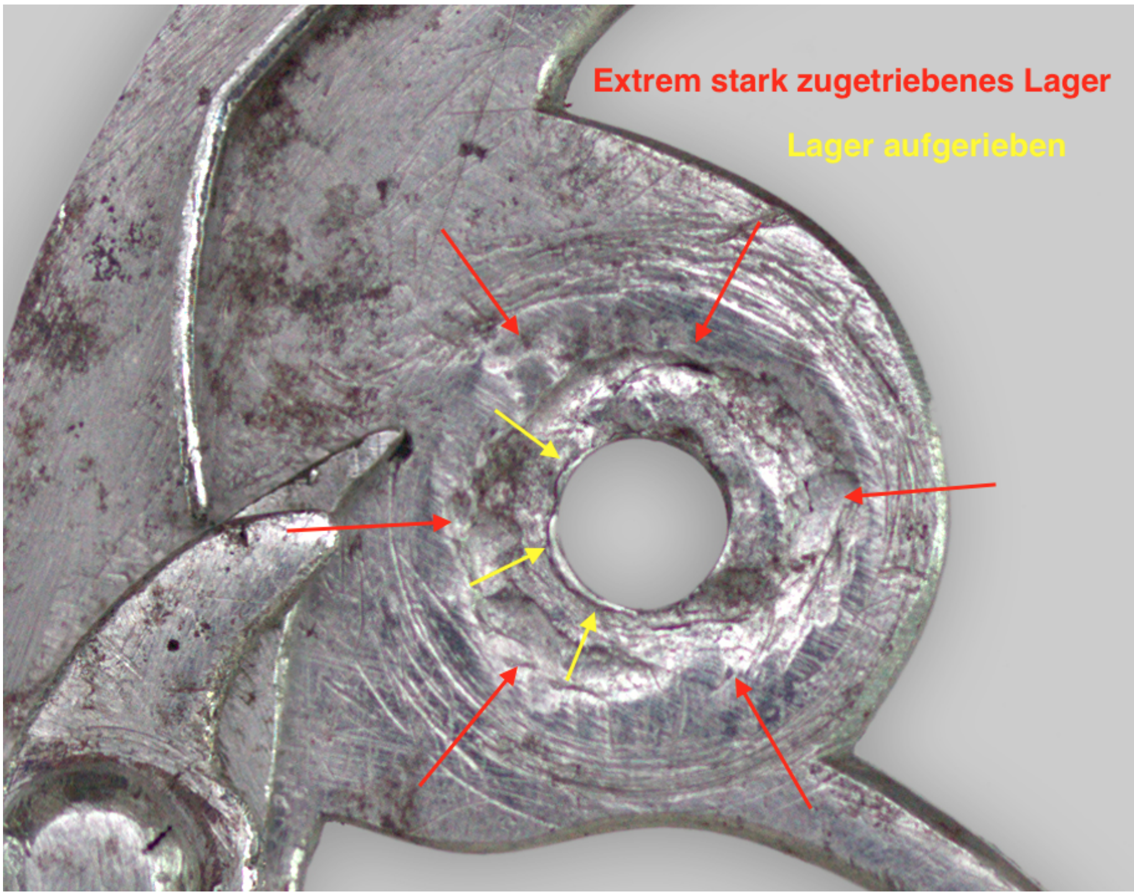


© Layout: Restoration studio Jürgen. Ehrt
CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth

The bearing for accommodating the barrel arbor in the lower plate was initially driven in very tightly (see red markings), apparently for accommodating an arbor with a smaller diameter barrel arbor. To adapt it to the correct diameter, the bearing was subsequently reamed. This is evident from the folds in the metal (see yellow markings).

Assuming that the arbor with the barrel arbor does not rotate but, when tensioned, locks the barrel to let it run down on itself, only wear on the barrel bottom bearings can occur, not on the arbor pin of the barrel arbor or its bearing. This is another indication of a component addition. Subsequently, I will demonstrate that the barrel was originally not part of this movement cage.

Image: Bearing for the Barrel Arbor Shaft



© Layout: Restoration studio Jürgen. Ehrt
Photo: R. Schewe, G. Janßen (GNM)

II.2.2 The Mainspring Barrel

The CT-supported examination of the mainspring barrel indicates several interventions and modifications on the object that cast doubt on the synergy of this component in the so-called Henlein clock.

- The height of the mainspring barrel was reduced by approximately 1.5 mm.
- A previously existing mainspring in the barrel was removed and replaced by a construction using two pocket watch mainsprings from the 19th century.
- The original wedge holding the end of the mainspring and insertable into the barrel was renewed.
- The bottom of the mainspring barrel was lathe-turned after a copper soldering.
- The spring shaft supporting the mainspring was reworked, but more likely, it was supplemented.

The cover of the mainspring barrel exhibits two out of four locking mechanisms as defective.

Two out of four perforations in the mainspring barrel cover are damaged or broken at their outer edge. In my opinion, this potential loss of stability in the locking mechanism might not necessarily have required such an elaborate and substance-altering modification of the mainspring barrel.

Preserving the mainspring would certainly have been preferred, and even in the case of a postulated loss of the mainspring, with such an unconventional construction featuring two mainsprings, there would still have been sufficient space.

There would have been several effective options for repairing the two defective tabs.

The alterations found here, such as the creation and replacement of the mainspring shaft, soldering the mainspring, the rudimentary and substance-altering filing down of the mainspring barrel, the perforation for two newly made tabs, and not least, the creation of the function-impairing problem of the nonlinear transition of the chain from the fusee to the mainspring, contradict the assumption of a logically preservation-focused modification or repair of the mainspring. Also, due to the skewed positioning of the mainspring barrel, I assume that this mainspring barrel also houses a construct within itself and, therefore, was not originally present in the examined movement cage.

Image: Component distances between the fusee and mainspring barrel.

CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth

The measurement of component distances in the movement, as well as the computer tomographic evaluation, reveals that this mainspring barrel, in its original dimensions before shortening, could not have corresponded with the drive wheel or the fusee located in the movement cage.

The distance, i.e., the vertical clearance between the drive wheel and mainspring barrel tab, now amounts to a maximum of 1.6 mm. Considering mechanical imponderables such as bearing play, vertical clearance in the pivot bearing, and the non-circular rotation of the drive wheel and mainspring barrel, one can reasonably assume further reduction of this measured 1.6 mm at rest. There would have been no space left for proper functioning.

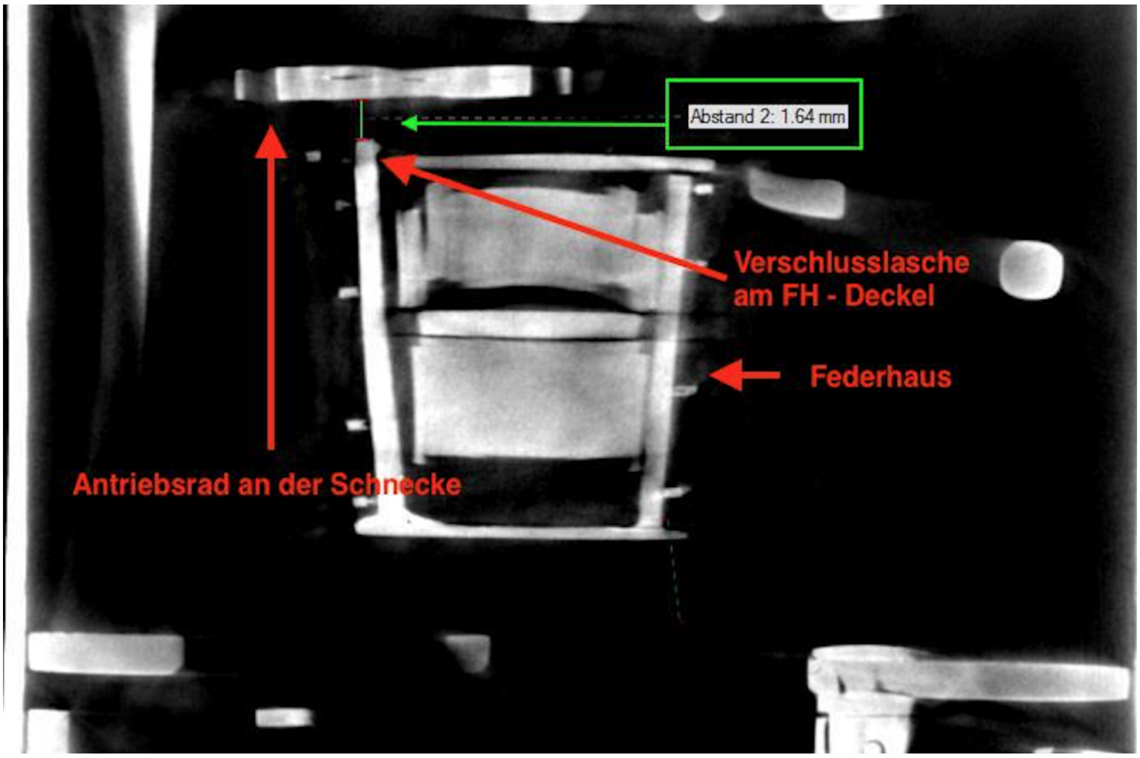
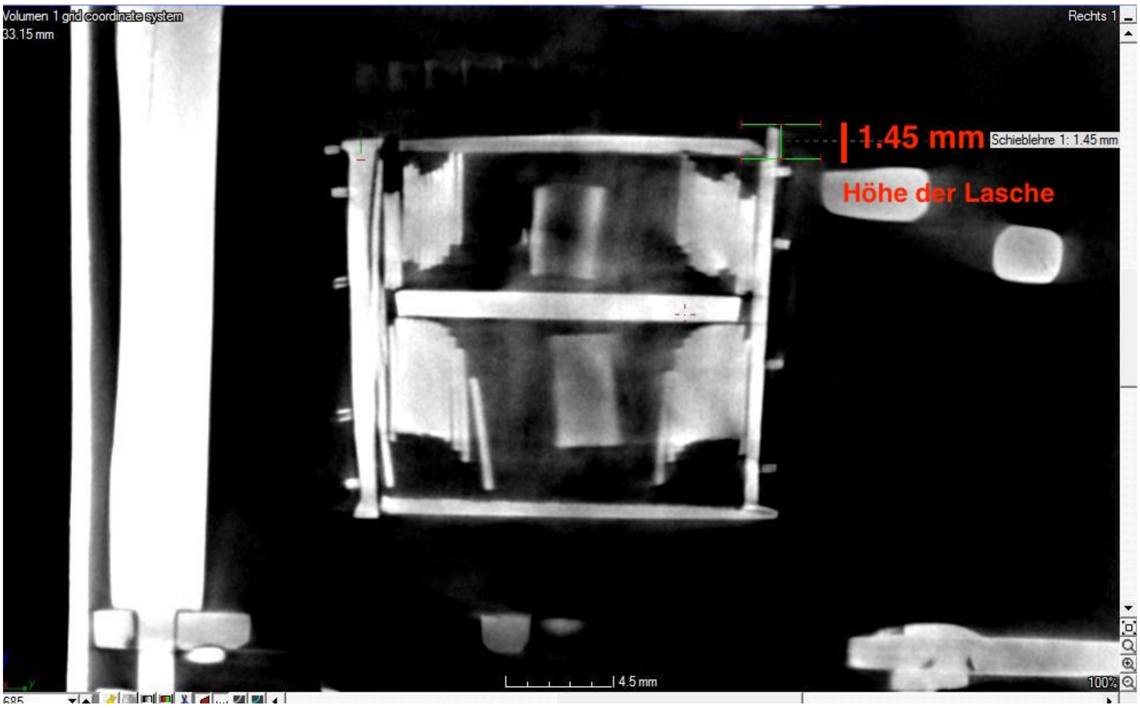


Image: Component distances between Fusee and mainspring barrel
© Layout: Restaurierungsatelier Jürgen Ehrt
CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth



A Image: Component distances between Fusee and mainspring barrel
© Layout: Restaurierungsatelier Jürgen Ehrt
CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth

As mentioned earlier, we are confronted with a newly manufactured mainspring barrel arbor, the installation of which also required modifications to its anchorages, the bearings in the plates.

Solely shortening the mainspring barrel in its height would not necessarily have required the creation of a new mainspring barrel arbor. The existing arbor could have been adapted accordingly.

Here, we encounter a constructed chain of errors, which often arises in empirical approaches to repairs or alterations. It is not clear how the constructor proceeded. Did the fusee with the drive wheel force the adaptation of the mainspring barrel, or vice versa? Both scenarios are possible when neither one nor the other component originates from a common source.

I would like to refer once again to the section on the "Movement Cage" and emphasize the insight that we are dealing with the fragment of a movement cage that served as the starting point for the created construct.

II.2.2.1 The Mainspring / Mainsprings

It can be assumed that the sheet metal strip riveted to the mainspring barrel's wedge is a remnant of the mainspring, which was previously hooked onto the two screw hooks in the mainspring barrel.

The breaks (see green markings in the image) correspond in their dimensions to the distance between the screwed-in hooks in the mainspring barrel**.**

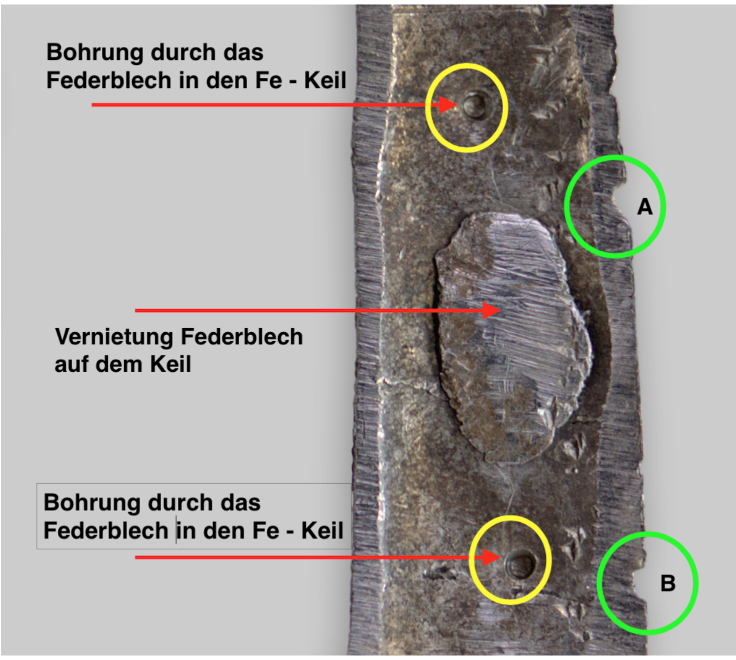


Image: Remnant of the old mainspring riveted to the closure wedge of the mainspring barrel©
Layout: Restoration studio Jürgen. Ehrt
Photo: R. Schewe, G. Janßen (GNM)

The holes located within the yellow circular markings go through the mainspring plate into the closure wedge of the mainspring barrel. This may have been an attempt to shorten the old mainspring in height, thus adapting it to the shortened mainspring barrel. After this was unsuccessful, a remaining piece of the mainspring was riveted onto the wedge as a closure lock.

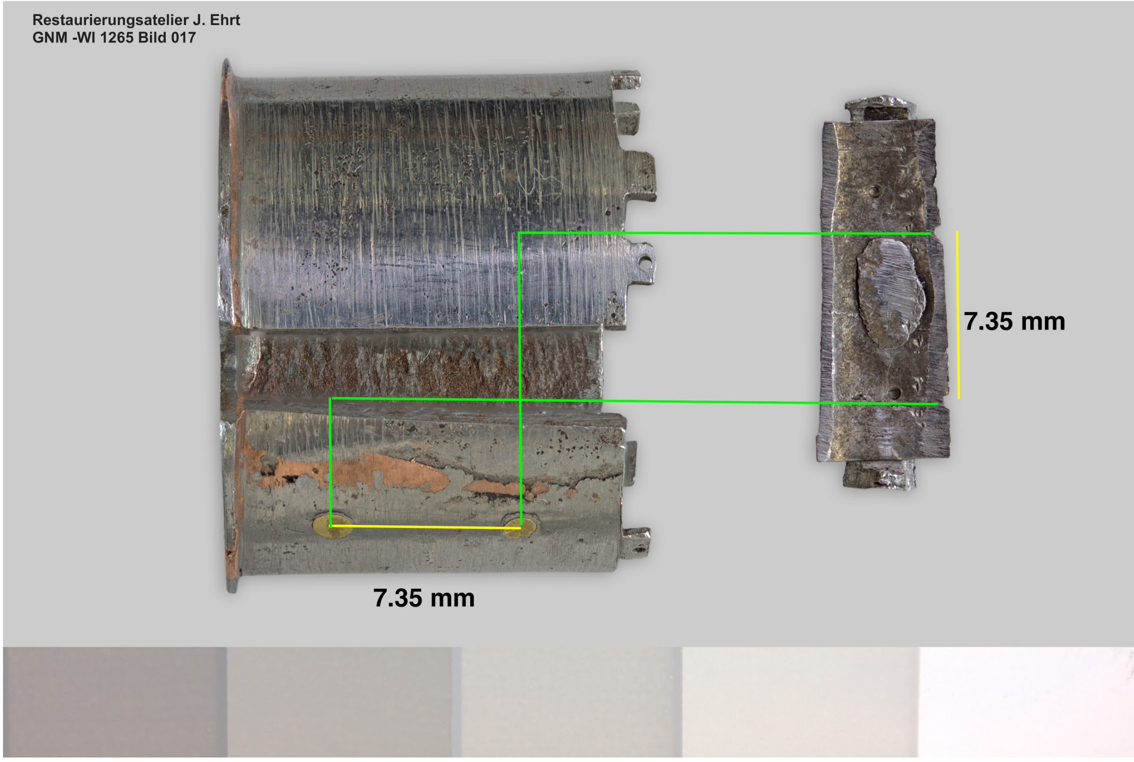


Image: Remnant of the old mainspring riveted onto the closure wedge of the mainspring barrel.
Layout: Restoration studio Jürgen. Ehrt
Photo: R. Schewe, G. Janßen (GNM)

The corresponding distances of 7.35 mm at the screwed and riveted spring-end hooks and the break points of the riveted remnant of the mainspring onto the closure wedge of the mainspring barrel indicate a connection between the components.

The height of the old mainspring is presumed to be 13.35 mm.

If we subtract the height of the riveted mainspring remnant (13.35 mm) from the 14.75 mm of the mainspring barrel's inner dimension and add an approximate measure for the mainspring barrel's shortening at the closure tabs of approximately 1.45 mm, we get a clearance of about 2.85 mm. This should have been sufficient for a friction-free operation of the mainspring.

After the shortening of the mainspring barrel, a friction-free operation of the mainspring was no longer guaranteed with the modified mainspring shaft in the remaining clearance of about 1.4 mm.

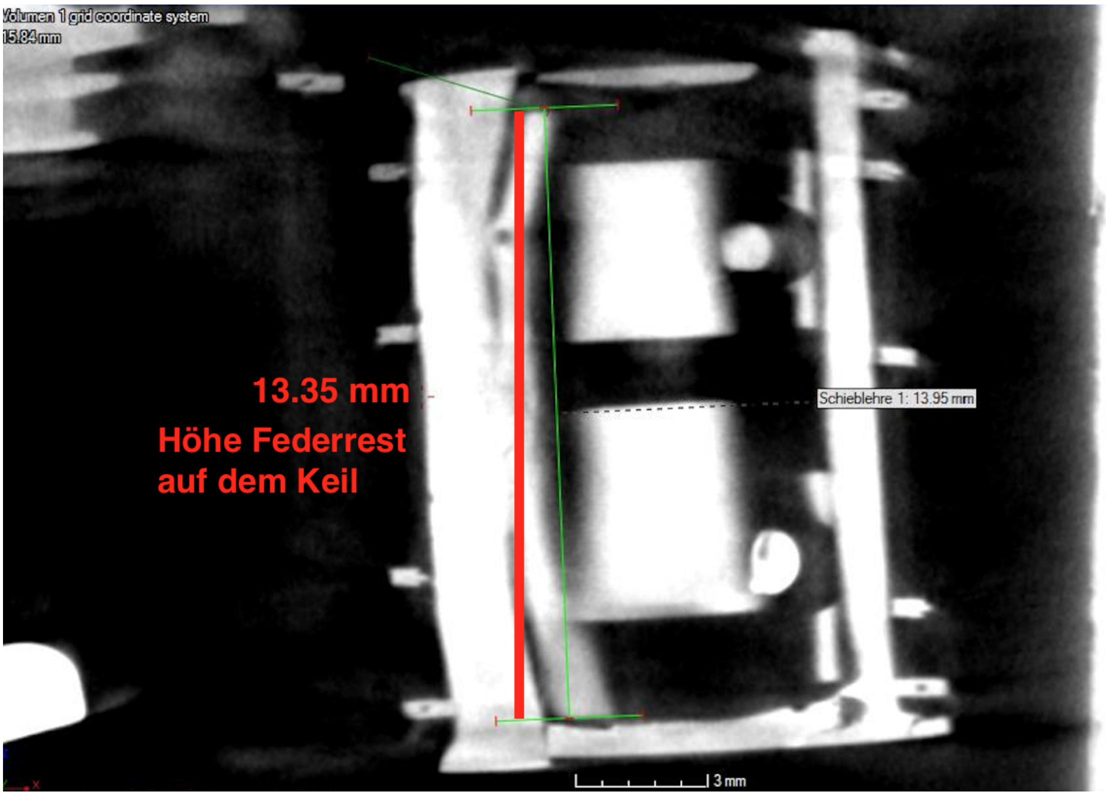


Image CT: Dimensioning of the component remnant on the mainspring barrel
© Layout: Restoration studio Jürgen. Ehrt
CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth

Whether the assumed old mainspring, with a height of 13.35 mm, was removed due to freewheeling issues in the mainspring barrel or perhaps an imperfect or non-durable hanging of the mainspring on the two screwed mainspring hooks was ensured cannot be factually proven.

However, it is plausible that the two broken perforations at the rupture point of the mainspring sheet (see green markings A + B), which correspond precisely to the spacing of the screwed mainspring hooks, represent the suspension of the old mainspring. The installation of the two 19th-century pocket watch mainsprings likely occurred later.

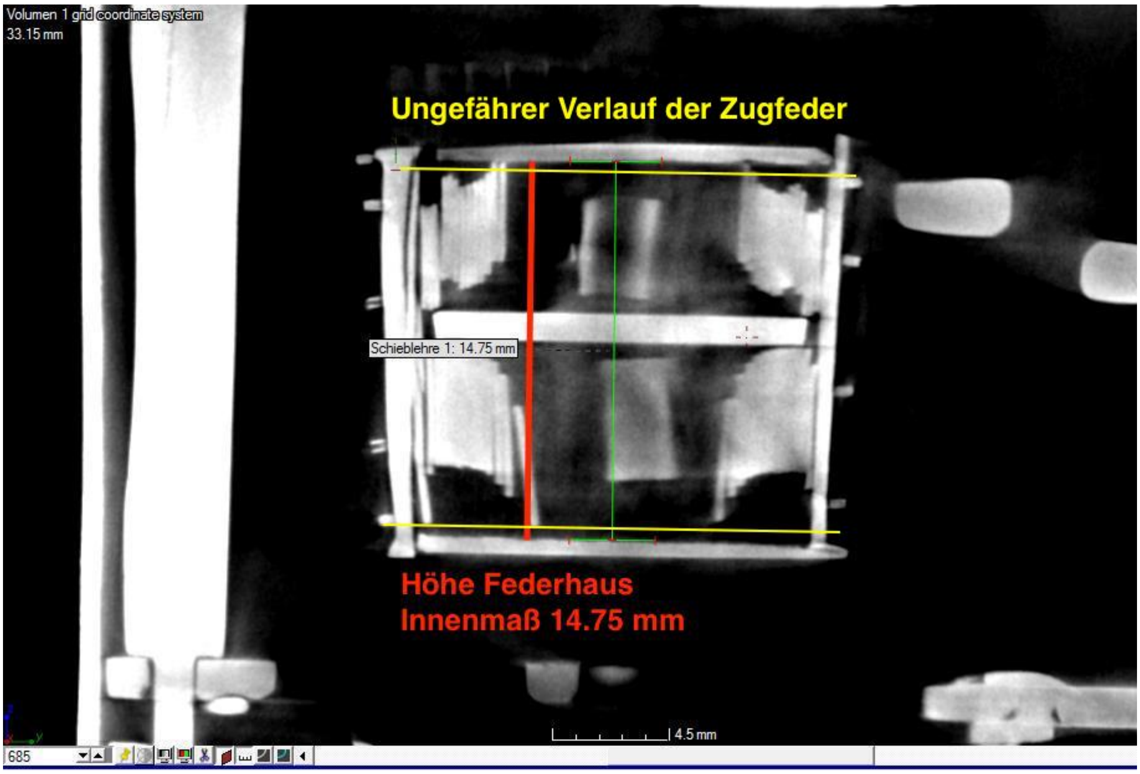


Image CT: *Dimensions of the barrel*
© Layout: Restoration studio Jürgen. Ehrt
CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth

II.2.2.2 "The mainspring barrel bottom

The stereoscopic surface examination of the mainspring barrel bottom, combined with a more in-depth construction analysis using 3D micro-computer tomography, also calls into question the homogeneity of the mainspring barrel.

The mainspring barrel bottom, shown here greatly magnified from the outside, exhibits the following peculiarities:

The mainspring barrel bottom was centered on point C on the lathe. It can be assumed that the workpiece to be machined - mainspring barrel bottom - had a half-radius greater than 8.98 mm minus the bore. The machining traces of the chip removal are a clear indication.

The lathe tool is likely to have been guided by hand, possibly in the form of a hand chisel. The different depths of engagement and irregularities confirm this method.

