

Jacques David

Richard Watkins

American and Swiss



Watchmaking in 1876

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Reports to the Intercantonal Committee
of Jura Industries on the manufacture of
watches in the United States

1877

translated by
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Translated with permission of the Longines Watch Company.

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Preface to the translation

Significance

I was going to write a summary of the two reports written by Jacques David, but I found they contained so much covering so many aspects of watchmaking that I could not find a way to encompass them all in a few coherent words. Instead I have simply added some comments as footnotes in the appropriate places. However, there are two points that I would like to raise.

First, I believe this is the most important document in the history of modern watchmaking.

It contains the most comprehensive, detailed description of how American companies manufactured watches. The American watchmakers and mechanics were too busy making watches to bother describing how they did it, and so only a very small amount of patchy information was written down. It took a foreigner with an urgent need to provide us with a full and satisfying understanding of watchmaking at this time. For this alone the document is an outstanding contribution to our knowledge.

Further, it also contains a very important analysis of the state of Swiss watchmaking which, unlike many other books, does not try to be polite by evading unpleasant truths. David does not avoid the problems of a democratic society and the inevitable unscrupulous manufacturers who damage the reputation of the honest.

Second, I believe Jacques David can rightly be regarded as the father of modern Swiss watchmaking in the same sense that Aaron Dennison is regarded as the father of American watchmaking.

The lucidity, authority and perceptiveness of David's writing is astounding, and in hindsight we can see him as one of those very rare people who successfully and correctly guide others to a productive future. Undoubtedly neither David nor Dennison could have succeeded without the help of many others. But these two were the necessary visionaries, minds that could grasp the essence of a problem and drive themselves and others until they had successfully turned a dream into reality.

My admiration for David stems from his ten recommendations. He demanded the establishment of groups of manufacturers and associations, and organisations like Ebauches SA came from this.¹ He wanted the regulation of gold and silver standards, the development of the horological schools, the introduction of patents, the creation of mechanics' workshops, and even the fine detail of standardising screws, not to mention the introduction of machinery. This list encompasses nearly all of the main developments in Switzerland from 1877 onwards, and it doesn't include David's probable influence on industrial organisation.

1876 was one of the most important years in the history of horology throughout the world, and the American Centennial Exhibition at Philadelphia can rightly be seen as the catalyst for future successes and failures in America, England and Switzerland.

Because of the frequently quoted report by Favre-Perret², the effect of this exhibition on Swiss watchmaking is well if rather vaguely understood. The accepted wisdom, that the Swiss makers were shaken to the core by the competition from America resulting in a radical change towards mechanisation, can be seen to be wrong. Only a few people realised the imminent danger and initially the Swiss reaction was to bury their heads in the sand. It took considerable effort by David and others before the need to change was recognised and the Swiss were able to re-assert their previous dominance.

But 1876 was also a turning point in American watch making. Although the father of American watchmaking, Aaron Dennison, had conceived the idea of making watches by machinery some 28

1 See P. Coulon *Les Ebauches, deux siècles d'histoire horlogerie*, 1951, Baconnière. Coulon, who does not give sources, says the first ebauches syndicate was formed in October 1876 by some 20 manufacturers and included Malleray, Reconviiller, Landeron and Langendorf. David's report suggests the date may be wrong and should be 1877.

2 Favre-Perret: *Rapport présenté au haut conseil fédéral sur l'industrie de l'horlogerie, Exposition de Philadelphie 1876*, 1877. I do not know if this has been printed. Many authors quote one particular passage from it, but I suspect all these references come from a single original source. It is possible that the only information about it is in newspaper reports; Moore *Timing a century* (1945, Harvard University Press) cites a speech quoted in *La Nationale Suisse*, November 17, 1876.

years before and the Waltham factory had been producing movements for 22 years, all that this work had shown was that interchangeability was *possible*, but it had not yet been achieved.³

What happened after the public display of prowess in Philadelphia tells us a lot about the three major watch producers in the world; America, Switzerland and England. Their responses to a large extent set the direction for the 20th century. England, for reasons not well understood, ignored the message and its industry died. America continued, but after the first flush of achievement its industry became stale and suffered from leaders (such as Dumaine) who did not understand the message. In contrast, Switzerland, led by people like David, conquered the world.

Jacques David and the manuscript⁴

Jacques David was born in Switzerland in 1845. He showed a marked ability for mechanics and went to the Central School for Arts and Manufacture in Paris where he completed his studies in 1866.

On his return to Switzerland he began training as a watchmaker, but in 1867 he was invited by his cousin Ernest Francillon to join the newly formed Longines company. Both David and Francillon were convinced of the need to manufacture watches by machinery and Longines had been set up with this goal; indeed, Ernest Francillon is said to have been one of the first in Europe to embark on such a venture.⁵ Near the end of summer, Jacques wrote to his father:

I am working particularly with Mr Chatelain, our watchmaker-mechanic, the only pilot of this ship with regard to manufacture. He is an elderly person who knows a great deal about horology and mechanics and he has an almost inexhaustible collection of ideas. Unfortunately these ideas are muddled and cling to each other, his mind being an extremely complicated labyrinth. He leaps from one idea to another and stops at the most interesting. My role at his side is to execute that which pertains directly to production, to influence him and to draw his attention to problems which need to be solved.

Later, Jacques David took over control of the technical development, designing and building machinery.

The United States decided to celebrate the centenary of independence by organising a great international exhibition for 1876, after the style of the grand exhibitions that had preceded it in London, Paris and Vienna, and every country was invited to display their best products. Despite the poor economic climate and a financial crisis in the United States, Switzerland's watch and tool makers decided to attend. Edouard Favre-Perret was made a member of the international jury for pocket watches and Théodore Gribi led the Swiss delegation. The Longines company sent a watch to be exhibited as one which was entirely machine made; it made a great impression according to Favre-Perret: "*Mr Francillon is one of the Swiss pioneers of complete manufacture by machines and we owe him our sincere congratulations ...*".

3 I discuss the concept of interchangeability later. What I mean here is that some parts were interchangeable, but those which are most critical and most likely to be damaged (pivots, balance staffs and jewels) were not. This partial interchangeability was a great step forward, but until the critical components could be manufactured accurately by machines the making and repair of watches still depended on hand work. Landes *Revolution in time* (1983, Belknap Press) suggests this did not occur until the 1930s.

4 This is condensed from the biography by Jacqueline Henry Bédât and the history of the manuscript by Jean-Marc Barrelet in the 1992 Longines facsimile edition.

5 This points to a common problem; when someone writes of watchmaking by machinery it can mean many different things, including the mass production of similar but unique ebauches, making interchangeable watch parts and manufacturing complete watches. Japy had been making rough ebauches by machinery for a very long time and had been selling thousands of them to Swiss watchmakers. Japy, we are told, produced 43,000 pieces in 1780 (see, for example, Cutmore *Watches 1850-1980*). Jaquet and Chapuis *Technique and history of the swiss watch* (1945, Urs Graf) suggest that in 1793 he supplied 40,000 ebauches to the Jura. To do so he would have to have had about 1,300 workers to make the 80,000 plates and 200,000 wheels and pinions (based on 20 man days per watch and assuming making the ebauche took half of the total time to complete a watch). The Swiss also established an ebauche factory at Fontainemellon and Landes *Revolution in time* suggests that by the 1840s Japy and Fontainemellon were supplying 500,000 movements. There can be little doubt that interchangeability played no significant rôle.

From David's report we can be confident that Francillon had not yet envisioned interchangeability and "machine made" included a large amount of hand work, as at Waltham.

The Swiss delegation was shocked by what it saw in Philadelphia and Théodore Gribi summed up their reaction when he wrote:

During the last few days I have been examining, as an expert on the jury, the products and tools of the Waltham Watch Company (Massachusetts) and I must admit that I was filled with admiration for their watches of various types and quality, and for the splendid machines and tools that this factory has exhibited. It must be recognised that we have been left behind by our New World competitors and any Swiss manufacturer who comes here for more information will, without prejudice, be convinced of this point.

The general feeling was that, because of American competition the Swiss watch industry was facing the most critical crisis it had ever experienced.

Swiss watchmakers were well aware the industry had problems, and earlier in 1876 they had set up the Intercantonal Society of Jura Industries with the aim of protecting industrial and commercial interests in the region.⁶ When news came from Philadelphia, the Society agreed to send Jacques David to the United States to join Théodore Gribi in Philadelphia and carry out a study of the American watch industry.

Jacques David went to America from mid August to November 1876 and after going to the Philadelphia Exhibition he visited American factories with Théodore Gribi.⁷

After their stay in the United States, Edouard Favre-Perret and Théodore Gribi spoke openly about what they had seen, in an attempt to stir the Swiss watchmakers into action. Favre-Perret was reproached for having spoken so highly of the merits of the American companies, which used his words in their advertising. Théodore Gribi argued there was a need to imitate the American watchmakers:

It is thus a matter of not wasting time and getting to work to radically change our manufacturing methods if we want to preserve the watchmaking industry in our country. We must adopt American manufacturing processes, follow their system of uniformity and benefit from their experiments; then we will achieve victory, especially as the American customer favours us".⁸

An attempt was made to silence these experts, and the chronometer maker, Henry Grandjean of Le Locle, demanded the suppression of Théodore Gribi's account: "On reading the report which has just appeared ... I noted with surprise that it seems to be a glorification of their watchmaking industry, rather than the views of a Swiss delegate".

When Jacques David returned to Switzerland in November he wrote a long, detailed report which was presented to the Intercantonal Society in January 1877. Less than two months later, David wrote a second report which he presented to the Society. In this report he aggressively attacked the complacency and lack of action over the previous months and predicted the end of watchmaking in Switzerland unless his first report was treated seriously.

At the first meeting, the Society agreed with David's request not to publish his reports. Instead some eight manuscript copies were made to be distributed to members of the Society. At which point this document vanished.

But although his reports disappeared from view, Jacques David's opinions were heeded. As Jean-Marc Barrelet wrote:

Jacques David, Théodore Gribi and the others were the principal agents for the modernisation of the Swiss watch industry. With courage and perseverance they convinced

6 It is sometimes forgotten that the Swiss watchmaking industry was a massive part of the country's economy and, indeed, almost the sole source of income for much of the Jura and Geneva. Consequently, a crisis in the watchmaking industry threatened the entire population of Switzerland. In contrast, although watchmaking was important in America and England it was a minor part of the economies of those countries, utterly dwarfed by other major industries.

One indication of this difference is J.S. Ingram *The Centennial Exposition Described and Illustrated* (1876, Hubbard). There is not one mention of American watchmaking in its 770 pages.

7 Nobody has clarified who understood English. Presumably all three (David, Favre-Perret and Gribi) were fluent English speakers, but that may not have been the case.

8 Gribi is a little optimistic suggesting American consumers were on the side of the Swiss. David makes it quite clear that, except for perhaps price, the Swiss watch was not well regarded. But then telling the whole truth may not have been wise.

the tardy of the need for mechanisation and the need to persuade the watchmaking world to move from the bench into the factory.

In later life David continued working for Longines, becoming its director in 1880, and he participated in many horological organisations in Switzerland. He was also involved in public affairs and served on government bodies until his death.

Jacques David died 1912 and more than 1,000 people attended his funeral. A Swiss newspaper summed up his life in these words:

He was a technician, an administrator, a business man of the first order, with a precise, clear mind, and he was endowed with an uncommon capacity for work. He enjoyed to the full an undisputed authority and a confidence which were justified by his rare abilities, integrity and honesty. Fundamental to his character was kindness. The solution of various problems held his attention and he tried to resolve them peacefully and successfully. He will be remembered not only as an enquiring mind in the field of watchmaking, but even more as a noble-hearted man who continually and energetically strove for the good of his community and his homeland.

Perhaps only one copy of Jacques David's reports has survived and we are extremely fortunate that the Longines Watch Company found a copy. In 1992, on the occasion of the 125th anniversary of Longines and 115 years after the reports had been written, Longines published a facsimile of this extraordinary manuscript describing American competition and the complacency of the Swiss watchmaking industry.

The translation

I had some doubts about translating this manuscript when I read that some watch parts were made by sheep (moutons) and American watches are full of kittens (chatons). I was also occasionally discouraged by the difficulty of reading some pages, which probably would have been easy for a native French speaker but created some interesting problems for me. Still, unlike Mary Booth⁹ I know enough about watches not to be led too far astray by unlikely alternatives.

I have attempted to produce a readable translation. In doing so I have deliberately strayed from a literal interpretation of the words, preferring to find ways to express David's purpose in suitable language. I have been happy to rearrange sentences, paragraphs and illustrations to achieve this aim as best as I am able. Hopefully I have not introduced any misinterpretations in the process.

Acknowledgements

I am indebted to the Longines Watch Company for giving me permission to produce this translation. Also, I must thank Daniel Sauvage, who helped me with some obscure sentences, and John Kessell, who read the draft, finding many errors and making many useful suggestions.

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9 Mary Booth, *New and complete clock and watchmakers' manual*, John Wiley, 1860. This interesting but rather pointless book shows why understanding the subject is as important for a translator and a publisher as understanding the language.

First report, 22nd January 1877
Report
to the Intercantonal Committee of Jura Industries
on the manufacture of watches
in the United States of America.

Mr. President and Gentlemen,

The delegates that you sent to the United States to study the manufacture of watches in that country have the honour to present to you this report on their mission¹⁰.

The talks Mr. Favre-Perret recently gave to you revealed the immense progress in watchmaking achieved in the United States, and presented the current situation, which is extremely worrying for our country.

Unfortunately we can only confirm everything said by Mr. Favre-Perret; competition is very vigorous and very skilfully organised. It is high time we made serious efforts if we are not to lose more ground and be completely supplanted within a short time, by this industry which has existed for only a few years and which is already powerful and sophisticated.

Tests were carried out in Switzerland over the last few years based on what was known by hearsay of the American establishments. And although these tests were carried out on a very small scale and with insufficient resources and information, they showed that if we study the new methods and apply them suitably to our Swiss manufacture, we will obtain the same results as were obtained in America, probably avoiding most of the expenditure that our competitors had to make to organise their manufacture.

Thus we should not as yet despair of the future, but quite the contrary, we should study the new methods and courageously but prudently engage in them.

The investigation which was entrusted to us, the results of which we communicate to you today, should only be considered as a first step which will have to be followed by many others. Although we have made every effort to give you an idea of the state of matters as we found them, we could not, for lack of time and lack of favourable occasions, examine everything in detail. Moreover, this is a subject which changes continuously.

What distinguishes the American method of work in their watch factories, as in their other establishments, is their eagerness to make progress. Underpinning everything they organise is a comprehensive method of studying improvements in machines, simplifications in work, reductions in labour, and even organisation; in effect everything concerning the administration of their establishments in detail from a theoretical point of view. No detail is ignored, and the roles of all the employees are clearly defined and even more exactly controlled.

In their organisation a large place is reserved for studies and investigations in every field.

The two principal establishments, the factories of Waltham and Elgin, have complete technical offices, comparable to what is found in the large companies of Europe, but of which there is, as yet, no example in the watch industry.

We do not admit that at present the American industry has the state of prosperity and stability that it itself says it has, but we are convinced that with the methods it employs it will not be long before it acquires the qualities currently missing, because these technical offices will certainly perfect these companies and develop the best ways to work.

Thus it is necessary that the investigation started in 1876 be continued, so that the Swiss watch industry is directly informed of the situation in the United States.

On this subject we believe it our particular duty to insist on a significant condition that has to be observed if the continuation of this investigation is to be fruitful and produce useful and exact

10 The use of “we” in this report refers to the delegation and not to the authorship. There is little doubt that Jacques David was solely responsible for writing it; he explicitly states this at the start of his second report. It should be remembered that David was only 31 at the time and just a “boy” compared with the other people present. He may well have used “we” to give his opinions more weight. David frequently uses the neutral “one” which I have replaced by “we”. He was presenting his report to colleagues and friends and I have no doubt that his approach was personal and not abstract.

information. It is of the greatest importance that the information we have collected and which is contained in this report is not printed or published in journals, and so cannot be put in the hands of people who, either semi-officially or out of interest, would communicate it to the American competition.

The most exact information was obtained directly from visiting the factories, from discussions with employees, the workmen in particular, and finally from discussions outside the factories with well informed people. All these means are more or less in the hands of the companies which can take severe measures to prohibit visits to the factories and communication with workmen, which they will not fail to do as soon as they know that these visits and conversations were used to the profit of a Swiss investigation.

The employees at all levels, in fear of losing their jobs, will cease all communication. And it would be the same with people not in the factories, mechanics and others, who could be persuaded to be silent by some skilful means that the American companies will be able to discover, to keep us in ignorance. We have, moreover, to safeguard the interests of the people who provided us with information. Some are employed in the factories and their situation would be seriously compromised if an indiscretion occurred.

It is thus of the first importance not to talk about the present investigation and to communicate this report only to reliable people who can extract from it portions useful for this country. In this manner we can hope to maintain the relationships which we have made and continue to be informed by people in close contact with the factories¹¹.

We divided this work into seven parts.

- I The number and importance of American factories.
- II Financial condition of the factories.
- III Internal organisation.
- IV Production.
- V Sales.
- VI Manufacturing processes.
- VII Conclusions.

We have added to the chapter on manufacturing processes some sketches of the machines and like information. To the other chapters several addresses of manufacturers of tools and machines applicable to watchmaking have been added, with some examples of the current prices of American watches and movements, and advertisements produced by the United States factories.

Finally, we provide with the report a dozen movements chosen from the types which would directly compete with Swiss manufacture. These movements are accompanied by repair parts as they are made available to watch repairers in the United States¹².

11 I have never seen a reference to this report in other books and it would appear that this condition was scrupulously observed for 115 years. Also, it is likely that the American people who supplied information are and will remain unknown to us.

12 David says the following were annexed to the report when it was presented:

- 12 watch movements.
- Repair parts for watches with a table of their measurements.
- Advertisements.
- Details of salaries at Elgin.
- Details of patent regulations at Elgin.
- Leaflets and current price lists from watch manufacturers.
- Leaflets from and addresses of tool makers.

I Number and importance of American factories

Since 1845 there have been a number of attempts in the United States to manufacture watches and watch movements, and the factory system was adopted from the beginning.

The shortage of workers¹³ and especially the idea which dominated these companies, the idea that we will detail later, made the adoption of this system necessary.

The various establishments which have been created until now are as follows:

- 1 American Watch Company, Waltham Massachusetts
- 2 National Watch Company, Elgin Illinois
- 3 Springfield Watch Company, Springfield Illinois¹⁴
- 4 United States Watch Company, Marion N.Y.
- 5 E Howard & Company, Roxbury, Boston Massachusetts
- 6 New York Watch Company, Springfield Massachusetts
- 7 Robert Schell & Company, Newark N.Y., which became the Cornell Watch Company at Hyde Park, Chicago Illinois, and then the Cornell Watch Company, San Francisco.
- 8 Weston Watch Company.¹⁵
- 9 Fitchburg Watch Company.¹⁶
- 10 Tremont or Melrose Watch Company, Massachusetts
- 11 Rock Island, Illinois
- 12 Freeport Watch Company, Illinois
- 13 Rockford Watch Company, Illinois
- 14 Adams & Perry Watch Mfg Company, Lancaster Pennsylvania.
- 15 W.B. Fowle, Auburndale Massachusetts¹⁷

These establishments have had to overcome many difficulties and only some can be regarded as having produced good results. Others are still struggling or being created, but a great number have disappeared.

The companies which can be regarded as active and functioning are:

- American Watch Company in Waltham.
- National Watch Company in Elgin.
- Springfield Watch Company in Springfield Illinois.

Later we will give details of these establishments, which are the only ones that can usefully be taken as examples, and we will say a few things about the others now.

E. Howard & Company at Roxbury was for a number of years the best in respect to the reputation of its products. Its tooling is complete, although much less powerful than that of other factories, and the workshops have enough space to employ approximately 150 workmen. The manufacture of watch movements has stopped completely at this moment because of competition from other factories. It appears, moreover, that a recent change in the personnel of the factory has resulted in a notable reduction in the quality of its products, and consequently this company needs to find new customers.

At the moment the company has redirected its resources to the manufacture of pendulum movements and tower clocks, for which it enjoys a very good reputation. The facilities for clock manufacture are new, very large, and completely independent of the manufacture of watch movements.

The United States Watch Company at Marion is in liquidation. Efforts are being made to reconstitute the company, but considerable sums have already been absorbed by this factory and they seem to have been directed in a not very honest manner to the detriment of the shareholders. Its tools

13 David is one of the few authors I have read who is aware of the problem caused by the lack of skilled people. Although Dennison was motivated by the goal of interchangeability, he was also motivated by this very real problem.

14 Illinois Watch Company.

15 There is no mention of a Weston Watch Company in other books. David may be referring to the Western Watch Co, but other sources suggest this company was not created until 1880.

16 The history of the Fitchburg Watch Company is given in Meibers *The Fitchburg watch, history of a masterpiece*, 2002, Martin & Lawrence Press.

17 The Auburndale Watch Company.

are in very bad condition and the principals have lost hope. The capital of this defunct company was about a million dollars and the stated liabilities have risen to \$1,700,000 with the tools not being accounted for much value.

The facilities are imposing and housing for workmen was provided by the company. This factory still does some work, probably finishing movements that had been started, but everything shows signs of discouragement and complete abandonment.

The New York Watch Company of Springfield Massachusetts has complete tooling to produce good movements. The establishment has had to be sold and has been idle for several months. The products, though of good quality, cannot be sold because their prices appreciably exceed those of the watches made by the large factories.

The factory at Newark (Robert Schell & Company) was organised at the instigation of Mr. Adams, the founder of Marion. This factory was soon transferred to Chicago where it took the name of the Cornell Watch Company and it was useful, we were told, as an instrument for land speculation.

It was enlarged with some of the tools of another failed company, Rock Island, and was sold to a business in San Francisco. It was transported to that city preserving its name of Cornell Watch Company and worked for only a little time. The tools are now idle and the company has been dissolved. It was this business that wanted to use Chinese labour. The attempt could not be continued because of resistance from other workmen.

We could not collect any positive information on the Weston and Fitchburg factories. They probably have not existed for long.

The factory of Tremont or Melrose was established 8 miles from Boston and directed by Mr. Dennison. This establishment was sold and transported to England in 1868 and we have been told that it is still under the same management.

The factory of Rock Island in Illinois, not far from Chicago, had a very short life. Its tools were sold to the Cornell Watch Company and to Freeport.

The Freeport company was created recently; it was set up in 1872. It was established about 70 miles to the west of Elgin and had started to produce watches when the buildings and tools were destroyed by fire in 1874. The shareholders did not start another business. The tools, we were told, had been in good condition and came partly from the Rock Island factory.

The factory at Rockford, Illinois is at this moment being constructed. It is directed by former workmen of Elgin whose aim is to produce quality movements. The stated capital is \$150,000, but not all of it has been provided because work has stopped recently in consequence of lack of funds, and the sum spent to date does not exceed \$90,000. The shareholders appear to fear the consequences of the current crisis and want to wait until better times.

At the moment the factory employs 70 workmen who produce about 10 movements per day. Construction is of brick, after the style of Elgin, and could contain 300 workmen.

The Adams & Perry Watch Company, in Lancaster Pennsylvania, is at this moment making tools which will be able to produce 40 movements per day. The construction of the building is extremely elegant. It is composed of a central block of 4 floors with 8 windows in the facade, and two wings with three floors. These facades have 36 windows on each floor. The style is like that of Elgin.

The factory of W.B. Fowle in Auburndale Massachusetts awaits its tools which are being built in Newark, N.Y. The goal is the construction of a special watch whose movement rotates and is pendant wound. This system is very complicated and does not appear, on first examination, to have the advantages which the inventor claims.

The factory called the Philadelphia Watch Company imports its products from factories in Switzerland.