The semi-open solder joint of the soldered tab (A) suggests an approach where the bottom was first soldered to the mainspring wall and then filed to the desired circumference, leaving a raised edge."

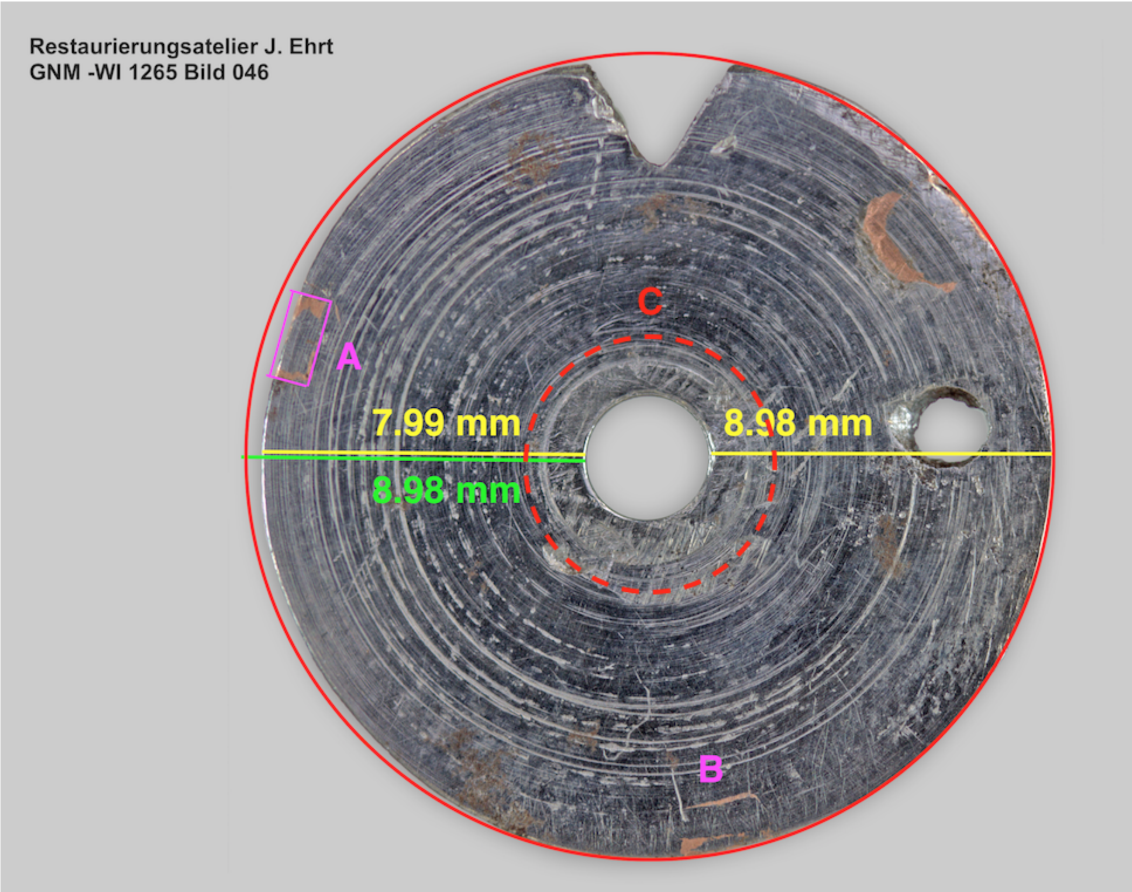


Illustration: Machining marks on the mainspring barrel bottom
Layout: Restoration studio Jürgen. Ehrt
Photo: R. Schewe, G. Janßen (GNM)

"On the image on the following page, points (A) indicate areas where the cutting tool did not remove material. We can see the original material before processing at these points. The cutting traces of the turning tool, marked at point (C), also notably go through the copper hard solder seam marked with (D). This solder seam deserves a bit more attention.

It appears to be a course of the copper solder on the bottom cover during the soldering of the mainspring barrel wall to the bottom. Imaging techniques show a rudimentary course of the copper solder between the bottom cover and the inner mainspring barrel wall. Through this assembly, the copper solder capillarity penetrated from the inside to the outside onto the bottom cover. This excess solder on the mainspring barrel bottom was finally removed by machining.

Point (B) marks a breakthrough that likely originated from the previous use of the cover and should not be mistakenly seen as a passage for a no longer present gut string."

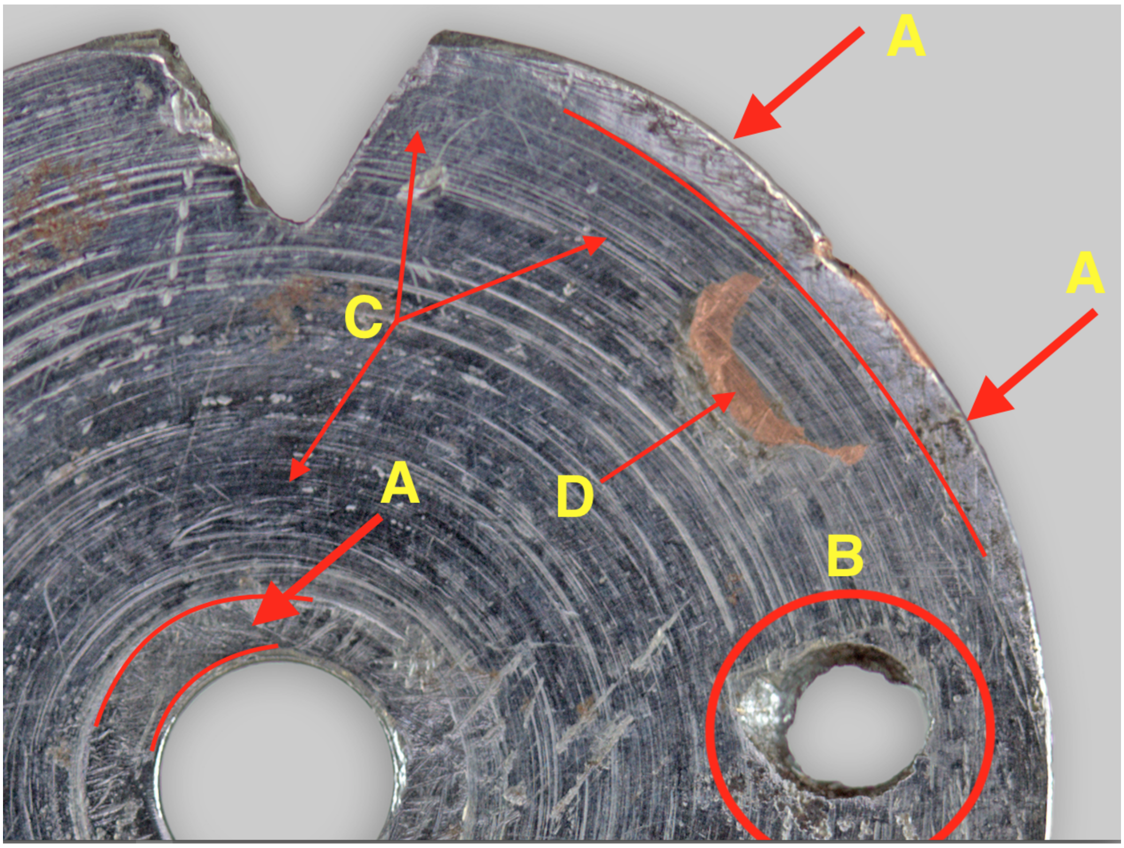
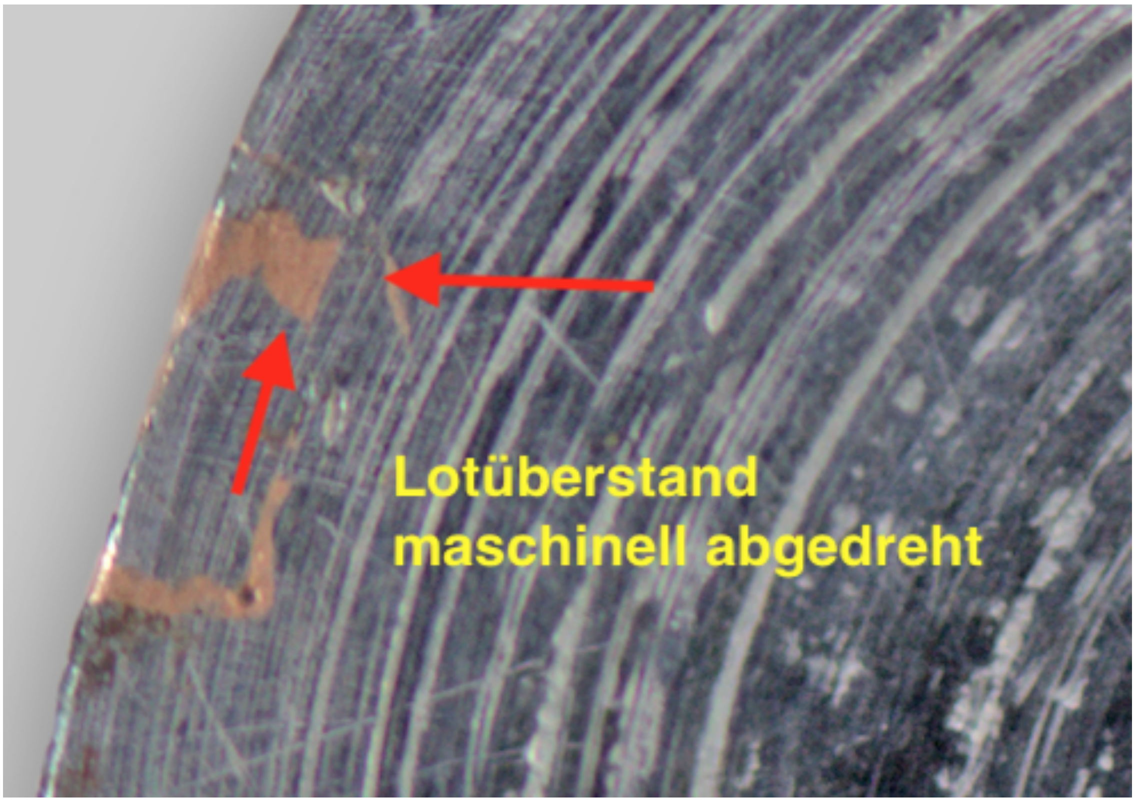


Illustration: Machining Marks on the Mainspring Barrel Bottom
Layout: Restoration studio Jürgen. Ehrt
Photo: R. Schewe, G. Janßen (GNM)



The red arrows mark the cutting traces going through the brass solder, indicating the mechanical machining process.
Layout: Restoration studio Jürgen. Ehrt
Photo: R. Schewe, G. Janßen (GNM)

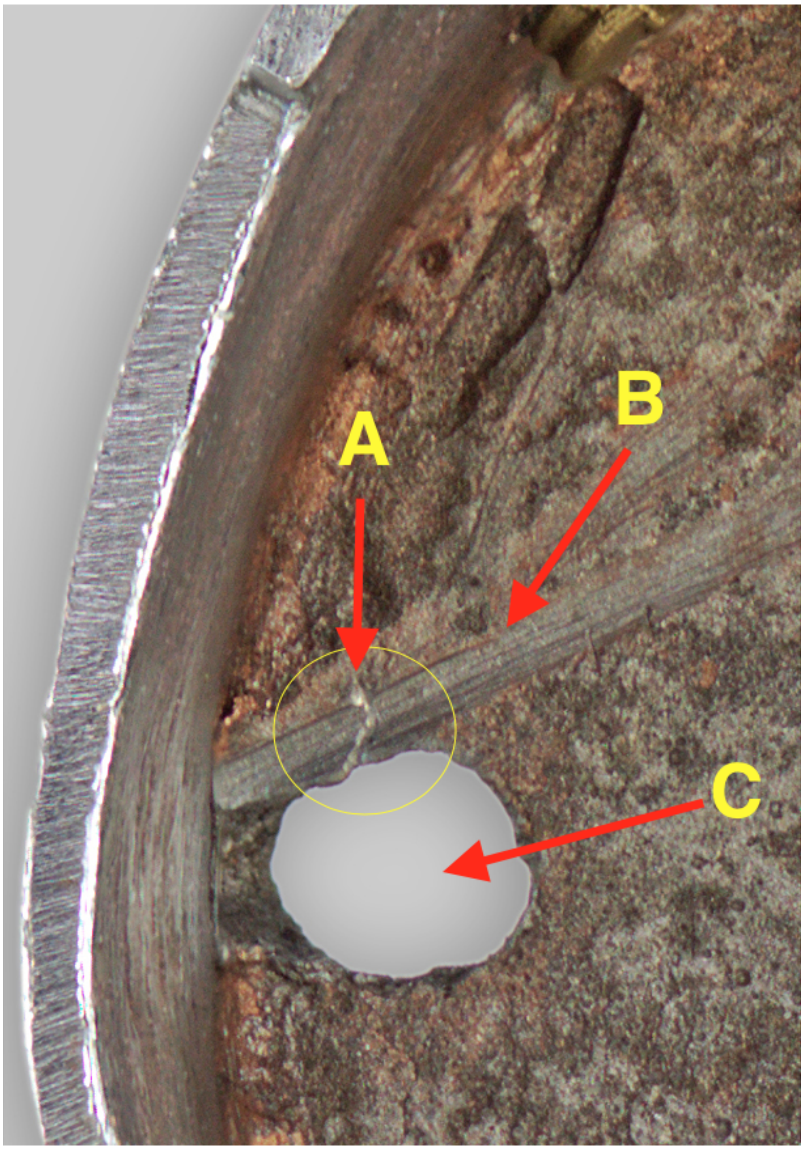
II.2.2.3 The Mainspring Barrel from the Inside

The point (C) marks the previously described breakthrough from a previous use for the end knot of a possible gut string. The end hook of the chain is hooked into the corresponding hole on the outer wall of the mainspring barrel, marked by this point.

The internal view of the mainspring barrel shows machining traces for adapting the engagement of a chain end hook. The threading hole for the gut string on the mainspring barrel wall has been widened. Point (B) shows clear file marks of an adaptation that was passed through the threading hole.
At the position marked with (A), milling traces, as left by a rapidly rotating drill or mill, can be found. This intervention, the interruption of the brass solder seam by the file and milling traces, is also evidence that the soldering of the mainspring barrel cover to the outer wall must have occurred before this intervention.

Assuming that the mainspring barrel bottom was machined after soldering to remove excess solder, among other things, it can be ruled out that it was made in the 16th century. The stereoscopic examination of the inside and outside of the mainspring barrel cover also shows a very smooth, blued surface with similar machining traces. Rudimentary scratch and grind marks obscure a smooth, blued surface, as is known from industrially manufactured semi-finished products.

Such component productions based on industrially prefabricated semi-finished products with recurring reworking traces were also found in the further examination of other components.



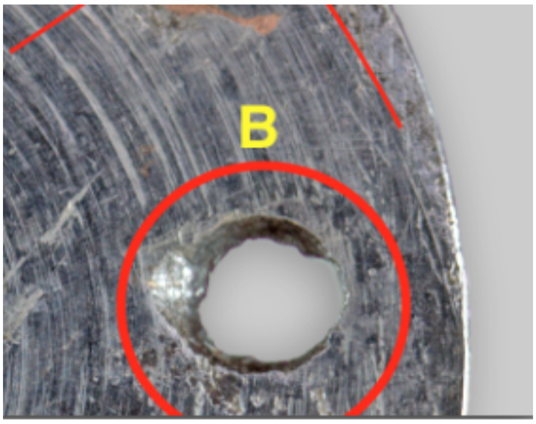
Layout: Restoration studio Jürgen. Ehrt
Photo: R. Schewe, G. Janßen (GNM)

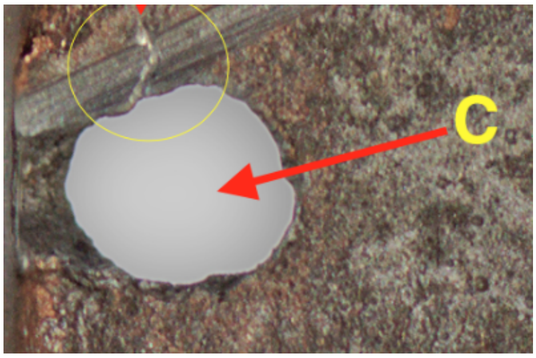
In the so-called Henlein clock, the gut string is led from the outside through the lateral mainspring barrel wall into the mainspring barrel. Then it is threaded from bottom to top through the cover and knotted (see B and C).

There is a high probability that the gut string will wear against the mainspring or obstruct its operation.

Usually, mainspring barrel bottoms had an extension beyond the mainspring barrel wall, through which the gut string was threaded from the outside and knotted through two holes. This is not present here.

Stereoscopic examination of the mainspring barrel bottom reveals abrasion with flaring of the hole for the mainspring shaft. Coherent running traces, as typically seen when the mainspring runs on the mainspring shaft at the bottom of the mainspring barrel, are also not evident here.





Layout: Restoration studio Jürgen. Ehrt
Photo: R. Schewe, G. Janßen (GNM)

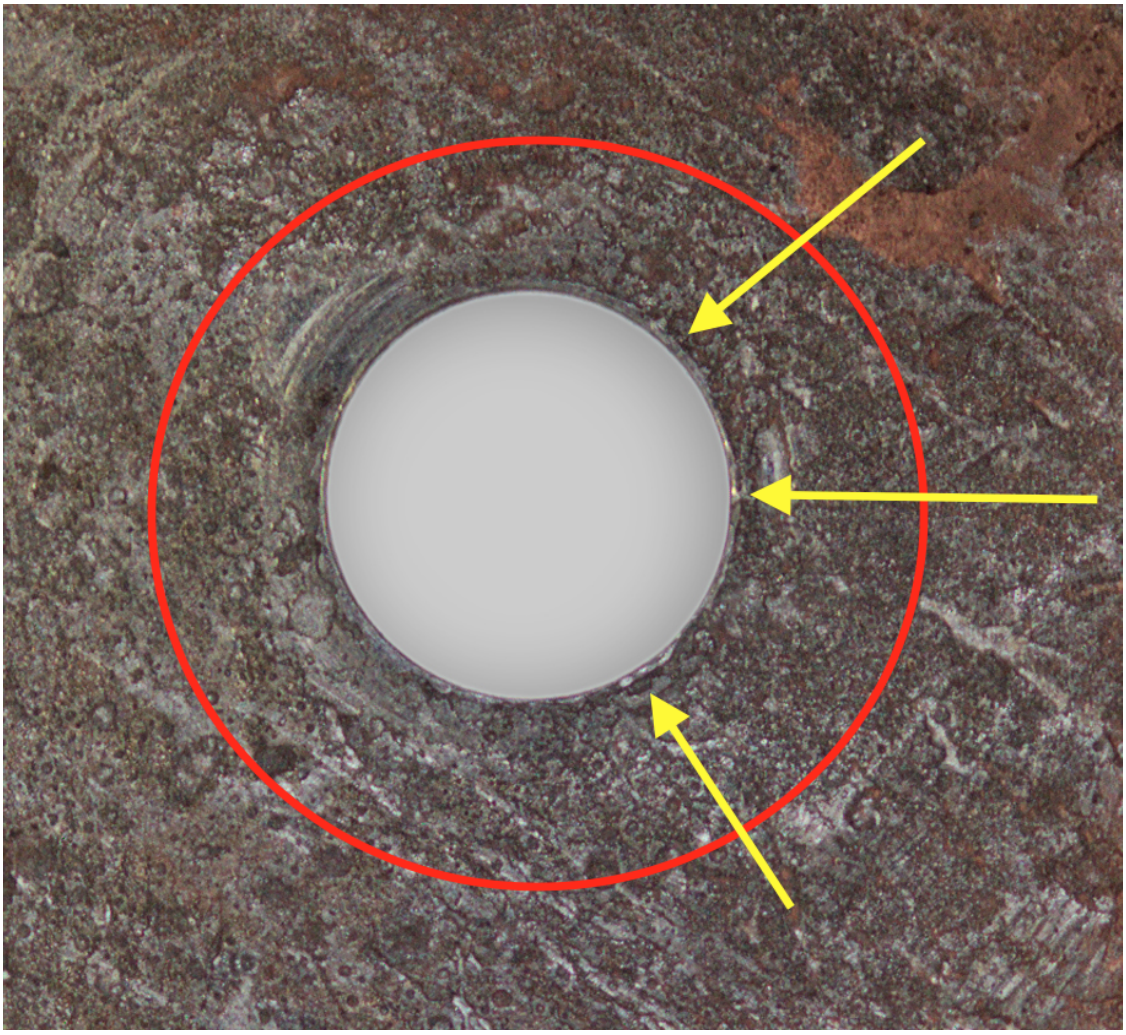


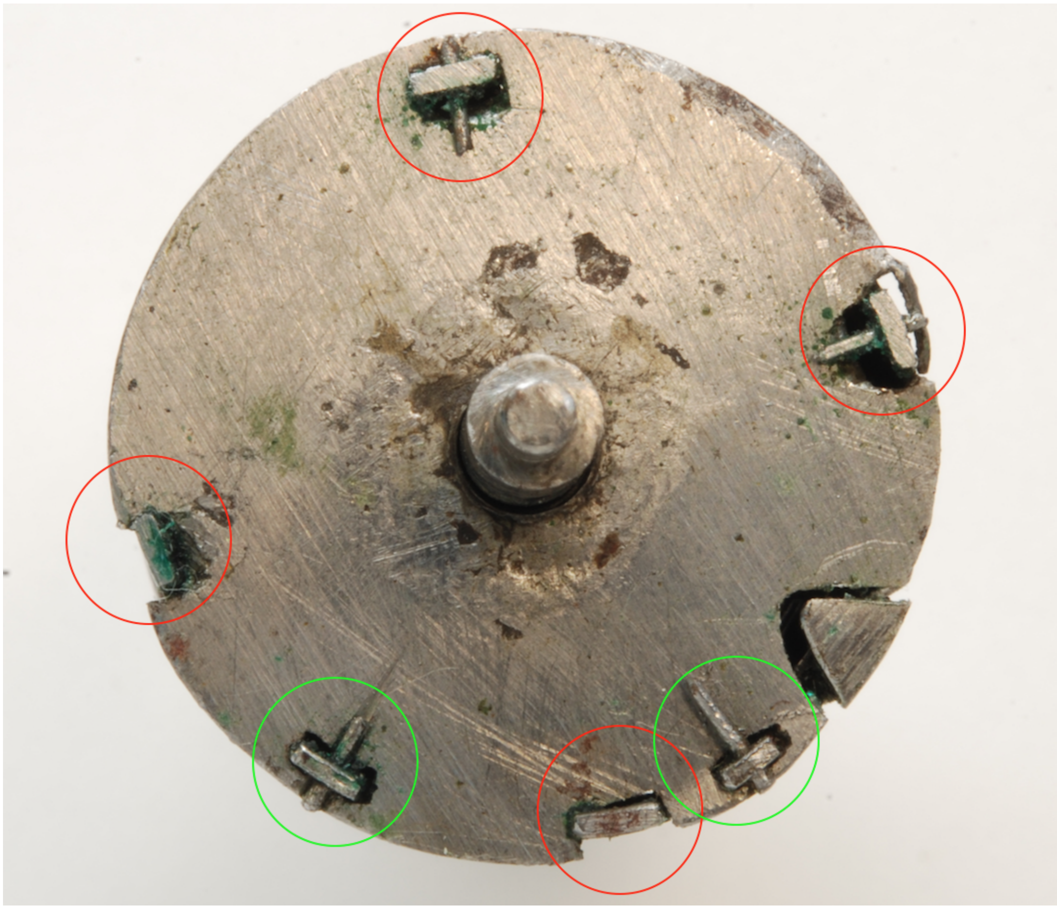
Illustration: Inside of the mainspring barrel bottom, shaft bearing for the mainspring shaft.

Layout: Restoration studio Jürgen. Ehrt
Photo: R. Schewe, G. Janßen (GNM)

II.2.2.4 The Mainspring Barrel Cover

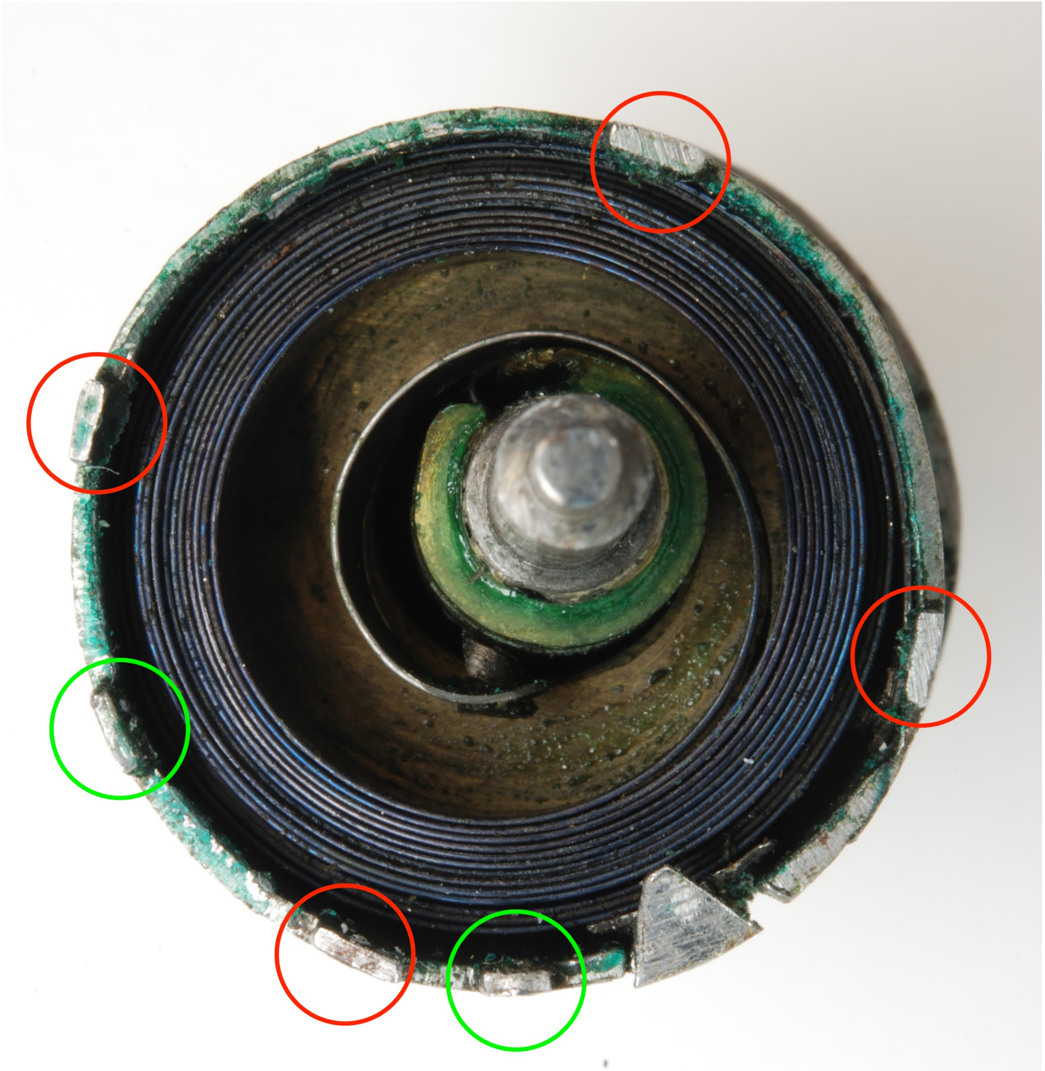
In our joint article in the 2019 annual journal of the German Society for Chronometry[6], Johannes Eulitz writes about the manipulations to the mainspring barrel:

"The modifications to the mainspring barrel affect all its components. The entire mainspring barrel has been reduced in height by at least the amount of a length corresponding to the vertical tabs that hold the cover and are pierced for the front pins. Two of the four tabs had to be worked out of the mainspring barrel wall at another location due to defective areas at the openings in the cover. In the cover, two new openings were inserted accordingly. Two now unused rectangular openings in the cover indicate the old position of the removed tabs."



The locking mechanisms marked with a red circle in the image are the original tabs. These were shortened to the dimension of the newly worked-out tabs from the mainspring barrel wall, marked with a green circle.

[6] Vgl. Deutsche Gesellschaft für Chronometrie - Jahresschrift 2019, Band 58, S.100. Die Henlein-Uhr. Befund ihrer technischen Untersuchung - Autorengemeinschaft Jürgen Ehrt, Thomas Eser, Johannes Eulitz, Markus Raquet, Roland Schewe.



The locking mechanisms marked with a red circle in the image are the original tabs. These were shortened to the dimension of the newly worked-out tabs from the main-spring barrel wall, marked with a green circle.

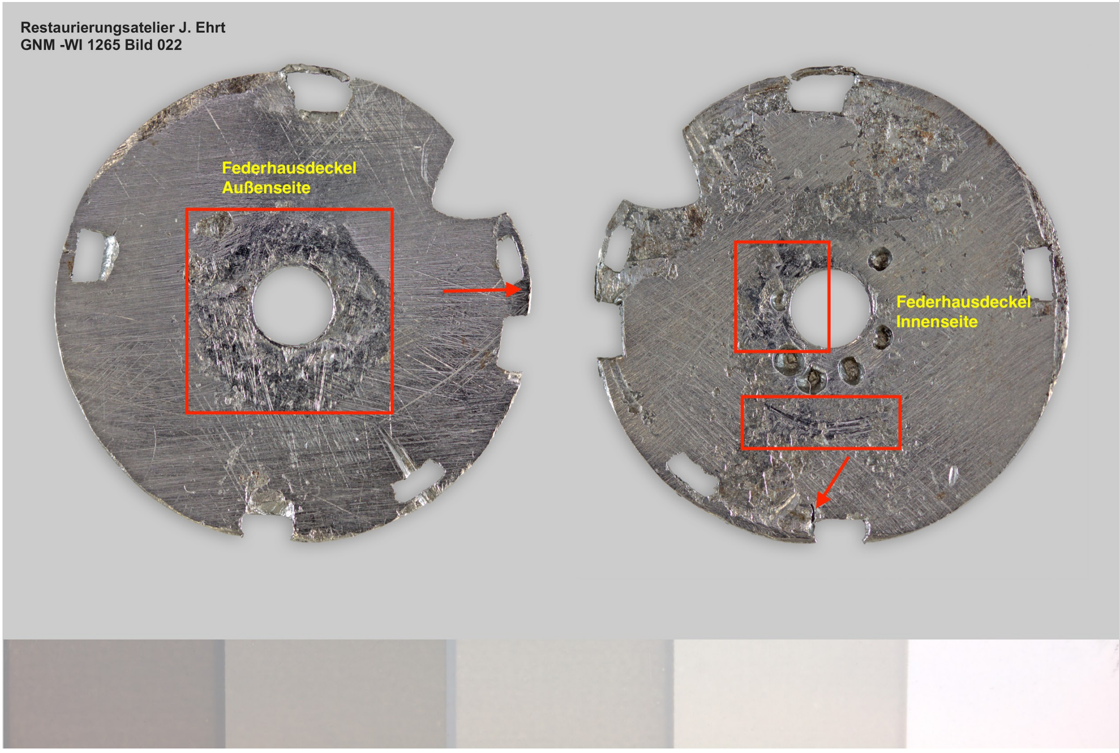


Illustration: Mainspring Barrel Cover Exterior and Interior
Layout: Restoration studio Jürgen. Ehrt
Photo: R. Schewe, G. Janßen (GNM)

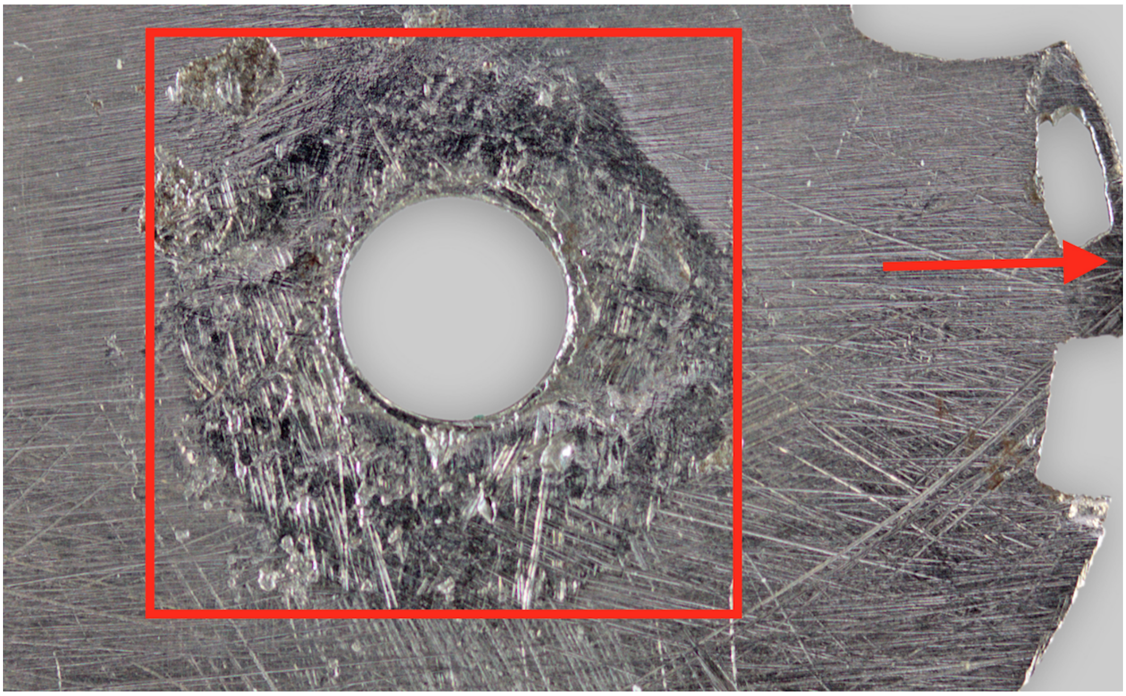


Illustration: Mainspring Barrel Cover Exterior - Bearing Hole for the Mainspring Arbor
Layout: Restoration studio Jürgen. Ehrt
Photo: R. Schewe, G. Janßen (GNM)

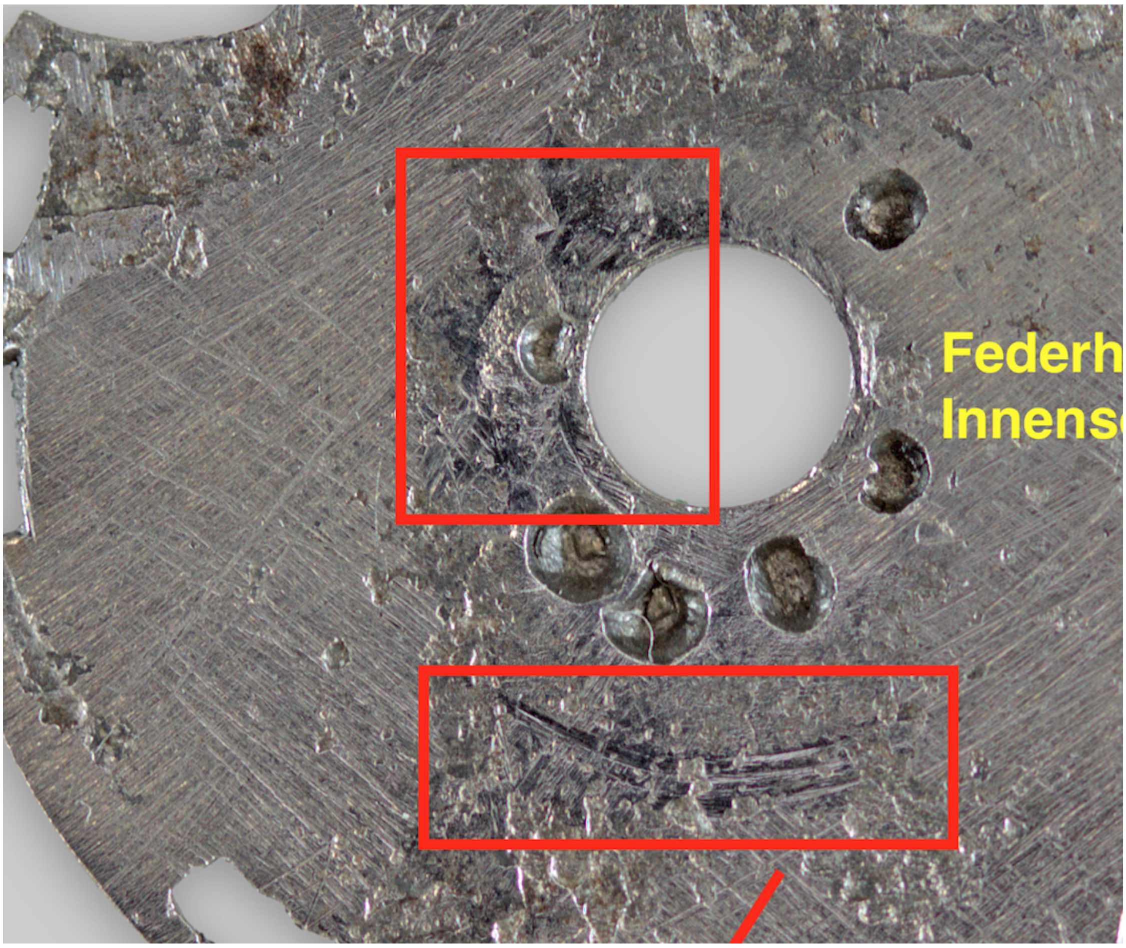


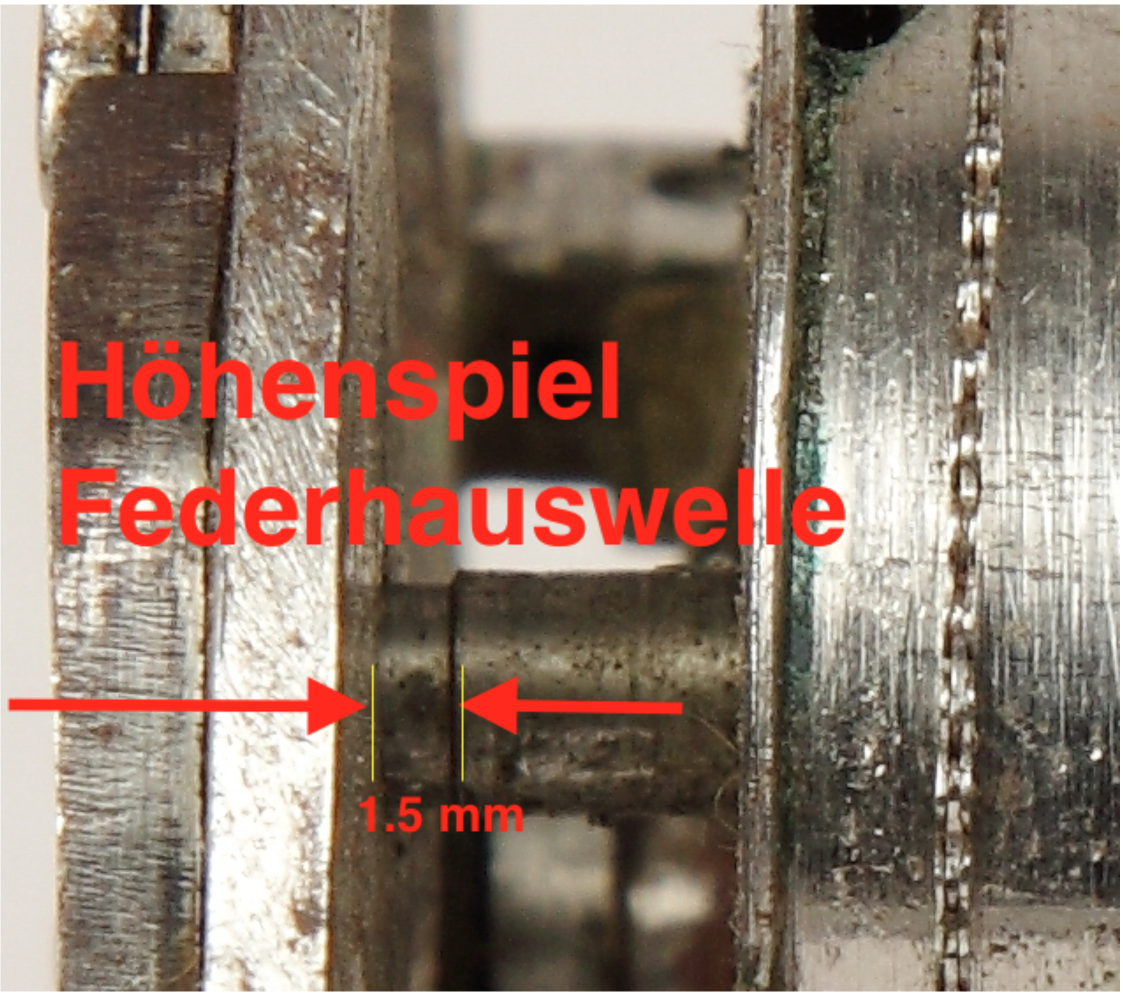
Illustration: Mainspring Barrel Cover Interior - Bearing Hole for the Mainspring Arbor
© Layout: Restoration studio Jürgen. Ehrt
Photo: R. Schewe, G. Janßen (GNM)

The manipulative alterations are clearly evident in the above illustrations of the mainspring barrel cover. Initially, an old, overly wide hole was closed by six punch strikes and then reamed to the required size for the mainspring arbor. Also noted here, as previously observed on the mainspring barrel bottom, are the missing expected coherent running traces of the mainspring arbor on the cover.

II.2.2.5 Mainspring Arbor with Shaft (The Mainspring Arbor)

The mainspring arbor exhibits machining traces that would not be expected in a creation from the first half of the 16th century.

Machined subtractive manufacturing features indicate the creation or modification of the arbor for this mainspring barrel. Dimensional deviations in the height play of the mainspring arbor, which do not ensure flawless functionality in the interaction between the mainspring barrel and the fusee, are compounded by the faulty arrangement of these two components.



Height play of the mainspring arbor
© Layout: Restoration studio Jürgen. Ehrt
Photo: Johannes Eulitz, MPS Dresden

The square for locking the mainspring arbor using the winding wheel also lacks the expected signs of use that would be present in the winding system of a 16th-century clock.

There is no coherence between the almost unused mainspring arbor and other, partly worn-out components in the clock, which will be discussed in more detail later.

The **mainspring arbor with the mainspring** is a new creation adapted to the dimensions of the mainspring barrel assembled from old parts. The constructor did not even bother to deburr the edges.

As Johannes Eulitz[7] already points out: *"...This dimensional error can hardly be related to the aforementioned modification, just like the too short lower pivot of the mainspring arbor, which in its length corresponds to only three-quarters of the plate thickness, and the subsequent square, which (functionally disturbingly) submerges up to four-fifths of its length in the bearing."*

Computed tomography reveals that the brass sleeve was soldered onto the arbor to hold the unspecified pocket watch springs on the arbor.

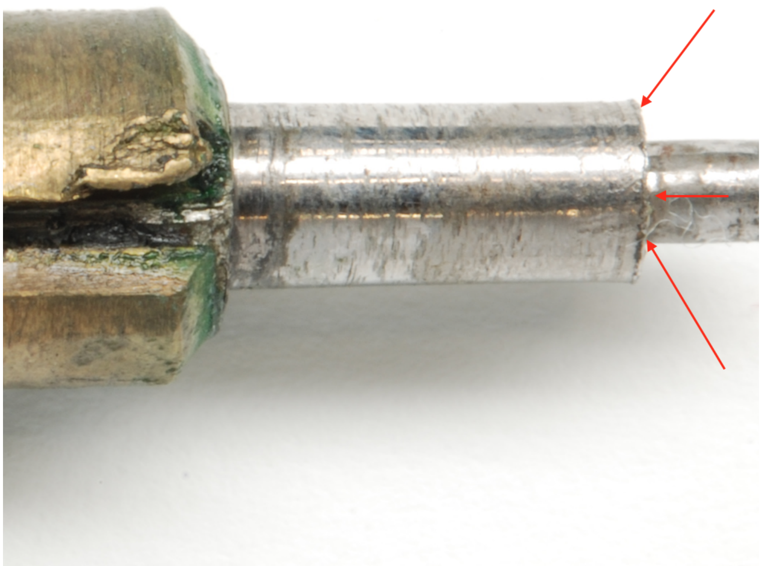


Illustration: Mainspring arbor, not deburred, with soldered brass sleeve

© Layout: Restoration studio Jürgen Ehrt
Photo: Johannes Eulitz, MPS Dresden

[7] Vgl. Deutsche Gesellschaft für Chronometrie - Jahresschrift 2019, Band 58, S.100. Die Henlein-Uhr. Befund ihrer technischen Untersuchung - Autorengemeinschaft Jürgen Ehrt, Thomas Eser, Johannes Eulitz, Markus Raquet, Roland Schewe.

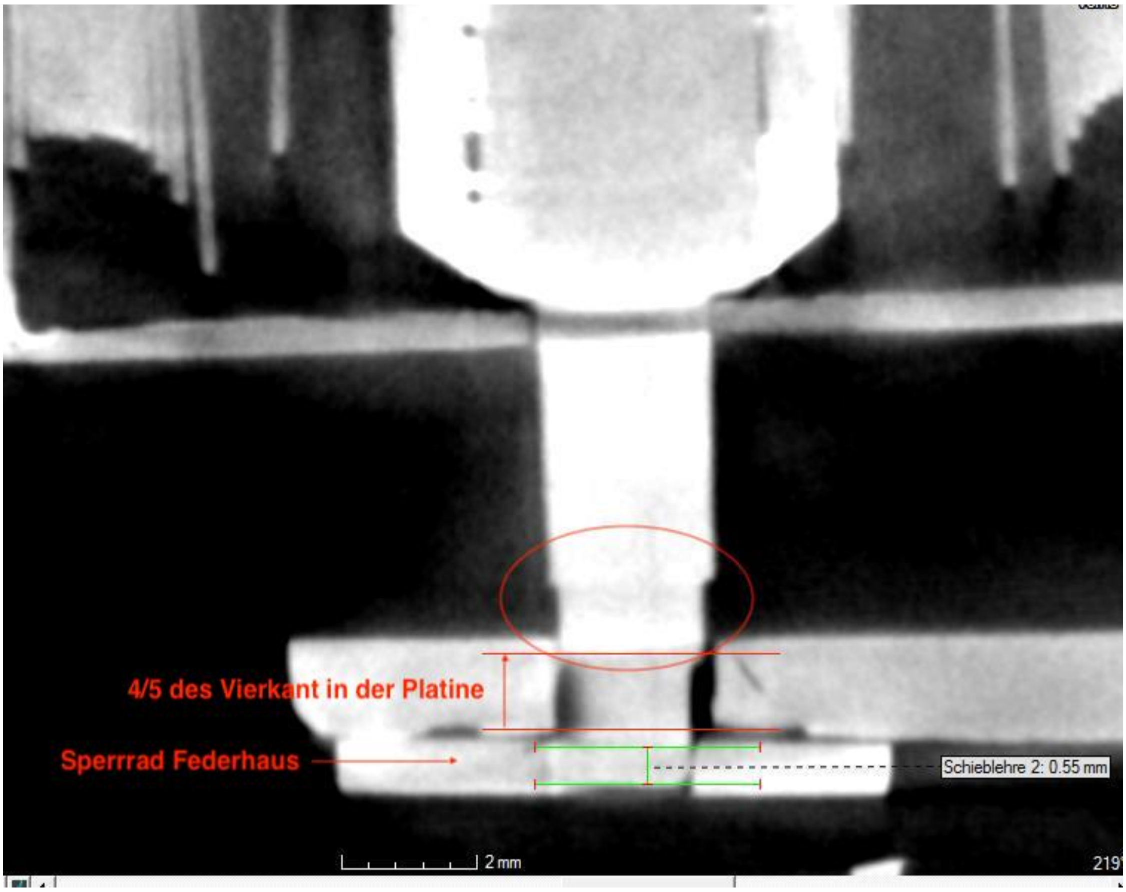


Image CT: Mainspring arbor with square and ratchet wheel
© Layout: Restoration studio Jürgen Ehrt
CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth

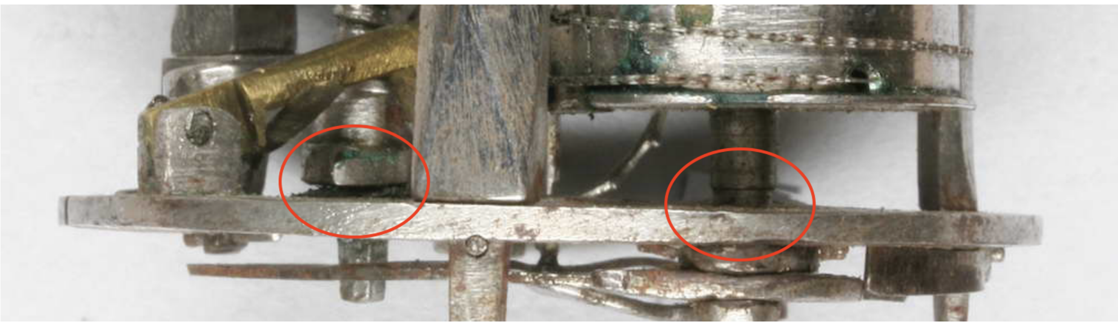


Illustration: Bearings of the mainspring arbor and worm gear shaft
© Layout: Restoration studio Jürgen Ehrt
Photo: R. Schewe, G. Janßen (GNM)

II.2.3 The Gear Train

II.2.3.1 Drive wheel and hour wheel

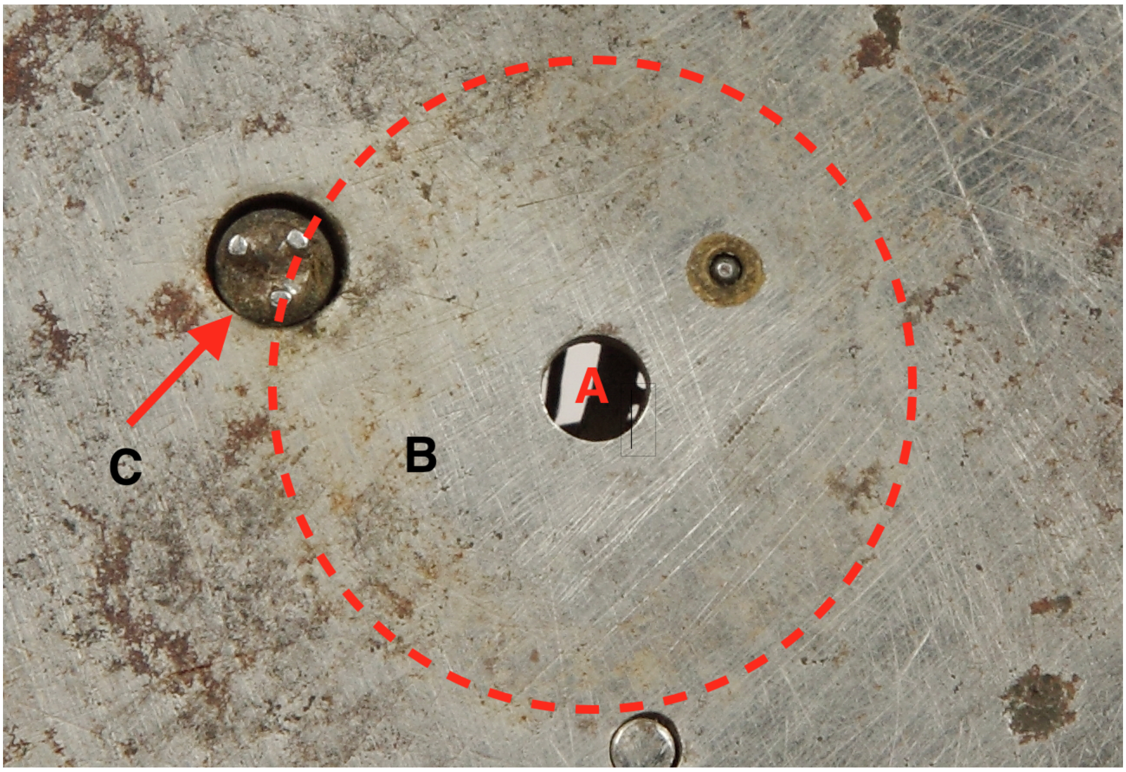


Image: Upper plate outer side

The upper plate should exhibit coherent running traces of the hour wheel on its surface (B). The barrel bearing for the drive wheel (C), with its three teeth, represents an inhomogeneous circular runoff pattern, which is not expected. Assuming that the bearing was circular in its original state, it must acquire an oval structure through usage-related wear from the hour wheel, thus resulting in an uneven circular shape. Also, no running traces corresponding to the hour wheel were found on the drive wheel's drive pins. The corrosive and incoherent surface of the drive wheel in its bearing to the hour wheel also does not indicate originality.