American Watch Company in Waltham, Massachusetts

In 1845, Mr. Dennison, a watchmaker in Boston, suggested to Mr. E. Howard the idea of competing with overseas factories by manufacturing watches by mechanical processes. They entered into partnership with Sam Curtis of Boston and in 1850 founded the first watch factory in the United States at Roxbury. After producing approximately a thousand movements in that factory, they formed a new company under the name of the Boston Watch Company.

One person remembers having gone with Mr. Dennison to the watchmaking localities of the Jura and remaining there during the years 1850 to 1852, to study Swiss manufacture and to base the procedures that he initiated in the United States on this knowledge.

The new company moved its establishment to Waltham Massachusetts, approximately 10 miles from Boston, and in 1854 an incorporated company was formed.

In 1857 this company went bankrupt and the property was sold at auction. It was bought by R.E. Robbins of New York, on behalf of the Appleton Tracy company, for a sum of \$56,000. This included a certain quantity of land around the establishment. The property of the business was soon transferred to the Waltham Improvement Company which was composed of the owners of the land close to the factory on the south side of the Charles River.

At this point in time the American Watch Company was founded and was incorporated in 1858, with a capital of \$200,000, raised soon after to \$300,000 by subscription. This capital was successively increased to its current figure of \$1,500,000.

The buildings of the American Watch Company now cover two acres and easily contain the 900 people who work there. This number could be increased somewhat. The space between the various buildings is occupied by elegant gardens and very neat lawns surround the establishment.

The land, which originally belonged to the Waltham Improvement Company and which was approximately 100 acres, has been covered with cottages and apartment buildings, some constructed by the employees and workmen. There are currently nearly 300 houses of various types and sizes, but all comfortable. They are mainly surrounded by gardens filled with fruit trees, flowers and lawns, which give this industrial district a remarkable appearance of prosperity.

The tools at Waltham are valued at \$400,000 and would, we were assured, cost as much to make now. The expenditure on their construction was vastly higher than this figure^{17a}. It is estimated that the grounds and buildings cost \$300,000. The total capital of the factory is \$1,800,000.

The driving force is provided by two steam engines, one of 25 horsepower and the other of 30 horsepower.

National Watch Factory, Elgin Illinois

The factory in Elgin was founded by the current owners in the year 1863, at the instigation of Mr. Adams. It was incorporated and appears at this moment to be prosperous.

The buildings, only finished in their current state in 1874, are vast and elegant. They contain at the moment 650 employees producing 225 movements per day, but they can certainly, like Waltham, be occupied by more than 900 workmen.

The driving force is furnished by a single steam engine of 75 to 80 horsepower.

We were told that the original capital did not exceed \$800,000 and, moreover, all of it was employed in the construction of the buildings and tools.

The shareholders of the factory charge a very small interest and push for the development of the factory.

Springfield Watch Company, Springfield Illinois

This company was also incorporated. It employs 300 people and manufactures 80 movements per day.

The different factories in the United States have as much good intelligence of each other as comprise the requirements of business, and a few reports that they naturally share. They have the same interests and their principal difficulty at the moment is to place their goods.

The successive lowering of prices, and the economies that are made, do not have as their main objective the destruction of competition from the small American factories, which have very little effect on the large establishments. They are aimed at getting work and selling their products to the detriment of imported goods.

The three principal firms, which are actively working at present and prove to be reliable, enjoy the confidence of the public.

The establishments which are in deep water¹⁸ are well supported and they languish at present only because of the bad business conditions and general distrust. As soon as there is a recovery their

17a See Hoke *Ingenious Yankees* (1990, Columbia University Press) which gives investment in machinery for 1859 to 1879 (including miscellaneous costs and, presumably, maintenance).

18 *océation?*

shareholders will again take courage and work will be re-activated. It is certain that at the same time companies like Howard and Springfield Massachusetts, which proved reliable and which have good tools, will not remain inactive.

If we compare the position of the United States factories to those factories which import their products, we find that the former are in a particularly favourable position, thanks to protective duties. But we should not exaggerate the advantages of this position. These factories must employ more expensive workers, all wages are higher than in Europe, which compensates over and beyond the difference of the tariffs. The American firms without their machines, which reduce labour, would be totally prevented from competing because of the daily rates of workers and the high cost of employee salaries.

So, with regard to the importation of Swiss watches, a lowering of import duties would not make a big change to the current balance. If, one day, the laws were struck out and import duties were abolished only on the watch industry, there would be need to examine the impact of this abolition, but it is probable that tariffs would be reduced initially on articles of greater consumption than those of the watch industry.

This lowering would necessarily produce a significant fall in the general expenditure of the country, and the watch factories would benefit, like any other industry, from the lower cost of labour which would then occur. The lowering or suppression of tariffs on all imported goods would only modify the current circumstances in that importers could, more easily than now, export to other markets the goods for which they have no use in the United States. We can wonder whether this action would not be prevented by other obstacles and if it would be really applicable.

In the future, the number of watch factories will rise if those which currently exist succeed in maintaining themselves and increasingly drive out foreign competition, which they are in a good position to do.

It is a very significant consideration for countries who, like ours, live by the manufacture of watches. They must take the necessary steps as fast as possible to transform their manufacture in ways which cannot be avoided.

The more we wait, the more America will have time to create tools and the more likely it is that her companies will succeed and firmly place themselves. One of the obstacles which they will meet, due to the fast and uncertain development of the number of factories, is the difficulty of finding men able to direct a manufacture both complicated and delicate.

On the other hand, we must warn that when business returns to normal conditions capital will take the opportunity to lay the foundation of a watch company with skilful men moving into this manufacture.

In the same way the existing factories will be able to increase their capital by the issue of new shares. But this facility is extremely variable from one company to another, and it would certainly be impossible for some which do not have the means to do it.

Elgin and Waltham who, in these variable years, have considerably increased their capital by accumulating profits, would easily find new capital if it were necessary.

II Financial Conditions

Information about the capital absorbed by the United States factories, from the time of their creation, is very difficult to obtain.

The Waltham factory was bought in 1857 for \$56,000. It had previously been three different companies which had improved the tools, enlarged the buildings and hoped for success. These first three companies were ruined, and the fourth was also on the point of collapsing when the American Civil War revitalised it, by suddenly creating the need for a great number of watches which importation alone could not satisfy. From this time the fourth company built a reputation on the good quality of its products and it achieved significant successes.

The National Watch Company of Elgin has never lacked. The shares are in the hands of some financiers in Chicago, from whom we could not obtain information. The subordinate employees and the workmen do not have even a few shares; all have remained with the first owners and we do not know if there have been several calls for funds, but it is more than probable because the initial capital was advertised as \$200,000 and it is currently \$800,000.

The factory at Springfield Illinois operates under same the conditions and we could learn nothing.

The establishment at Springfield Massachusetts has cost a lot; it has to be sold at the full price raised, which must be lower than the sums expended on the construction of the machines and buildings. We were told that the selling price is \$125,000 for tools able to produce 60 movements a day and which have not produced more than 40 until now.

The owners of the Cornell factory in Chicago were speculators in land and it is said that this venture succeeded. The establishment in Chicago is now occupied by the Wilson Sewing Machine Company and the land in question is built up.

It is estimated that the sum expended on the creation of the American watch factories exceeds \$10,000,000; the capital of these factories can be estimated as approximately \$3,500,000, currently being worth between 40% and 85%.

The watch factories, being mainly private companies, do not publish any reports and it is difficult to know exactly what dividends they pay.

It is from Waltham that we could draw the little definite information that we have.

In the past this company has remunerated its capital as follows:¹⁹

In	1859	it paid	3.25%
	1860		13%
	1861		0%
	1862		4%
	1863		11%
	1864		22%
	1865	60%	plus 150% in stock.
	1866	28%	
	1867	5%	
	1868	11%	
	1869	20%	
	1870	20%	plus 66% in stock.
	1871	18%	
	1872	12%	
	1873	12%	
	1874	5%	
	1875	6%	
	1876	3%	

In 1865, the capital, which was \$300,000, grew to \$900,000 in consequence of the profits of that year; it thus tripled in only one year.

19 These figures are probably a reasonable reflection of the state of the American economy. As David notes, his visit occurred during a period of depression and perhaps he did not stress this enough. Later he comments on the problems Switzerland experienced during the good years of 1863-66.

This almost incredible success, affirmed by all the people who know this American company, was the signal for the creation of several other companies, which later failed because of the weakness of their resources and bad management.

It is said that Elgin has never paid more than 3% to 4% to its shareholders, and that its profits have been used to increase its facilities and to supplement and improve its tools. Based on the importance of tools and facilities, the profits must have been comparable to those of Waltham.

The shares of these companies, as we have said, are not quoted on the market and we do not know how they have varied.

However, it is known that shares in Waltham, which were first sold at \$100 in 1862, have gone up to \$250 in 1865 and 1870. At the moment they are worth \$80 and it is possible that they cannot be bought. The employees of the company have only a small number of them, excepting the higher management. The latter, moreover, participate in the profits, and this participation is reputed to be very significant. We could not determine the amount of it.²⁰

The capital of all these companies is constituted in shares. There can be obligations on privileged shares, but the public is unaware of them.

The overheads of the large factories being very considerable and of much importance to these companies, the principals engage in, and many personnel are employed on, monitoring and control of the work; personnel without whom it would not be possible to obtain the quality and the uniformity which distinguish the products of these American factories.

We will give some figures which can only be approximate but which we can guarantee are sufficiently exact to be of interest.

With this detail of overheads we will include some information concerning the expenditure on labour and you will be able to see the approximate cost of movements in a large factory.

From 1873 to 1875 salaries of the superintendents at Waltham rose from \$3500 to \$6000. The foremen were paid from \$1500 to \$3000. The treasurer received \$10,000. There is a tendency for these figures to fall and we will take this into account.

We know that Waltham has 930 employees who can be divided into 2 categories; those whose work is the manufacture of movements and those who work on cases. We estimate the number of workmen who make cases at 120 and we will deal only with the other 810²¹.

We know, moreover, that the factory spends approximately \$50,000 per month on this personnel, omitting case manufacture; and approximately \$60,000 per month including case making.

We will divide the overheads as follows:

2 superintendents	at \$4000 to \$6000	\$10,000
3 office employees	at \$1800, \$1600, \$1200	\$4,600
20 foremen with	2 at \$2500	
	5 at \$2100	
	5 at \$1800	
	8 at \$1500	\$36,000
10 examiners with	5 at \$1100	
	5 at \$500	\$8,000
10 clerks	at \$380	\$3,800
5 assistant foremen	at \$1000	\$5000
50 mechanics	10 at \$1200	
	20 at \$900	
	10 at \$800	
	10 at \$500	\$43,000
Heating and engine		\$4,500
Insurance	at 0.75% on \$800,000	\$6,000
Gas lighting		\$3,500
Building repairs and maintenance		\$1,000

20 See Moore *Timing a century* (1945, Harvard University Press) for more details.

21 800 in the ms, but 810 is meant.

Night guards, cleaning, scouring, transport	\$5,000
Various imported watch parts, jewels, balances	\$4,800
Various watch parts bought in America	\$2,400
Steel, brass, oils, tools, jewels, grinding stones, etc.	\$75,000
Total²²	\$213,100

The distribution of this expenditure per piece gives:

For 80,000 pieces per annum (258 x 310), per piece ²³	\$2.66
For 100,000 pieces per annum (322 x 310), per piece	\$2.13
For 120,000 pieces per annum (385 x 310), per piece	\$1.77

The number of people employed on movement production is 810, approximately 115²⁴ being included in the list above.

There remain 695 people for whom we can detail the wages as follows:

310 women who earn on average	\$1.00	\$310
20 apprentices who earn on average	\$0.70	\$140
365 workmen who earn on average	\$2.50	\$900
695 workmen earning together per day		\$1,350
Total annual expenditure on labour \$1,350 x 305		\$411,750

This amount on each piece is:

80,000 pieces per annum gives for each piece	\$5.15
100,000 pieces per annum gives for each piece	\$4.12
120,000 pieces per annum gives for each piece	\$3.44

The expenditure of the factory would thus rise to:

Overheads	\$213,100
Labour	\$411,700
Total:	\$624,800

which is approximately \$52,066 per month.

If we allow only 6% interest on a capital of \$1,500,000, the \$90,000 necessary would be:

on 80,000 pieces per annum	\$1.12
on 100,000 pieces per annum	\$0.90
on 120,000 pieces per annum	\$0.75

The least cost for these movements would be, on average:

	80,000 pieces	100,000 pieces	120,000 pieces
For overheads	2.66	2.13	1.77
For labour	5.15	4.12	3.44
To service the capital	1.12	0.90	0.75
Total	\$8.93	\$7.15	\$5.96
	Fr 41.95	Fr 33.60	Fr 28.00

computing the dollar at Fr 4.70.

If this factory made five hundred units per day, as some supporters say it will do in 1877, which is about 150,000 movements per annum, the cost per movement could drop to \$4.75 or approximately 22.00Fr²⁵.

22 David, although aware if it, has not included depreciation of the machinery, which would add perhaps \$0.50 per movement depending on the period over which the cost is written down. He has also omitted the treasurer.

23 258 x 310 = 79,980, 322 x 310 = 99,820, 385 x 310 = 119,350. Although coincidentally there are 310 female employees, David means the number of movements made per day over 310 working days. Unfortunately a few lines later he chooses 305 working days. 310 days represents working 6 days per week with an extra 3 or 4 days off. 305 days represents the same pattern with an extra 9 days off.

24 125 in the ms, but 115 to be consistent.

25 From serial number figures (such as Waltham Watch Company *Serial numbers with descriptions of Waltham movements*, 1954), 1857-1877 can be viewed as the developmental stage when it took 20 years to produce

We repeat that the above calculations are only approximate and, especially, that there is an extremely variable state of affairs at this time. A fall in wages and salaries can change all these figures completely.

A similar evaluation could be done for the other establishments of less importance, by taking one as a model, but it would be of little interest because the data which can be obtained is extremely dubious; none of these less important establishments are running normally at the moment.

We can be sure that, regarding production costs, no establishment at present is in better condition than the large factories of Waltham and Elgin.

To the overheads mentioned above it is necessary to add an expenditure which is slowly rising, but which is real and extremely high. This is the cost of the sale of products, that is to say advertising and entertainment.

Advertising absorbs enormous sums. We have been assured that in 1874 Elgin alone spent \$15,000²⁶ on advertisements in journals, almanacs, catalogues sent to jobbers and retailers, address cards, pewter medals used as certificates, and watches given to people whose co-operation or appreciation is useful. Waltham did not lag behind and we were told they spent a similar sum in 1875. At the moment this expenditure is not as high as \$15,000, but it is still extremely high and all possible methods are employed to make the public aware of the progress of this industry and how they can procure the products.

We were told that there are always articles in journals on this subject and it is not just in a few trade journals, as would be done in Europe, that these advertisements are placed. It is in all journals. The public reads stories and boasts of Waltham and Elgin everywhere, it cannot avoid them, it is urged to buy their goods by every journal which is opened.

These advertising activities will certainly redouble to let the whole world know of the successes obtained by American movements at the Philadelphia Exhibition. We must be very careful that this report, which flatters United States manufacture a little, is not used by them in their provoking advertisements.²⁷

We should not be very far from the truth if we estimate \$80,000 per annum as the current average expenditure of these two factories. But we should not count this as a regular expenditure, because it can decrease considerably or even cease once the effect produced is judged to be sufficient.

The smaller firms are much more modest in this area and are satisfied with some advertisements in watch industry journals and the publication of their current prices.

The two big companies have, moreover, agencies in the principal towns of America and even in Europe. Waltham has agencies in Boston, New York and London. Elgin has agencies in New York, Chicago, London and St Petersburg. These agencies are extremely luxuriously organised and must significantly increase the price of the products so that it would not be correct to ignore them.

It is estimated that the overheads of the Waltham agency in New York are at least \$100,000 per annum and that the office in Boston costs the company approximately \$50,000. The rent of the London office alone costs Fr 25,000, and the representatives salaries must be considerable, if one judges by appearances.²⁸

1 million movements. The second million was produced in only 6 years from 1878-1883, an average of about 170,000. Thereafter a million movements took about 3 years between 1884 and 1889, and 1 or 2 years from then on. During this time the number of man days to make one watch plummeted from about 22 in the first years to about 3 in 1865 and then gradually declined, being about 2.5 in 1876 and less than 2 from about 1889 onwards (see Moore *Timing a century*). Thus David's calculations were too conservative and unit costs for yearly productions of about 200,000 movements would have been more realistic and more terrifying.

26 Both figures in this paragraph are \$150,000 in the ms. Moore *Timing a century* gives the actual expenditures by Waltham from 1865 to 1877 and it never exceeded \$65,000. I am assuming \$150,000 is an error. In 1875 Waltham spent \$17,131.25 on advertising and in 1877 it rose to \$45,442.51, including \$15,054.27 for the Centennial Exhibition. Perhaps David meant francs.

27 In this first report, David tries to be polite. A mere two months later he found that the Swiss reaction to this report was, also to be polite, passive. In his second report he becomes aggressive and at time rude as he attempts to stir the Swiss watchmakers out of their complacent lethargy. He succeeded.

28 As in the case of the advertising expenses, these figures seem incorrect. It may be that they are all given in Francs, in which case they are more sensible. Fr 25,000 was about \$5,320.

These large companies need to sell a lot to maintain their workshops, which forces them to be somewhat careless about the placement of their goods, and many losses have resulted which do not contribute to increasing their profit.

All these elements of expenditure must be taken into account and must appreciably modify the cost price per unit which we established above.

If we suppose an average production of 100,000 movements and we roughly distribute them between the most usual watch styles, we find that the sale of 100,000 movements would produce:

1,000	pieces	American Watch Company:			
	with	30 pieces at \$150			\$4,500
		150 at \$100			\$15,000
		400 at \$50			\$20,000
		420 at \$25			\$10,500
3,000	pieces	Appleton Tracy Co.	at \$30 list	net \$14	\$42,000
14,000	pieces	Waltham Watch Co.	at \$30 list	net \$14	\$196,000
16,000	pieces	P.S. Bartlett	at \$23 list	net \$10.55	\$168,800
16,000	pieces	W. Ellery	at \$13 list	net \$6	\$96,000
25,000	pieces	Home Watch	at \$11.50 list	net \$5.30	\$132,500
25,000	pieces	Broadway	at \$9.50 list	net \$4.40	\$110,000
100,000	pieces sold, producing about				\$795,300

These movements cost approximately \$7.15, as was established on page 16:

100,000 x \$7.15	\$715,000
Difference in favour of the company	\$80,300

This sum is certainly not enough to cover the additional overheads and the considerable sale costs which we considered above.

The distribution that I made above, of the 100,000 pieces between different qualities, is purely an assumption that I believe is close to reality. The relative quantities of production in each quality varies so much that we could not collect consistent information on this subject. If, for example, 10,000 Broadway were replaced by 10,000 P.S. Bartlett there would be an additional income of $10,000 \times (10.55 - 4.40) = \$61,500$. However, the statistical nature of this information does not completely prevent us making the above calculations with reasonable certainty.

The current crisis weighs as heavily on these firms as on European companies. But it is less likely to lead to their ruin because of their advancement and their consolidation; at least with regard to the two large factories which are well supported to survive the crisis, or they seem to be.

At present these factories have introduced significant economies in administration, the system of manufacture, the cost of monitoring and control, and especially labour. At the point which they have reached, and with a personnel perfectly accustomed to the current tools and the uniformity required in the work, these reductions can be made with great likelihood of no deterioration in quality, and they will almost certainly produce an increase in quantity, as is generally the case.

The factory at Waltham, after closing during July and August 1876, resumed in September with a hundred workmen, and in October and November worked only 5 days per week.

Elgin closed in 1875, but at this moment it is increasing its personnel and is asking its workmen to extend working hours to produce more.

The Waltham company had between 50,000 and 60,000 unsold movements in October and November, these movements representing a value of at least \$600,000. Elgin did not have any stock to sell and, on the contrary, had very large orders to fill. The opposite situation could occur, because these two companies are on an equal footing with regards to the quality and prices of their products.

The efforts of these companies to lower their prices are generally not regarded as being intended to harm each other, although it is actually one of the direct results of this drop.

These efforts are openly directed at imports. The Americans want to drive out the Swiss watch and have a monopoly. They imply that they can make the necessary sacrifices to discourage importation for a long time, and that they will do so.

It appears difficult for such an impertinent undertaking to continue seriously for a long time, because a result of this fight is that the principal factories must sell too cheaply to be able to

adequately remunerate their capital, and they cannot hope to suppress any manufacture in Switzerland.

Neither can they hope to produce enough to satisfy the American market by themselves. At the moment they only make 250,000 movements, and that is only a part of what the United States consumes in normal times. It will take them a considerable time to develop their establishments so that they can produce all that the United States needs.

The factories will be obliged to raise their prices before reaching this goal, and importation will immediately benefit from this rise. And so, after driving out imports, the period during which the United States factories would control the market, and would be able to raise their prices, would be much too short for them to make up for the sacrifices which they will have made in the pursuit of this illusory target.²⁹

29 David makes no reference to smuggling, which later became a significant tool in the fight against tariffs and had been used extensively for exports to France and England. See Moore *Timing a century*, 1945 and Bowring *Report on the commerce and manufactures of Switzerland*, 1836, His Majesty's Stationery Office.

III Interior organisation

Regulations, principal officers, organisation, accounting, stores

The regulations of the large American factories are made to ensure, as far as possible, order and monitoring of the work in these great agglomerations of workmen occupied in meticulous work.

These regulations must necessarily be severe, but we cannot say that they are excessive and that they require workmen to give up too much freedom, if we consider how much this firmness facilitates production and contributes to maintaining the quality of the products. We can say that it is to the benefit of each workman to observe the rules, and he understands that all of his interests are dependent on the company.

The monitoring of arrivals and departures during regular hours, and outside them, is done in a precise way. At Elgin and Waltham everyone must enter the workshops before the time to begin work. The entrance to the factory is closed exactly at that hour, and from that time a gatekeeper notes the time of arrival of all latecomers. He also notes all departures during working hours.

Absences from each workshop are constantly controlled by the foreman or his assistant, and each workman who has to leave must ask permission. Foremen who have to leave the establishment must request authorisation from the superintendent or his substitute.

The purpose of this system is not only to obtain well organised work and to make too frequent absences known, which would be the cause of irregularity in such an employee, but it is also to determine exactly what the work costs. The notes taken by the gatekeeper, combined if necessary with those taken by the workshop heads, are used by the superintendent to establish the time employed on various jobs, which he does for the day's work because it is done at piece-rates.

This question of cost price is one of great significance in these establishments. They have until now made considerable sacrifices to become established, and to equip and organise their work. They have, as we can see, completely succeeded in this regard, but they have not yet adequately remunerated their capital. They consider their products too expensive for the fight they are engaged in, and it is this point to which efforts are being directed.

The observations which they make, by the means outlined above, indicate to them exactly what each workman earns and allows them to haggle with them over prices for this or that work. It is based on this knowledge that the last drop in wages was made with an authority that any reasonable person could not oppose.

Inside the factory, the employees and workmen do not smoke, and they do not whistle or sing in a way that inconveniences their neighbours. They do not go from one workshop to another, they do not talk loudly, and the greatest courtesy reigns in the relationships between all personnel.

The observation of these simple details facilitates the work of everyone. The workmen are free to give all their attention to their activities, and a perfect cleanliness and peace reigns in these workshops that, from the point of view of work, one could not find better anywhere else.

Drunkenness is absolutely forbidden and it is not tolerated in any factory. The workmen can use their evenings and Sundays in any suitable way, and it is rare that repressive measures have to be taken against them for this vice.

In ordinary circumstances, the rules require a reciprocal two weeks notice for the resignation or discharge of a workman.

The general direction of the factory is given to two people, each of whom has their speciality and who must work in collaboration. These two people are the Director (Business Manager) and the Superintendent of tools (Mechanical Superintendent).

The Director is charged especially with carrying out the resolutions of the company's Board of Directors, and he is required to deal with the interests of the company and the factory on outside matters.