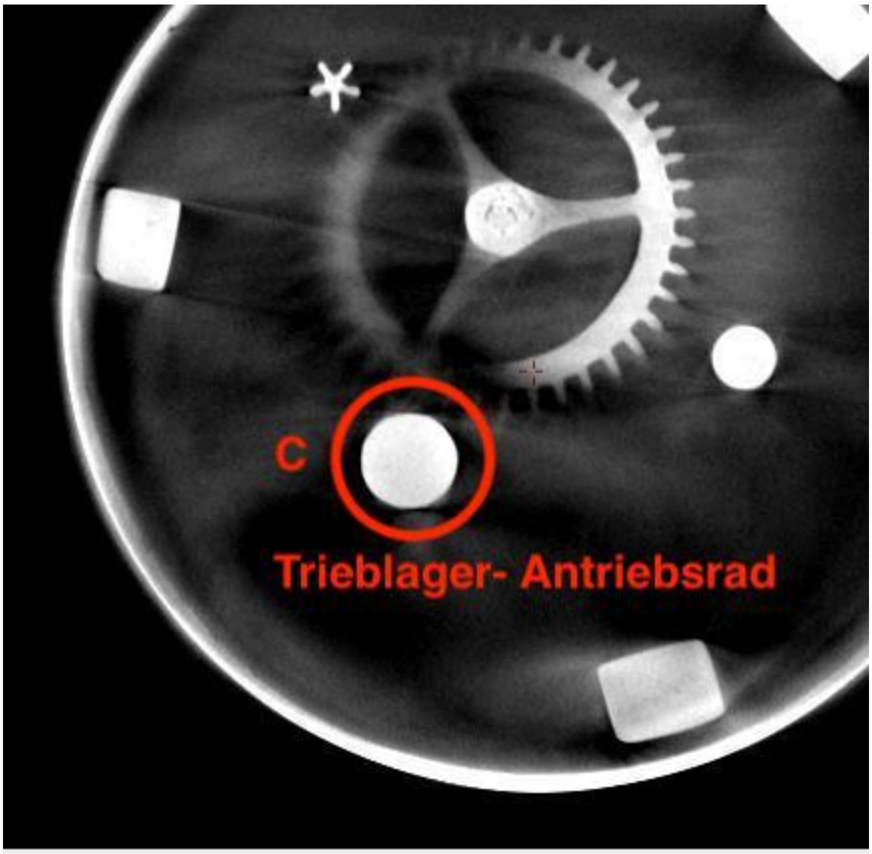


Image CT: Drive Wheel Arbor Bearing
© Layout: Restoration studio Jürgen Ehrt
CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth

The bearings of the intermediate wheel between the drive wheel and crown wheel were bushed on both sides with brass. The bearing bushing in the upper plate, in particular, stands out. The so-called bearing bushing and the hole in the upper plate were threaded and screwed in.

A technique[8] that only emerged in the late 18th century.

[8] Vgl. F. Vogel, Practischer Unterricht von Taschenuhren, Leipzig 1774, S. 207.

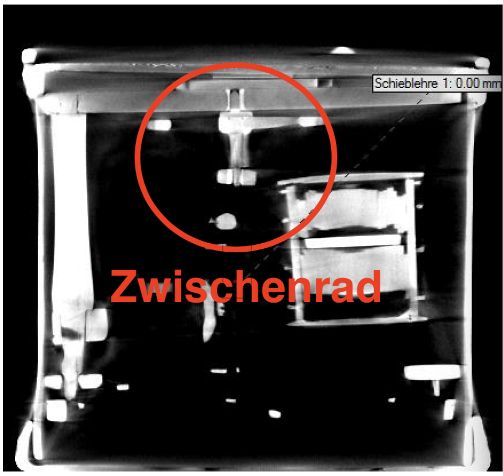


Image CT: Bearing of the intermediate wheel

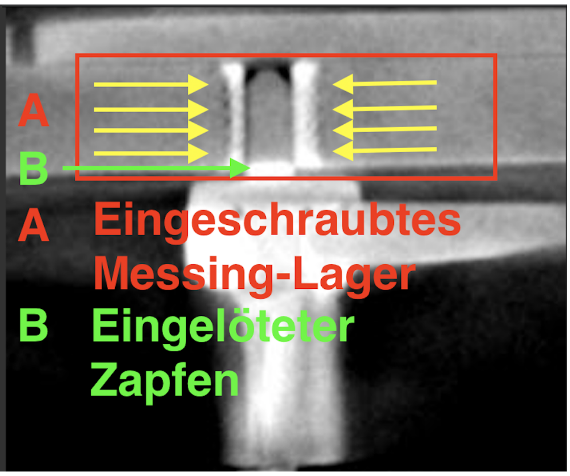


Image CT: Screwed-in bearing

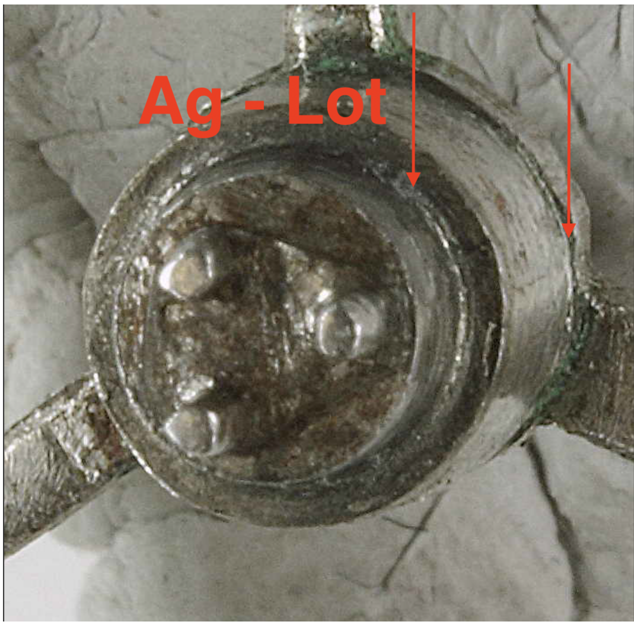


Image: Drive side of the drive wheel

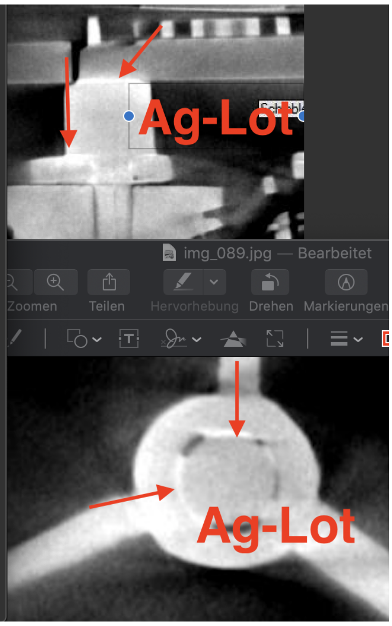


Image CT: Drive side of the drive wheel

The shaft of the drive wheel, with the driving pins propelling the hour wheel, is assembled from four parts by hard soldering (Ag). One would expect a shaft manufacturing with driving pins made from a single piece here.

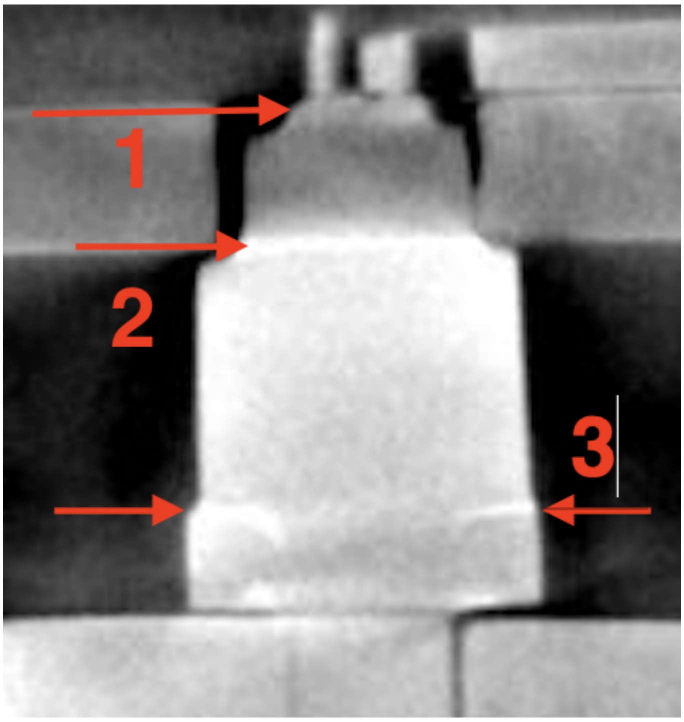


Illustration CT: Assembled structure of the drive wheel's driving shaft
© Layout: Restoration studio Jürgen Ehrt
CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth

Illustration: Soldered assembly of the drive wheel's driving shaft
Photo: R. Schewe, G. Janßen (GNM)

The hour wheel was covered with a brass sleeve to adapt it to the oversized hole in the top plate. This evidence confirms the incompatibility between the movement frame and the hour wheel and, ultimately, between the hour wheel and the drive wheel with its constructed manipulations.

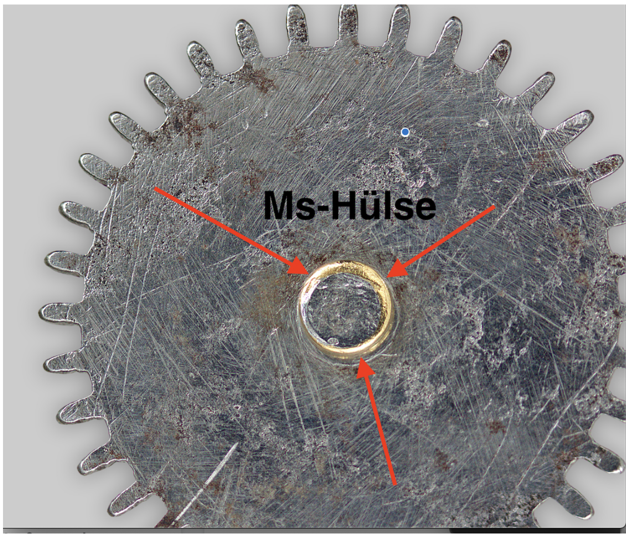


Illustration: Hour Wheel

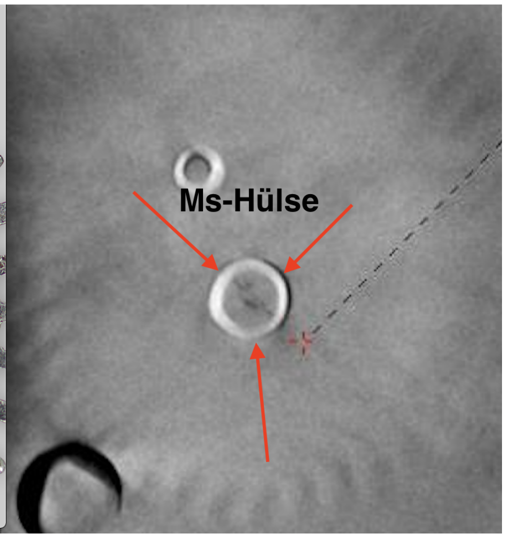
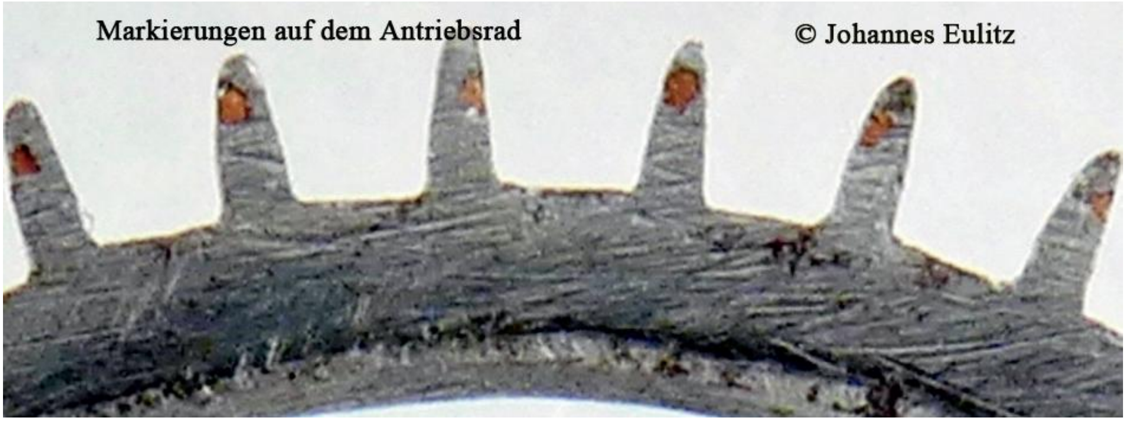


Illustration CT: Pinion of the Hour Wheel in Engagement

II.2.3.2 Drive Wheel and Intermediate Wheel

On the drive wheel mounted on the fusee as well as on the intermediate wheel, small grain markings can be observed on the gear teeth. These are commonly used in the manual production of gears to mark the division of the tooth spacing.



However, these markings are in absolute contradiction to the existing tooth division. The grain points are not placed as expected in the middle between the tooth flanks but seem to be randomly applied without centering.

A centered image would be essential, as one would use the markings as a reference to work out the tooth spacing and thus create a module that could smoothly engage with the corresponding wheel.

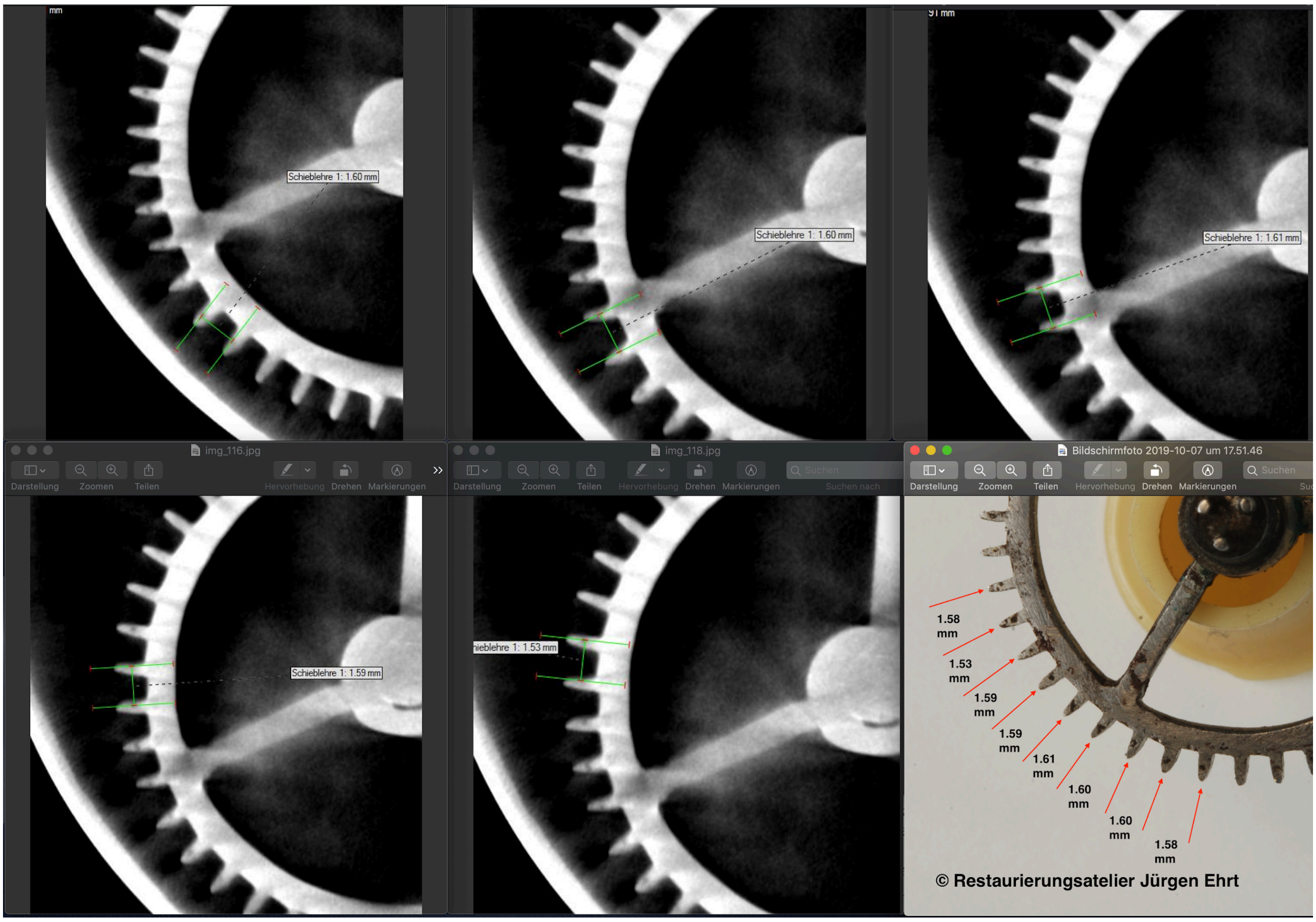
Johannes Eulitz[9] interprets this mystery as follows:

"Apparently, the worker did not primarily follow the markings but relied on his intuition or his own template for both wheels. A decision necessary from a technical point of view, as the markings sometimes deviate significantly from the better-placed tooth and even more from the ideal dimension. What these grain markings could have served for is not clear. They at least suggest a traditional manufacturing process."

After thorough research of the image and X-ray documents, I come to a different assessment. The measurement of the punched marking distances on the drive wheel results in markings accurate to tenths. The distances range from approximately 1.53 mm to 1.62 mm. The marking distances of the intermediate wheel move precisely between 1.4 mm and 1.51 mm. This very precise marking, to be evaluated, would be counterproductive if it were not used afterward, and a rudimentary division measure, as found here, was produced. It is correct that we have two gears from an earlier production or other clocks with a precise module, which were empirically modified for use in the examined clock with incompatible modules.

[9] Vgl. Deutsche Gesellschaft für Chronometrie - Jahresschrift 2019, Band 58, S. 99 ff. Die Henlein-Uhr. Befund ihrer technischen Untersuchung - Autorengemeinschaft Jürgen Ehrt, Thomas Eser, Johannes Eulitz, Markus Raquet, Roland Schewe.

Under this premise, one can also see the different thickness of the steel used for the intermediate wheel and the drive wheel. The drive wheel has a material thickness of



1.4 mm, while the intermediate wheel has only 1.0 mm. This discrepancy in dimensions alone would not necessarily be unusual, but in the context of the further findings on both wheels, this unusual constellation already deserves attention.

Dimensions of the Drive Wheel:

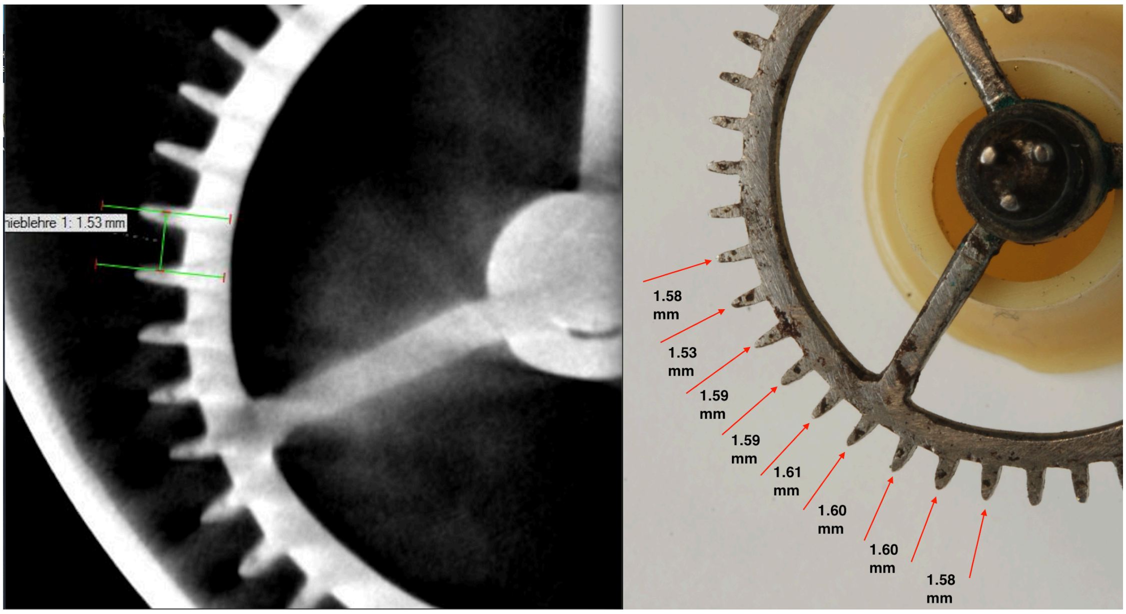
Diameter:
Pitch Circle: 23.60 mm
Root Circle: 21.24 mm
d: 1.40 mm
Number of Teeth: 46

Dimensions of the Intermediate Wheel:

Diameter:
Pitch Circle: 19.80 mm
Root Circle: 17.50 mm
d: 1.00 mm
Number of Teeth: 40/6

The examination revealed further evidence of significant modifications to the drive wheel. It can be assumed that the drive wheel, along with the detent and the detent spring on it, originally did not belong to the fusee. Instead, we are dealing with the modification of a drive wheel from an early 16th-century clock.

The components placed on the drive wheel, namely the detent and detent spring, were not originally positioned as they are in the wheel's holes. The detent is mounted "up-



side down" compared to the escapement wheel. This is an extremely rare configuration, as seen, for example, in the Dresden Table Clock by Jakob Zech from Prague (see photo) and its counterpart in London.

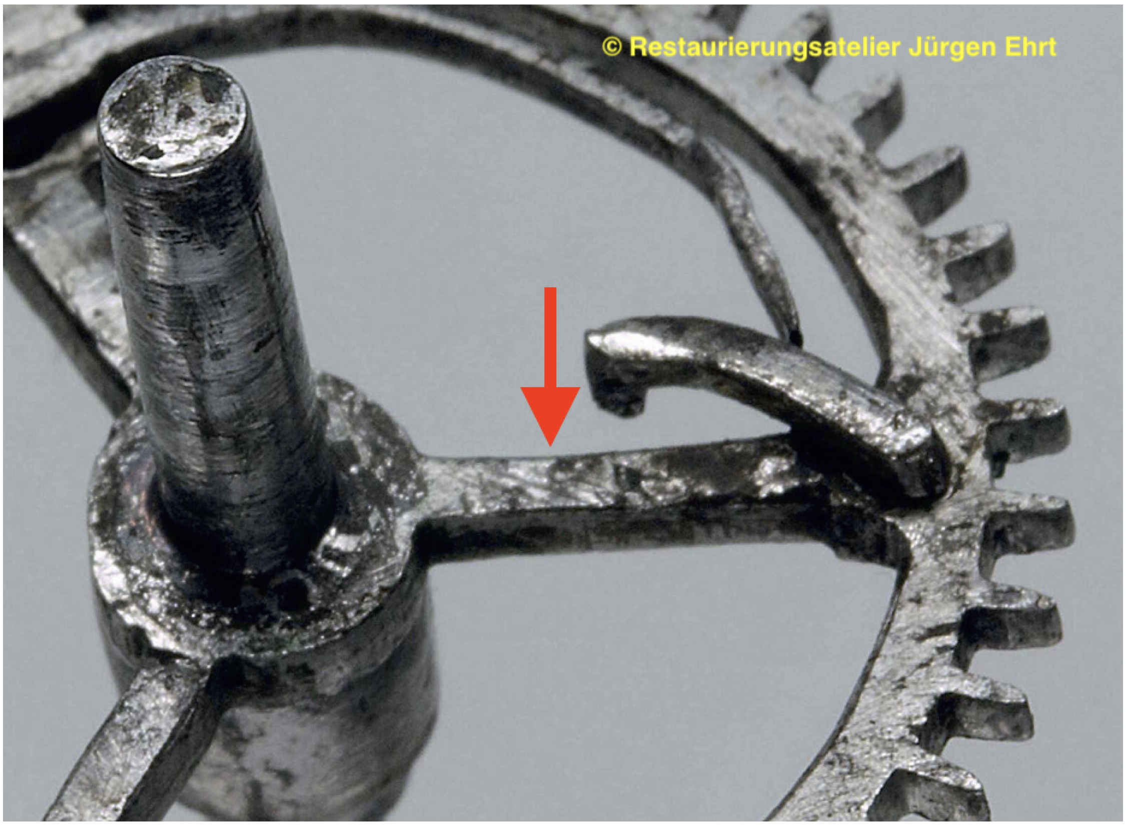
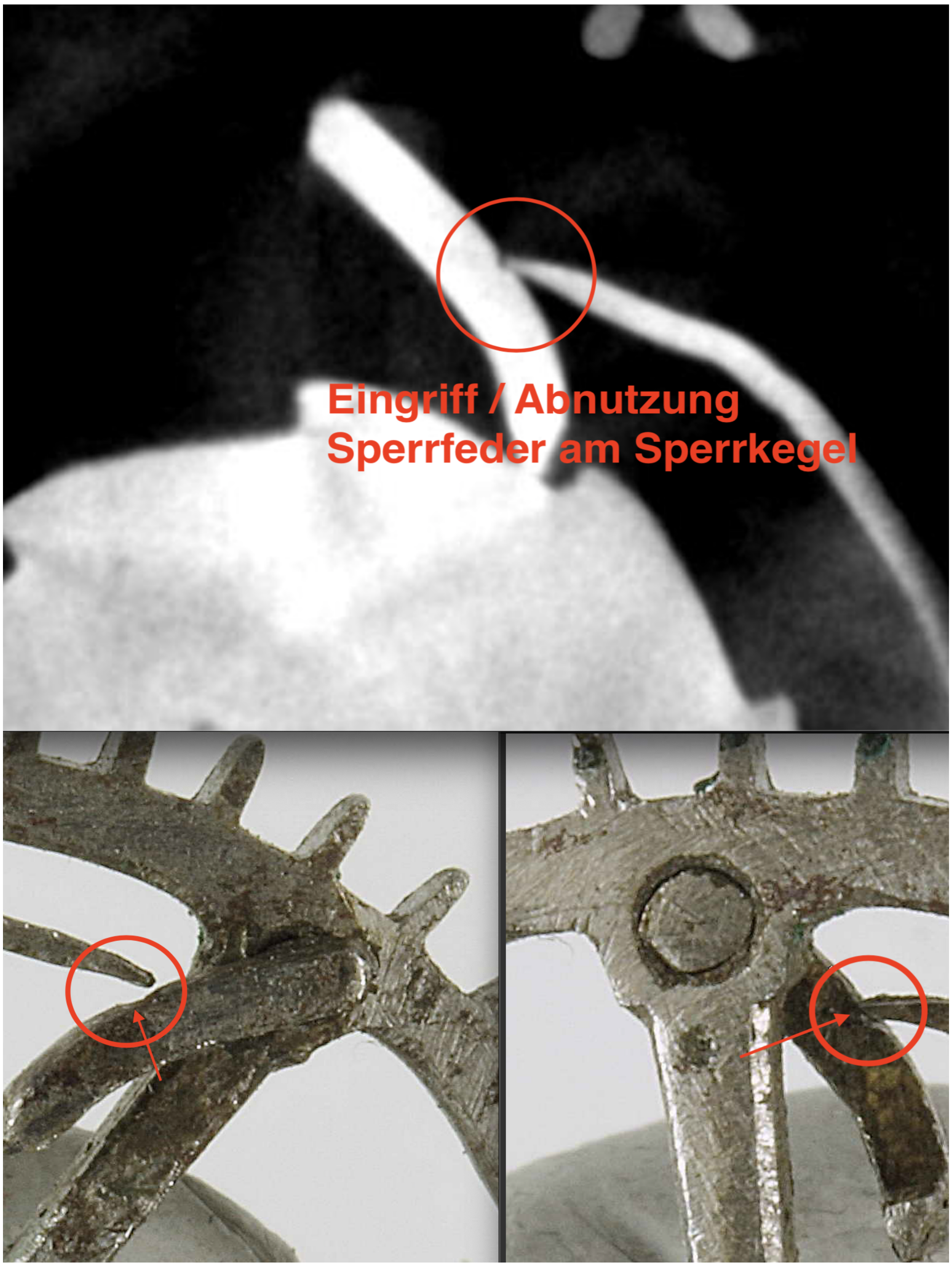
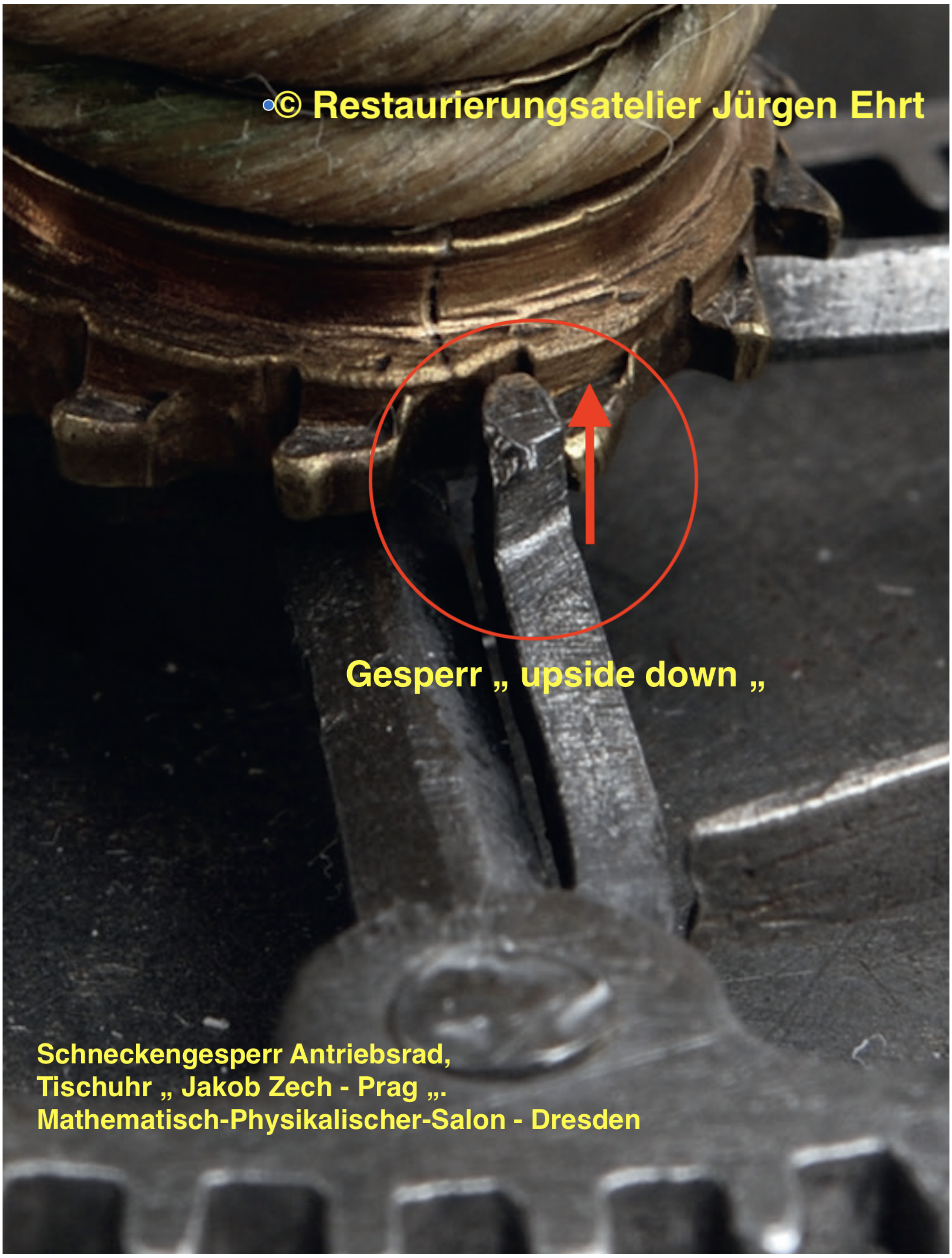


Illustration: Locking mechanism on the drive wheel

In the examined clock, this type of mounting is counterproductive and is likely due to the fact that the components for this construction, namely the ratchet wheel, the click spring, and the ratchet, were originally located on the opposite side of the drive wheel. Alternatively, the ratchet may not have reached through the wheel due to its dimensions (2.47 mm) and thus could not engage with the ratchet wheel on the fusee. The constructor decided to relocate the click spring and the ratchet to the opposite side of the drive wheel, requiring an exchange of the existing attachment points. This explains, among other things, that the ratchet is no longer mounted on the wider wheel spoke, which provided more stability. The exchange of components, the click spring and the ratchet, without any loss of distance, is also evident in the coherent engagement trace of the click spring tip on the ratchet. Here is the evidence for the coherence of the components: the ratchet wheel, the click spring, and the ratchet. The click spring had to be soldered with silver (Ag) since the opening left by the previously placed ratchet was too large. For the installation of the ratchet, only a reaming of the mounting hole of the click spring was necessary. This can be clearly demonstrated by the computed tomographic examination.



© Layout: Restoration studio Jürgen Ehrt
CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth
Photo: R. Schewe, G. Janßen (GNM)


© Restaurierungsatelier Jürgen Ehrt
Gesperr „ upside down „
Schneckengesperr Antriebsrad,
Tischuhr „ Jakob Zech - Prag „.
Mathematisch-Physikalischer-Salon - Dresden

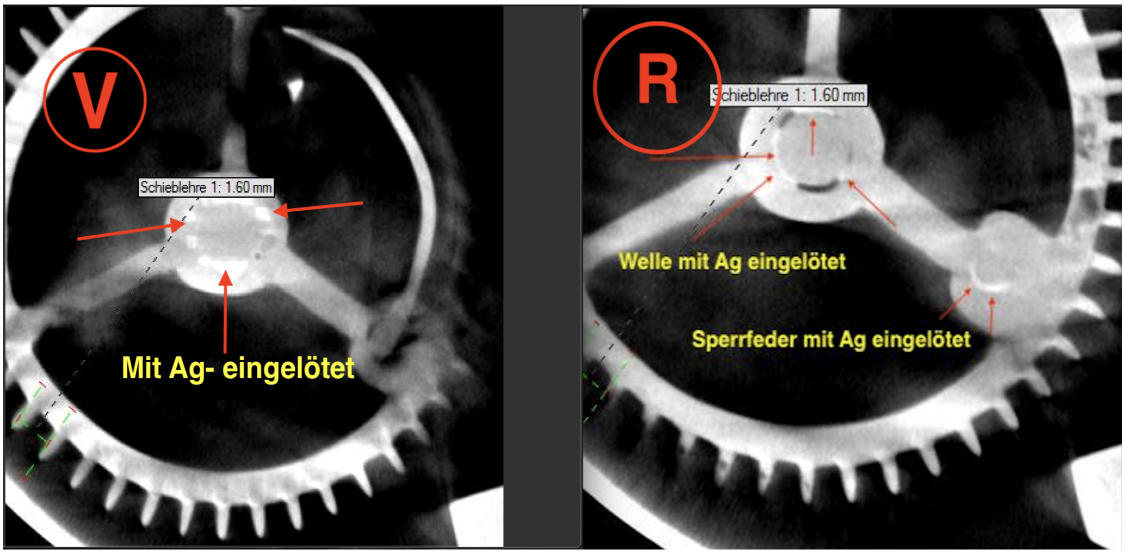
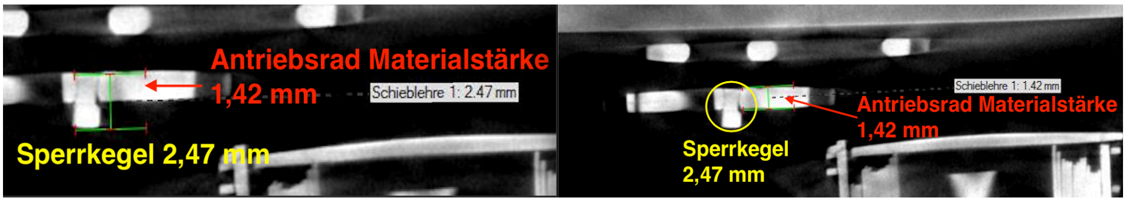


Illustration CT: Modifications to the Drive Wheel
© Layout: Restoration studio Jürgen Ehrt
CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth



Johannes Eulitz explains this very convincingly[10]:

"...The Pull-out piece (locking cone) seated on the fusee wheel is angled at its end. This form would only make practical sense if the locking wheel were dimensioned in such a way that the angled end of the Sperrkegel could rest against the wheel spoke. However, this possibility does not exist since the diameter of the locking wheel is too large. This could indicate a former locking wheel, including fusee, with a smaller diameter that was later replaced by the current parts".

The two clocks by the Prague clockmaker Jakob Zech in the British Museum and the Mathematisch-Physikalischen-Salon in Dresden have a somewhat similar variant, where the Sperrkegel is also angled. In these clocks from the contemporary of Peter Henlein, the angled ends of the Sperrkegel, however, reach through the wheel to the other side, all the way to the locking wheel, which makes sense technically. This is a quite advantageous solution, as it brings the barrel closer to the fusee wheel without risking collision with the locking spring and cone. In the so-called Henlein clock, however, this angled form of the Sperrkegel is non-functional."

[10] Vgl. Deutsche Gesellschaft für Chronometrie - Jahresschrift 2019, Band 58, S. 99 ff. Die Henlein-Uhr. Befund ihrer technischen Untersuchung - Autorengemeinschaft Jürgen Ehrt, Thomas Eser, Johannes Eulitz, Markus Raquet, Roland Schewe.

The intermediate wheel exhibits additional peculiarities. Firstly, the two almost unused bearing pivots catch the eye. The pivot surfaces show a rolled and rounded appearance. Both pivots have grain marks, indicating processing with a precision lathe. The pivot facing away from the drive side also has a typical run-in characteristic, suggesting its clamping on a lathe with a conical tip.

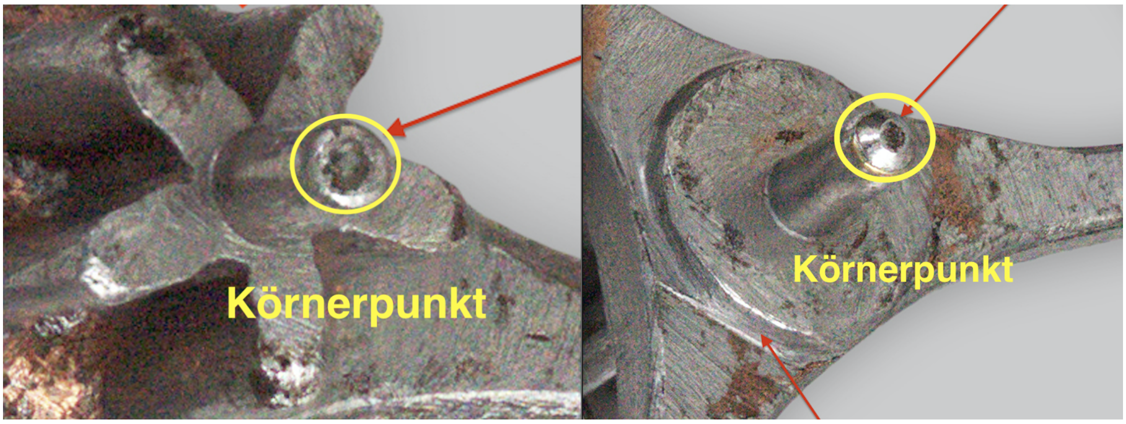


Foto: R. Schewe, G. Janßen (GNM)

The CT scan reveals that the drive forms a unit with the pivot on the opposite side (engagement with the drive wheel). The pivot on the drive side is inserted into the shaft, and the whole assembly, similar to a wheel hub, is soldered into the intermediate wheel.

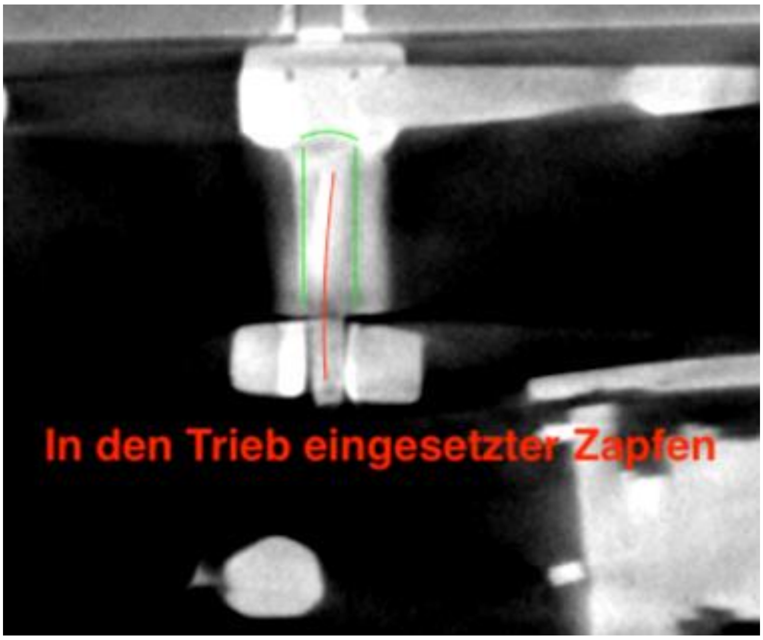
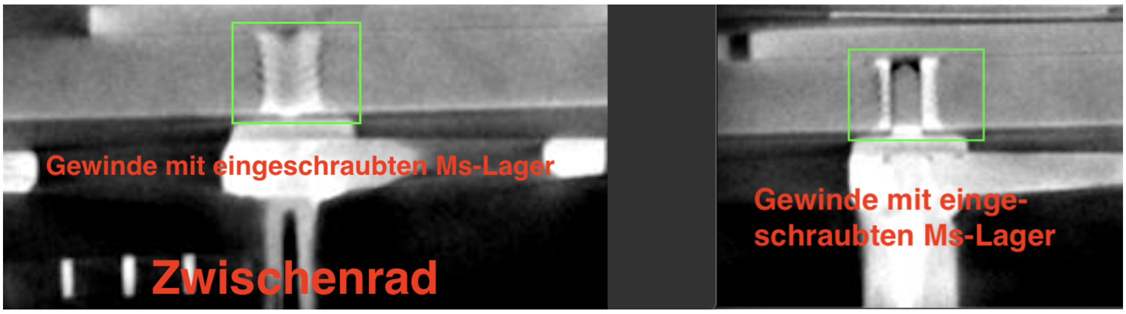


Illustration CT: Inserted Pivot
© Layout: Restoration studio Jürgen Ehrt



CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth

Illustration CT: Intermediate Wheel
© Layout: Restoration studio Jürgen Ehrt
CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth

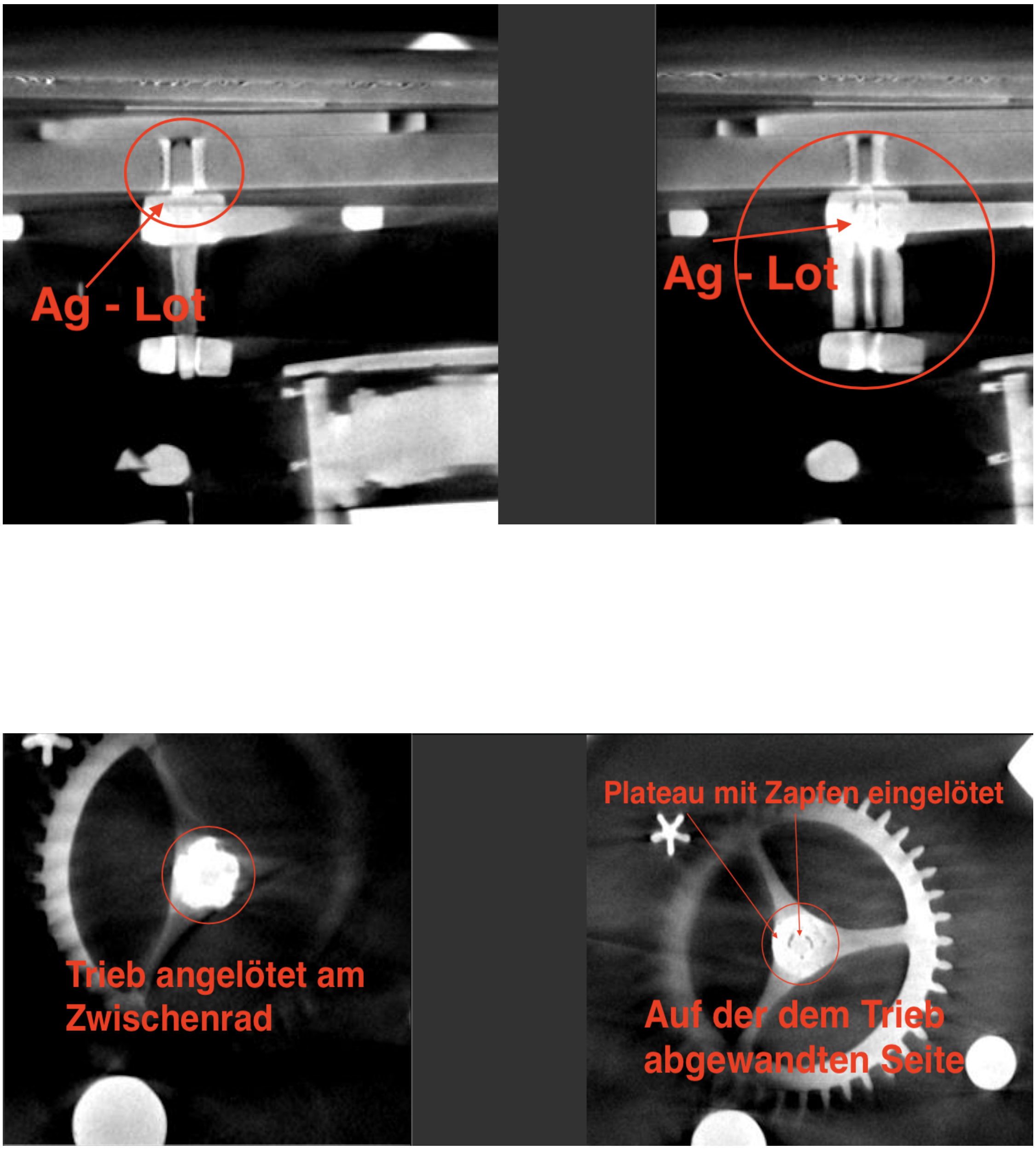


Illustration CT: : Intermediate Wheel

© Layout: Restoration studio Jürgen Ehrt

CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth

Comparing the craftsmanship evident in the production of the wheels leads to the conclusion that they must come from different manufacturing processes. On one hand, the *Antriebsrad* (driving wheel) exhibits a very rudimentary and coarse workmanship, while the *Zwischenrad* (intermediate wheel) demonstrates a certain level of artisanal craftsmanship typical of a locksmith from the 16th century. This further confirms that we are dealing with a situation where components were sourced from different places or periods, resembling a mix of spare parts.

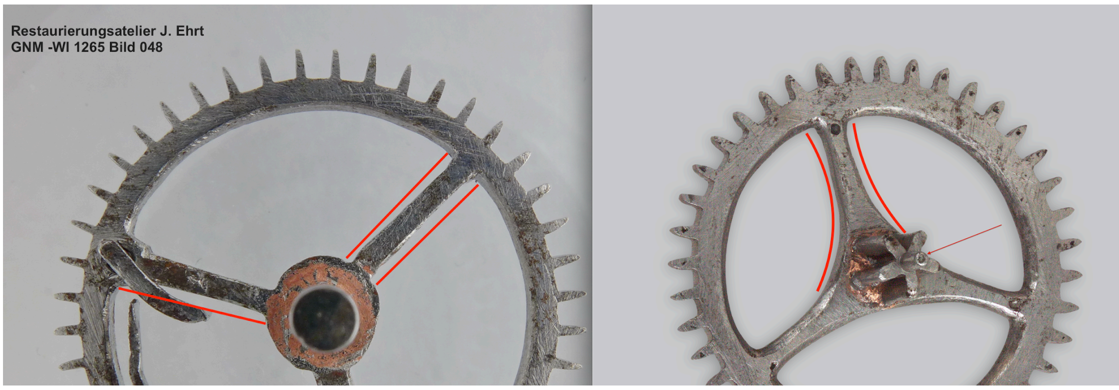
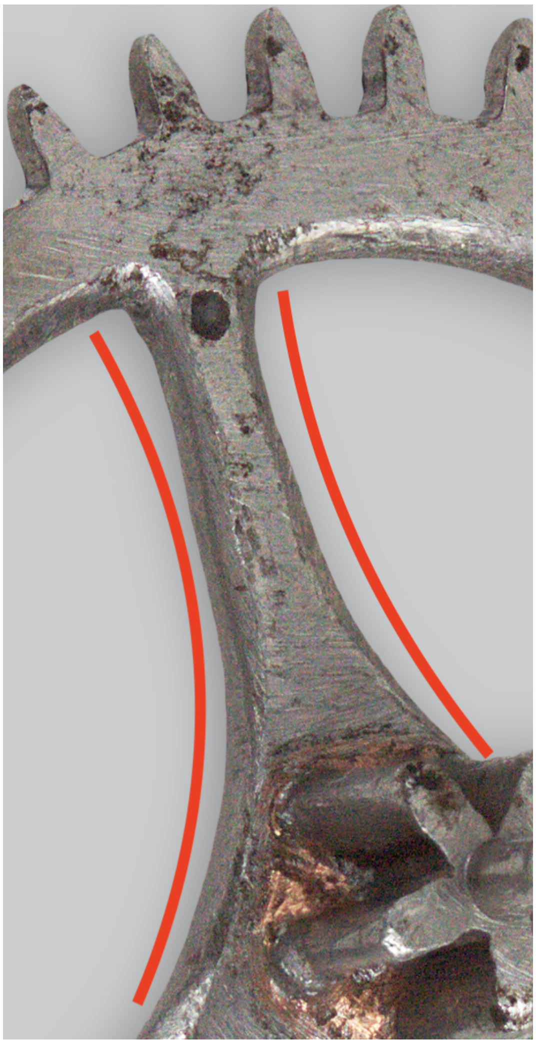


Illustration: Driving wheel - Intermediate wheel
Photo: R. Schewe, G. Janßen (GNM)



Driving wheel - Intermediate wheel

Photo: R. Schewe, G. Janßen (GNM)

II.2.4 The Fusee

With the fusee, we are clearly dealing with a modification of an old fusee to the technical requirements and existing dimensions of the corresponding components of the constructed so-called Henlein clock.