It is his duty to pay wages, organise the books and be responsible for all the company. He must prescribe or advise the foremen (the heads of workshops) on keeping the books, accounts and reports which they must maintain to control the quality, quantity and price of production. He must deal with all the supplies to be purchased and organise the factory and outside suppliers so that all

the assortments³⁰ are complete and ready to use. He gives the necessary directions to keep the workshops active and fixes the type and quantity of work to be undertaken. He contracts with the staff and workmen for work and oversees its execution.

The Superintendent of tools deals with the machinery. He gives directions to the foremen to achieve the wanted production and he must take care of the cost and quality of production. He must deal with producing the goods required by his fellow superintendent and work with the foremen on all questions relating to tools, the improvement of tools, raw materials, the workmen whom they require or who are in excess of needs, the means of preventing manufacturing errors and fixing them, etc.

These two high employees must confer together on all these questions to give the same direction to their efforts. Special rules regulate their sharing of responsibility to the board of directors and define the particular and numerous points which they must study in collaboration.

They each have their own office with the necessary book keepers, secretaries and draughtsmen, and usually the Superintendent of tools also has a specialist who deals only with the organisation³¹ of the machines and the introduction of improvements suggested by practice or competition.

Work is carried out in a number of workshops which are under the direction and monitoring of heads of department or foremen.

There are 15 to 20 of these departments in the large establishments. There are fewer in the small companies, but the organisation is the same.

The *foreman* or workshop head is responsible to the two directors and the board of directors for the observation of regulations by himself and all the people in his department. He is responsible for all the details of his department, whether or not they are mentioned in these regulations. He is responsible for all that relates to quality, quantity, price of the work, the orders in his books, direction of the workmen, good harmony in his workshop, etc. For all that he deals directly with the workmen; he engages them in his workshop, fixes their wages, discharges them or modifies their conditions.

He must communicate with the two directors and co-operate in a friendly way with all the other employees in the interests of the company, correct and avoid errors, lower costs, improve quality, and generally improve his department.

While having, to a large degree, the right to take initiatives, each foreman must observe certain rules when he believes it is his duty to introduce any improvement, so that everyone is warned of this improvement and all departments can contribute to it.

Wherever possible each department has an assistant who is jointly appointed by the two directors and the foreman of the workshop. The functions of the assistant are the same as those of the foreman. He replaces him in the event of absence and works under his orders on the monitoring and organisation of the workshop. In general the assistant is selected from the mechanics who have given satisfaction over several years of service. He is more or less designated to succeed the foreman and the latter must keep him up to date with all that is done.

Each of these employees has the right to communicate directly with the board of directors if, after having discussed some measure with the directors or the other heads of departments, they take a contrary position to that of the foreman and he does not want to take full responsibility.

A very formal etiquette is used for all relationships between the higher executives and their subordinates, but nevertheless everyone has the right to express his opinion and to have it examined, and this is one of the reasons for the extraordinary progress of this industry in America.

In each workshop there is an office for the foreman. This office contains everything necessary to facilitate the running of the department. The books are kept there by one or two young ladies who, under the direction of the foreman, distribute the work and take part in counting and inspections. They record the incoming and outgoing jobs and the time wasted, they keep the notebooks and have a place in the workshop to usefully employ the time which is not taken up by their clerical work.

30 *assortiment*. A complete set of parts that belong together, such as the pieces that make up an escape-ment. The English word *assortment* is used in this sense. However, the word is also used to mean a set of similar items, as in the chapter on cases.

31 *combinaison*.

For difficult inspections, the foreman has at his disposal the necessary number of *examiners*.³² During the day, some workmen help the assistant to adjust the machines and to monitor the workers regarding the quality of their work.

In general the workmen look after their own gravers, drills, etc., and have at their disposal the means for measuring and checking their work so that it conforms exactly to the established model.

Almost all workmen have to ask for help from the assistant or their neighbouring workers for the maintenance of their tools. The automatic machines monitored by the workmen are not touched except by special mechanics.

The working hours are usually 10 per day; that is to say, in summer from 7 am to midday and from 1 to 6 pm. In winter, they can start and finish later. If there is a rush, as Elgin has at the moment, work continues into the evening for one or two hours in as many of the workshops as is necessary. Rarely are workmen authorised to work at home, because it is acknowledged that an excess of work generally harms the quality of the product. Usually the workmen do not ask for more work, because they are remunerated enough by their regular six days work per week.

The system of accounting applied to manufacture is extremely variable from one factory to another, and we can only say that it is applied to ensure the quality of the work and to collect from each workman the necessary observations to enable the foremen and the central office to judge value of a person as producer.

In each workshop bulletins accompany the work. These bulletins show for each job the name of the workman, the date of reception of the work, and the number of parts received.

When the workman returns the work, he must return the same number of parts and to indicate how many are good, how many are bad, why they are bad, the amount lost, the date and hour of delivery, and the number of hours that he took to do this work.

This bulletin, which has all the elements to price the work, is collected by the workshop office and a new bulletin is provided for the following task.

The foreman has in his office suitable storage places to keep all the jobs which are done in his workshop. There is in general a great quantity of parts being worked on which are scheduled according to *written* requests and complaints sent from other workshops through the central office.

When a batch of parts is finished in the workshop, the bulletins attached to this batch make it possible to price it exactly. When it is judged necessary, the results of the work are recorded and delivered to the central office.

The central office receives the produce of all the workshops. These products are stored there in labelled bottles and are distributed in the cardboard movement boxes for *ebauches*³³ to be delivered to the assembly *en blanc*³⁴, escapement or other workshops. Each set of boxes returns to the central office after each process, or passes directly from one workshop to another by a written order from the central office.

In this office there are some inspectors under orders from the directors; they visit daily and check some of the delivered parts either as supplies or assembled. They also look at all the movements, but it is only a simple check preceding packing, because these movements are finished and delivered by the foreman of the assembly department (the finishing workshop).

The work of the central office is very complicated and the offices at Waltham and Elgin are extremely large. It continuously keeps control of work and records all the communications of the foremen relating to the cost of work, the number of parts delivered and the number of parts requested. All this information is recorded in special registers and then communicated to the relevant workshops.

32 All work was inspected and rejected if not satisfactory. David considers this more fully later.

33 *ebauche* is generally used for an unfinished movement, but it has a number of interpretations; for example the Ebauches SA companies produced completely finished movements ready for adding dials, naming and casing. David uses the term to refer to an unfinished part, which may be the whole movement or simply a piece of something.

In this sentence David is referring to collecting together in a cardboard box all the parts which make a particular movement. From now on I will call this a movement box.

34 *remontage en blanc*. I think the closest English expression is *assembly in the grey*, preliminary assembly of the *ebauche* for testing. I don't know why the English use the word *grey* and the Swiss *white*, but the term derives from the appearance of the parts before gilding.

In these registers are noted all the tools and supplies delivered to the foremen. Repairs from all the factory are received there, noted and transmitted to the relevant departments. None of these faults (including broken jewels, pivots or dials) are paid for by the workmen, but the *Record* or register for each watch must be corrected, and it is for this reason that everything must be noted in the central office. We will see in the chapter on manufacturing procedures how each movement is recorded.³⁵

Pay, notebooks, apprentices, conditions

Usually wages are paid once per month. At Elgin and Waltham wages are paid on the 10th or 11th of each month for the previous month.

Each workmen on piece-rates has a notebook and must make sure that what he has done is also recorded by the clerk of the workshop. At the end of each month a check is made between the two notebooks. The workmen, after a day's work, see that their time is registered in a table in the workshop office. At the end of the month this table is displayed outside the office for long enough that the interested can examine it. About the 5th day of the month, the checks having being made and complaints discussed, the accounts of the workmen are delivered to the central office. These accounts are checked by the cash clerk who then makes out receipts and prepares the sums in envelopes bearing the name of the workman and the amount of pay.

The pay is handed out in each workshop during working hours; the cash clerk and another clerk do it together. One calls the workmen one by one, according to the order of the workshop roll. The cash clerk pays and gets each workman to sign his receipt. Work is not stopped by this operation and each workman returns to his place and checks the contents of his envelope. If a workman is not present, he can get the workshop clerk to take his envelope and sign for him. Otherwise he must go to central office when he is able to.

The cash clerk at Elgin takes 2 hours to collect the signatures of all the workmen and no disorder results from this operation.

Absolute secrecy reigns between the workmen on the amount of their pay, and they appear to maintain this discretion to avoid competition and the supply of labour at reduced rates.

No deduction is made from the workmen on piece-rates, nor those on day wages, for tool supplies or for breakages of jewels, pivots, dials, etc. This results in a large expenditure for the factory, but each repair is noted and the workmen who spend too much in this manner are known and dismissed if they do not improve.

Workers are given advances only in very exceptional circumstances. In nearly every factory there exists a relief society. Each member pays a certain fixed contribution on pay day. The sums received are normally managed by the workmen and are used to help members who are in need, in consequence of disease or other circumstances. Those who are comfortable in such circumstances and who have their own means of support do not receive anything from this fund. The company generally contributes to the maintenance of the fund and is represented by one or more people on the committee.

The institution of such funds renders a very good service and is strongly supported by the workers.

The mechanical system of manufacture adopted in America enables the factories to employ many people who know nothing of the watch industry. They ask that their workmen and women be conscientious, intelligent enough to be interested in their work and to have the capacity to understand it. That is enough for the majority of men and women employed on the machines, but these qualities are absolutely essential. The least voluntary negligence or defect in intelligence or activity causes immediate dismissal.

The workmen who have difficult jobs, like jewel setting and adjustment, are good watchmakers who are in demand everywhere. These positions are occupied by workmen from all countries, but those who are preferred are the English, American and Swedish. The Swiss are in small but good numbers and they are generally well placed, although their collaboration is not particularly necessary for these establishments. They are taunted for adapting less easily to the factory rules.³⁶

35 The *Record*, discussed later, was a core reason for the success of American companies, because it enabled them to compensate for the fact that many parts were not interchangeable.

36 An interesting observation. Steinberg *Why Switzerland?* (1966, Cambridge University Press) gives a very good insight into Switzerland and its people, and explains why the Swiss might have been less tolerant of what could be seen as dictatorial control.

As far as possible the companies try not to take on apprentices but, depending on the circumstances, if a good person is found he will be taught.³⁷

Women are very much appreciated in these establishments and they are organised and taught with the aim of making the greatest range of jobs available to them. They are satisfied, as elsewhere, with lower wages and for many tasks they are equivalent to men. Despite years of work in these factories, the only situations where they are generally not seen are the difficult jobs. The factory reserves the easy jobs for them and their number increases each year. They represent at the moment a little less than half of the personnel in the large factories. In the small factories women are fewer in proportion because the work cannot be divided in the same manner.

The jobs which are reserved for them are:

In the plate and screw workshop: drilling, screw making and polishing screws. Men are used to turn plates and large pieces and women are seldom employed for that work.

In the wheel and pinion workshop they occupy almost all the positions. They make pinions (on automatic machines that turn and part them), barrel arbors and wheels, and they polish steel parts. Very few men are employed in this department. They also pivot wheels before hardening and polish pinions, pinion leaves, and stems after hardening.

In the jewel making workshop they occupy all the places and only a few men are seen carefully finishing off jewels and operating the jewelling tools.

In the escapement workshop they make pivots and they work on almost all the parts of the assortments, pallets and roller jewels.

In the dial workshop they occupy most of the positions doing ordinary painting.

They occupy many assembly-line positions in the assembly *en blanc* workshop³⁸, they adjust ordinary movements, and they are used exclusively on the final assembly (after gilding) of all the wheels as far as the balance.

They do the delicate task of measuring pivots and jewels, as will be explained later.

Finally they occupy the clerical positions (controlling the work, workmen, repairing, etc.) in the department offices and in the central office.

In general they enter the factory on a wage of \$0.70 per day, and it is a rule that they are given an increase of 10 cents every 2 months during the first 6 months; after that they are allocated jobs and earn an average of \$1.25 per day at Waltham. The profits of Elgin are a little lower and the average income of the women is \$1.10.

A certain number of women earn \$1.50 regularly, but there is a tendency for their number to decrease.

The women employed in the watch factories are of irreproachable morality. They are generally characterised by much seriousness and assiduity. Their appearance is always very neat and their clothing, although simple, is often elegant. Hairstyles are in fashion, and flowers, collars, brooches and rings are frequently worn. They have a certain coquetry in their workshop dress, generally consisting of a large apron which is not very elegant but which they decorate.

Many of them belong to good families and would be in more elevated employment elsewhere. All are treated with respect. The administrations of the establishments described in this report have such perfect order that they are regarded very favourably and employment in these workshops is very honourable. Provisions are taken so that those who are alone can be placed in suitable hostels, depending more or less on the company, but almost all are placed with good families in the district.

A few of them are married. They have no advantages and they must stay in hostels and attend the factory at the same hours as the others. Usually they leave work when they marry.

Generally we can say that life is very comfortable in the two large watchmaking localities of the United States. The small factories do not have as many facilities because they could not afford the expenditure to provide such good conditions. The two large factories embellished their environ-

37 It is interesting that, as in England, formal education was not regarded as important, the focus being on job training. The Swiss emphasis on education and training in horology schools is almost certainly a major factor in their success.

38 *parties brisées* are positions where each person does only a few operations. Henry Ford is credited with inventing the assembly line, but it is likely he got the idea from Waltham.

ments and made it possible to put all their personnel above the ordinary condition of employees in this industry.

In the factories all the facilities are organised in a way that would satisfy most difficult; steam heating, gas lighting, ventilation using special equipment, the height of the rooms, the large space given to each workman, water distribution, acoustic tubes³⁹, elevators, water closets and all kinds of facilities for cleanliness, cloakrooms, bathrooms, etc.; you could find none better and no expense has been spared.

In all the workshops the most rigorous cleanliness is maintained, and this care is encouraged by the pretty pieces of furniture, the offices, the lighting, and the very appearance of the benches which furnish the rooms. Some workshops are decorated with curtains, paintings, photographs of the workers, flowers, etc., which make being there very pleasant.

Outside the factory the same elements of comfort are found everywhere. In Waltham especially, we were struck by the cleanliness of the city, the elegance of the majority of the houses, and the good appearance of everything. Comfort is every where and these maisonettes, surrounded by greenery and flowers, must be perfect for taking away the tiredness of the day and inspiring good and honest resolutions for the following day.

All this is the work of the factory, which spread much money around it, and the labour of the workmen, who took the opportunity to benefit from what was offered to them and created a comfortable life by ensuring the company's future.

The company did not create all these things directly; it is not what is properly called the working city. The company built approximately 30 houses in various places and sold them to the workmen; some still belong to the company. But there are about 300 houses built on the land surrounding the factory and they were built directly by the workmen, that is to say by owners of Waltham city⁴⁰.

Each house is isolated from its neighbours by an area which is almost always a garden, or else a carefully tended lawn or a courtyard. They are built from wood, which is the custom in this country, and the majority have water and gas in all the rooms. The most modest only have a ground floor and very little land; others have a second floor and contain 6 to 8 rooms. The majority of the houses are occupied by only one family.

There are, however, a few which can house 4 families, but they are exceptions. The rent of an apartment in these houses, with a kitchen and 4 rooms, is \$9 per month. There is only one staircase and these houses are not very comfortable.

There are double houses containing 2 separate apartments, each having a ground floor, second floor and their own staircase, with 4 rooms and facilities. At present they cost \$16 to \$17 per month. A detached house with only one apartment is rented for \$20 to \$23 per month.

It is estimated that married workmen pay on average \$12 per month rent.

Before 1873 some workmen built their own houses which cost them, including the land, between \$2,000 and \$4,000.

The Waltham company maintains two hostels for unmarried workmen. Thomas house contains rooms for men and women. Adams house contains rooms for women only. Together these two establishments have places for about 100 people. The price for bed and board varies from \$4.50 to \$5 for men and from \$3 to \$3.50 for women. A part of Adams house contains rooms for \$2.75.

The cost of board in the city is based on that of the hostels run by the factory and there is little variation.

In Elgin the living conditions are the same. A workman can have good board for \$5 and the board for women is \$2.50 or \$3. The rents are a little lower, but the houses are much less pretty. A hostel was built for single people near the factory in imitation of what was done at Waltham, but this enterprise did not succeed. In general the workmen prefer to live with private individuals.

The localities of Waltham and Elgin being large, like all American localities, transport services have been organised, which function particularly at the start and end of work. In Waltham the

39 Tubes connecting different rooms. A person would speak into one end while the person at the other end listened. I think this is better than the telephone because two people cannot speak at once.

40 David had some difficulty in expressing the distinction between Waltham the watch company and Waltham the city. The land of the city was originally owned by the Waltham Improvement Company and by 1876 I presume much of it had been sold to the landlords and residents in the city.

company has a fleet of cars connecting the factory to the edges of Waltham. In Elgin the service is by an omnibus which traverses the village and carries people for a very small sum.

It can be said that the workmen in these factories are happy, when they have accepted the practices for control and the conditions imposed on them by the regulations. Those who are especially good workmen and strong researchers can earn higher wages, and a faithful and skilful workman has more chance to succeed in these watch factories than in any other trade in the country.

In these establishments it is necessary that each workman strives to improve, because it is the character of the working American constantly to seek to better himself and to work faster. Those who do not work with their head as well as with their fingers are outdone and discarded. This tendency to do better is seen everywhere and perhaps it is developed in the soul of the workmen as much as in the factory.

The workman surrounds himself with all possible comforts and makes economies so that his spirit and all that depends on it are happy. There is in this respect no difference between the married workmen and those who are single.

Other than a few exceptions (and these are seldom of American, English or Swedish nationality) they use their leisure time usefully or suitably. They are not prevented from going to inns, but they do so with reserve and there are never scandals or the sounds of drunkards, as happens elsewhere. Drunkenness is a mean vice which is forbidden and whoever wants to be respected and to stay employed must avoid it.

There is, among young people especially, a great desire to make good. They leave school when 15 years old and are devoured by the desire to improve themselves and to escape from parental supervision. They learn very quickly and many use their leisure hours to study the basics which they lack.

Wages are extremely variable and only averages can be indicated. For men they go from \$1 to \$5 per day, an average roughly of \$2.50 if we disregard inspectors and mechanics who generally earn \$3. For women the average is \$1, if we omit the clerks and some skilled workers employed in adjustment and escapement tasks who can earn much more.

In the years 1863 to 1870 the average wage for workmen at Waltham was \$3.50 for all employed men. It was \$3 in 1875 and \$2.75 in 1876.

Saving was considerable and is still so now, although it is less because of the fall in wages and rising prices. Several employees and workmen from Waltham have truly made their fortune and have retired, encouraging others by their example. Much money is put aside in Elgin as well, and under the current conditions the good workmen can save.

Taxes are moderate. Each man only pays a poll-tax, a personal tax which gives him the right to vote and which goes up to approximately \$2. There is no other tax on incomes lower than \$1000, and above that it is not very high.

The regulations of the large factories contain very clear provisions on how transactions must be handled with employees and workmen regarding inventions or improvements to the process of manufacture introduced by them.

In all cases provided for by these regulations, the whole or part of the ownership of the idea, the patent or the benefit resulting from application to the factory or sale to other factories of the invention or patented improvement, returns to the workman and inventive employee. This is done even in the case of an invention by an employee who is especially paid by the company to research improvements. These very liberal provisions will be found at the end of the document, which details payments to the higher employees of the company at Elgin, that we annex to this report.

IV Production quantity and quality

The American factories make the whole watch in their workshops, and if some supplies are still imported from abroad these are the exception, and it is only while waiting for the manufacture of these supplies to be organised in their own workshops. We must put out of mind all hope that any of these watch parts cannot be made in their factories.

The factory at Waltham draws from Switzerland and England some jewels, main springs, balance springs, hands and dials, but in extremely small quantities that are decreasing as their manufacture improves. We can say that this factory produces the whole watch in its workshops.

The factories at Elgin and Springfield Illinois do not manufacture movements of as high quality as Waltham and have little reason to import supplies. Their jewellery workshops are not yet organised and these two factories buy their jewels in England, finished up to the enlarging and polishing of the holes, and do these final operations in their own workshops. Elgin is working at the moment to fill this gap and it will soon make these jewels.

The production of these factories varies a lot. However it can be estimated from the following figures. We can say that:

American Watch Company	could make	420	movements per day.
National Watch Company	"	300	"
Springfield Watch Company	"	100	"
New York Watch Company	"	60	"
United States Watch Company	"	150	"
E. Howard & Company	"	40	"
Rockford Watch Company	"	30	"
Lancaster Watch Company	"	30	"
Which is a daily production of		1130	movements per day. ^{40a}

The American Watch Company announced that it will make 500 per day in 1877.

What is actually produced at the moment is at most:

American Watch Company	360	At present, October 1876, Elgin makes 280 to 300 per day.
National Watch Company	260	
Springfield Watch Company	85	
New York Watch Company	0	
United States Watch Company	10	
Rockford Watch Company	10	
Lancaster Watch Company	0	
Total approximately	725	movements to a maximum 800 per day, December 1876.

As for the average quality of the movements, we can get a rough idea from the table below, which gives the average composition of 100 movements from Waltham:

			Price list key wound
Movements of quality:	American Watch Co.	1	\$50 to \$200
	Appleton Tracy Co.	3	\$30
	Waltham Watch Co.	14	\$25
	P. S. Bartlett	16	\$16
	William Ellery	16	\$12
	Home	25	\$11
	Broadway	25	\$9.50
	Total:	100	

40a 1140 in the ms.

These 100 pieces are composed of approximately:

	70	movements key wound, size 18
	10	pendant wound, size 18
	20	key and pendant wound, sizes 16, 14, 10 and 8
Total	100	

The proportion of pendant wound movements has increased a lot. It was less than 5% 8 years ago and now it is almost 25%.

The proportion of pendant wound watches produced by Elgin compared to the number of key wound watches is 10%. In this factory the production is mainly of two significant types. We can estimate that it makes of each type:

Taylor and Wheeler	about	40%
Avery	about	40%
all other types	about	20%

In 1875 the factory at Springfield Massachusetts produced in one six-month period:

			Price list
Movement name:	John Hancock	745	\$14
	Novelty	319	\$15
	Geo S. Rice	493	\$16
	Chas E. Hayward	1285	\$18
	Aaron Bagg	196	\$20
	Theo E. Studley	563	\$24
	Hampden	213	\$25
	Chester Woolworth	561	\$28.50
	J. C. Bury	494	\$35
	Fred Billings	195	\$37
	Railway	55	\$60

The leaflets and current price lists that we attach to this report indicate the exact number and types which are manufactured in the United States factories.

Between the companies of Waltham, Elgin, Springfield Illinois and Springfield Massachusetts, there are manufactured, according to these price lists:

2 types	20 size, key wound	1 name
54 types	18 size, key wound	38 names
1 types	17 size, key wound	1 name
4 types	16 size, key wound	3 names
3 types	14 size, key wound	1 name
11 types	10 size, key wound	7 names
2 types	8 size, key wound	1 name

The total is 127 types key wound using 52 names, but representing only 15 different calibres⁴¹.

Moreover, these same establishments manufactured:

22 types	18 size, pendant wound	13 names
7 types	16 size, pendant wound	5 names
3 types	14 size, pendant wound	2 names
4 types	8 size, pendant wound	2 names

A total of 36 types pendant wound using 42 names, but representing only 15 different calibres.

We can estimate that the production of pendant wound watches is 15% to 20% of the total, but this proportion will rise quickly because all the factories are making efforts to this end.

41 The word *calibre* is used inconsistently by different writers. David means a particular watch design; size, layout of train, winding mechanism, and so on. I presume by *type* he means variations in jewellery, adjustment and so on, between watches of the same calibre, the *grade* of the movement.

The movements named *Home*, *Broadway*, *Avery* and *Leader* are characterised by their low price. They are special movements made by the two large factories in response to the harshness of the times, and considerably extend the range of their sales.