I also assume that the fusee and the drive wheel - also referred to as the fusee wheel - were not originally a matching pair.

This is also an adaptation focused on function, lacking coherence.

Significantly, the fusee and fusee wheel are both too short in their overall height by the same measure as the mainspring shaft. This results in another error with excessive height play. To compensate for this error, a brass bearing, filling the missing dimension, was driven into the fusee shaft bearing.

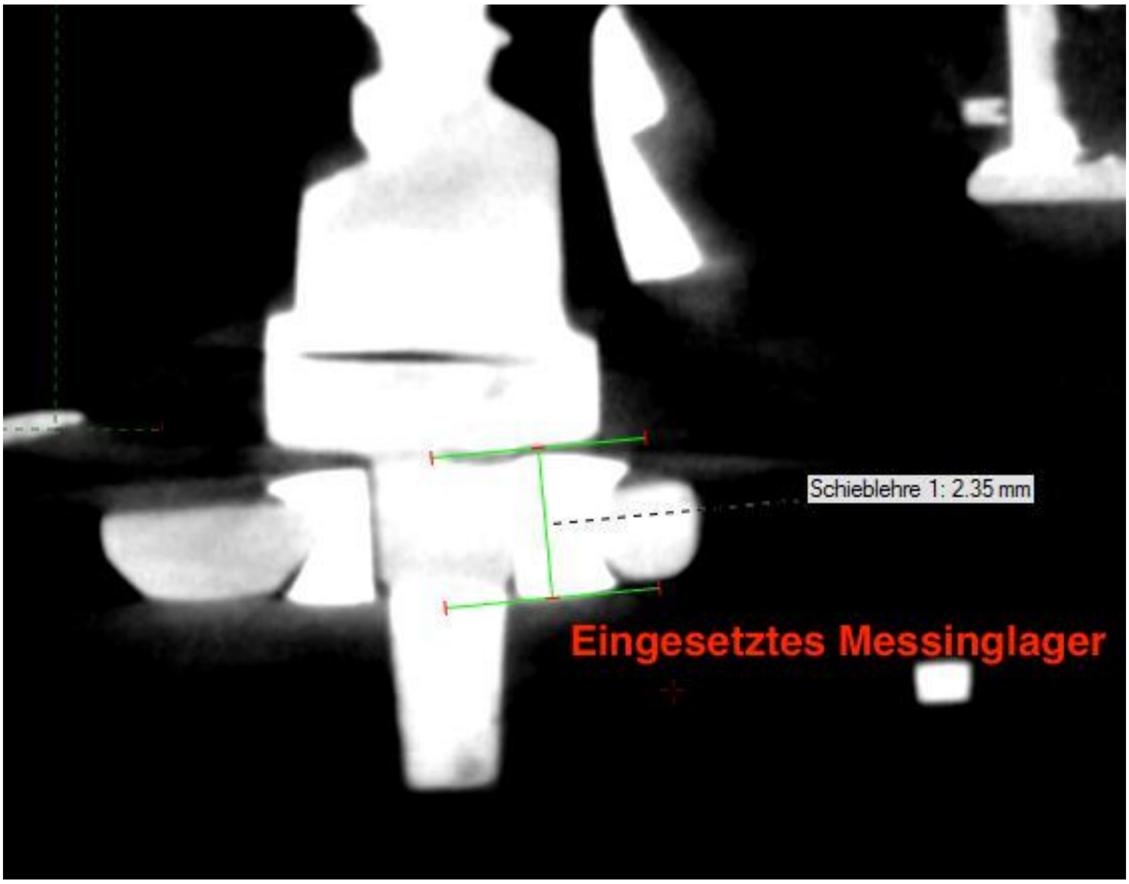


Illustration CT: Inserted brass bearing

It can be assumed that this bearing, among other functions, also prevents the escape wheel pinion from engaging in the void due to excessive play between the fusee and the escapement wheel during winding. The resulting damage to the movement could potentially be irreversible.

The winding square on the fusee, also modified and supplemented, was inserted into the fusee neck with a dovetail joint.

The execution of this rudimentarily performed assembly leaves no doubt as to the intention behind these manipulative renewals.

There are no significant signs of wear on the winding square and the bearing pivot, which should be present in relation to the corresponding surfaces.

Furthermore, we observed that a hole in the escapement wheel, intended to accommodate the end knot of the gut strings, is located immediately and thus too close to the tooth of the escapement wheel. As expected, the pallet fork has pressed in the outer wall at this point.

Assuming that a reduction in the diameter of the escapement wheel crown at the fusee was caused by the reconstruction, a coherent picture emerges.

In this regard, I also refer to the presentation of my colleague Eulitz[11]:

"Surely, since this intervention, the clock has hardly been used or could be used. This is not a repair to restore operability. Well-preserved file marks across the functional direction and a clearly raised burr on the end faces of the teeth indicate this".

The remaining appearance of the fusee is also the result of serious changes that cannot be primarily associated with the conversion from gut string to chain. There are two holes instead of just one for the gut string. With the additional hole and the extended guide groove, the effective interaction of the fusee increases by three-quarters of a turn. In this area is also the pin for attaching the chain. The escapement wheel had to be reduced by half of its height at the corresponding point.
This modification leads to the gut string or chain jumping off the barrel during the clock's operation, as it is now guided below the receiving area of the barrel. In general, the described extension of the fusee turn contradicts the reduction in the height of the mainspring drum!"

[11] Vgl. Deutsche Gesellschaft für Chronometrie - Jahresschrift 2019, Band 58, S. 102 ff.. Die Henlein-Uhr. Befund ihrer technischen Untersuchung - Autorengemeinschaft Jürgen Ehrt, Thomas Eser, Johannes Eulitz, Markus Raquet, Roland Schewe.

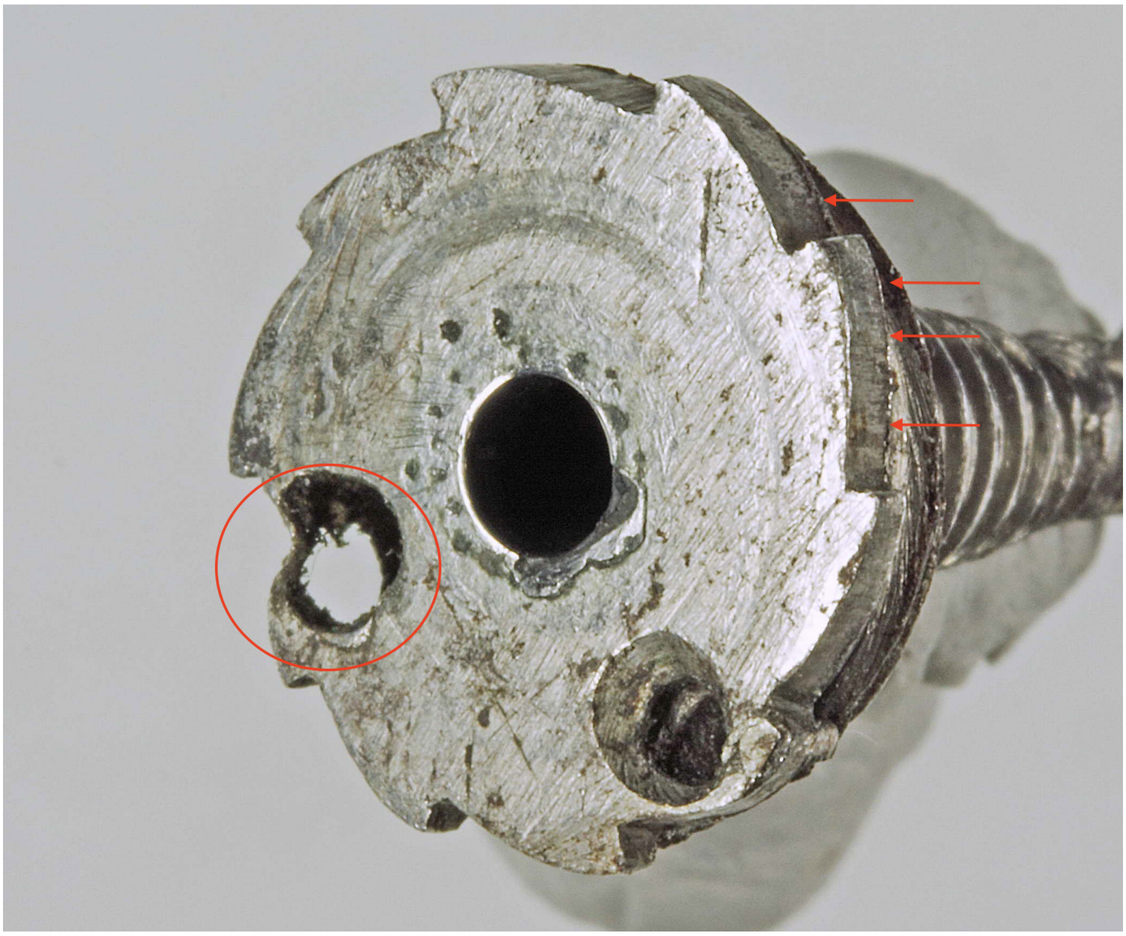


Abbildung: Hole for holding the gut or cord and un-deburred filing marks

Photo: R. Schewe, G. Janßen (GNM)

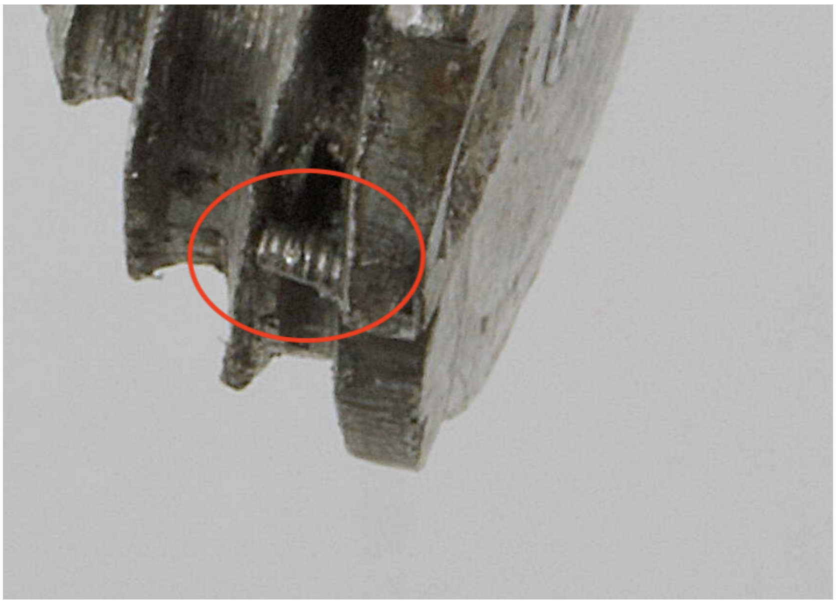


Illustration: Pin for hanging the chain, made from a screw

Photo: R. Schewe, G. Janßen (GNM)

The fusee neck was reduced in diameter by filing down the last turns, creating space for the chain to run without contact. The measured distance after shortening is approximately 0.40 mm, just enough for the chain to run without rubbing.

Assuming that originally this fusee was designed for a gut string, and the gut string had a certain protrusion beyond the wall of the fusee turns, operating the clock with this fusee would have been impossible anyway. gewesen.

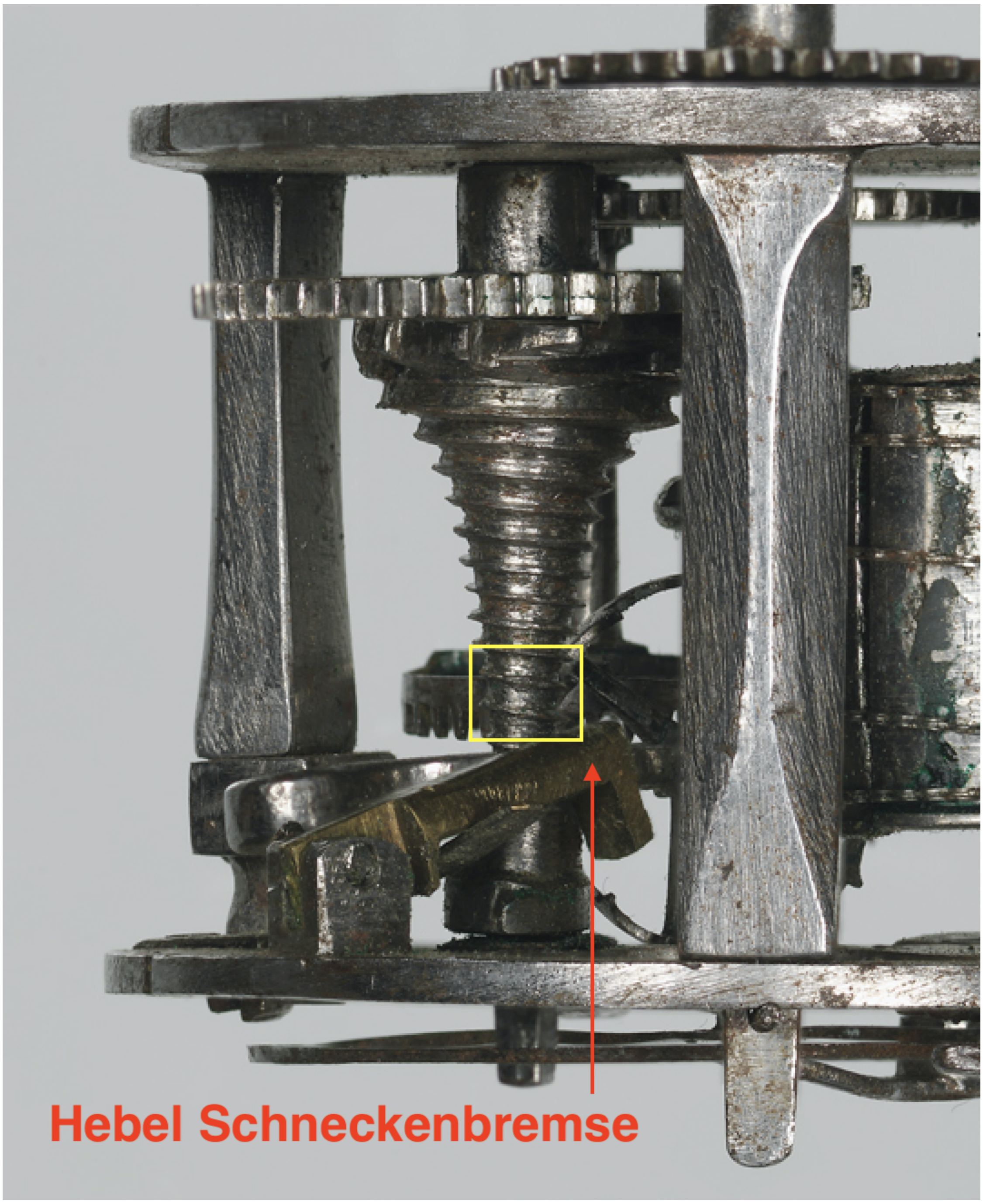


Illustration: Constriction on the lever of the fusee brake

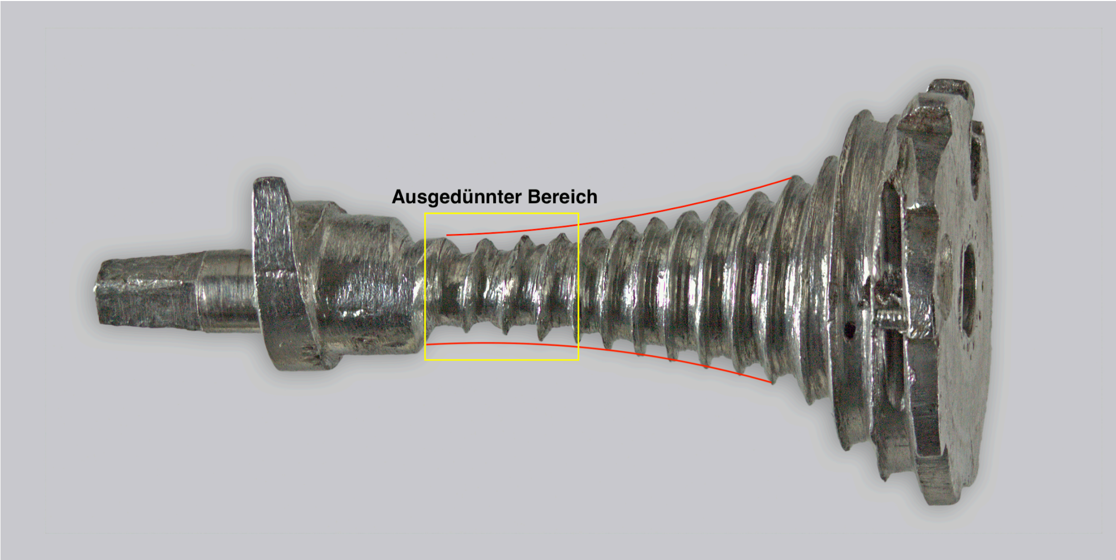


Illustration: fusee with filed-down fusee windings
© Layout: Restoration studio Jürgen Ehrt
Photo: R. Schewe, G. Janßen (GNM)

Illustration CT: Distance between fusee and the lever of the fusee brake
© Layout: Restoration studio Jürgen Ehrt
CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth

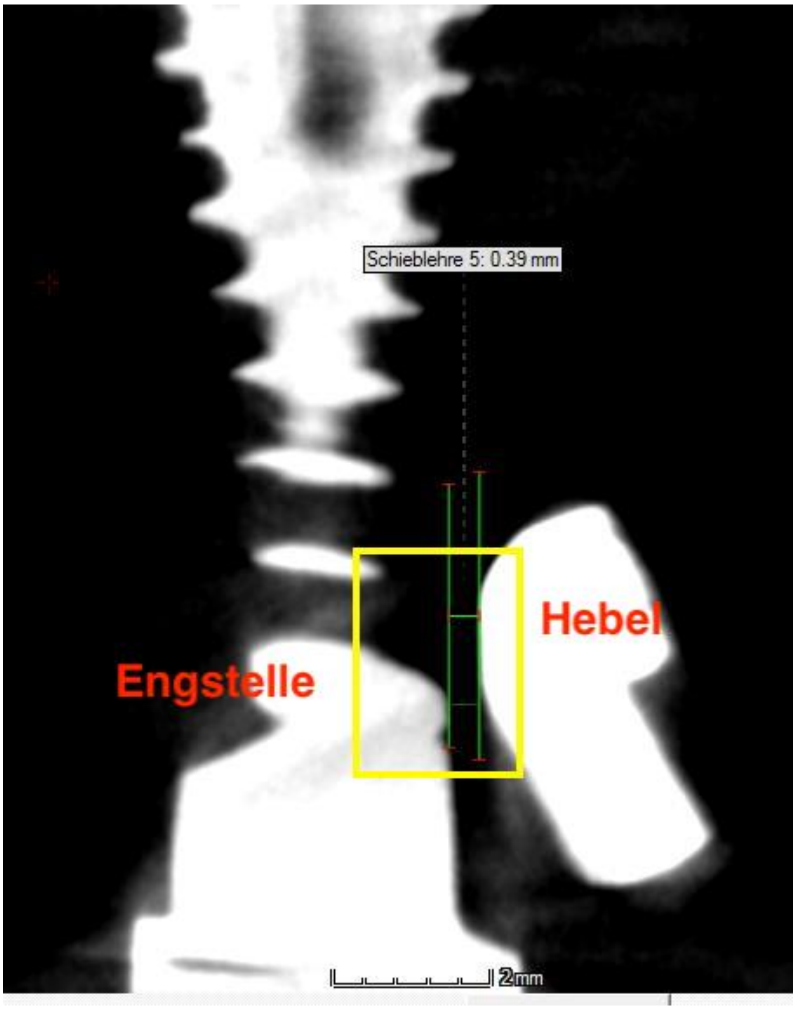


Illustration CT: Distance between fusee and the lever of the fusee brake
© Layout: Layout: Restoration studio Jürgen Ehrt
CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth

The **crown wheel** shows an extraordinary manipulation. The inner part of the spokes has been flattened to adapt to the height of the pallets of the escapement and crown wheel. The wheel shaft, originally not belonging to the crown wheel, was soldered and provided with two new pivots.

The pinion located on the supplementary shaft, originally too long in its dimensions, was adjusted to the size of the intermediate wheel by shortening the pinion wings. This explains the incompatibility of the intermediate wheel module with the crown wheel drive and its empirical modification.

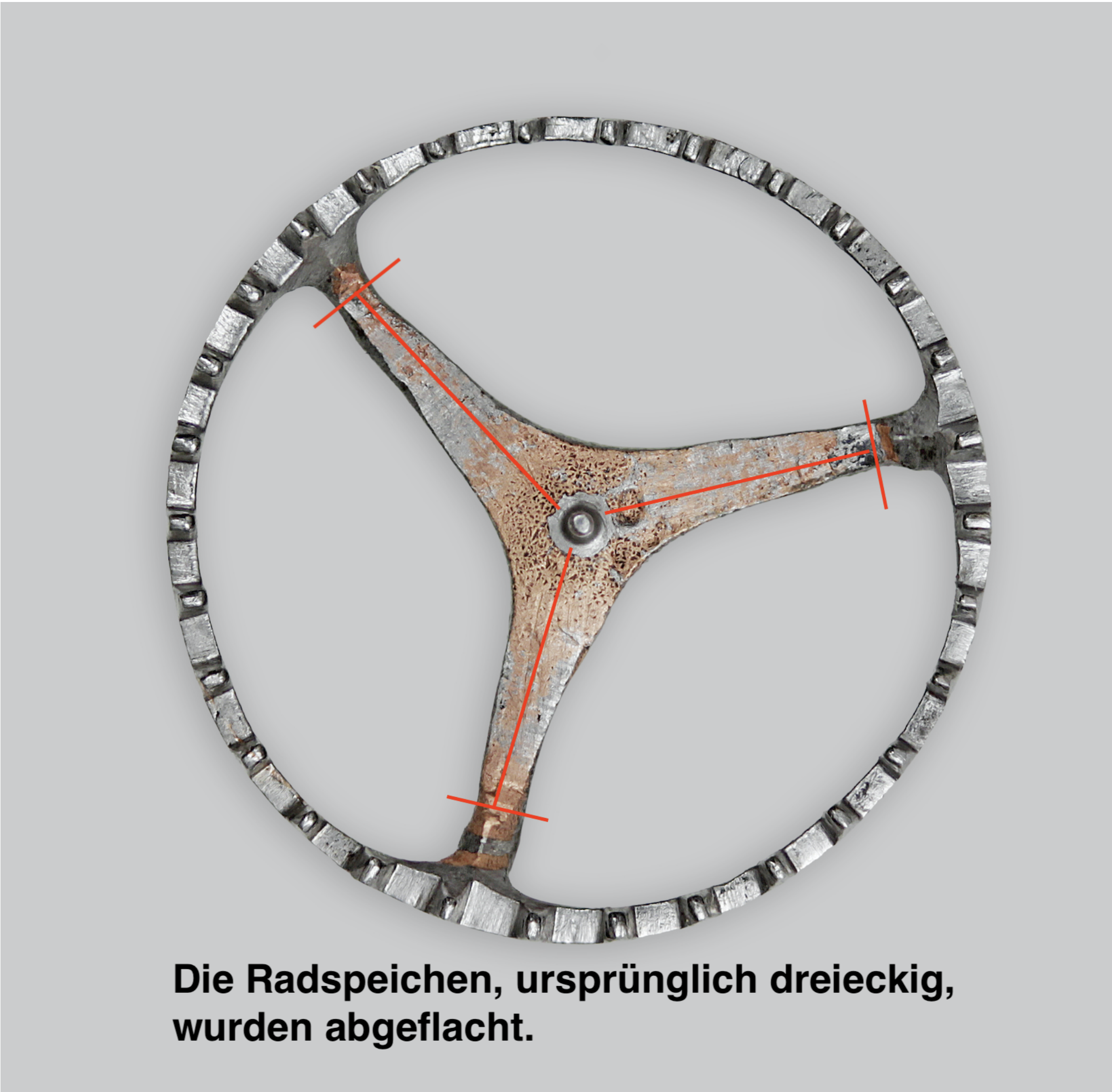


Illustration: Modified wheel spokes on the crown wheel

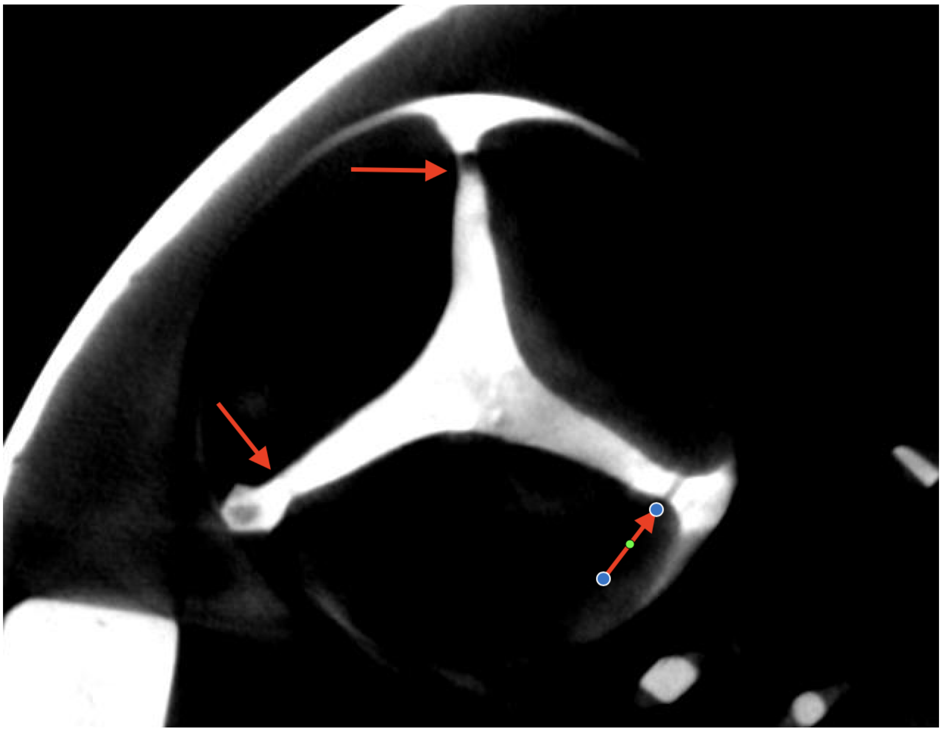


Illustration CT: Modified wheel spokes on the crown wheel
© Layout: Restoration studio Jürgen Ehrt
CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth

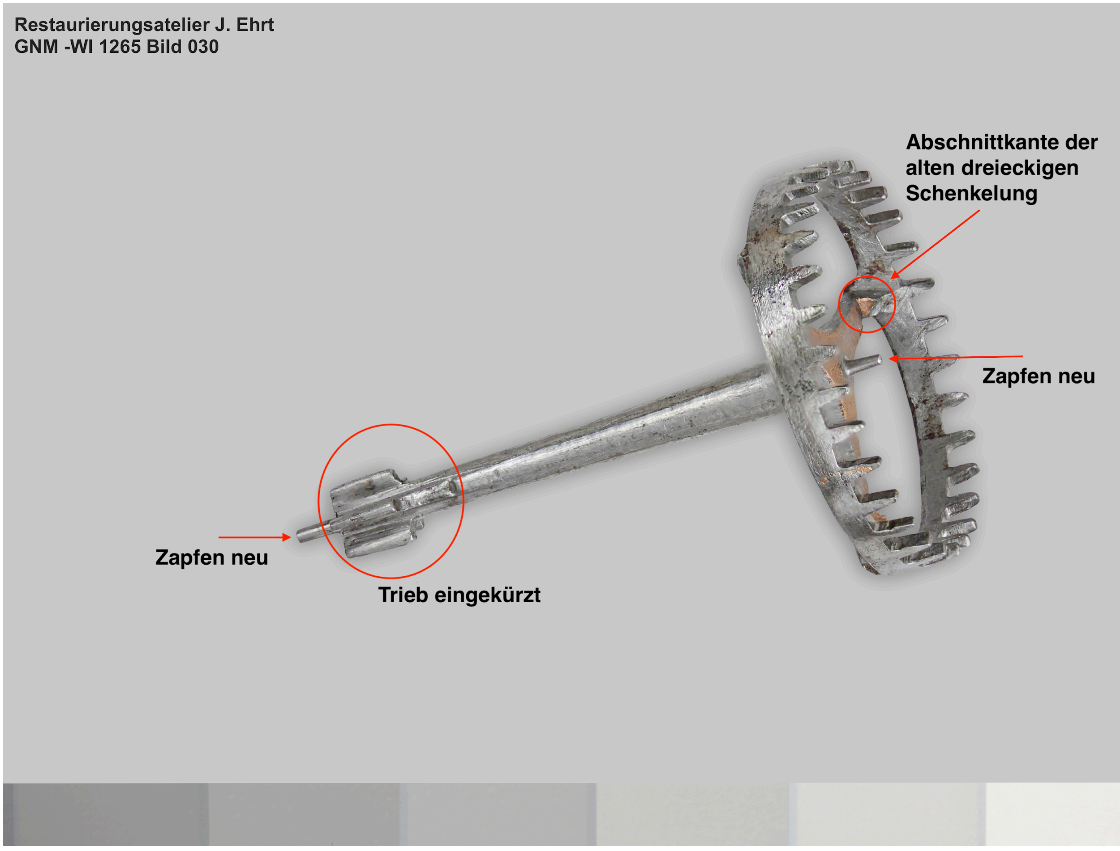


Illustration CT: Modified wheel spokes on the crown wheel
© Layout: Restoration studio Jürgen Ehrt
Photo: R. Schewe, G. Janßen (GNM)

Abbildung: Umgearbeitete Radspeichen am Kronrad
© Layout: Restoration studio Jürgen Ehrt, Photo: R. Schewe, G. Janßen (GNM)

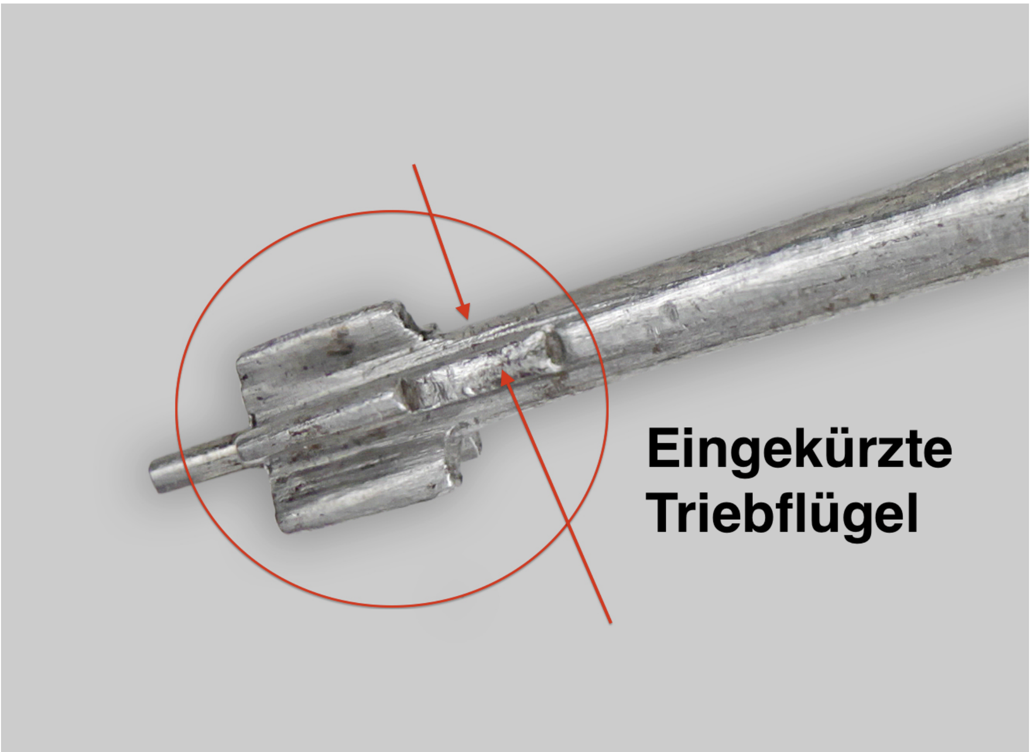


Illustration: Shortened arbor on the crown whee
© Layout: Restoration studio Jürgen Ehrt, Photo: R. Schewe, G. Janßen (GNM)

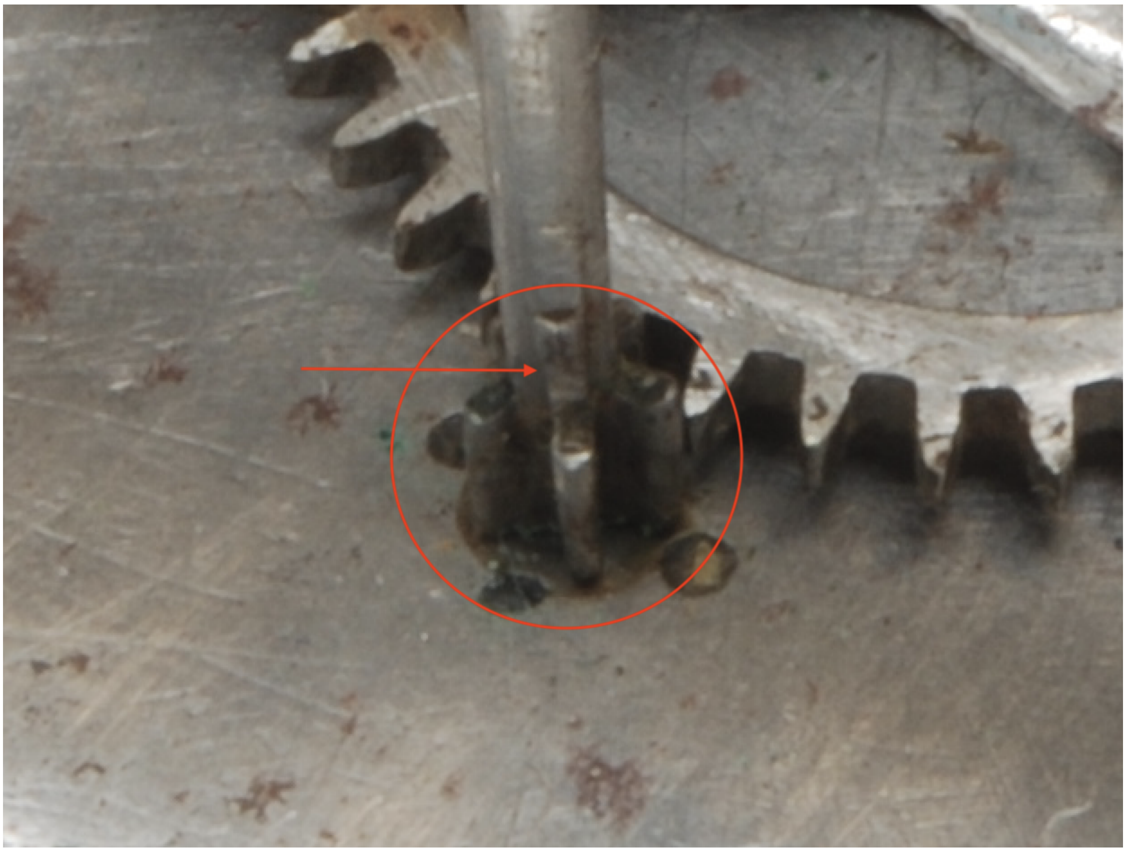


Illustration: Modified drive on the crown wheel engaging with the intermediate wheel
© Layout: Layout: Restoration studio Jürgen Ehrt
Photo: R. Schewe, G. Janßen (GNM)

The pinion bearing on the upper plate side of the crown wheel is also made of brass using the previously described technique and screwed in.

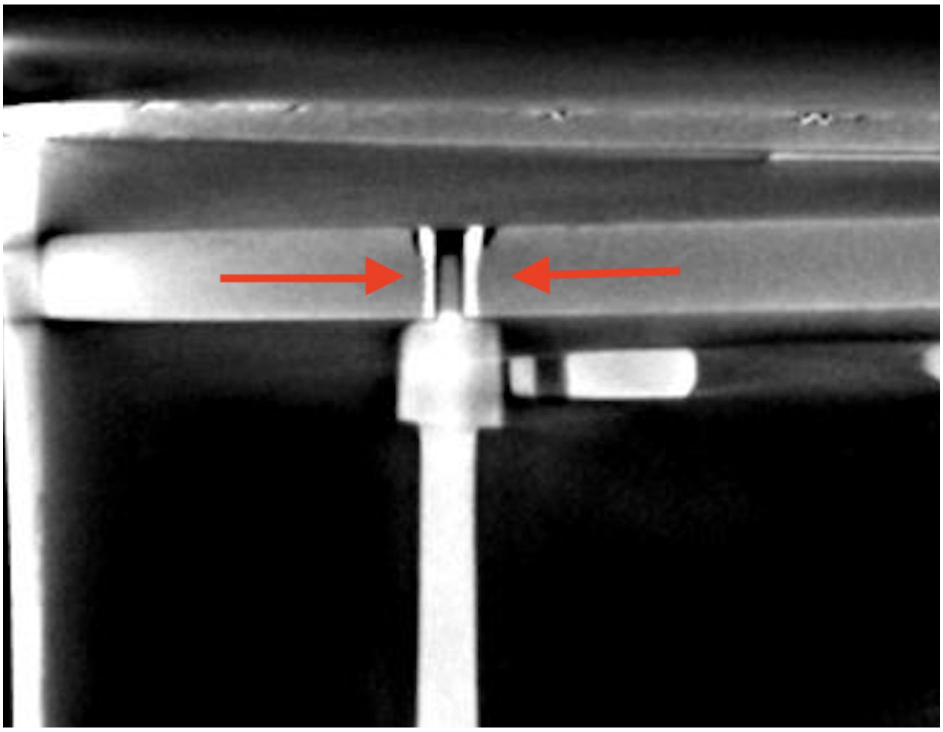


Illustration CT: Screwed-in pinion bearing of the crown wheel
© Layout: Restoration studio Jürgen Ehrt
CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth

The pinion facing away from the drive is subsequently inserted flat into the spoke without a shoulder and shows no signs of use.

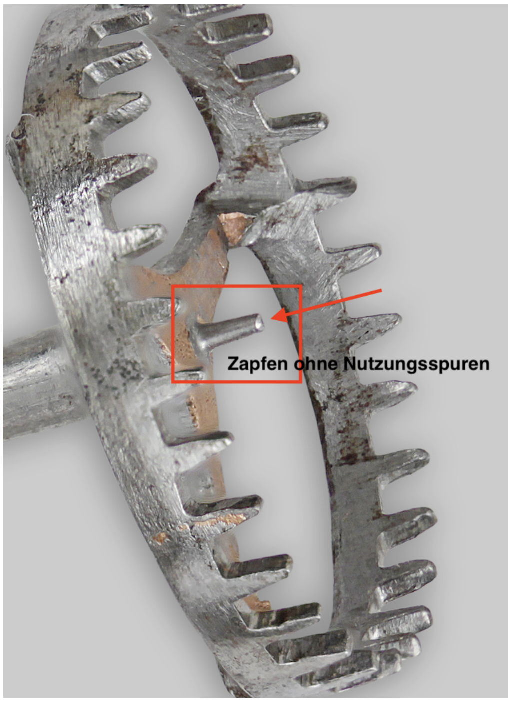


Illustration: Supplementary pivot, pallet wheel.
© Layout: Layout: Restoration studio Jürgen Ehrt
Photo: R. Schewe, G. Janßen (GNM)

The **escape wheel** also bears significant machining marks that exclude its original connection with the corresponding wheel components.

New pivots were inserted here as well, and a machine operation (lathe) - indicated by the ratchet marks - was performed to create clearance for the engaging pallet lever arm. The expected pivot shoulder from the original configuration is also missing here.

On the pivot rounding, there is clearly a "hat" shape formed by clamping in a counter-brooch on the lathe.

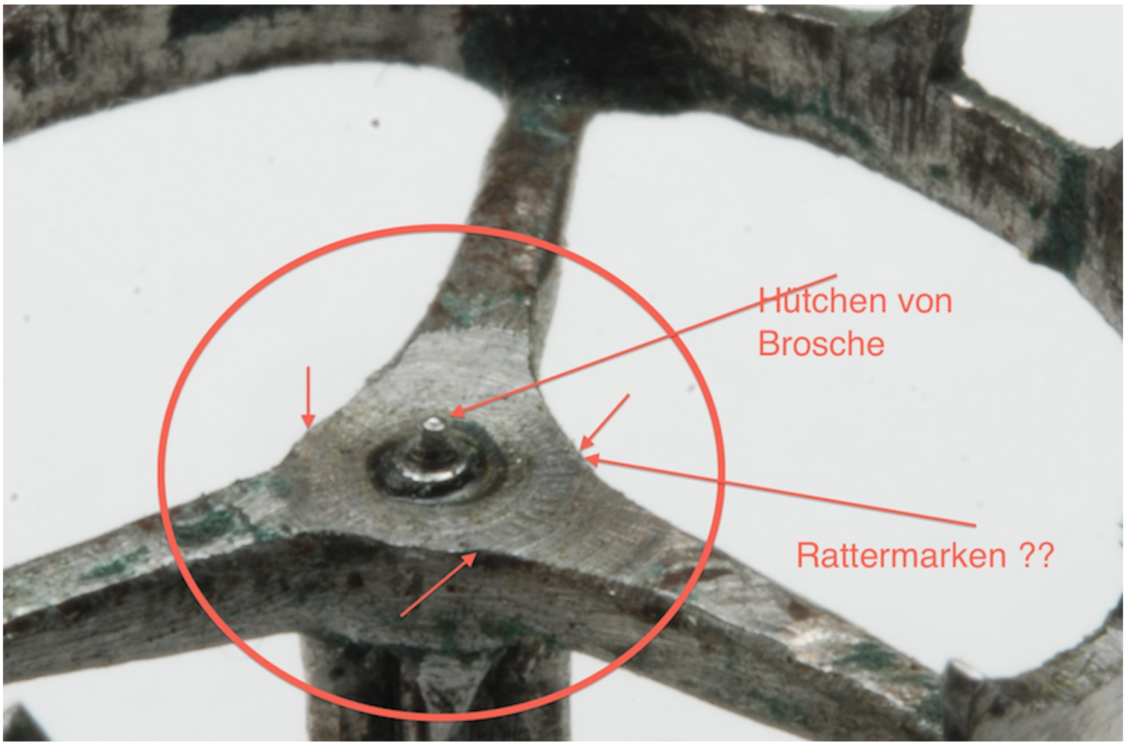


Illustration: Supplementary pivot, pallet wheel.

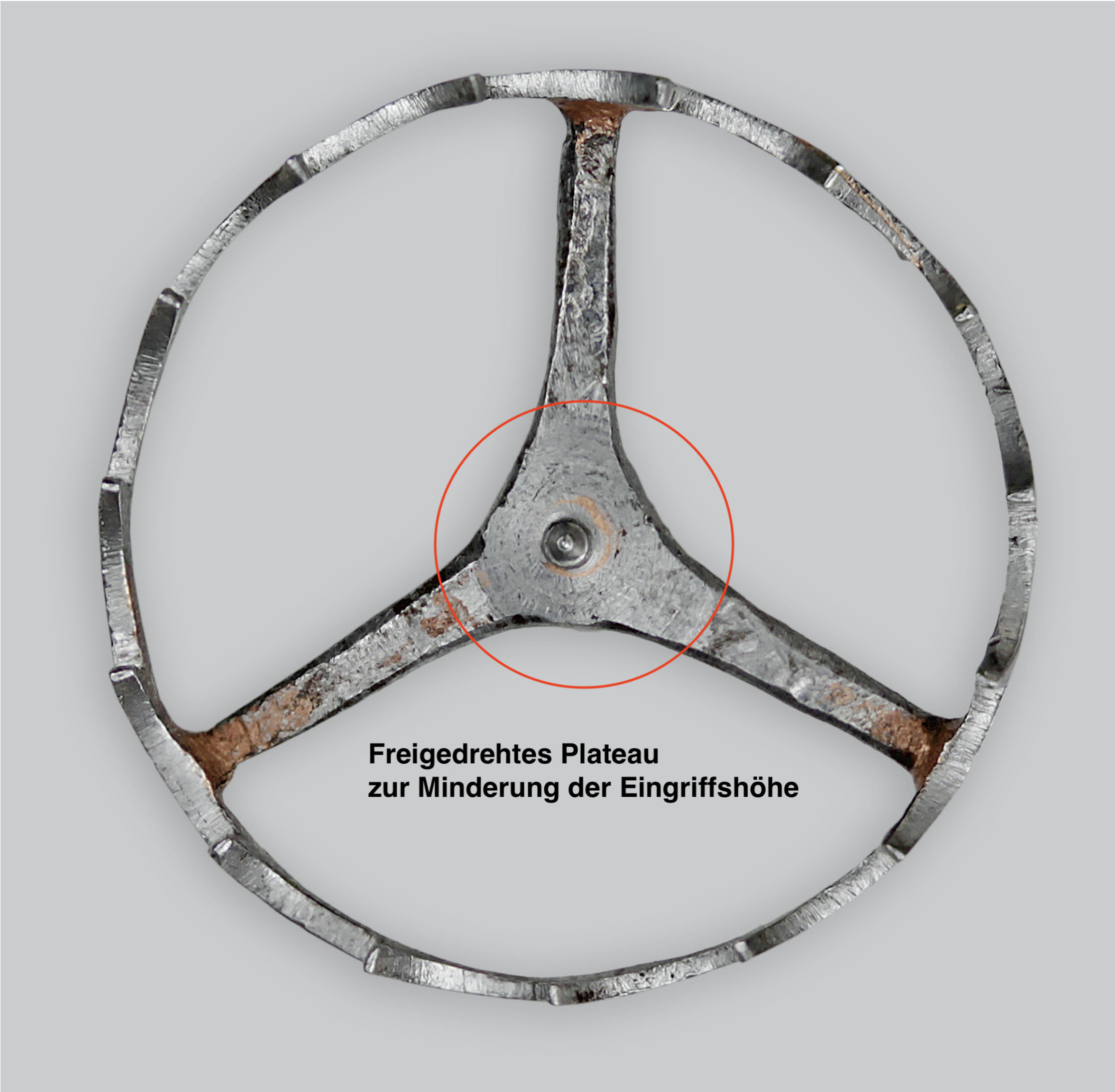


Illustration: Supplementary pivot and machining marks on the pallet wheel.
Layout: Restoration studio Jürgen Ehrt
Photo: R. Schewe, G. Janßen (GNM)

The **hour wheel**, which carries the hand (previously mentioned above), was also taken from the spare parts box and adapted to the 18th-century hand.

The axle of the hour wheel, covered with a brass bearing, was adjusted to the over-sized bearing diameter through this adaptation.