The advantages obtained by the companies from creating these new types are very significant. The main advantage is to put American products in competition with the ordinary imported movements. Hitherto the high price of American movements meant that a class of consumers, the largest class, could not easily access them and bought Swiss watches. By producing the Broadway and reducing its price as much as possible, the Waltham factory created an American watch that all in this class of purchasers could acquire. That this goal was reached we can see because at this moment these two factories are actively producing these 4 types and most of their workmen are occupied with them. In contrast, the less important factories, which could not or did not want to attempt this experiment, are idle.

Another advantage, which is of some importance from the point of view of the economy of manufacture, lies in the fact that a quality of parts can be used in these very ordinary movements that, because of defects in running and the strength of the movement, had until now been discarded.

The American companies involved were required to fix an extremely low price for these ordinary products in order to get work. It is necessary to realise that these prices cannot be maintained, especially if the demand increases and these cheap movements become their principal product. The data given in the preceding chapter clearly shows this.

Until now this very cheap watch was only made in 18 size and we do not know of anything in another size. There is no reason why the Americans cannot produce a similar article in a different size, and they will certainly do so if they see a significant advantage.

As all the reports indicate that these movements give good results, it is likely that, after having been an article made for a crisis, they become a normal article of production.

At the moment they constitute the most complete example of what manufacture by machines can produce, because we have been told that there is no hand work.⁴²

All the above products are also remarkable for a characteristic which seems to be of secondary importance but which is actually a great advantage. All the movements of the same size have exactly the same diameter and exactly the same height from one factory to another.

The result is that the same cases can be used for all movements of the same size. Some differences are met in the position of fixing and the position of the barrel, but they occur in few movements and are of little importance.

The pendant wound watches are built with the same idea and the only difference between them is the system for hand setting. They have the same outside dimensions as key wound movements of the same size.

This uniformity, which we can say is absolute in the most common 18 size, constitutes a very great advantage for case making. It allows the case manufacturer to be completely equipped to make cases intended for American movements by machine, and consequently these cases are cheaper than those for any foreign movement. It also makes it possible for the watch merchant to have a set of uncased movements and to buy cases only when he has a need for them.

It appears that Elgin was tempted to produce a different size, but these watches were so inconvenient that it had to bring this movement back to a standard size to be able to sell it as easily as the others.

The latest movements built by Waltham are the *Home Watch* and a 14 size especially made for England. It has made a pendant wound *Home Watch* without hand setting, which was to be sold for \$1.50 more than the key wound watch with the same name.⁴³ This type did not succeed because it was incomplete and it has been given up for the moment. There is thus no pendant winder which can be put beside the cheap key wound watch.

Elgin is working at the moment on a cheap key wound watch in a lady's size, but this movement is not available as yet. It is the same for a pendant wound lady's size, which will be within the normal range of American pendant wound watches. This movement will not appear for a few months.

42 This seems unlikely if taken literally, as will be seen later. The source probably meant minimal hand work.

43 Presumably the hands were set by a key.

Last December, the arrival on the market of a movement coming from the Springfield Illinois factory was announced, which is currently sold for \$4.50. It is similar to the movement named *Leader* from Elgin, and must compete with the low price movements from Waltham and Elgin.

The quantity of goods in manufacture is considerable. It is estimated that Waltham has stock in the process of being manufactured which is more than 75 times the daily production, and the time necessary to complete a movement is three months. This proportion of stock in manufacture to the daily production is certainly much less than that which the watch manufacturers in Europe are obliged to maintain, and we can note it as one of the advantages coming from the system of manufacture adopted in America and of the attention which is given in their factories not to have a large number of calibres.⁴⁴

The pendant winding system generally adopted is the system under the dial. Each factory has its own particular methods for the intermediate wheels and setting, but there are no major differences. The Waltham pendant wound watch called *Crescent Street* has a visible mechanism. It is at present the only one which has this feature.

These pendant wound watches all have concealed hand setting and the preferred system, which makes independent casing easiest, is the lever⁴⁵ system used by Waltham.

The American factories have patented a number of particular designs relating to the train, the winding mechanism, the click and ratchet work, the manner of fixing the index, and finally the dust band.

Among these patents some relate to advantageous new designs, but a much greater number only represent changes and not improvements.

These patents are very useful for advertising. Some of them could be usefully applied to Swiss products, but it is possible that we would have difficulty in acquiring them to make use on imports into the United States. These matters are handled as in France, by intermediary agents who know the formalities to be followed, and it is to them that it would be necessary to go if we wanted to obtain the list and the descriptions of the patents in force, or the right to exploit one or more of these improvements.

The company at Waltham uses or has:

The patent for the loose pinion on the center⁴⁶ wheel which protects against breakage of the main spring. This patent bears the name of Fogg.

2 patents on the keyless mechanism,

2 patents on the index,

2 patents on balance spring studs,

1 patent on the main spring end piece, and

1 patent on the dust band.

Elgin has another dust band patent and another center wheel pinion patented under the name of Burt.

The Springfield Illinois factory uses a dust guard similar to that of Waltham, but it does not carry a patent indication.⁴⁷ Springfield Massachusetts uses a similar dust guard to that of Elgin.

44 Three months is the time from when the pates are cut out until the completed movement is delivered to the central office. If Waltham was making 360 movements per day then there would be about 27,000 movements in production at any one time. However, watches were started in large batches and some of them (the high quality movements) may not have been finished until months or even years later.

The number of watches in production is a function of the number of man days needed to make one movement, as well as the number of workers. David's remark about European manufacturers not only reflects the advantages of fewer calibres, but also indicates that the number of man days to make a watch in Europe was higher.

45 *came*, *cam*, which must be wrong.

46 The spelling of *center* is not entirely for the benefit of American readers. Rees *The cyclopaedia or universal dictionary of arts, sciences, and literature* (1818, Longman), one of the most famous of the English encyclopaedias, uses this spelling and not *centre*. This somewhat surprised me and I now wonder if the accepted spelling is a rather recent affectation. However, I refuse to write *color*!

47 David has too much integrity to be suggesting that this design could be used without acknowledgement.

The Howard factory has patented a very complex steel barrel for a fantastic click and ratchet work, and also an index system intended to be used on a very small movement.

The companies take their rights very seriously and prosecute counterfeiters.

They encourage their workmen to undertake research as we have already seen (page 26, interior organisation).

American movements are very carefully adjusted. We obtained the tables of observations on 7 Waltham movements, made by the members of the jury at the Universal Exhibition in Philadelphia. These seven movements were pendant wound, nickel 18 size of first quality, listed at a price of \$300. By taking account of all allowed discounts they are sold new for about 700 Fr.

These watches were observed for a very short time, only 5 days from the 10th to 15th July, and in 5 different positions. This observation is too short and does not make it possible to obtain sufficient information on the daily variations in each position.

The average of the daily rates (calculated for 24 hours) for each of these watches in 5 positions was:

- I. 5.4 seconds
- II. 5.4 seconds
- III. 3.8 seconds
- IV. 4.0 seconds
- V. 13.6 seconds
- VI. 18 seconds
- VII. 8.3 seconds

By eliminating numbers 5 and 6, which are insufficiently adjusted, we get for the others a general average of 5.3 seconds.

Number III, which went best, had daily variations in the 2 flat positions⁴⁸ of:

- + 2.77 seconds
- 0.46 seconds
- + 1.36 seconds

an average of 1.52 seconds.

In the 3 hanging positions:

- 1.18 seconds
- + 4.75 seconds
- 3.75 seconds
- 3.48 seconds
- + 2.53 seconds

giving an average of 3.14 seconds.

The general average of daily variations is 2.53 seconds. That is, taking for comparison the daily variation observed during these 5 days, these pocket chronometers would not be comparable with any of those deposited at the Neuchâtel Observatory in 1875. Indeed, the report of the Director of the Neuchâtel Observatory states that the most imperfect of those chronometers varied on average 1.40 seconds in the 5 positions and that the average of the daily variations was 0.46 seconds.

These same American pocket watches were then examined by one of the personnel who had co-operated on the first observations, Mr. Watson⁴⁹, Director of the American Observatory, Ann-Arbor. He conducted tests which lasted 15 days and which gave results completely different from those of the first observations, according to which these watches would be superior to the chronometers tested in 1875 at the Neuchâtel Observatory.

He is clearly of the opinion that Swiss makers should seek permission if they wanted to use any of these American patents. However, Switzerland did not introduce patent law until 1907 and it is likely that the attitude to patents in that country was different from countries which provided protection.

Unfortunately, as David makes clear later, not all Swiss manufacturers were honest, and their unscrupulous behaviour is a central theme in David's recommendations.

48 Dial up and dial down.

49 *Watson?*

With regard to watch movements, we have completed observations of the 12 movements bought on behalf of this investigation. These observations lasted 12 days and the results obtained were:

A pendant wound movement named *Taylor* from Elgin and costing 78 francs had an average daily rate of 1m9s. The variation in the rate was on average 0m4s.

A 16 size movement named *Lady Elgin* had an average daily rate of 1m23s and the mean variation was 0m2s. This movement cost 56 francs and can be considered to be well adjusted.

A pendant wound movement named *William Ellery* from Waltham, costing 43 francs, had an average daily rate of 3s45, and the mean variation was 11s.⁵⁰

All these movements were observed in only one flat position. The general average of the rates was 1m30s and the general average of the daily variations was 0m9s

We do not believe that these rates and these variations are much different from the rates and variations of Swiss movements of similar prices.

We present, as having given relatively the best result, a *Leader* movement from Elgin, costing 23 francs which had a rate of 1m59s per day and whose rate varied only 8s on average.

We will note in passing that a *Crescent Garden* movement, which had a rate of 15s when we bought it in New York, gave in this test a rate of 1m35s, which provides proof to the people who do these adjustments that the watches do not preserve them.

50 3s45. I presume this notation means 3.45 seconds, but I am not sure if the fraction is 45/100 or 45/60. But it may be an error for 3m45s.

V Sales

The system adopted by the American companies for sales is not exactly the same for all of them.

Waltham sends all its products to Robbins & Appleton, whose heads are the principal shareholders of the company. The relationship between Waltham and Robbins & Appleton is not known exactly and they are generally regarded as being one and the same undertaking. It is in the name of Robbins & Appleton that all the announcements, advertisements and sales are made.

They sell to *jobbers*⁵¹ who pay different prices according to the quantity of goods that they take.

The basic price is published in a list which is made public. The jobber gets a reduction on this price which varies from time to time. Last October a purchase of \$5000 worth of goods was given a discount of 50% for cash on delivery, plus 5%⁵².

The purchasers who take larger batches get, we were told, an additional 5% to 10%, and at the beginning of the year the American Watch Company had invited some customers to associate and jointly take a batch worth \$60,000 that would have given them extremely advantageous conditions. I do not know if this offer was accepted.

During the successive price drops that the American Watch Company made, it guaranteed its most important customers against losses caused by these falls, compensating for the difference between the old and new prices by an allowance paid in movements. This measure does not apply generally and, in any case, it applied only to purchases made within a rather short time, because we understand there have been many complaints about the consequences to tradesmen of these falls in price.

The jobbers sell the American movements to watch merchants and to intermediaries of less importance, and give them the same system of discount and cash on delivery which applies to themselves.

The company does not normally sell directly to watchmakers, but if it does it raises its prices considerably, so that they always buy from the jobbers.

Waltham should be strongly criticised for making its lists public. This system is deplorable for the most important purchasers and even for those of second importance, but it is very advantageous for the watchmaker and the public.

The large purchasers deal with Waltham watches only because they are forced to do so by their customers. They can only make it advantageous for themselves by buying large numbers and paying in cash, thus benefiting from all the discounts that the company grants in these cases.

Consignment was employed a little in the first years, when the company used every means possible to make its products known. I cannot be sure that the system is no longer used. One person told me that two firms of little importance, by virtue of an old agreement, probably still have watches on consignment from the American Watch Company. The sale of Waltham products is quite easy now so they do not have any need to resort to consignments.

Elgin has organised itself more skilfully with its jobbers. It does not publish its price lists, or at least it does not give them to the public. It deals with a certain number of firms and it sends the list only to them, and these firms also take a minimum discount of 18.5%. Those who sell below the set price are denounced and cannot buy any more goods.

Like Waltham, Elgin grants a larger or smaller discount for cash to the purchasers who take large lots, but the same discretion is observed in these transactions and the public and Waltham know nothing about them.

Elgin attracts customers by a different kind of advertisement to that employed by Waltham. Waltham publishes articles in journals. Elgin publishes cartoons and almanacs which it gives to the public, and for its dealers it provides invoices, address cards, calling cards and envelopes which are full of the most fantastic sketches, and which it sells to them at reduced prices. There is a printing firm in Elgin which works almost exclusively for the factory.

The large companies have expanded to other countries by setting up agents in London; for Waltham it is the firm of Robbins & Appleton. In London they both make a big effort to invade South America

51 I am not sure if David is using the right word. I thought a jobber was a watch repairer rather than a wholesale dealer.

52 50% de remise, plus encore 5%.

where, we were told, they have already sent a great quantity of products. It will probably be through the English agents that American watches will be carried to the Indies, Australia and Japan.

The less important watch factories sell where they can. They do not have the same resources as Elgin and Waltham, and they are obliged to more or less conform to the prices set by these companies. Their business relates to very much smaller amounts. They all have one or two principal firms which take their goods. They have agents in New York, but they say little about them. They have price lists on which they make larger or smaller discounts for cash according to the circumstances.

We append to this report price lists of the companies.

VI Methods of manufacture

General principles

The general principles on which watch manufacture in America is based are completely different from those which form the basis of this manufacture in Europe. These principles are:

1. To make everything with machines that can be done so.
2. To avoid the intervention of hand work and to suppress it wherever possible, to obtain economy and uniformity.
3. To obtain complete uniformity, so that all parts are interchangeable,⁵³ with the aims of facilitating movement assembly and reducing the work of repairers to a minimum.
4. To produce only good work, solid and in good condition, which is a continual advertisement for the firm who produced it and so ensures the factory's prosperity.

53 I have normally used *uniformity* rather than *interchangeability* because, as will become clear later, the American companies were still a long way from achieving the latter. But I need to say something about interchangeability because it is a concept that has been misinterpreted and misunderstood.

Landes *Revolution in time* (2nd edition only, 2000, Belknap Press) provides a correct definition of interchangeability: "the ability to choose any part in a pile and insert it in its place, where it functions *without further adjustment or treatment*". The problem of interchangeability only arises when components which must fit together are mass produced, so that a complete item is constructed by putting together a random selection of such parts. Such mass production of parts that must fit without alteration raises a number of problems.

First, words like *complete* and *perfect* cannot be used. In the mass production of a piece some variations in size and shape are inevitable, due to play in the machines, wear of cutting tools and changes in the size, shape and consistency of the raw material. As Tarasov *Technology of watch production*, 1964, points out, a part is interchangeable with another only if both lie within prescribed *tolerances*.

Second, acceptable tolerances vary from one part to another. A watch pivot with a diameter of 0.1 mm, for example, may be acceptable if it is within 0.01 mm of its correct size, an accuracy of about 1:10. In contrast, a 45 mm diameter dial-plate seat in a pocket watch case would be unacceptable if it could vary by 1:10 and be 40.5 or 49.5mm. Equally, it would be pointless to turn it within 0.01 mm, an accuracy of 1:4500.

Third, the ability to make interchangeable parts depends on the ability to design and construct a suitable machine. For example, the diameter of wire can affect where and how it is gripped in a lathe chuck and alter the size of the finished piece; which is why the invention of the slide spindle by Charles Mosely was so important. It is also why David stresses that wheels were finished by gripping the outside of their teeth to ensure the center hole was concentric. Of course, the smaller the part the harder it is, but the shape and critical dimensions are very significant. It is far easier to turn a round pin than to make a square peg, and it is much easier to make screws automatically than it is to cut escapement levers.

Fourth, physical dimensions are not the only criteria and variations in raw materials can be vital. For example, very small changes in the steel quality, hardening and tempering of balance springs will dramatically alter their behaviour, even though the springs are apparently identical in shape and size.

Consequently, a watch manufacturer may achieve *partial interchangeability*, where some parts are interchangeable and others are not. This is precisely the case with the American watch manufacturers in 1876.

The failure to appreciate such points is presumably why some writers talk glibly about mass production. Japy, for example, did mass produce movements around 1800, but rarely does anyone comment on how *interchangeable* they were.

The concept of partial interchangeability raises a very important question: to what extent were techniques developed to make parts interchangeable and to what extent were they developed to overcome a *lack* of interchangeability? When we read this chapter it becomes clear that this question was central to David's approach. He often says a process is "not interesting"; this is because there is no problem with interchangeability as, for example, case making where the tolerances are such that the methods are quite simple. (Also some processes are not described simply because they are common knowledge. For example, David glosses over hardening and tempering, but does notice that only one person does it, a division of labour he feels is noteworthy.) What he does find very interesting are processes to achieve interchangeability (such as using the dial foot locations for turning plates) and the processes to overcome a lack of interchangeability (such as the method of setting jewel chatons). It is this division of processes that explains David's choice of procedures to be described in detail.

5. To avoid a wide variety of calibres and sizes so that each movement can be made with perfect tools that are always maintained in good condition. A large variety of calibres would involve an enormous expenditure and it would be necessary to make less complete tools so as not to consume an excessive capital to reach that goal.
6. To manufacture great quantities at the same time, to benefit from all the advantages of the machinery.
7. To adopt for each movement size exactly the same dimensions in all the factories, to simplify as much as possible the construction of cases and to make their manufacture completely independent of the movement.⁵⁴

These seven rules, generally adopted by the factories which let us study them, involve particular conditions and difficulties which hamper the initial development of these companies, but they ensure very important advantages when these difficulties are overcome.

The most significant point is the construction of tools. The machines must be perfect, from the simplest to the most complicated, and it is impossible to take too much care and consideration in their construction. It results in them being extremely expensive and that, once finished, it is necessary to make them very productive. Their maintenance is also expensive and several establishments ceased, not through negligence or economy, but because of this maintenance.

Thus one of the first conditions to satisfy is to have a large enough capital to be able to build very good tools, cope with no income during their construction, and cope with the losses resulting from expensive machines which do not answer the purpose for which they were created.

Difficulties with tooling in the beginning are cited by every factory, and it is only in recent years that this problem has been studied enough for new companies to know in advance what their machines will cost them. The tools at Waltham cost \$400,000, at Springfield \$125,000.⁵⁵

When the tools are built and are successful, a large advantage can be obtained over manufacture as it is practised in Europe. These advantages are:

The work is of a uniformity that is impossible to obtain by manual work.

The quantity produced is generally much more than could be made by good workmen without machines.

Consequently the price of the work is reduced, even when the normal depreciation of the machinery is included.

In the majority of cases, male or female machine operators can be employed who have no knowledge of the watch industry, and this is another source of economy in the cost price of the product.

Another of the problems, which results from the principles that are essential to the American factories, consists in the absolute uniformity which they want to obtain to facilitate movement construction and the work of the repairer.

To obtain this uniformity they especially need, in addition to perfect tools and much care on behalf of the workmen who manufacture the watch parts, much awareness and control, or a very complete and very severe inspection of the products.

This control increases costs, and it is very expensive so long as the workmen perform any step completely and as long as it is necessary to check all the parts.

All the parts which are not in exact conformity with the admissible specifications must be discarded, even though they would otherwise fulfil their functions in a watch and would be used in a manufacture based on less rigid principles. But once this uniformity is obtained and all work is done exactly according to the specifications of a model, the advantages of the system are really significant.

The principal ones are:

The assembly of the various parts of the watch, from the barrel to the escapement, is a very easy operation which does not have any resemblance to the equivalent tasks that we know in Switzerland.⁵⁶

54 The extent to which this was accidental is not clear. Machinery was copied from Waltham and it may be that separate case manufacture came about by good luck rather than deliberate intention.

55 A very crude comparison suggests Waltham's tools would cost about \$40,000,000 today.

56 Probably the best explanation of this point is to compare the American procedures described here with the English procedures detailed in David Glasgow *Watch and Clock Making*, 1885, Cassell & Co.

The advantage pointed out above, to be able to employ workmen with no watch industry experience also applies to this work.

The final assembly is done with the same facility, and in all this manufacture only the essential and delicate tasks are reserved for watchmakers; such as jewel setting, building the escapement, the hands, and the rating and observation of the movement. Because of this there is a considerable saving of labour which compensates for the initial cost of establishing such manufacture.

From the point of view of repairing, the advantage is even larger and the watch merchant has notable economies by buying a new piece from the factory instead of trying to put a defective part in order.

The merchant can dispense with maintaining a repair shop, which is necessary for Swiss watches. If some difficult problem arises he uses the invitation made to him, to send the repair to the factory where a special workshop is organised for that purpose. These considerations will push the small watch merchants to promote American watches whose repair is much simpler than that of Swiss watches.

The American machines are distinguished by their solidity from those which have until now been employed in the watch industry. It is quite rare that any are seen which can be criticised on this point. They are, moreover, normally adapted to only one purpose, in order to fit it well, and the increase in expenditure which results from this manner of production is compensated by more speed and more uniformity in the work produced by each machine. The idea which dominates the construction of tools, is to build them so that they are protected from wear and accidents, and anything that, under pretext of economy, would harm their durability is rejected.

There are two categories of machines:

1. Those which are intended to facilitate the tasks of the workman and make them more exact, like lathes, drilling machines, machines to cut, polish, etc. They are as simple as possible, practical and easy to adjust. They are the greatest number and it is by them that most of the work is done in all the factories.⁵⁷
2. Those which work by themselves and only need the workman to receive the finished pieces. These are limited and cannot carry out all tasks.

We cannot yet determine the value of some of these extremely complicated and very expensive machines, and it is necessary to see them working for a longer time to know if their use is advantageous.⁵⁸

The most common automatic machines, which are recognised as valuable by all the mechanics, are the wheel cutting machines, pinion cutting machines, those to cut the barrel arbor squares and especially the pivoting machines. This last machine is used for arbors and pinions in all the workshops which we have seen. We give a sketch of one of the more commonly used machines in the section on barrel arbors.

The American machines are very similar from one factory to another, because they all are more or less copied from those at Waltham, which carried out most of the tests and paid for most of the experiments.

The frames are strongly built of iron and generally very solid. The lathes usually have a very heavy semi-cylindrical bed (Figure 1) with a face plate on which the head stock and the accessories are mounted.

The greatest care is given to the adjustment of the slides, the return screws, etc. But what is most successful, and very uncommon in the manufacture of watch tools in Switzerland, is the construction of the arbors, pins, pump centers and, in general, all of the adjusted cylindrical parts.

All these parts are made out of very hard, tempered steel, and turn in bearings or tapers also of hard steel. The moving parts built in this manner, with very careful attention to greasing, resist any wear and are one of the principal reasons for the good service which these American machines render.

⁵⁷ It is also these machines that inhibit interchangeability.

⁵⁸ Here we see the point I mentioned in my introduction. 1876 was a bit too early because much more development was yet to come. In this sentence we see one of the few places where David's vision has let him down.