Illustration: Modified hour wheel
Layout: Restoration studio Jürgen Ehrt
Photo: R. Schewe, G. Janßen (GNM)

Illustration: Lined wheel axle on the hour wheel
Layout: Restoration studio Jürgen Ehrt
Photo: R. Schewe, G. Janßen (GNM)

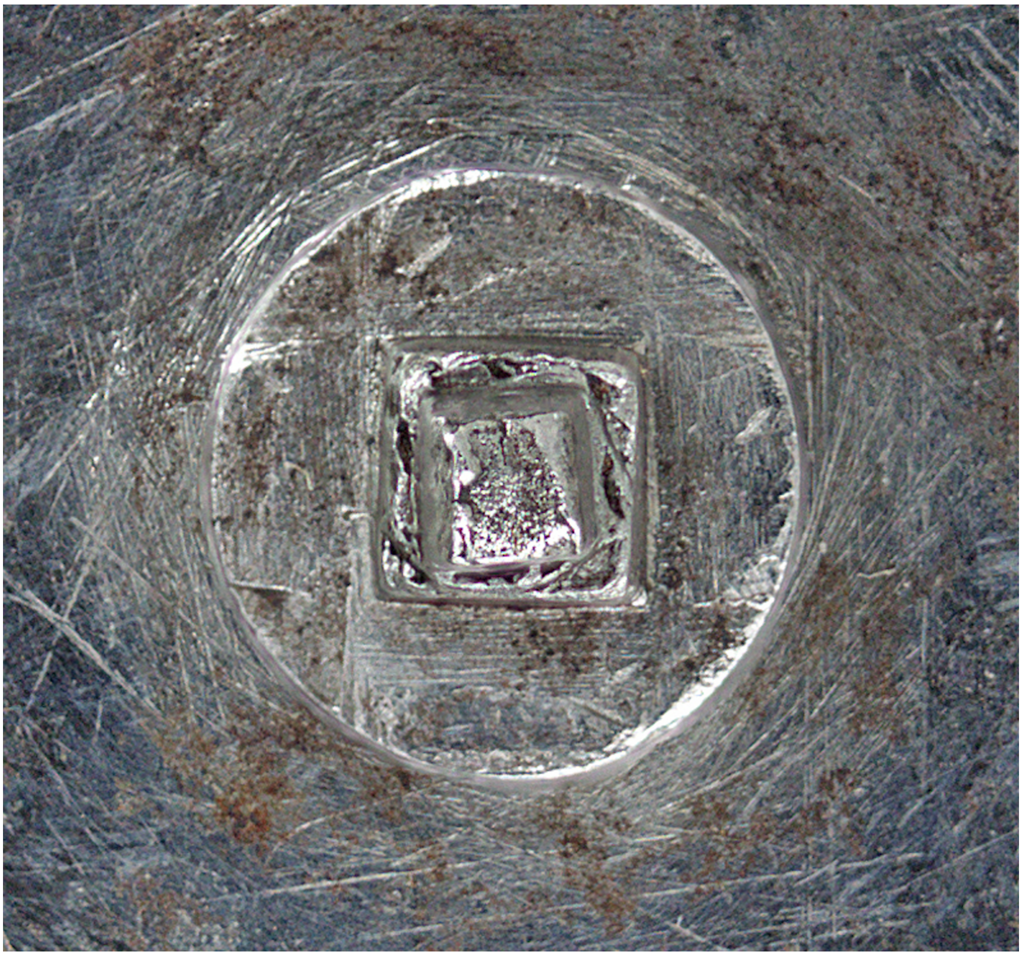


Illustration: Umgearbeitete Zeiger-Aufnahme für den Stundenzeiger
Photo: R. Schewe, G. Janßen (GNM)
© Layout: Restoration studio Jürgen Ehrt

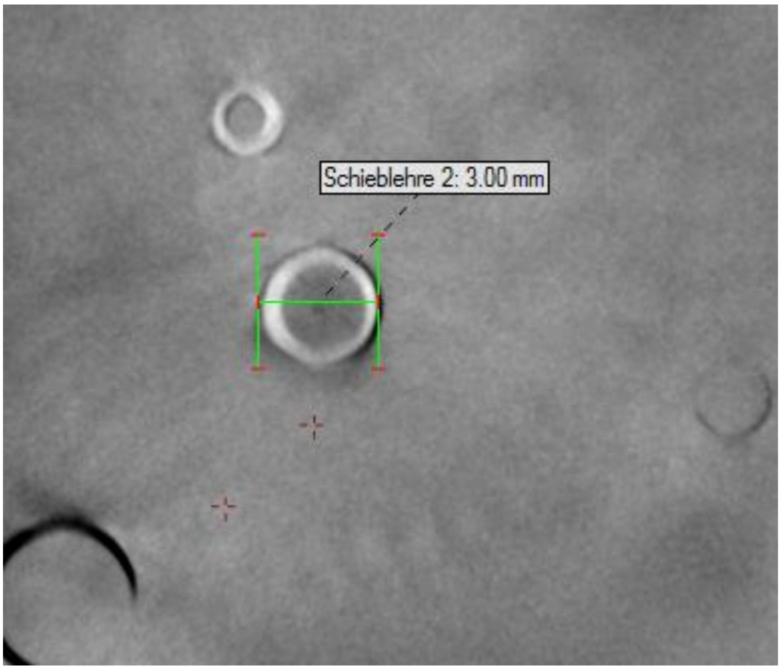


Illustration CT: Lager für den unteren Zapfen des Stundenrades
© Layout: Restoration studio Jürgen Ehrt
CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth

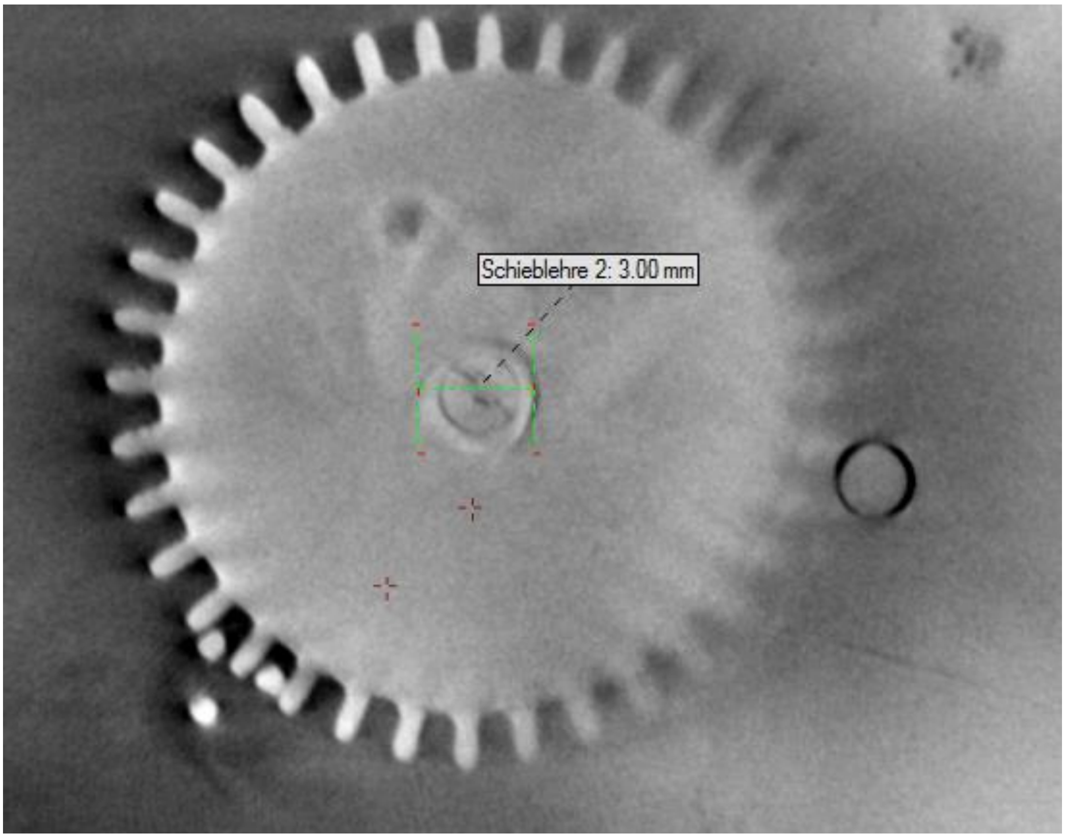


Illustration CT: Lined wheel axle of the hour wheel - outer diameter
© Layout: Restoration studio Jürgen Ehrt
CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth

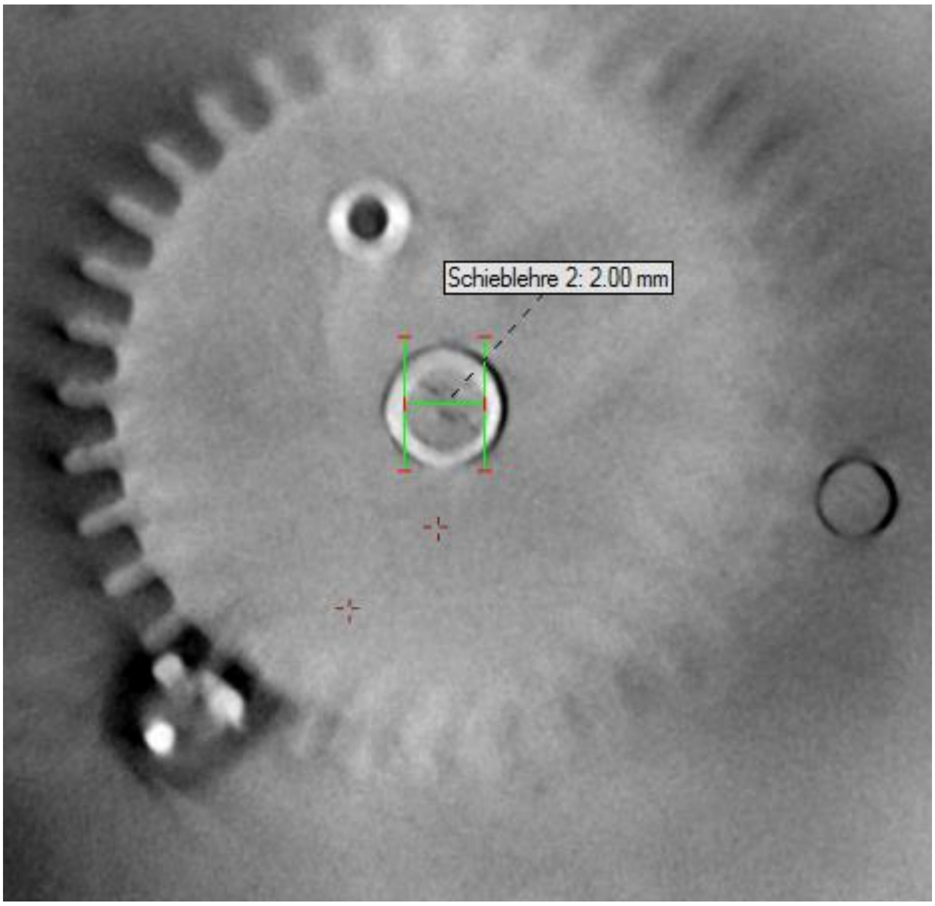


Illustration CT: Lined wheel axle of the hour wheel - inner diameter
© Layout: Restoration studio Jürgen Ehrt
CT: Fraunhofer-Institut für Integrierte Schaltungen, Fürth

III. Review der Peter Henlein depiction at Wikipedia

On Wikipedia we find under the Link https://de.wikipedia.org/wiki/Peter_Henlein[12] , including the following illustration:

"Before November 1511, Henlein was already producing small iron clocks, 'which can be taken everywhere.' In 1512, Peter Henlein was mentioned by the humanist Johannes Cochläus in his 'Kurze Beschreibung Deutschlands' (Brevis Germaniae descriptio) as a maker of small, portable clocks; these were said to run for 40 hours, 'even when carried in a pocket in the folds of clothing.' According to Cochläus, Henlein was considered the first in Germany to realize wearable watches.

Henlein's portable watches may have had the shape of a musk apple, which was very popular around 1500. Additionally, they could have been cylindrical in shape. The first documented musk apple clock by Henlein is from 1524 (according to the Nuremberg city records, he received 15 guilders on January 11, 1524, for a 'gilded musk apple for all things with a timepiece'). There is speculation that some of his portable watches also had a striking mechanism. This is based on a passage in Cochläus's geography book published in 1512 (if the Latin 'pulsant' is translated as 'strike' and not with 'tick'). These watches should not be confused with the Nuremberg Eggs, a clock shape that emerged after Henlein's death. Anyway, the term is a distortion of the then-common term for small clocks."

So far, so good, we have a scientifically based description and documentation. However, with the following presentation, the author enters the realm of fantasies and desires, devoid of any scientific verification and the resulting validation.

[12] Access on July 9, 2020 at 2:19 PM

"A cylindrical clock in the British Museum in London can be attributed to him with high probability. Also, a clock allegedly dated to 1505 (Roman numerals MDV) and presented in various places on the internet, housed in a bisamapfel case, is associated with Henlein due to the monogram PHN.".[12][13][14]"

The statement *"can be attributed to him with high probability"* is in no way and at no point substantiated; it is based solely on the author's wishful thinking. There are no scientific findings supporting this claim, and the British Museum does not confirm this hypothesis.

In fact, the cylindrical clock with inventory number 1888,1201.105 at the British Museum in London is not identified by the museum's experts as an artifact of Peter Henlein. The silver case surrounding this clock bears a hallmark from the city of Nuremberg before 1533. Drawing the conclusion that this clock originates from Peter Henlein is scientifically untenable and, in my opinion, far-fetched. There has been no examination or verified confirmation that the case and the clockwork belong together. Moreover, the clockwork lacks any signatures or significant features that would allow for a personalized attribution to Peter Henlein or any other workshop. As the author writes in the next sentence, *"While products from his hand are difficult to trace, Peter Henlein is a historical figure".* Products from Peter Henlein are not only difficult to trace but simply do not exist to this day and thus cannot be traced.

Furthermore, I would like to point out in advance that the clock at the British Museum would need to undergo an examination like the one conducted in the GNM project on early portable clocks. The illustration of the movement and case provided to me from the British Museum's archives suggest that we might be dealing with a questionable construction here as well.

The clock in the Bisamapfel case with the PHN monogram, mentioned in the above text, has been extensively studied and scrutinized by experts in the field for years, with the result that this clock, too, has not been definitively attributed to Peter Henlein.

Acknowledgments

The interdisciplinary collaboration in the so-called Henlein Project of the Germanisches Nationalmuseum Nürnberg (GNM) was essential for obtaining my assessments in this documentation. The dedicated and close cooperation with colleagues from the Germanisches Nationalmuseum Nürnberg, Thomas Eser, Markus Raquet, Roland Schewe, and Johannes Eulitz from the MPS Dresden, not only inspired me to write this documentation but also proved to be valuable and highly motivated assistance during my investigations and studies on Peter Henlein. For this, they deserve my thanks and professional recognition.

I would also like to thank Peter Plaßmeyer for facilitating my access to the collection of historical Renaissance clocks at the Mathematisch-Physikalischer Salon Dresden. Discussions with him and his staff were stimulating for me and often helped me in my considerations.

For legal advice, I express my gratitude to attorneys Ketel Martin Preisler in Oberkirch and Wolf Gregor in Munich.

Finally, the most thanks go to my dear wife Brigitte, who, with her tireless patience, has consistently motivated and supported me in my work. In many diligent hours, she was also a valuable editor through her collaboration.

Special thanks are also extended to my daughter Manuela, who patiently assisted me in designing the layout.

Dresden - Meißen, 8th March 2024

Jürgen Ehrt
Restorer for historical clocks,
Expert in Renaissance clocks,
Publicly appointed and sworn expert
of the Chamber of Commerce IHK Dresden

FurtherReading

Abeler, Jürgen (1980): Jürgen Abeler, In Sachen Peter Henlein, Wuppertal 1980

Albrecht, Rud (1916): Rud Albrecht, Die Räderuhr, Druck und Verlag der Graph. Kunstanstalt Rud Albrecht in Rothenburg ob der Tauber, um 1916

Arnau,Frank (1959): Frank Arnau, „Kunst der Fälscher – Fälscher der Kunst“ - „Dreitausend Jahre Betrug mit Antiquitäten,“ Econ Verlag GmbH – Düsseldorf 1959

Ausstellungskatalog Uhrenmuseum Genf: Musée de´art et d´histoire, Musée de l´horlogerie, Genf 1990

Ausstellungskatalog MUSÉE D´HORLOGERIE LA CHAUX-DE-FONDS (1968): Horloges de Table Du XVI-Siècle, Collection J. Fremersdorf 1968

Ausstellungskatalog Württembergisches Landesmuseum Stuttgart (2001): Andrea Schaller, Prunkuhren der Renaissance, Stuttgart 2001

Ausstellungskatalog Württembergisches Landesmuseum Stuttgart (1974): V. Himmelein und J.H. Leopold, Prunkuhren des 16. Jahrhunderts, Sammlung Joseph Fremersdorf, Stuttgart 1974

Ausstellungskatalog MUSÉES D´HORLOGERIE LA CHAUX-DE-FONDS LE LOCLE (1993): Catherine Cardinal und Francois Mercier, Zürich 1993

Ausstellungskatalog Deutsches Museum (1986): Uhren und Automaten aus dem Vermächtnis von Werner Brüggemann, Kastner & Callwey, München 1986

Ausstellungskatalog Musée de la Renaissance Chateau d´Ecouen (1989): Catalogue de l´horlogerie et des instruments de précision du début du XVIe au milieu du XVIIe siécle, par Adolphe Chapiro, Chantal Meslin-Perrier,Anthony Turner, Edition de la Réunion de musées nationaux Paris 1989

Bassermann-Jordan, Ernst von (1920): Ernst von Bassermann-Jordan, Uhren - Ein Handbuch für Sammler und Liebhaber, Verlag Richard Carl Schmidt & Co., Berlin 1920

Bassermann-Jordan, Ernst von (1926): Ernst von Bassermann-Jordan, Alte Uhren und ihre Meister, Verlag Wilhelm Diebener G.m.b.H., Leipzig 1926

Bassermann-Jordan, Ernst von (1927): Ernst von Bassermann-Jordan, Die Standuhr Philipps des Guten von Burgund, Verlag Wilhelm Diebener, Leipzig 1927

Die Welt als Uhr (1980): Ausstellungskatalog Die Welt als Uhr. Deutsche Uhren und Automaten 1550 – 1650, hrsg. von Klaus Maurice und Otto Mayr, Bayerisches Nationalmuseum , München 1980

Donath, Adolph (1917): Adolph Donath, Psychologie des Sammelns, Verlag: Richard Carl Schmidt & Co. Berlin 1917

Bobinger, Maximilian (1969): Maximilian Bobinger, Kunstuhrmacher in Alt-Augsburg 1969, Abhandlung zur Geschichte der Stadt Augsburg, Schriftenreihe des Stadtarchivs Augsburg, Bd. 18, 1968

Cardinal, Catherine (1998): Catherine Cardinal, TRESORS d´HORLOGERIE, le Temps et sa mesure du Moyen Age à la Renaissance, Palais de Papes Avignon 1998

Cardinal, Catherine (2000): Catherine Cardinal, Les montres et horloges de table du musée du Louvre, Tome I & II, Réunion des Musées Nationaux 2000

Gabriel, Theresia (2004): Theresia Gabriel, Esterházy Schatzkammer, Uhr-Werke, hrsg. von der Esterházy Privatstiftung, Eisenstadt 2004

Coole, P.G. (1972): P.G. Coole & E. Neumann, The Orpheus Clocks, Hutchinson of London 1972

Dohrn, Gerhard (2007): Gerhard Dohrn-van Rossum, Die Geschichte der Stunde – Uhren und moderne Zeitordnungen, Anaconda Verlag 2007

Egg, Erich (1982): Erich Egg, Das Handwerk der Uhr- und der Büchsenmacher in Tirol, Universitätsverlag Wagner – Innsbruck 1982

Egger, Gerhart (1970): THEATRUM ORBIS TERRARUM – Die Erfassung des Weltbildes zur Zeit der Renaissance und des Barocks, Österreichisches Museum für angewandte Kunst, Wien 1970

Ehrt, Jürgen (2019): Jürgen Ehrt, Thomas Eser, Johannes Eulitz, Markus Raquet und Roland Schewe: „ Die Henlein-Uhr. Befund ihrer technischen Untersuchung. Jahresschrift 2019, Band 58, Deutsche Gesellschaft für Chronometrie e.V. , Nürnberg 2019

Engelmann, Max von (1927): Max von Engelmann, Die Burgunder Federzuguhr um 1430, Verlag des Zentralverbandes der Deutschen Uhrmacher E.V., Halle (Saale) 1927

Eser, Thomas (2015): Thomas Eser, Die Henlein Ausstellung im Germanischen Nationalmuseum: Rückblick, Ausblick, neue Funde, Jahresschrift 2015, Band 54, Deutsche Gesellschaft für Chronometrie e.V. , Nürnberg 2015

Eser, Thomas (2015): Thomas Eser, Die älteste Taschenuhr der Welt? – der Henlein Uhrenstreit. Der Band zur Ausstellung im Germanischen Nationalmuseum, Verlag des Germanischen Nationalmuseums, Nürnberg 2014

Fléchon, Dominique (2011): Dominique Fléchon, THE MASTERY OF TIME, Printed by Toppan Leefung – China 2011

Guye, Samuel (1970): Samuel Guye und Henri Michel UHREN UND MESSINSTRUMENTE des 15. bis 19. Jahrhunderts, Orell Füssli Verlag Zürich 1970

Graf, Johannes (**2019):** Johannes Graf und Eduard C. Saluz, Time Made in Germany, Jahresschrift 2019, Band 58, Deutsche Gesellschaft für Chronometrie e.V. , Nürnberg 2019

Grötzsch, Helmut (1978): Helmut Grötzsch, Dresden, Mathematisch-Physikalischer Salon, E.A. Seemann Verlag, Leipzig 1978

Hausmann, Tjark (1979): Tjark Hausmann, Alte Uhren, Katalog des Kunstgewerbemuseums Berlin Bd. VIII 1979

Hayard, Michel (2004): Michel Hayard, Chefs-d`oauvre de l`horlogerie ancienne, Collection du musée Paul-Dupuy de Toulouse, Francois Combal Paris 2004

Helmut-Kienzle-Uhrenmuseum (1984): Katalog der Sammlung, die nicht zur Versteigerung kam, Schellenberg Druck AG, Verlag Ineichen Zürich, Pfäffikon CH 1984

Koeppe, Wolfram (**1992):** Wolfram Koeppe, Die Lemmers-Danforth-Sammlung Wetzlar. Europäische Wohnkultur aus Renaissance und Barock, Heidelberg 1992

Koeppe, Wolfram (2019): Wolfram Koeppe, Making Marvels, SCIENCE AND SPLENDOR AT THE COURTS OF EUROPE, The Metropolitan Museum of Art – New York 2019

Kugel, Alexis (2016): Alexis Kugel, A Mechanical Bestiary, Automaton Clocks of the Renaissance 1580-1640, Paris 2016

Leopold, J.H. (1971): J.H. Leopold, THE ALMANUS MANUSCRIPT, Hutchinson of London 1971

Leopold, J.H. (1974): J.H. Leopold, Die Große Astronomische Tischuhr des Johann Reinhold, Augsburg 1581 bis 1592, Sammlung Joseph Fremersdorf, Luzern, Keller und Co. Luzern 1974

Lloyd, Alan H. (1964): Alan H. Lloyd, THE COLLECTOR`S DICTIONARY OF CLOCKS, Balding & Mansell Ltd, London 1964

Matthes, Dietrich (2018): Dietrich Matthes, ZEIT HABEN, Tragbare Uhren vor 1550, Carpe Diem Publishing Delaware USA 2018

Matthes, Dietrich (2015): Dietrich Matthes, Eine Uhr von Peter Henlein, Jahresschrift 2015, Band 54, Deutsche Gesellschaft für Chronometrie e.V., Nürnberg 2015

Matthes, Dietrich (2016): Dietrich Matthes, Petter Henlein – Eine Spurensuche, Jahresschrift 2016, Band 55, Deutsche Gesellschaft für Chronometrie e.V. , Nürnberg 2016

Maurice, Klaus (1976): Klaus Maurice, Die deutsche Räderuhr, 2 Bde., C.H. Beck´sche Verlagsbuchhandlung, München 1976

Maurice, Klaus (1980): Klaus Maurice und Otto Mayr, Die Welt als Uhr – Deutsche Uhren und Automaten 1550-1650, Bayerisches Nationalmuseum München 1980

Mitteilungen aus den Sächsischen Kunstsammlungen (1911): Das Meisterstück des Nürnberger Uhrmachers Paulus Schuster, Seite 31 ff., Leipzig, Druck und Verlag Breitkopf & Härtel 1911

Mitteilungen aus den Sächsischen Kunstsammlungen (1910): Die Uhrensammlung Pleissner im Mathematisch-Physikalischen Salon zu Dresden, Seite 82 ff., Leipzig, Druck und Verlag Breitkopf & Härtel 1910

Mraz, Gottfried (1980): Gottfried Mraz, Die Rolle der Uhrwerke in der kaiserlichen Türkenverehrung im 16. Jahrhundert, S. 39-54 im Ausstellungskatalog: Die Welt als Uhr. Deutsche Uhren und Automaten 1550-1650, München 1980

Neumann, Erwin (1967): Erwin Neumann, Der Königliche Uhrmacher Moritz Behaim und seine Tischuhr von 1559, Sammlung Joseph Fremersdorf Luzern. Druck: Christoph Reisser´s Söhne Aktiengesellschaft, Wien 1967

Oechslin, Ludwig (2006): Ludwig Oechslin, Johann Wolffgang Hartich Meisterstück, Augsburg, Athena-Verlag Oberhausen 2006

Oestmann, Günther (**2019):** Günther Oestmann, Räderuhren aus Nürnberg und Augsburg im 16. und 17. Jahrhundert, Jahresschrift 2019, Band 58, Deutsche Gesellschaft für Chronometrie e.V. , Nürnberg 2019

Patrizzi, Oswaldo (2009): Osvaldo Patrizzi, AN EXTRAORDINARY COLLECTION OF RENAISSANCES PRE-PENDELUM CLOCKS, Auktionskatalog – Patrizzi & Co. Milan, Italy 2009

Pippa, Luigi (1966): Luigi Pippa, OROLOGI NEL TEMPO, Sperling & Kupfer Milano 1966

Plaßmeyer, Peter (2009): Peter Plaßmeyer, Weltenglanz, Der Mathematisch-Physikalische Salon Dresden zu Gast im Maximilianmuseum Augsburg, Deutscher Kunstverlag Berlin München 2009

Schlosser, Julius von (1908): Julius von Schlosser, Die Kunst- und Wunderkammern der Spätrenaissance, Verlag von Klinkhardt & Biermann, Leipzig 1908

Sénéca, Bernard (2009): Bernard Sénéca, les Inventeurs du Temps – Trésors de la haute époque horlogèré (1500-1700), Degeorge, Arras 2009

Sotheby´s (2004): Auktionskatalog Masterpieces from the Time Museum Volume I, New York, October 2004

Tait, Hugh (1986): Hugh Tait, Clocks in the British Museum, W & J Mackay & Co Ltd, Chatham 1986

Tait, Hugh (1987): Hugh Tait and P.G. Coole, CATALOGUE OF WATCHES IN THE BRITISH MUSEUM, I – The Stackfreed, British Museum Publications Ltd, London 1987

THE ABBOTT GUGGENHEIM COLLECTION A NEW YORK KUNSTKAMMER (2015): Auktionskatalog Christie´s New York 27. January 2015

Thompson, David (2004): David Thompson, „THE BRITISH MUSEUM CLOCKS”, British Museum Press, London 2004

Thompson, David (2008): David Thompson, „THE BRITISH MUSEUM WATCHES”, British Museum Press, London 2008

Vincent, Clare (2015): Clare Vincent and Jan Hendrik Leopold, European Clocks and Watches in the Metropolitan Museum of Art, New York 2015

Vogel, C.F. (1774): C.F. Vogel „Practischer Unterricht von Taschenuhren sowol für Verfertiger, als auch für die Liebhaber derselben“, verlegt von Bernh. Christ. Breitkopf und Sohn, Leipzig 1774

Wagner, Michael (2016): Michael Wagner und Lena Hoppe, Dresdner Kunstblätter 3/2016, „ FÄLSCHUNG? Der Pokal der Dresdener Goldschmiedeinnung“ – Spurensuche zwischen Original und Kopie, Staatliche Kunstsammlungen Dresden 2016

Winters, Laurie (1999): Laurie Winters, A RENAISSANCE TREASURY – The Flagg Collection of European Decorative Arts and Sculpture, Milwaukee Art Museum, Hudson-Hills Press New York 1999