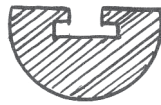


Figure 1

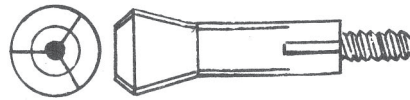
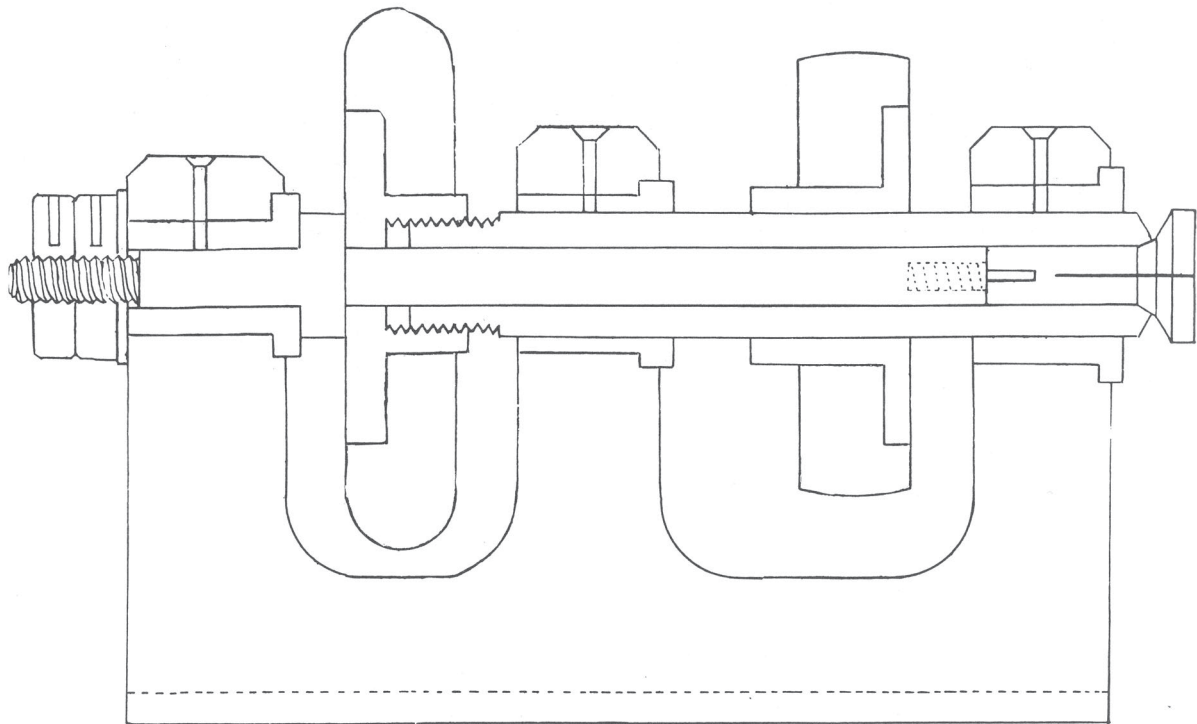


Figure 2

Another characteristic of the American machines is the perfect construction of the clamps and other tools used to hold the parts being manufactured. These clamps, called *chucks* are of various designs according to the use for which they are intended. The simplest and most widespread is a small cylindrical support finished with a conical head (Figure 2). This clamp is cut in three and tightens on the part when it enters a cone turning on the shaft. This clamp, of which the active parts are very hard, resists wear for a long time and provides a very firm and well centered support.

The engineering department which builds the machines is the principal workshop in every American factory. It is primarily from there that improvements and savings in manufacture come, and we can say that it is the workshop on which the future of the company depends. These workshops are generally magnificently equipped, extremely large and have everything necessary to facilitate the work and to ensure maintenance of the tools.

Figure 3: Sliding spindle headstock.⁵⁹

In each of these workshops there is an office or separate store which is used to house, under the monitoring of a special employee, all the gauges, cutters, dies, taps, broaches, gravers, etc. used in the workshop. This material is constantly checked and is always maintained in excellent condition and in exact conformity to the specifications adopted. The arbors of the machines and a number of other parts have precise dimensions and good proportions. These parts are always made to the same specifications so that they can be interchanged without any problems. It is particularly the case with the head stocks and accessories of lathes (tool holders to turn recesses, chucks, etc.), all of which are the same height and can be mounted indifferently on any lathe bed.

⁵⁹ Originally Plate VI, Figure 1. The collet remains stationary, always staying in the same position relative to the tools, and the spindle moves to clamp or release the work. Although not mentioned in the text, David recognised this as one of the essential requirements to make interchangeable parts.

The principal tools used in the mechanics workshops were built by the following companies:

The best lathes come from Pratt and Whitney in Hartford, Connecticut, and the workshops of Putnam Company and Hill Clark & Company in Boston. The planers come from the same places; they are numerous and run automatically. The milling machines for dividing come from the workshops of the Bramard Milling Machine Company in Boston. Milling machines, punching machines, hammers, etc., are built by Stiles & Parker at Middletown, Connecticut.

All these tools are in large numbers and in very good condition.

The mechanics' workshop at Waltham is equipped to manufacture and repair all the tools and machines of the factory. It currently employs 40 to 50 mechanics. There are 20 mechanics at Elgin and other establishments have a large number of these workmen. The mechanics working on watch tools are selected from the best in the land, and they earn from \$3 to \$4.50 per day. Because of the difficulty in finding enough mechanics for each factory, and especially a very able mechanic to be head of the workshop, the smaller factories have their tools made by specialists who have established small workshops independent of the factories and who keep up to date with progress in the large establishments.

Manufacturing processes

Watch movements are manufactured in a series of workshops, each one having a speciality. The workshops are:

The cutting workshop.

The steel and steel finishing workshop.

The plate and screw workshop (the ebauche workshop).

The wheel and pinion workshop (the Motion Room).

The jewel setting workshop.

The escapement workshop.

The assembly *en blanc* and adjustment workshop.

The gilding and engraving workshop.

The finishing (final assembly) workshop.

The jewel making workshop.

The balance workshop.

The dial workshop.

The dial painting workshop.

The case workshop, which is divided into the rough work and press workshop, and the turning and finishing workshop.

We will review each of these workshops, giving some details of the tools and the operations particular to them.

Cutting workshop

The cutting workshop is where the punching machines are, which produce the raw material in blanks. The cutting of large nickel and brass parts, such as pillar plates,⁶⁰ top plates, barrels, bridges and cocks are not done in the factories; the watch factories only cut out small brass and steel pieces. Waltham and Elgin get their large parts cut out at the brass factory of Scoville Company in Waterbury, Connecticut.^{60a}

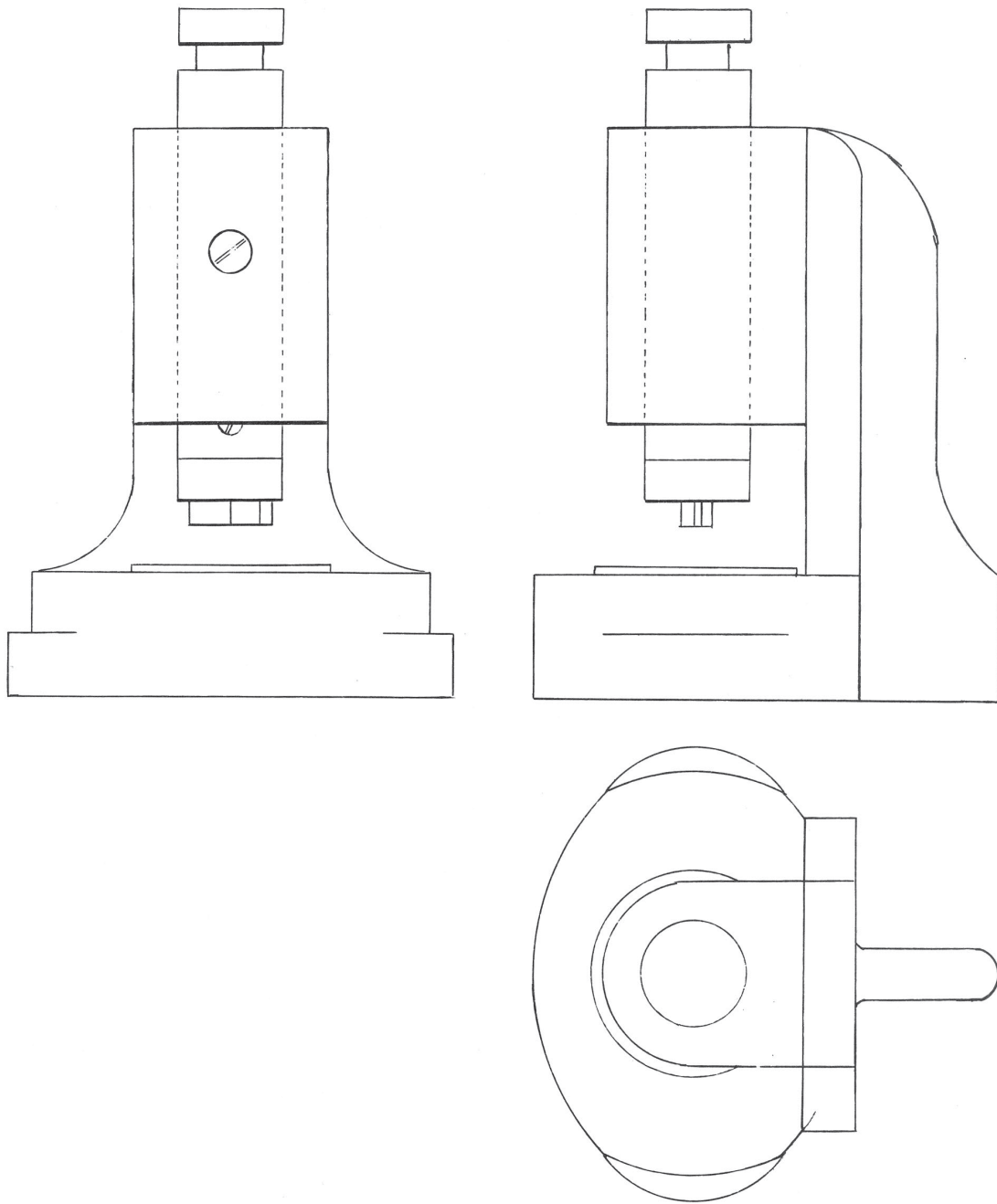
Brass comes from the Scoville company. Steel rods and plates come from England. Round steels are those generally used in the industry; that is, those from the Wilson firm in Sheffield.

The stamping machines are the various common systems and do not present anything of interest. There are many of these machines, appropriate to the various jobs in the workshop, and they are well maintained.

The punches and dies are fixed in blocks of cast iron carried on a steel cylinder which always brings the punch exactly in the center of the die. These are never disassembled and are carefully stored in trunks near the forge. We give a sketch of one of these blocks (see Figures 4, 5, 6).

60 Also called dial or bottom plates.

60a *Scowill* in the ms.



Figures 4, 5, 6: Punch block.⁶¹

All the small parts of a watch are cut out in these workshops, particularly the indexes, wheels and hands, which undergo other operations in the same workshop.

The hands are cut from a strip and then shaped with a hammer, or rather forged cold with only one blow⁶². They leave this operation completely formed, particularly having the correct canon size, length and hole. The roughing of the hand is finished by removing the excess matter formed during forging by using a punch on a small punching machine.

All the steel parts where the thickness is not always the same (like indexes, hands and mainspring end pieces) are forged by this process.

⁶¹ Originally Plate I, figures 1, 2, 3.

⁶² Drop hammers are described in the section on case making.

Train⁶³ and escapement wheels are cut by only one blow, then passed through the same punch a second time. They leave perfectly shaped and the punch is so well maintained that the traces of cutting can barely be seen. The wheels are so clean that no finishing is needed.

All the parts cut out in this workshop are carefully examined, counted and delivered to the store.

Steel workshop

In the steel workshop the ratchets, clicks, springs and winding parts are made and delivered to the store polished. The operations are very numerous and they can be classified as milling, drilling, shaping, dressing and polishing after hardening.

Milling is done on strong machines which cut on an oblique or horizontal axis. These machines are generally hand controlled, but some are automatic. One machine cuts several ratchets at the same time.

The shaping of springs, indexes, balance spring studs, etc., is done in two different ways. In one method, the edge of the part is formed by a cutter which traces the shape of the part. In the other system the edge of the part is formed by a steel grinder charged with oil stone dust, or a shell charged with diamond. Shaping with a lap is used for the fine parts (like levers, pallets, etc.) and the delicate levers and pallets are done after hardening.

The steel parts are dressed before shaping. This dressing is done on a machine with a squared, cast iron platform charged with oil stone dust. The part is rubbed against this platform by a cranked arm with a point. The part is allowed to turn until surface is true.

The dressing being done on one side, the part is hardened and tempered. After hardening the other side is dressed. Then a number of these parts are cemented onto a square cast iron plate. The cemented parts are rubbed by a crank against a platform coated with emery powder until they are free and brought to the desired thickness.

The thickness being reached, detergent is used to carefully remove the emery and the parts are smoothed with finer emery on a similar platform. They are washed and the operation repeated with oil stone dust. The brilliant polish is given by rubbing these parts, still cemented, on boxwood well coated with Vienna lime. This operation is done by hand and is extremely fast. All the steel parts are polished before being distributed in the movement boxes, and they are installed without further work.

Hardening is one of the operations which requires the most care. A special workman hardens all steel in the factory, and no hardening is done in the workshops. Hardening is done in cases on the fire of the forge, and small parts with a blowtorch.

Plate and screw department (the ebauche workshop)

The plate and screw department, as well as the following departments, are the most characteristic and offer notable differences from the methods followed in Europe.

The reference points for all the operations which the plate has to undergo are the 3 holes of the dial feet. After the plates are dressed by a first turning, these 3 holes, as well as the pillar holes and the points for planting the mobiles⁶⁴, are made by one blow from a punch.

From this moment the 3 dial feet positions are used to hold the plates on the lathes for many operations. The thickness, size and recesses are turned on various lathes which hold the plate by the edge, or by the interior of the false dial, or only by the dial feet positions. In this last case, the plate is supported against the head of the lathe by small clamps which are tightened by particular methods which vary in the different factories.

The pillar plates are completely finished with their pillars, all the points for the escapement, motion work and train mobiles, the steady pins to receive the top plates and bridges (which are made with holes for the pins), etc.

The master plates for the pillar plates, for turning, drilling, jewel setting, etc., must be made very exactly so that these parts go together without any need to alter them. To arrive at this result, an eccentric platform is used for the construction of the master plates; see Figure 7.

63 *Les roues de finissage ...*, which seems wrong.

64 *Mobiles* are pieces that move and include wheels, pinions, arbors, levers, etc. The word is not commonly used in English but there is no good alternative.

This platform is composed of a large disc **A** in which is adjusted an eccentric disc **B**. In this disc **B** is another disc **C**. These 3 discs can turn one within the other, held by strong friction, and they can be locked in position by 2 pairs of clamps **DD** and **D'D'**. The interior of disc **C** has a large recess **E** in which the master plate to be constructed can be adjusted. These master plates are, moreover, locked in this recess by 2 pins **pp'** so that they can occupy only one position in the disc **C**.

The master plates in **E** and the points **pp'** are made identical one with another using suitable gauges.

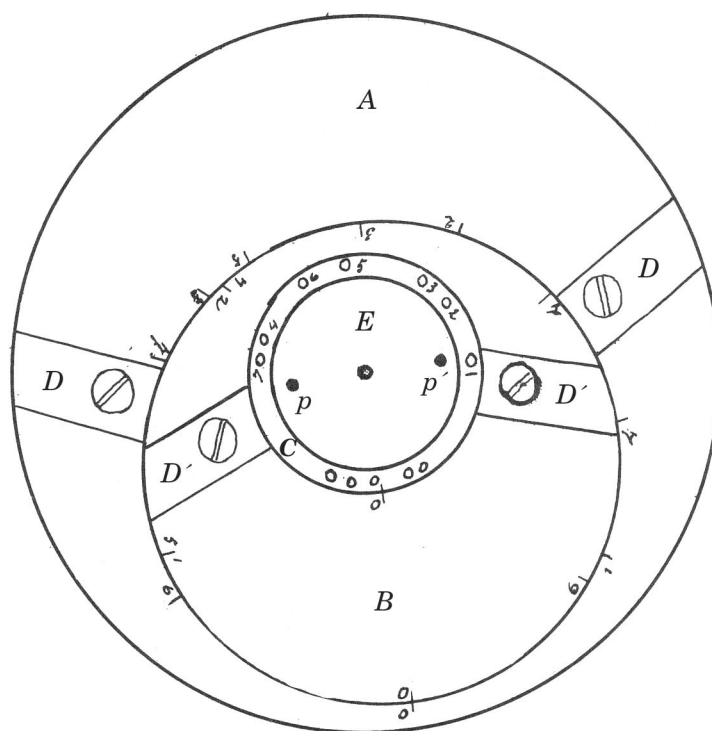


Figure 7

In consequence of the arrangement of the discs **A**, **B** and **C**, any point on the disc **C** can be brought to the center of the platform **A**.

So when there is a master adjusted exactly in the recess of **C**, each hole of this gauge is successively centered, and for each hole a reference mark is traced between discs **A** and **B** and another reference mark between **B** and **C**. For each center a hole is bored on the edge of the disc **C** which precisely fixes it to disc **A** by a carefully turned pin⁶⁵. The holes of the master plate, the reference marks between the discs and the holes for the fixing pins are all numbered with the same figure. This delicate and extremely time consuming work being finished, there is now the means of transferring, in a rigorously exact way, the points of the gauge in their correct relative positions to any plate which is carefully adjusted in the recess of the disc **C**.

The total diameter of the platform **A** is approximately 16 cm.

Top plates are started like pillar plates. They are roughly dressed, then removed from the cutting machine and, with only one blow, the holes for the pillars, balance and mobiles are punched.

To bore the other smaller holes exactly in their places (like those for chaton screws, steady pins and screws for cocks, balance spring studs, etc.) the plate is locked in a plate gauge where it is positioned by the holes which have just been cut. One face of this plate gauge carries holes furnished with hard steel canons. These canons are the exact sizes and in the exact positions which the holes

65 *disque O* in the manuscript, but there is no label **O** on the figure. Also note that some of the numbers written around the edge of **C** are incorrect. Both suggest that this is a copy of the original as I very much doubt if David would have been so careless.

must occupy. They are not only used to guide the drill bit, but also to measure it. The other face of the plate gauge has larger holes to let the drilling shards escape.

All the parts are drilled by this process, which requires extremely expensive tools but which ensures a perfect exactness, much higher than can be obtained by marking centers for the parts in a gauge as is done in Switzerland.

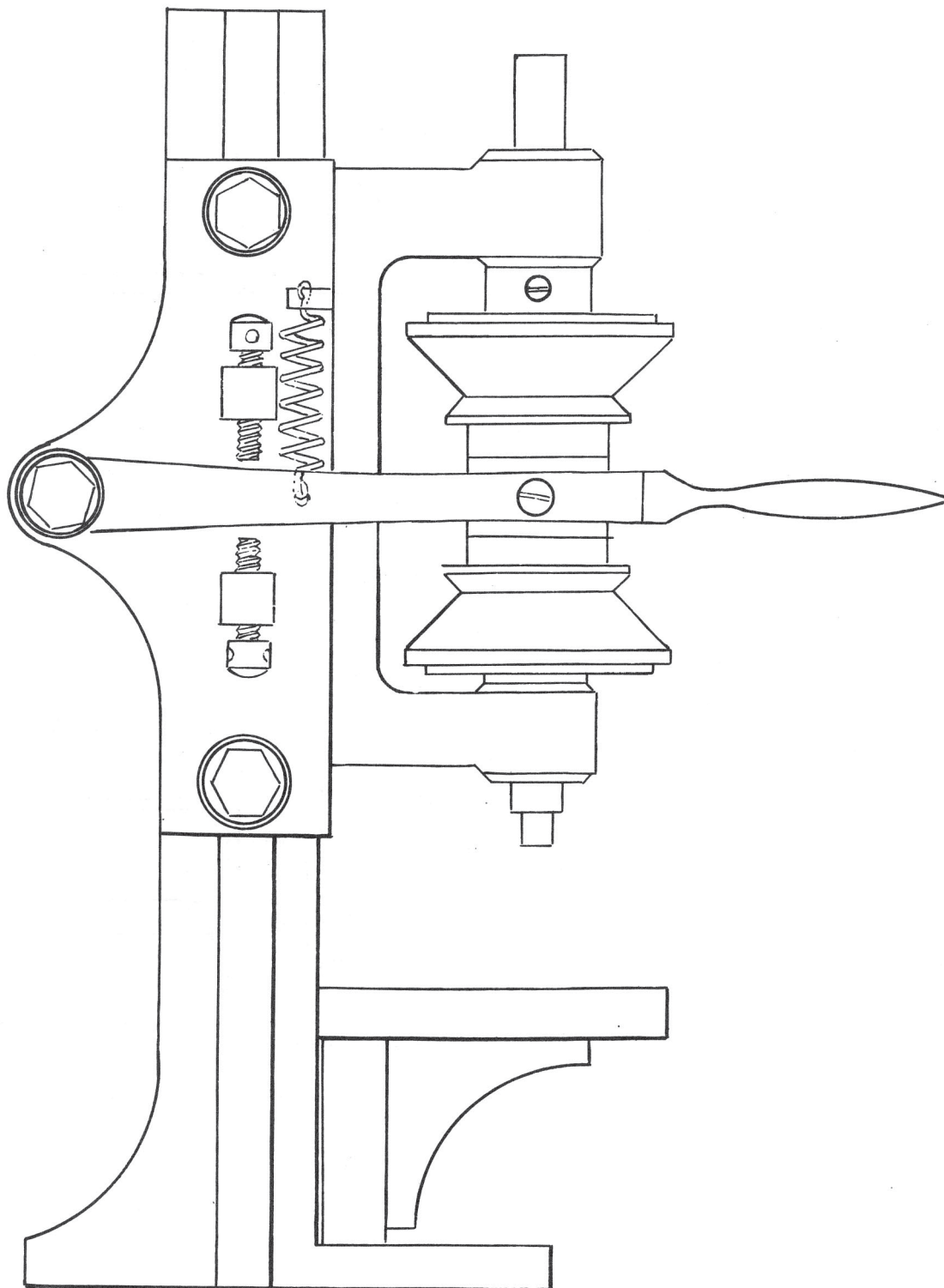


Figure 8: Hole tapping lathe⁶⁶.

The pillars are made in a lathe with 5 gravers⁶⁷ which turn them completely, and they are screwed into the plates; they are never riveted. They are simply threaded large enough to be forced into the tapped holes in the plate. The holes for the pillars in the top plates are not retouched and are used as they were cut.

There are always 4 pillars in full plate watches in order to ensure perfect stability of the top plate.

Bridges, cocks, small bridges⁶⁸, covers, etc., are treated in the same manner. To turn them they are held tight in chucks which have the exact form for milling. The sides are shaped using a cutter and this work is so clean that no re-dressing is needed.

The steady pins are generally large and very short. They are screwed in and, except on thin parts, the hole is not bored through, which prevents the pins showing after gilding. On the other hand, with thin parts like covers, cocks, and pallet bridges, the pins are almost always visible.

The steady pins are drawn from wire exactly to size and are always the same. The wire is fed into a hand-operated machine to make the threads. This machine threads the pin and cuts the wire exactly to length, but not completely through; the pin is screwed into the bridge under pressure and the wire breaks at the place where it was marked. The end of the pin is rounded with a small cutter. Bridges, small bridges, etc., are tapped in advance on a machine and this operation is done very quickly.

The pillar and top plates which must receive the steady pins are drilled very exactly, and the operation, which involves remounting the ebauches, is only one of screwing so to speak. Reaming the holes to allow the pins to enter is seldom necessary. After this operation all the parts are numbered and distributed into their movement boxes⁶⁹. This numbering produces a burr which must be removed in a delicate operation. To avoid this, the factories which are certain of their pin positions number all the parts before putting in the pins and easily remove the burr, the part still being flat.

In the majority of the establishments, screws are still made using a small machine operated by hand. This machine is much simpler than that which is used in Europe, but it appears to me to produce the same result for a like amount of work. Its advantage is in the quality of the work produced, which is certainly comparable with the best screws provided by Geneva.

(The screws used during the manufacture of the watch are not the same ones which are used after gilding. In fact hardened screws are constantly returned to the plate and screw workshop after having been used to hold the movement together until adjustment.)

The screw slot is made by a small automatic machine that each screw maker has in front of him. Instead of cutting off the screw completely and letting it drop, it is screwed into a circular or rectangular block. This block being loaded with about a gross of screws, it is put on the slotting machine which slots them without the workman having to do anything, and stops when all the screws are finished. There is a large variety of these machines. We attach to the report drawings of the type which appeared to us to be the simplest (Figures 9, 10).⁷⁰

Until now, automatic machines to make screws have rarely been used. The factory at Waltham displayed two in Philadelphia, which appear to be perfectly successful. They claim one of these machines can make 8000 screws per day with only 5% waste. The screws are well formed, well tapped and well slit, but the machine is very complicated and must present many disadvantages for regular production. These two machines are, none the less, very striking examples of the tools that American watch industry mechanics can design and build.

The screws are hardened and tempered, then polished. To polish them a great number (2 gross or 288) are screwed into very flat steel blocks, and they are ground as we described for the steel

67 *burin*, graver. David uses this word for any fixed or hand-held tool where the work rotates. He uses *fraise*, cutter, for any hand or machine operated tool that rotates (where the work is stationary). In English graver is generally restricted to hand-held tools, but I have followed David's usage.

68 *barettes*; small bridges, cocks and bars. There is no equivalent word in English.

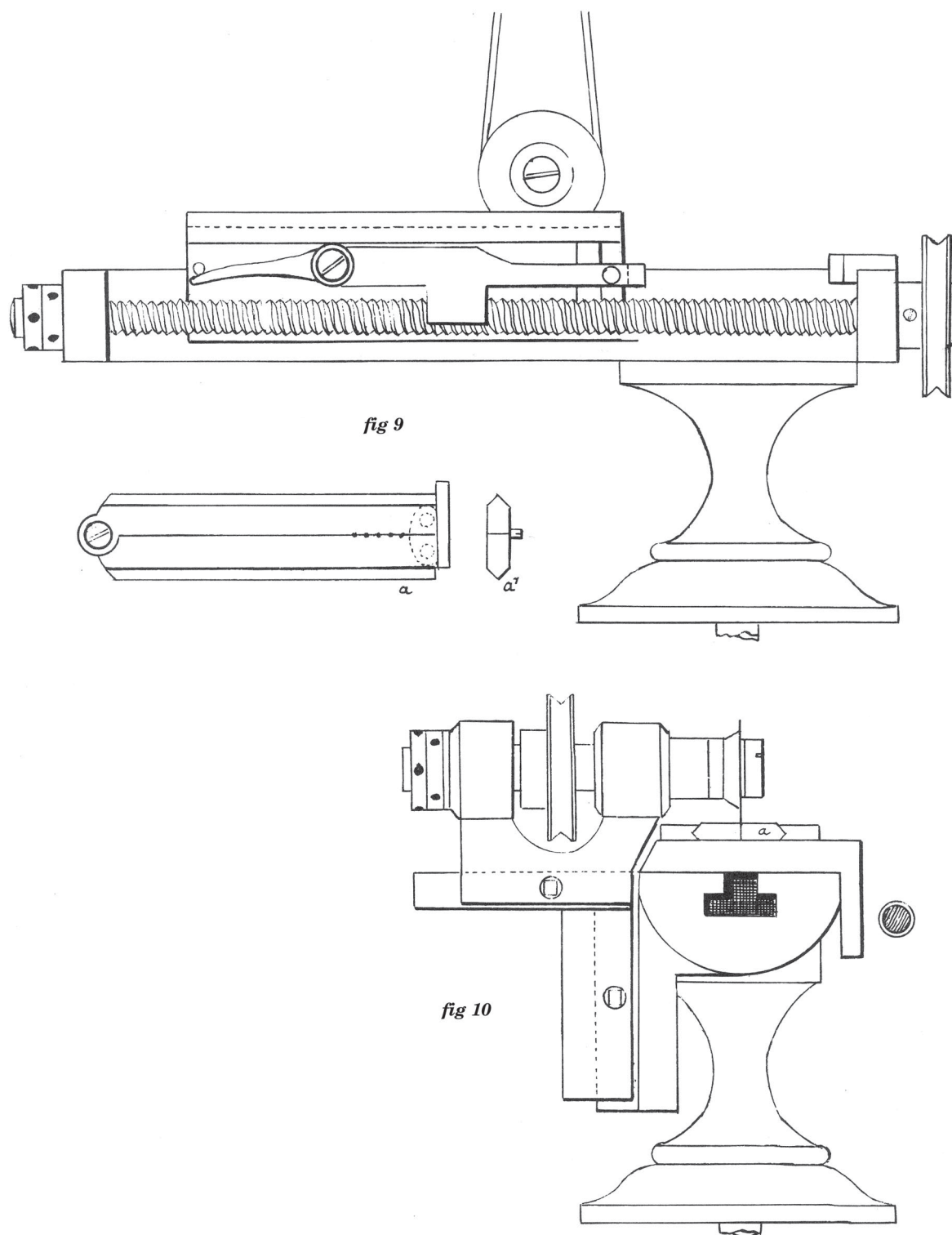
69 I have no idea what "is only one of screwing" means. More importantly, at this early stage the serial number has been stamped on the pieces and all parts for the one movement are stored in its own box.

70 See Donald Hoke *The Time Museum historical catalogue of American watches* (1991, The Time Museum). Hoke *Ingenious Yankees* (1990, Columbia University Press) also illustrates some escape wheel cutters and balance rim drilling machines.

workshop. Then they are smoothed with Turkey stone and given a brilliant polish with Vienna lime. They are tempered in large lots and sorted according to their colour.

The screws are then counted, bottled and held in the store until they are used.

In the plate and screw workshop some operations are done on the barrels and lids, but it is rough work which does not present anything of particular interest.



Figures 9, 10: Automatic screw slotting machine⁷¹.

71 Originally Plate II, figs 1, 2, 3. There is no *fig 3* on the original plate.

The motion room (the wheel and pinion workshop)

In the wheel and pinion workshop, called the Motion Room, barrels, arbors, pinions and wheels are manufactured. The importance of this work is such that often the department is separated into two workshops.

In all the factories the barrels are roughed out in several operations, their teeth cut either by hand or automatically. Then they are centered by being held by the outside of their teeth in an extremely accurate chuck and a graver is passed through the hole in the barrel to cut it to the exact size of the arbor, this graver taking a very fine cut. The lid is fitted and its hole is also centered by bringing it to the correct size of the arbor.

The machines which cut the barrel teeth are of various types. In Waltham there is an automatic machine that cuts and rounds 4 barrels at the same time. In other factories ordinary wheel cutting machines are used to cut all the wheels and each can cut only one barrel.

These machines center the barrels exactly and they remain centered, because thereafter the holes are never touched with a broach, but always with a graver, the barrel being gripped by the outside of its teeth.

We do not consider the question of cost at the moment, but only the result obtained.

The barrel arbors are made by an extremely simple and perfect process which is distinguished by the exact and indestructible machines employed for this work.

The steel rod (in 1 to 9 foot lengths) is sheared into pieces the length of an arbor. These pieces are gripped in a chuck and roughed out, making a point and leaving the rod slightly larger than final size. The roughing finished at one end, it is repeated on the other end in the same machine or a similar one, according to the size of the establishment.

This double operation, which requires the removal of a great quantity of material, is done guiding the gravers by hand. After the second operation, the arbors have exactly the same length from point to point, and the raised sections are in exactly the same place on all the arbors. This work is done with a gauge and is as exact as if it were a final turning.

The squares are then cut on machines which vary from one factory to another. The machine most widespread is an ordinary dividing engine in which the arbor is gripped by a spring chuck with a fixed base. Division and the cutter are controlled by hand. The squares are initially cut on one side for a number of arbors, and then the machine is adjusted for the second cut.⁷² These cuts must be exact because the arbors must be assembled with ratchets and stop fingers which have already been hardened and polished. Final adjustments are thus impossible.

Waltham has an automatic machine to make arbor squares which cuts, we were told, 400 arbors on two sides per day. This machine and the work which it produces are very remarkable. The arbor is attacked by two cutters, one of which forms the square and the other makes an undercut so that the base of the square is quite true (Figure 11). The 2 cutters do their work successively without the arbor being removed from the machine.

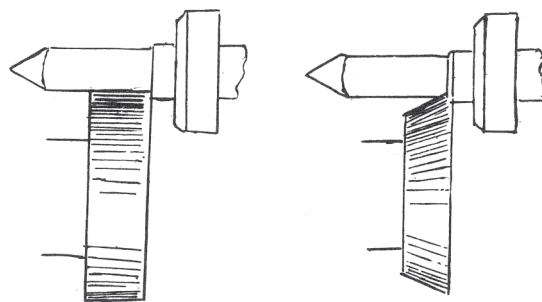


Figure 11

The squares being cut, the arbors are pivoted by automatic machines. These machines are the same type as those which are used for turning and pivoting pinions. They are found in all the factories and are of extremely simple construction; their design varies very little from one factory to another (see figs 14, 15).

⁷² As squares have four sides I presume two opposite sides are cut with the one indexing.

They are made to remove very small quantities of material, to cut the lengths and diameters exactly, to form the pivots, etc., on steel parts which have not been hardened.

Each part, which must be exactly the same length, is supported by one of its points, and a graver does its work at the other end. It advances slowly along the part up to a given point, moves away, returns to its starting point and the machine stops. The next part is set up, the machine started, does its work and stops. This happens rather quickly so that a worker can only operate one machine.

The barrel arbor undergoes 4 operations.

One drills it for the hook.

One hardens and then tempers it a very little; these arbors are very hard.

After hardening, it is polished on a particular machine called a *wigwag* which smooths the arbor and then polishes it with a thinned iron file given a rectilinear motion with very fast forward and back movements.⁷³ Polishing with a lap is exceptional. The wigwag is employed for polishing all cylindrical parts including keyless stems, barrel arbors, pallet arbors and pivots.

It is with this tool that the bodies of the pivots are polished perfectly straight and the pivots themselves are brought to size. It fulfils the functions of a square burnisher as it is used for pivoting in Switzerland.

The arbor, having been polished, is gripped in a clamp which presents it to an emery stone. This stone cuts down the ends, setting the arbor exactly to length, and it is finished by polishing the ends of the square and the pivot by a process which does not present anything of interest.

The arbors, which can be distorted by hardening, are carefully selected, either by a special inspection or while on the wigwag polishing machine, which shows if they are badly out of round by the way in which it polishes.

The arbors thus obtained are not perfectly exact. It is admitted that any tempered and polished steel part cannot be absolutely in conformity with a specification. The variations are extremely small, and the workmen are given permission not to be delayed by small irregularities in the barrel arbors.

The workmen who put in the barrel arbor use a small tool which we will describe here, although its principal use is with jewel setting.

This apparatus, called a *jewelling rest* by the Americans, is strictly speaking a tool rest which is put on the bed of a lathe. It is designed so that the graver moves away from the center of the lathe the precise distance necessary to make a hole or recess exactly the right size to receive a pivot or a jewel.

Figure 12 will make this clear:

A is the base of the instrument, and this sole is put on the lathe bed and fixed there by a bolt.

B is hinged on it and pivots around the axis **ab**. This piece **B** carries on its upper part a small tempered steel center **E**. This center meets another tempered steel center carried by the part **D** on the support **C**. These two centers **D** and **E** can be adjusted so that they take the various positions required by the different work to be done.

A runner **F** slides under light friction without any play in the piece **B**. This runner carries a graver and it is located exactly half way between the axis **ab** and the two centers **E** and **D**.

If between the centers is put, for example, the pivot of a barrel arbor, the graver will deviate from its original position by half of the diameter of this pivot, and if it is initially set up so that the point of the graver coincides with the center of the hole when the two centers **E** and **D** are in contact, one will be sure that the graver will cut a hole in which the pivot will enter exactly.

This clever tool is extremely expensive but it is exact and it renders many services, being used for various operations with great success. We will later see it used for jewel setting, fitting chatons, planting barrels and center wheels in pillar and top plates, etc.

73 The only pictures of wigwags that I have found are in F.J. Britten *Watch and Clockmakers' Handbook, Dictionary and Guide* (there is no description) and H.L. Belmont *L'Echappement a Cylindre 1720-1950* (which has a photograph of a hand-operated wigwag from Switzerland).

It is the same tool which, with a different system of adjustment, is used in some factories to turn the plates and recesses of the ebauche.

Using this tool one can fit arbors to barrels. The arbors are of exact height. The lids are of exact thickness.

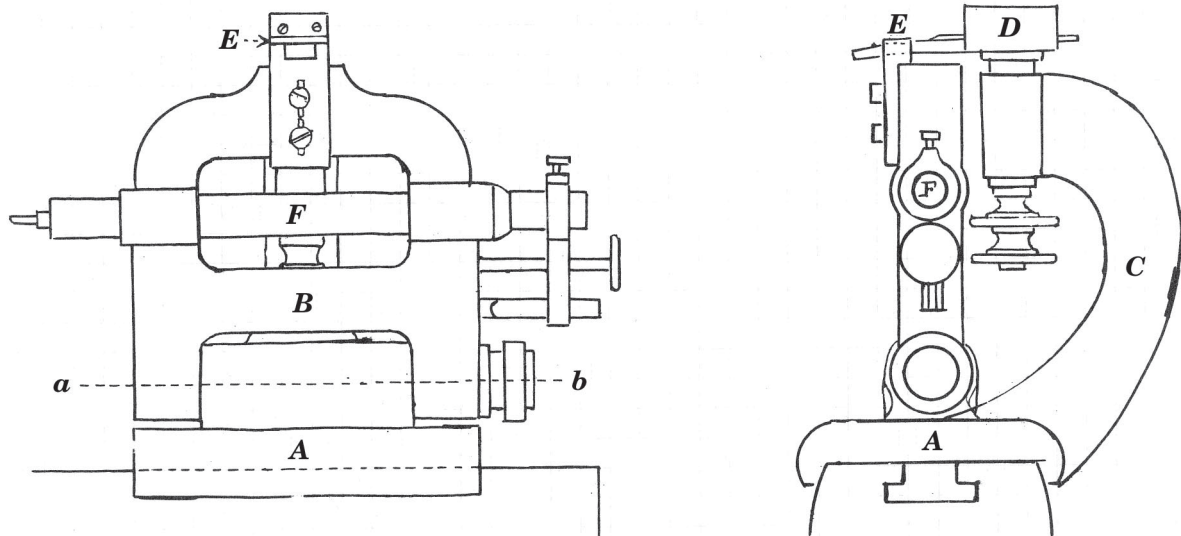


Figure 12: Jewelling rest.

The barrel is gripped by its teeth and the center hole is enlarged to fit the pivot of the arbor. The lid is placed on the barrel and its hole is bored in the same way to fit the other pivot of the arbor. The barrel being adjusted to the arbor, another operation is done later by the same workman, or by another person using a similar lathe, which consists in closing the barrel and giving the arbour the necessary play.

To finish the adjustment completely, a light touch with a broach can be given, but it is rarely needed if the workman who fits the arbors is a master of his tool.

The barrel arbors are drilled to receive the spring hook and then stored after being polished and inspected.

Pinions are made in American factories by very different processes to those of Europe.

These processes have the advantage of allowing very hard pinions because they are pivoted before hardening. Moreover, the wheels are not riveted to the pinions but only driven onto the arbors. This makes repairing easier and means that an American wheel lasts longer than any other, because in the event of pinion wear the wheel can be moved so that it engages with another part of the pinion.

The steel arbor is started as we have described for barrel arbors. There is a first cutting and 2 roughing out steps. Then the pinion is cut on a machine, which is operated by hand in some factories and in others it is an automatic machine. Elgin cuts pinions by hand.

Waltham has two types of automatic machine which are extremely clever. In these two kinds of machine the system of milling is the same. The first cutter is a flat cutter known as a *saw*; it does nothing but cut the desired number of leaves. The second cutter roughly rounds the ends of the leaves. The third cutter produces the exact shape.

These 3 cutters are sometimes set up on 3 different arbors mounted on a barrel with a horizontal axis, like those used in the hand machines at Elgin and in one of the automatic systems at Waltham. In the other method they are mounted on the same arbor, as in the more rigid system designed at Waltham. (See fig 13.)

After cutting, the pinions are treated by automatic machines, which turn the arbors exactly to size and dress the faces by removing the cutting burr.

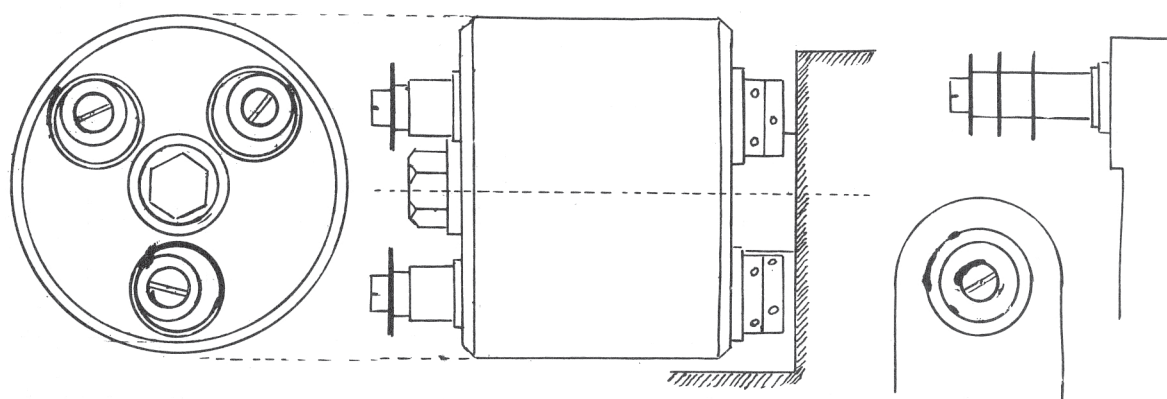


Figure 13. New and old systems for automatic pinion cutting.

This turning being done, the pinion is put into a guide⁷⁴ and the two ends are filed flush with the guide in order to bring all of the arbors to exactly the same length. The points are slightly damaged by this operation, but very little.

Pivoting still takes place on machines in the standard way, but is finer. For this pivoting, the pinion is supported in sapphire or tempered steel holes, and rotated by a small dog entering between two leaves. It is supported behind by a flat surface or by the face of the leaves according to the system. The first position is thus at a constant distance from a fixed point. This first position is used as a basis to turn the second pivot.⁷⁵ Hardening and tempering take place after this operation. The pivots are large enough not to be burned during hardening. Heating is done in a box and tempering with smoking oil. After hardening the leaves are polished; in some factories the cutting is rough and it is necessary to smooth the leaves before polishing. Smoothing and polishing are done using the wigwag which carries an iron or zinc blade as required. This blade is formed by a graver to the shape of the leaf which it has to polish. This graver is fixed on the machine itself and it is only necessary to raise the blade by turning it around its axis to bring it into contact with the graver.

In some machines changing leaves is automatic (Waltham), in others it is done by pushing the pinion with a finger.

In summary, these machines produce beautiful work, but they appear quite complicated and quite expensive for the work which they do, work which is carried out by infinitely less expensive processes in Europe. A very careful examination of the specimens produced would show if the polishing is done much better with the wigwag than with a small wheel.

The leaves being polished, the arbors and faces are polished with the wigwag. This operation reveals any pinions distorted by hardening. They are put aside and those which have badly formed leaves are separated out; they are excluded completely. Those which do not have poorly cut leaves but the arbor is out of round are corrected by grinding the arbour with small laps charged with diamond. Also it happens that some pinions are rifled during cutting and cannot be used.⁷⁶

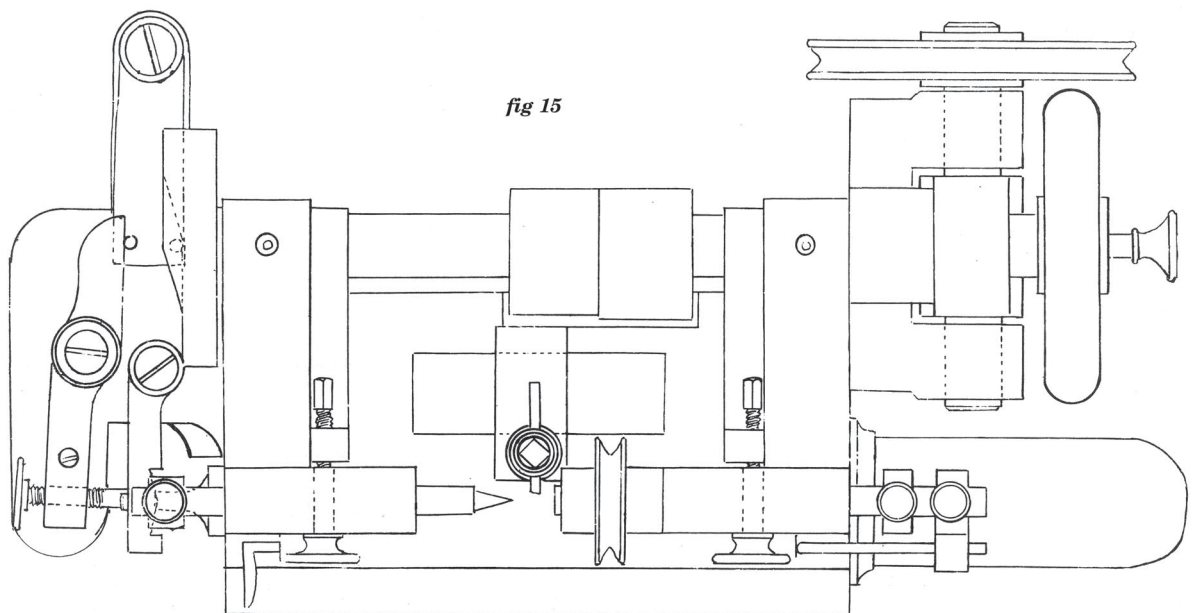
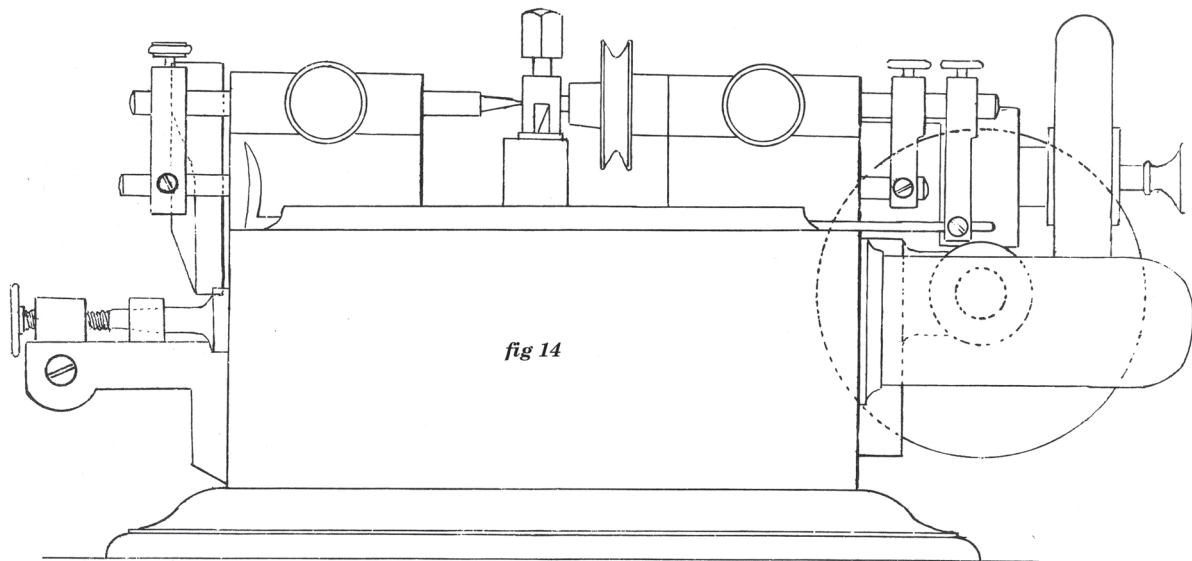
The pivots are polished by the wigwag. The pivot is put in a sapphire notch and the wigwag works on it until it arrives at the required size. After that it is polished on another wigwag and the end of the pivot is rounded with an Arkansas stone. The whole piece is brilliantly polished by boxwood covered with Vienna lime.

The cutters which are used to form the pinions are not cutters like those which are currently employed in Europe. In fact steel discs are shaped on their edge by a graver, using a process which facilitates this work, then divided into a certain number of sections by radial slits. These cutters must be very carefully sharpened and polished to cut steel easily.

74 *gâche*. I assume this is like a small trough with the ends slotted, so that the arbor can be put in it and trimmed.

75 David is vague. It is important that the length of the arbor is constant and so a single reference point is used for turning both pivots.

76 Rifled as in gun barrels - the leaves spiral along the pinion.



Figures 14, 15: Automatic pivoting machine.⁷⁷

We will give at the end of this chapter a description of the process and the machines employed for making these cutters, and at the same time describe the making of fly cutters for wheels.

The pinions of the center wheel generally use the system patented by Fogg.

Those which are made in one piece are treated like ordinary pinions, but drilling requires particular care for the centers of the machines for turning, polishing, etc. These centers are made out of sapphire and only very rarely steel.⁷⁸

For the Fogg system of pinions the center wheel arbor is treated as we saw for barrel arbors. The thread, which is used to retain either the pinion directly or the nut which tightens the pinion, is raised by a graver instead of being threaded with a die. Threading would put the arbor badly out of round and the thread would not be as strong. (Threading is done on an especially built pivoting machine). The pinion itself is cut and polished on the same machines which are used for making other pinions.

⁷⁷ Originally Plate V.

⁷⁸ These are hollow, Swiss style center wheel arbors with squared taper pins so that both hand setting and winding is done by a key from the back of the watch.

Wheels are cut out as we saw on page 41. They do not have a center hole when they arrive at the wheel and pinion workshop. They are cut on a chuck which holds them by the inside of the rim. This chuck is split into 5 parts to allow for the arms. Cutting and rounding up are done at the same time by a single fly cutter turning very quickly.

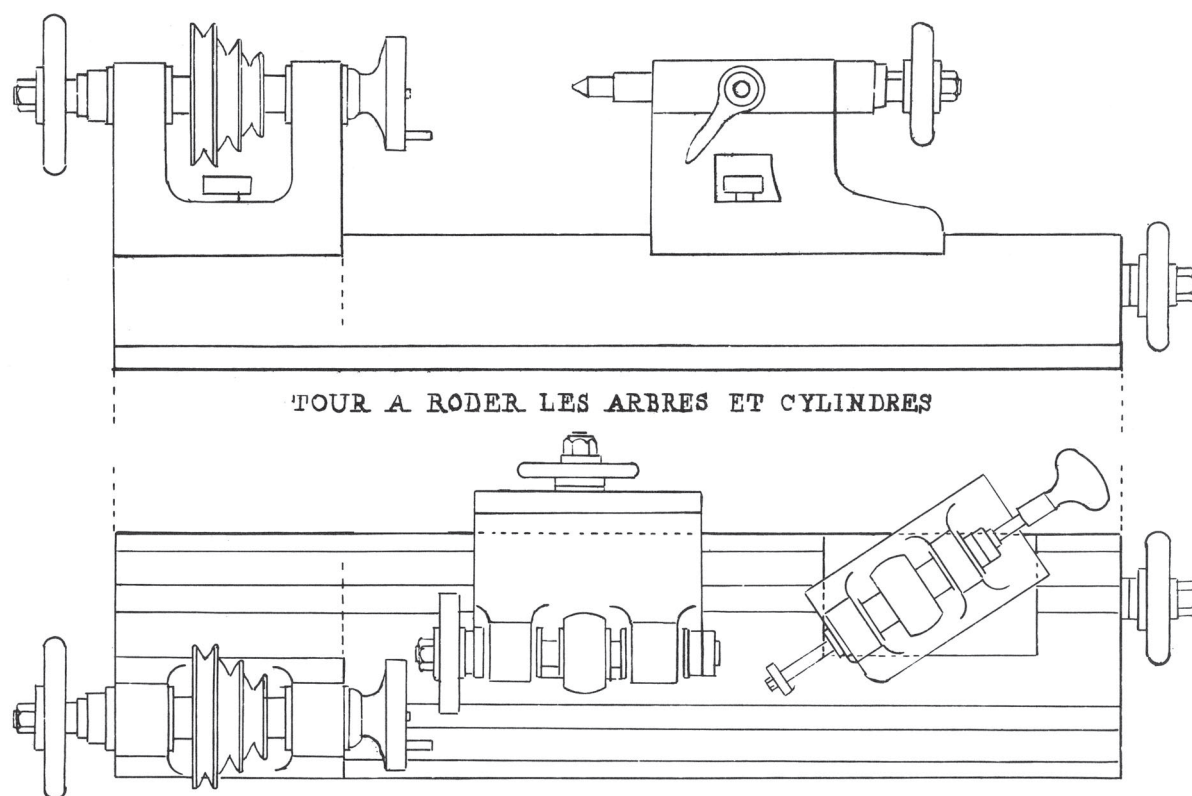


Figure 16: Lapping lathe for arbors and cylinders.⁷⁹

After cutting they are bored by holding them in a conical chuck which centers them by their teeth, and sometimes this hole is tapped. In some workshops the boss is not threaded but only riveted, which is not as good. The wheels are smoothed very flat and gilded.

After gilding the brass boss is screwed on and the wheel is put in the tool where it had been bored. The boss is bored with a suitable hole in proportion to the size of the pinion arbor and both sides of the boss are faced. In this state the wheel is ready to be driven onto the pinion arbor. It is driven by a stake held vertically in a cast iron frame.

The wheels and pinions are then carefully inspected and put into storage.

The making of cutters and fly cutters, to cut pinions and wheels, is a delicate operation. Various tools are used to make them of which we will say something, not in recommendation but to show the care the American manufacturers take to correctly realise every detail in their movements.

In each factory there is a tool to produce a graver having the epicycloid form necessary for gears⁸⁰. This tool is built differently in each factory and we give here the one which appears to us to best answer this purpose.

⁷⁹ Originally Plate VI, Figures 2 and 3.

⁸⁰ Unfortunately the following description is obscure and it is probable that David is describing a tool he had not actually seen. There is little help from other texts, which either ignore the problem or approximate epicycloidal addenda by circular addenda; see, for example, Charles Higginbotham *Precision time measures* (1913, Hazlitt and Walker) Louis & Samuel Levin *Practical benchwork for horologists* (1938, Horology) and George Daniels *Watchmaking* (1981, Sotheby). Tarasov *Technology of watch production* (1964, Israel Program for Scientific Translations) admits that the “reason for the replacement of the epicycloids by circular arcs in gear-wheel teeth lies in the difficulty of producing milling cutters of epicycloidal contour”. Indeed, this description by David is the only “practical” method for making epicycloidal cutters that I have read.

It is composed of a long cast iron frame on which a column **B** is supported. On this column is set a lever **ABD** which is held on the column by a spherical joint. This lever **ABD** can thus take any position around the point **B**.

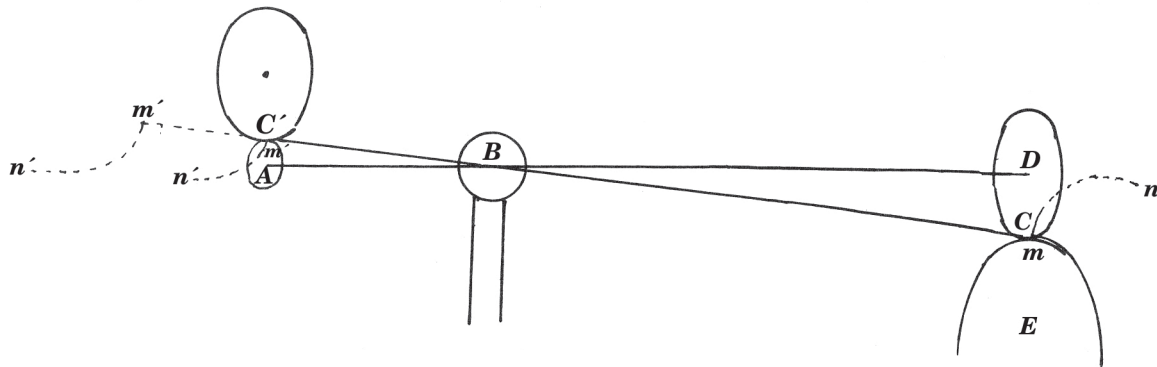


Figure 17: Epicycloid graver cutter.

To **D** is fixed a disc which can roll on the disc or segment **E**, itself fixed to the machine. The disc **D** is fixed rigidly to the arm of the lever **ABD**.

If the disc **D** is made to roll on the disc **E**, a point **C** on the edge of this disc will describe in space the epicycloid **mn**. All the points located on the generator cone **DCB** or on its prolongation will describe epicycloids **m'n'**. So, if the apparatus is built with a cupped disc **A**, with a diamond at the point **C'** on its circumference, on the prolongation of the generator cone **BC**, this point will trace an epicycloid. By choosing suitable proportions for the distances **AB** and **BD** and the diameters of the discs **D** and **E**, the edge of the serrated roller **A** will plot the epicycloid curve specific to the teeth which one wants to produce.

If a cutter blank, turning around its center, is presented at the point **A** of the serrated roller, the edge of this cutter will be shaped by the serrated roller into that epicycloidal profile. Thus a disc is obtained carrying on one side the desired profile. This disc is notched to form a cutter and hardened⁸¹.

81 The disks **D** and **E** generate epicycloids and the point **C'** will follow an epicycloid if **C'** lies on the generating cone. Thus the radius of the circle at **A** is defined; or, if you prefer it, a disc of a certain radius must be positioned a specific distance from **B** in order for **C'** to lie on the generating cone. The ratio of the diameters of **D** and **E** is the same as the ratio of the diameters of **A** and the unlabelled disk (usually 1:2). Like **D**, **A** must be rigidly fixed to the lever **ABD** so that the position of **C'** is defined. The unlabelled disk above **A** is irrelevant. It merely emphasises that **C** and **C'** must simultaneously be on the respective lines of centers.

If the point of a diamond is placed at **C'** it will trace an epicycloid on the plane surface of which **A** forms a part (perpendicular to **ABD**). The problem is how to use this to cut something big and thick enough to serve as a master tooth profile for wheel cutters. Unfortunately the rest of the explanation is confused, with David describing **A** (originally the center of the disc at **A**) as a *lentille diamantée* (a cupped? diamond disc) and a *molette* (a serrated or knurled roller) and vaguely suggesting presenting at point **A** of the *molette* a circular cutter blank. These conflicting descriptions don't make sense, but a knurled roller at **D** would be a good idea to ensure **D** rolls over **E** without slipping. The difficulty is to have only a diamond at the point **C'** acting without any other part of the disc interfering. However, no disk is needed at all, just a rigid rod connecting **A** and **C'**. Further, it is clear from David's diagram (Figure 18) that the machine in Figure 17 is used to cut a *graver* and not a disk (a *fraise*) as he suggests.

It needs to be remembered that the radius of the center wheel of a pocket watch is about 8 mm and a single tooth is about 0.25 mm wide. So the radius of a disk at **A** would be 4 mm and the width of the cutter to be made is about 0.125 mm; the problem only exists because of the very small dimensions involved, and it is perfectly understandable why watchmakers used to make teeth in the shape of a bay leaf or a thumb. Further, to build a credible machine the disc at **D** must be much larger than the "disc" at **A**, probably by a factor of at least 20, and the rod **AD** would probably have to be at least 4 mm thick to be rigid; that is, at least as large as the "disc" at **A**. So in reality there would be a diamond mounted at the end of a substantial rod and set about 4 mm from its center. Of course, for other watch wheels the diamond would have to be much closer to the center at **A**.

The graver is then fixed on the rest of a lathe set up so that the same arbor can be presented on the right and on the left of the rest, and at the same height.

A cutter blank is put on this arbor and initially turned on one side by the fixed graver on the rest. Then the arbor is installed on the other side of the graver and the cutter blank is turned on the other side.

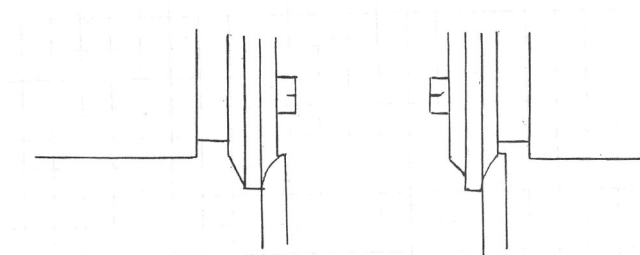


Figure 18

This piece is given the exact form of the space between two teeth by bringing a graver as near as necessary and turning the part which forms the square bottom of the space by hand.

In this way a master is made which is finished like a cutter and which is used to make a number of gravers (Figure 19) which will be used as masters to reproduce as many similar cutters as are needed.

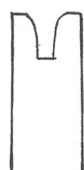


Figure 19

These cutters are then finished, either as round cutters to cut pinions and other steel, or as fly cutters to cut brass. We give some sketches showing the appearance of these cutters and fly cutters (Figure 20).⁸² These tools must be hardened and very carefully polished so that they give a true cut.

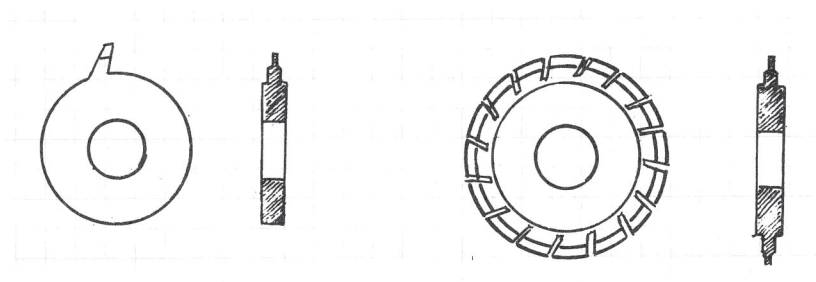


Figure 20

Put in this perspective there is no difficulty, in principle, in mounting a small steel graver on a slide rest and presenting it to a diamond mounted at C' , the graver being relieved beforehand if necessary. Note that one edge of the graver must be on the line AC' .

82 Thus a four stage process is used. A graver is cut to the correct epicycloid. This graver produces a master cutter. The master cutter is used to make a number of gravers in the shape of a tooth and half spaces on either side. Finally, these gravers are used to make the wheel or pinion cutters.

Escapement workshop

In the escapement workshop are made the levers⁸³, pallets, pallet stones, wheels, bridges and steady pins for the plates. In some factories the pivoting of pallet arbors is also done in this department.

The levers are cut out in the cutting workshop and the operations which they have to undergo in the escapement workshop vary according to their form and the escapement system adopted.

In the Elgin factory the lever and the pallets are one piece which is rather delicate to handle and has the disadvantage that there is no way to lengthen or shorten the lever without having to alter the pallets at the same time.

In other factories, the levers are generally separate from the pallets. Waltham appears to use the preferable system, which consists of a lever fixed to the pallets by two screws. The lever can be moved on the pallets if one wants to lengthen or shorten it.⁸⁴

The American factories have generally adopted visible pallet stones which lend themselves much better than covered pallet stones to the requirements of mechanical manufacture. Waltham started by making covered pallets and a test of visible pallets was done that showed there could be a saving of 12 cents (60 centimes) per set by using visible pallets. The adoption of this system indeed produced that saving and all the factories which have been organised since have adopted it.^{84a}

The levers are entirely finished and polished to a particular standard and nothing has to be done to them afterwards. They are bored exactly as we have described for making plates.

The notch for the impulse pin is generally made at the same time as the horns are shaped, using three coupled cutters, which sometimes cut only one lever at a time and sometimes a number of them.

The body of the lever is shaped by a grinding lap charged with oil stone dust. This lap is turned to the exact form which the lever must have, and it uses the rough cutting to follow this form. I do not know why cutters are not used, and it is necessary to experiment in order to determine the quantity of work which a lap of this kind can produce.

After hardening, the sides are polished with emery using the same form, or even with diamond in the case of quality movements.

Polishing takes place by cementing a number of these parts onto a plate and then successively grinding them with various materials. They are polished with Vienna lime.

The pallets are cut and drilled by the normal procedure. After drilling they are slotted on machines which vary from factory to factory. Sometimes the machine has only one cutter and the pallets are placed on a revolving platform which is presented to it; the first time to cut the entry pallet slot, for example, and a second time immediately after for the exit pallet slot. In this machine the cutter rotates around a center instead of being moved in a straight line. The system of two-way adjustment of the platform carrying the pallet is very complicated. This machine is at the Springfield Illinois factory.

Another system consists in having 2 superimposed arbors, one inclined to the other in two horizontal plains set at the angle which is formed between the pallets. The pallet is fixed on a strong slide and moved vertically. This machine seems to give a guarantee of uniform work.

After hardening, the pallet is polished on its edges like the levers, and polished flat by cementing a number of them on a perfectly flat block.

The pallet stones are made out of garnet or ruby, according to quality of the movement, and different methods are employed to work them so that they are exactly the same.

The rough jewel is sawn into small square rods of arbitrary length. These rods are cemented against each other on a steel plate which is fixed on a lapidary lathe and the visible sides of the rods are dressed and polished successively. They are cleaned and then are polished on the opposite face by the same process.

83 *fouchette*, fork. David uses this word for the body of the lever, here and on page 41.

84 This is mainly a distinction between the English right-angle escapement and the Swiss straight line escapement; in the former case the pallets are generally pinned or screwed to the lever, while they are usually an integral part of the lever in the latter case.

84a This is a saving of about 1.7% or less of the cost of a movement and shows how seriously American factories took cost reduction.

One thus obtains rods of jewel which have the correct thickness necessary to fit into the slots of the pallet. The second plate which is used to polish the third side is recessed by the exact thickness that the finished pallet stones must have. They are cemented to one of these plates to dress and polish the third side, which is the bottom of the pallet jewel. These 3 sides being polished flat, the top side domed.

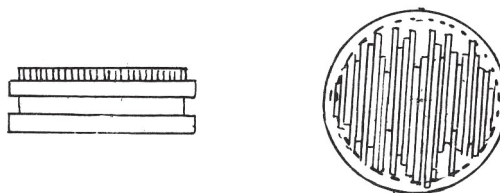


Figure 21

For that the rods are cemented into a chuck with countersinks of exactly the same dimensions as the rods. This chuck has a diameter corresponding to the convex surface which is to be obtained.⁸⁵ The pallets being cemented in the countersinks, the excess material is cut away and the domes are immediately polished. One thus obtains small rods which have exactly the same dimensions conforming to the pallet stones.



Figure 22

The procedure to finish the pallet stones differs from factory to factory. At Waltham the rods are placed side by side in a block with grooves milled at the desired angle (Figure 23), and the protruding ends of these rods are dressed and polished by firmly fixing the block on a lathe headstock.

One thus obtains rods of form *a*. They are sawn roughly to length using a thin lap charged with diamond. Then they are again cemented with the acting faces of the pallets well supported against a fixed part, and they are cut and polished all together. Thus all the pallets have the dimensions given by the block *B*, Figure 23.

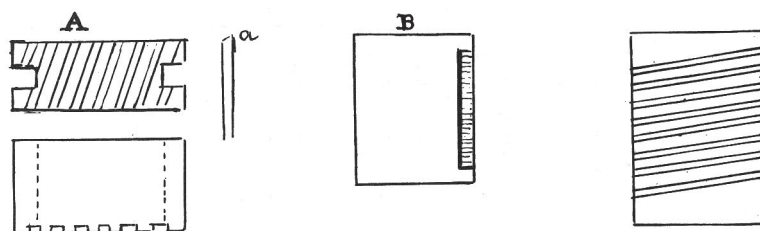


Figure 23

In the Howard factory, which makes very beautiful and good assortments, the system to finish the pallet stones is different. They are cemented once, which seems preferable, saving errors and avoiding a delicate operation.

The jewel rods, polished on all 4 sides, are sawn roughly to length and are cemented to a part which has the form shown at *C* in Figure 24.⁸⁶ The length *dd'* is the length of the pallet stone; the angle *add'* is the complement of the lifting angle and the angle *dd'f* is the lifting angle. This part *C* is

⁸⁵ Figure 22, which shows this chuck, is a very badly drawn end view. The chuck is a cylinder with grooves running along its length.

⁸⁶ Although not stated, presumably a number of rods are cemented side by side; it would be too slow to cut them one at a time.

put on a chuck *D*, first in position *I* and then in position *II*. If in each of these positions the protruding ends of the pallet stones are cut and polished level with the piece *C*, identical pallet stones of exactly the same length are produced. The pallet stones are then carefully examined and their lengths measured. Those which are by accident too long are put aside for repair and those that are too short are used for small wheel jewels.

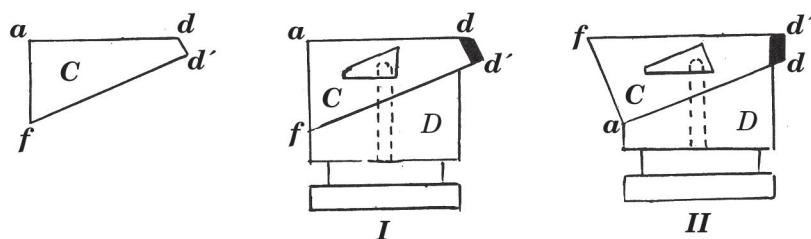


Figure 24

Escape wheels are always made from hard brass. They are cut out with a center hole by only one blow. They are carefully dressed and re-cut to clean them.

After this operation their teeth are cut on a special machine which has an arbor with a division plate for 15 teeth. This arbor carries a large chuck divided into 4 on which the escape wheels are put and centered by the inside of the rim. From 20 to 40 wheels are cut at once. The chuck has a particular method of tightening so that the wheels are firmly gripped.

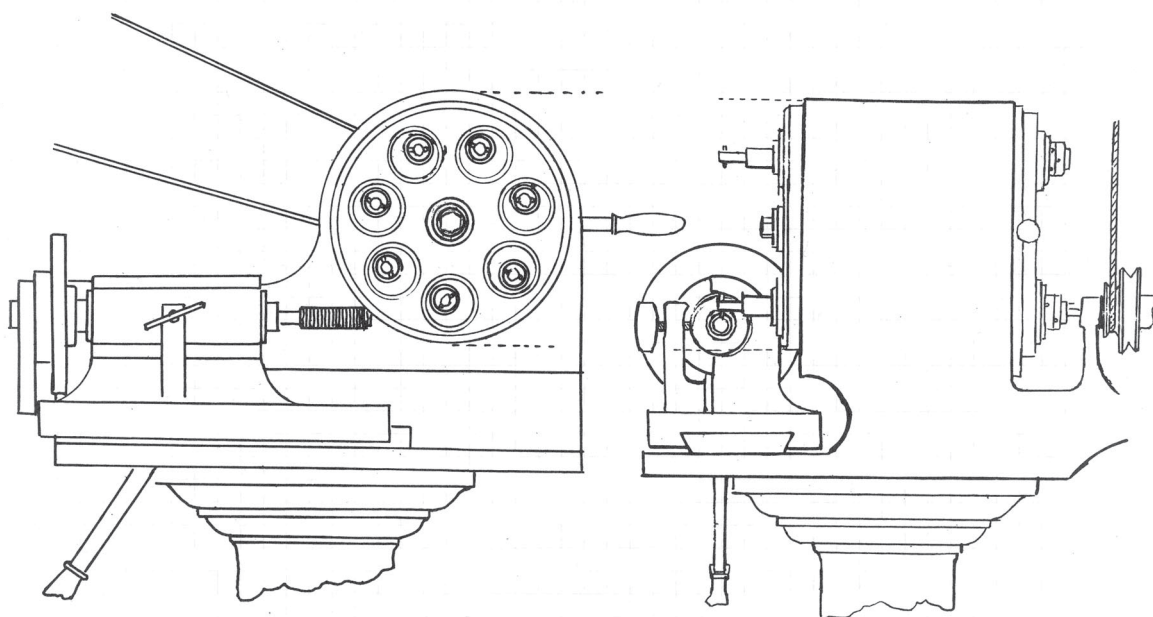


Figure 25

Cutting is done using 7 cutters which are carried on 7 arbors contained in a barrel rotating on a horizontal axis (Figure 25). Each one of these arbors can be adjusted independently of the others. To achieve this they are offset in a cylinder which can move in all directions. By rotating the cylinder the cutting depth is regulated and by moving it in or out parallel to the spindle the place where the cutter touches the wheel is altered.⁸⁷

The first cutter is made out of steel and removes the most material. The other cutters are made of perfectly polished sapphire. The sapphire cutters take a completely polished cut and these wheels do not undergo any final retouching afterwards.

⁸⁷ See, for example, Daniels *Watchmaking* (1981, Sotheby and 2002, Philip Wilson) or Gazeley *Watch and clock making and repairing* (1953, Heywood and 1998, Robert Hale) which describe the cuts needed to form a Swiss (club tooth) escape wheel.

The manufacture of sapphire gravers and cutters is the speciality of a workman in each factory, who constructs the tools or parts of tools made from jewels. The jewel holes for pivots, draw plates for steady pins, gravers for the manufacture of cutters and for turning jewels, etc., give much importance to the use of these special gems, and somebody is needed at the factory to work them.

The wheel is then treated, as we have seen, to finish the holes. It is centered by the tips of the teeth, bored and gilded. The boss is screwed on or riveted, and then finished and bored before it is driven onto the escape wheel pinion. After inspection and sorting by size using a pivot gauge⁸⁸, they are put in the store.

There is nothing of importance to say about the construction of the bridges, which use special tools adapted to the purpose.

The impulse pins are made with tools which cut them round on a machine. These tools have the necessary adjustments so that the diameters of all impulse pins are the same. These round rods are then cut to length and cemented onto a plate similar to that which is used for pallet stones. Using this plate, the front of the impulse pins are flattened the desired amount.

Generally, all these machines to cut and polish delicate escapement jewels are provided with a fixed grinding lap for the first cut and with a polishing lap which automatically moves with a light reciprocating motion. The workman only has to worry about the part being worked and does not have to manoeuvre the laps.

In the escapement workshop, the pallets and lever are assembled onto the pallet arbor. The pallet arbors are sometimes smooth and the pallets and lever driven on, and sometimes they are threaded. The friction arbor method is used at Waltham. The system of threaded arbors is adopted by Elgin.

A small tool fixes the lever to the pallets by putting it in its exact position relative the pallet stones. The lever is fixed on the pallet this way, and it is only in the case of a jewel setting error or a similar accident that the finisher has to alter this position.

Pivoting the balances takes place in the same department. The balance staffs are roughed out very exactly so that there is almost nothing to retouch. After hardening, each staff is put in a gauge which shows the exact length that the staff must have from the balance to the end of the pivot on each side. A touch with a file shortens the staffs that are too long. This operation being done, the staff is cemented in a chuck on the pivoting lathe. The pivot is shaped by hand, giving it a suitable length without shortening the overall length of the staff which is exact. The rough pivots are finished by hand and polished by a lap mounted on the machine. While the staff is in the chuck the pivot shanks are finished, but only by smoothing them. The adjustment of the roller is also done by smoothing, the staff having previously been turned exactly.

The staff is cleaned up, turned over and cemented in the same chuck, in order to treat the top pivot in the same manner and to smooth the collet and balance seats, which have already been turned to size.

Balance staffs intended for ordinary movements do not have conical pivots. They are pivoted before hardening in the same way as pallet arbors on a pivoting machine, and they are only cemented to make adjustments to the roller, collet and balance seats.

The staff being made, a workman rivets on the balance, another worker drives on the roller, and the balance is inspected in this state. They are checked to see if they are round, in poise, etc., and they are not delivered to the finisher unless they are in good condition.

Jewel making

The manufacture of jewels is complete only at the Waltham factory. The other factories do only one part of the work and receive them from England or Switzerland with nearly everything done. Waltham also has some drilling done outside.

The machines used to work jewels are very numerous. There are 4 garnet saws which each have 6 blades. The jewel is pressed against the saw by a weight. Several machines trim rubies, which are cemented about 20 at a time on a platform. Drilling is done in 2 operations with a diamond graver.

The turning of ordinary jewels is done on a lathe where the jewel is cemented as is done on jewellers' lathes. Instead of turning the jewel by hand, it is turned by a diamond graver held in a rest which makes it possible to control it. This rest initially moves toward the center to form the face of the

88 *filière pour la grandeur des roues*, wheel gauge, but I would hope the wheels were cut accurately enough for their diameters not to vary significantly. Pivot gauge seems more sensible.

jewel. The diamond graver is moved forward by a return screw and advances to a stop. The rest then moves to the side of the jewel and the graver turns the piece to size while advancing to another stop.

Another rest is then put on the lathe bed and a diamond graver, held in the hand and supported on this rest, is used to cut out the oil sink. The jewel is then polished by the usual procedures. Ordinary jewels are done by hand using a similar method.

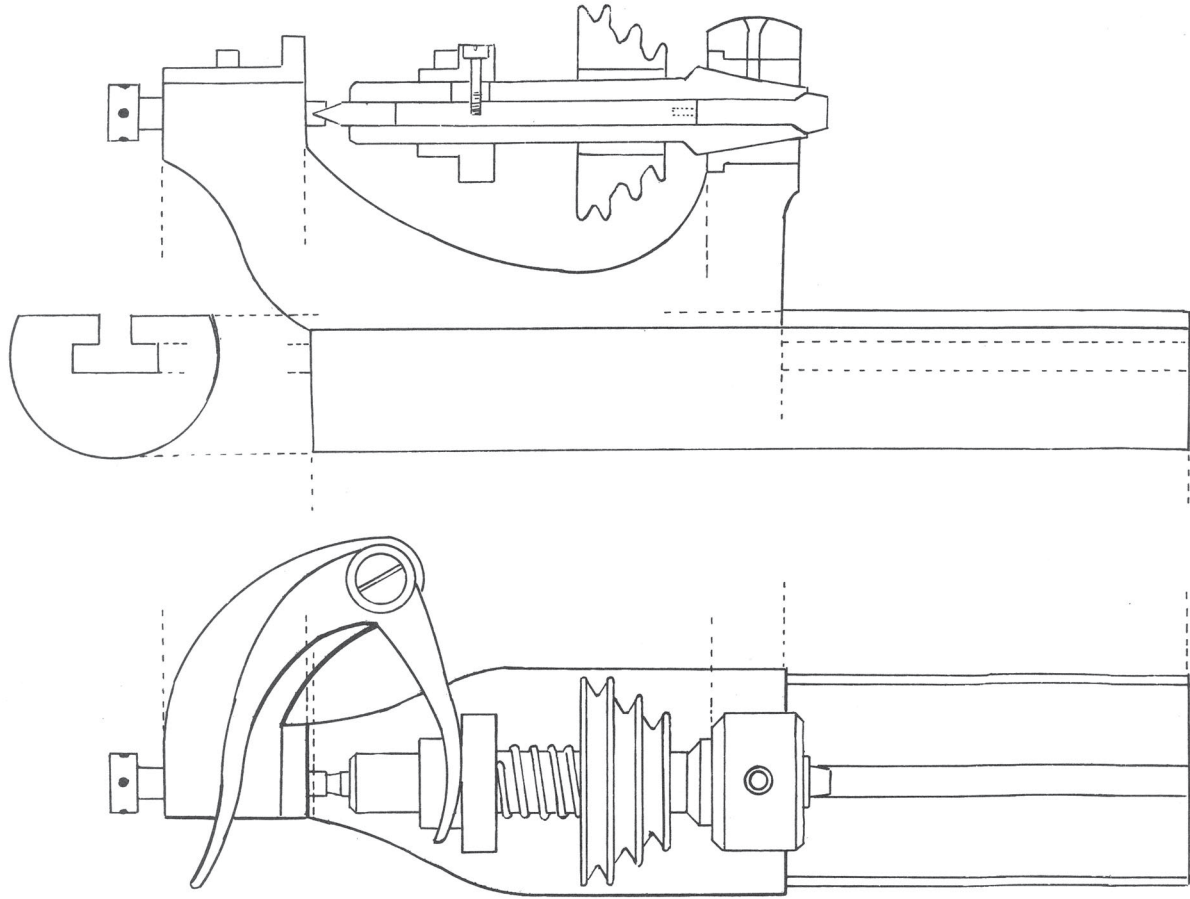


Figure 26: Jewelling lathe.⁸⁹

To size the jewels and polish the holes they are not cemented. The lathes which are used for this operation have chucks which hold the jewel by its external edge. The jewels that are badly out of round are put aside to be turned again or to be crimped in bouchons⁹⁰.

The chaton, a jewel crimped in a bouchon instead of being mounted directly in the plate, is used by all American manufacturers. We shall see that the ingenious system of jewel setting that these manufacturers have adopted is based on the use of the chaton on at least one side.

The chaton has, moreover, several advantages in that it makes it possible to use ordinary jewels, including those which are out of round, and that in many situations it facilitates repair.

To make these chatons short brass cylinders are bored and cut to length in advance. These cylinders are placed in a chuck on the jewelling lathe. To make the housing for the jewel the jewelling rest described on pages 47-48 is used. The graver makes the jewel housing and the jewel is pressed in with a pusher held in the hand. Once the jewel has been pressed in, a cut with a flat graver makes the lower part of the chaton quite parallel to and almost flush with the jewel.

The following operation consists in cementing the chaton on a chuck, the face of the jewel outwards, and turning all of the chatons to the same diameter, using a fixed graver. The cementing is done very carefully to ensure the jewels are well centered and there will be no need for retouching during the following operations. Figure 27 shows the chaton as it is stored, ready for jewel setting.

⁸⁹ Originally Plate 8.

⁹⁰ *bouchon*, a bushing, a brass plug.

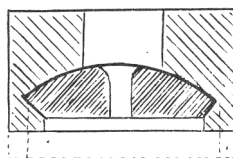


Figure 27: Rough chaton.

The unmounted jewels and the chatons are sorted not only by the type of jewel, but also by hole size. This operation is done using the graduated needle shown below and takes very little time.

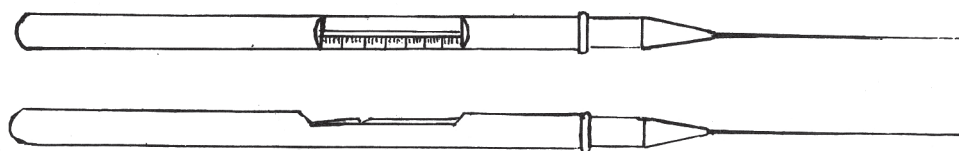


Figure 28

Jewel setting workshop and the record

Let us return to the ebauches where we left them, and follow them through the various operations of turning in the mobiles.

These operations are done in the jewel setting workshop. The barrel and the center wheel are turned in first, by enlarging the holes of the pillar plate, which is held on a face plate fixed to a planting lathe.

The sizing of the hole is done with a graver in the jewellery rest. Without disturbing the pillar plate, the top plate is put on and the top hole is enlarged.

Planting the mobile is done by another workman who has the same type of lathe to adjust the play if necessary and who has a reaming tool for adjusting freedom.

This tool (Figure 29) consists of a frame with a platform and a long canon perpendicular to the platform.

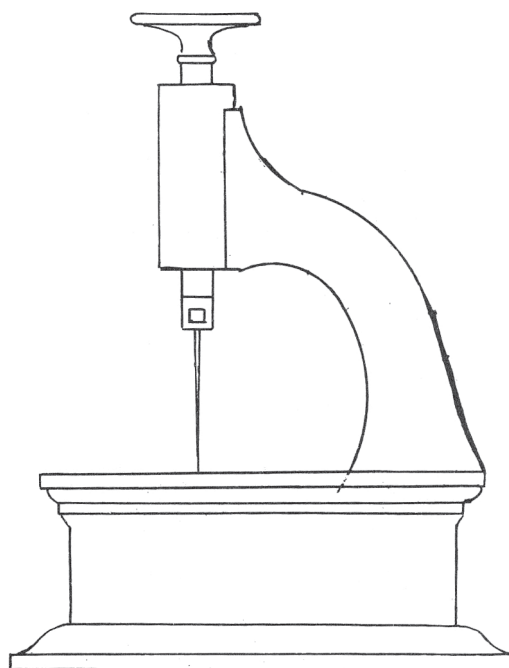


Figure 29

A cylinder, in which a broach is adjusted, passes through the canon. The pillar or top plate is held on the platform and the broach enlarges the hole without inclining it. This tool is rarely used, because the hole enlarging as it is done is almost always perfect.

When the barrel and the center wheel have been planted, all the other mobiles are placed in the movement boxes (that is to say, the 3rd wheel, the 4th or seconds wheel, the escape wheel, the pallet and lever, and the balance).

Then there is a special operation completely unique to the American factories and which has had a great influence on success that their movements have obtained at this moment.

This operation is called the *Record*. Recording consists of noting in a table the diameters of the 2 pivots of the 5 mobiles indicated above, and the lengths of these pivots⁹¹. This measuring is done very carefully for each part in the movement box and noted with the movement number.

When that is done, the necessary jewels are put in each box, in agreement with the list of pivot sizes which has been just made. This last operation is simple, since all the jewels and chatons are sorted according to their hole size. The jewels are naturally selected in order to have suitable side play on each pivot.

Even if a movement is to have only top plate jewels, or some mobiles are not to be jewelled at all, the sizes of all the pivots are noted, and a female worker passes a numbered broach through the holes which are not to be jewelled, the broach being held in a tool similar to that described above. These holes do not need any retouching. Jewel setting is done exactly according to the specifications in the Record, which the jewel setter has with him to check in case of any doubt.

It should be realised that if a mobile needs to be replaced later it is sufficient to send the movement number to the factory to receive an exactly similar mobile. The Record is also useful if there is an accident with a movement box before the chatons are fixed⁹². The woman who specialises in these operations quickly sorts the mixed chatons and puts them back in their places.

Repairs which occur during work on the movement and which involve changing a mobile must refer to the Record. This requirement necessitates a special control of repairs which we will consider later.

The Record also notes the size of the impulse pin, or the size of the fork notch, so that a replacement lever or roller can be sent for with the same ease as with pivoted mobiles.

The record sheet in each movement box, after having been in circulation in the workshops during the course of manufacture, arrives at the office where it is preserved in the event of a request for a repair part from outside.

The American factories put on the market a great number of repair parts which are very expensive, but extremely well made. We provide with this report some of these parts and you will be convinced of the exactness with which they are manufactured by comparing them with the same parts in the finished movements that we also provide with this report. The tables list the results given by precise measurement of these repair parts and shows their uniformity.

Interchangeability is not absolute with regard to the pivot diameters and lengths. We saw that to replace such parts it is necessary to send the movement number to the factory to receive without fail a suitable part. However in the majority of cases a part can be changed by taking it to the depots of the companies.⁹³

Three different tools or machines are used for jewel setting.

The planting lathe is composed of a solid bed on which there is a headstock which can hold the face plates on which the pillar plates are centered. These face plates are set up on the headstock and successively centered on each point of the mobiles. Plates are, as we saw, held by the dial feet.

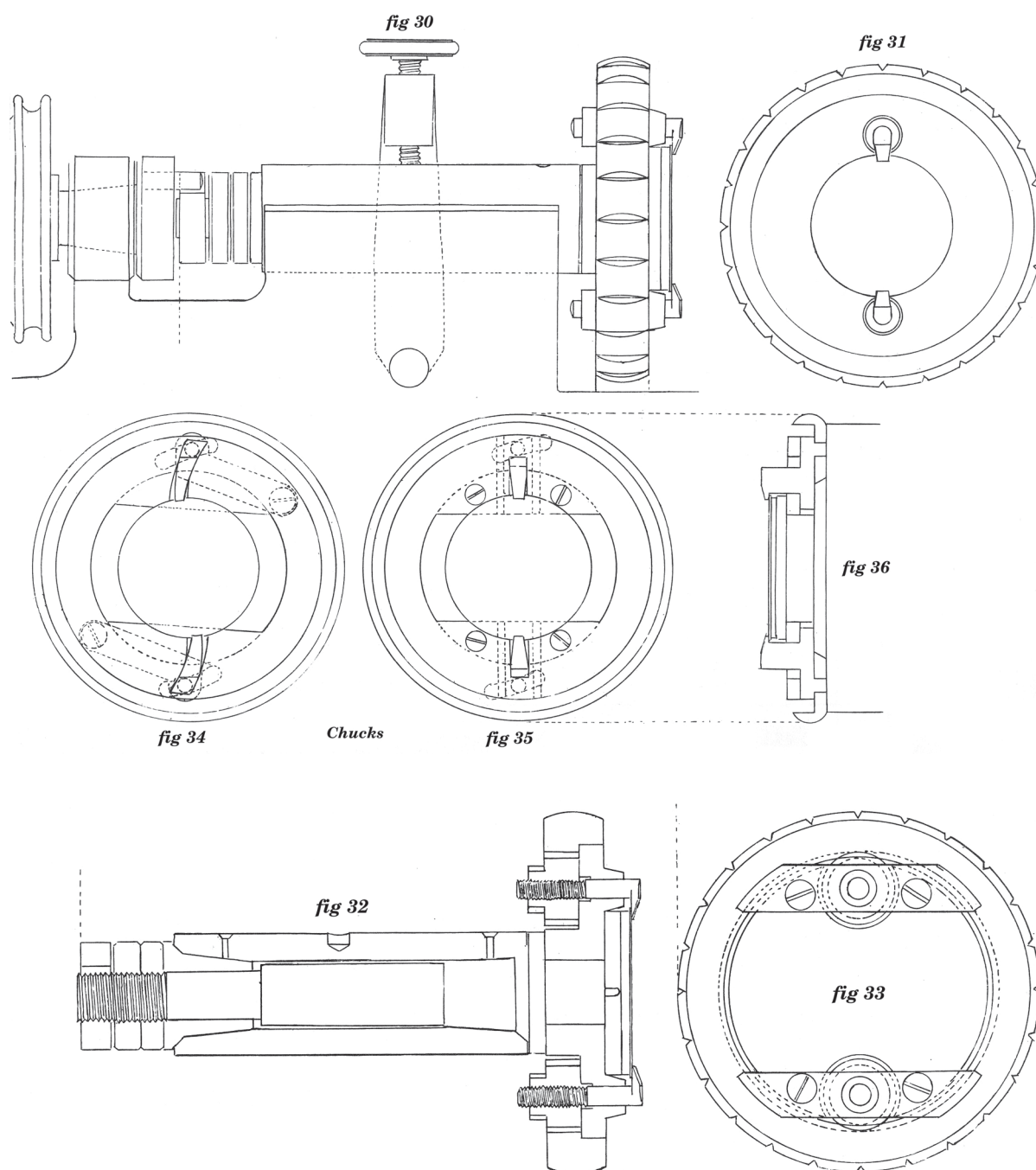
In front of the face plate is a slide rest similar to the jewelling rest described on page 47-48. The lathe is used in the following way:

The pillar plate and its top plate still have the holes for the mobiles as left by cutting on the punching machine.

91 *hauteur*, height. *Height* is strictly correct, but I think *length* is more comfortable in English.

92 All chatons have the same external diameter, but the jewels in them fit specific pivots. To ensure the chatons don't get mixed up and put in the wrong holes, they are kept in their plate holes.

93 This and the preceding paragraph were originally at the end of the section on cases. They were presumably added as an afterthought and I have moved them here.



Figures 30 - 36: Plate planting lathe.⁹⁴

The pillar plate is set up on the face plate, and the first hole is enlarged using a graver, that is to say the hole of 3rd wheel. The quantity of material to be removed is very small and the hole is opened to the size of the chaton which has already been turned, less a quantity necessary to make a good fit for the chaton. Then the top plate is put on and its hole is bored by enlarging it with the same graver.⁹⁵

This operation for the third wheel is done for several movement boxes. Then the centering of the plate is changed and the holes for the other wheels are enlarged in turn, in the pillar and top plates.

⁹⁴ Originally Plate IV.

⁹⁵ This process opens the *inside* of the holes to the diameter of the chaton seat. It must be done very accurately because the plates are centered by these holes for the next step. The next step opens the *outside* of the holes to the diameter and height of the chatons.

The holes being brought to size in this manner in the pillar plate, top plate, cock and bridges, the chatons are put in. For that the head stock illustrated in Figure 37 is used. The pillar plate is centered using the sliding centre inside the headstock and then tightened between **A** and **B**, the dial side being in front. The place for the chaton is turned exactly, by a fixed graver provided with suitable stops, to the same depth and the same size in all the plates.

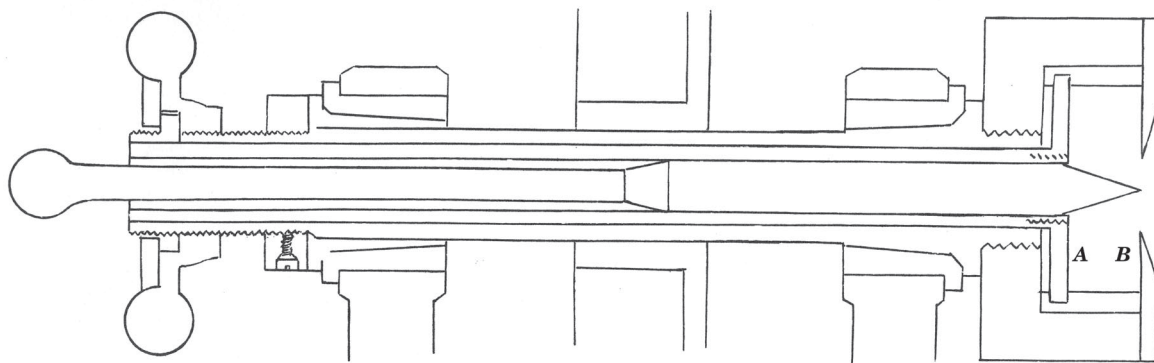


Figure 37: Jewel setting headstock.

The same operation is repeated for top plates and bridges, turning the top side.

It will be noticed that in order for this operation to give the desired spacing between the 2 jewels of the same hole, it is necessary that the ebauches are made extremely accurately. Indeed, the places for the chatons are turned to a constant depth measured from the outside of the top plate and the dial side of the pillar plate. If the whole ebauche is thicker or thinner than it should be, by an inaccuracy in the pillars for example, this difference will be exactly reproduced by the jewels. These differences in the height of ebauches do not, so to speak, exist, because they are not taken into account during manufacture. However, they cause repairs from time to time.

The movement would be ready to receive its jewels if it were not necessary to take into account variations of pivoting.

The mobile pivots do not have exactly the same length, either because of turning or as a result of polishing. These errors are rectified in the following way, by an operation as delicate as it is ingenious.

The chatons of the top plate are set up. They are still rough and they can be altered. They are cemented and the top plate is mounted on the pillar plate.

The difference between pivot lengths is allowed for by the chaton of the pillar plate. A shoulder is turned on it in order to insert it further into the plate if the mobile pivots are short and to insert it less if the mobile it must receive has long pivots. To be turned in this way, the chaton is gripped in a chuck to the left of the slide rest which is shown in Figure 39⁹⁶.

A is the left edge of the graver which turns the shoulder of the chaton. **B** is a center which rests against the jewel. The distance between **A** and **B** varies according to the lengths of the mobile's pivots.

The movement is placed between the centers **e** and **g**, with the top plate resting against **g**. The center **f** rests against the flat face of the top plate jewel; for that to happen **f** passes through the hole in the pillar plate. In the same way the center **e** rests on the shoulder made for the chaton in the pillar plate hole. Thus the distance between the ends of **e** and **f** is the distance of the planting of the 2 jewels.

If a correctly pivoted (standard) mobile is put between **c** and **d**, the position of the graver can be adjusted with respect to the point **B** in such a way that the graver **A** finds the edge of the chaton slightly higher than the jewel, as indicated in Figure 38. The difference between **m** and **n** will give end play to the mobile.

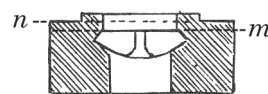


Figure 38

96 This tool is also described in N.B. Sherwood *Watch and chronometer jewelry* (1892, George Hazlitt, reprinted 1988, Arlington Book Co). Sherwood's explanation is obscure and inadequate.

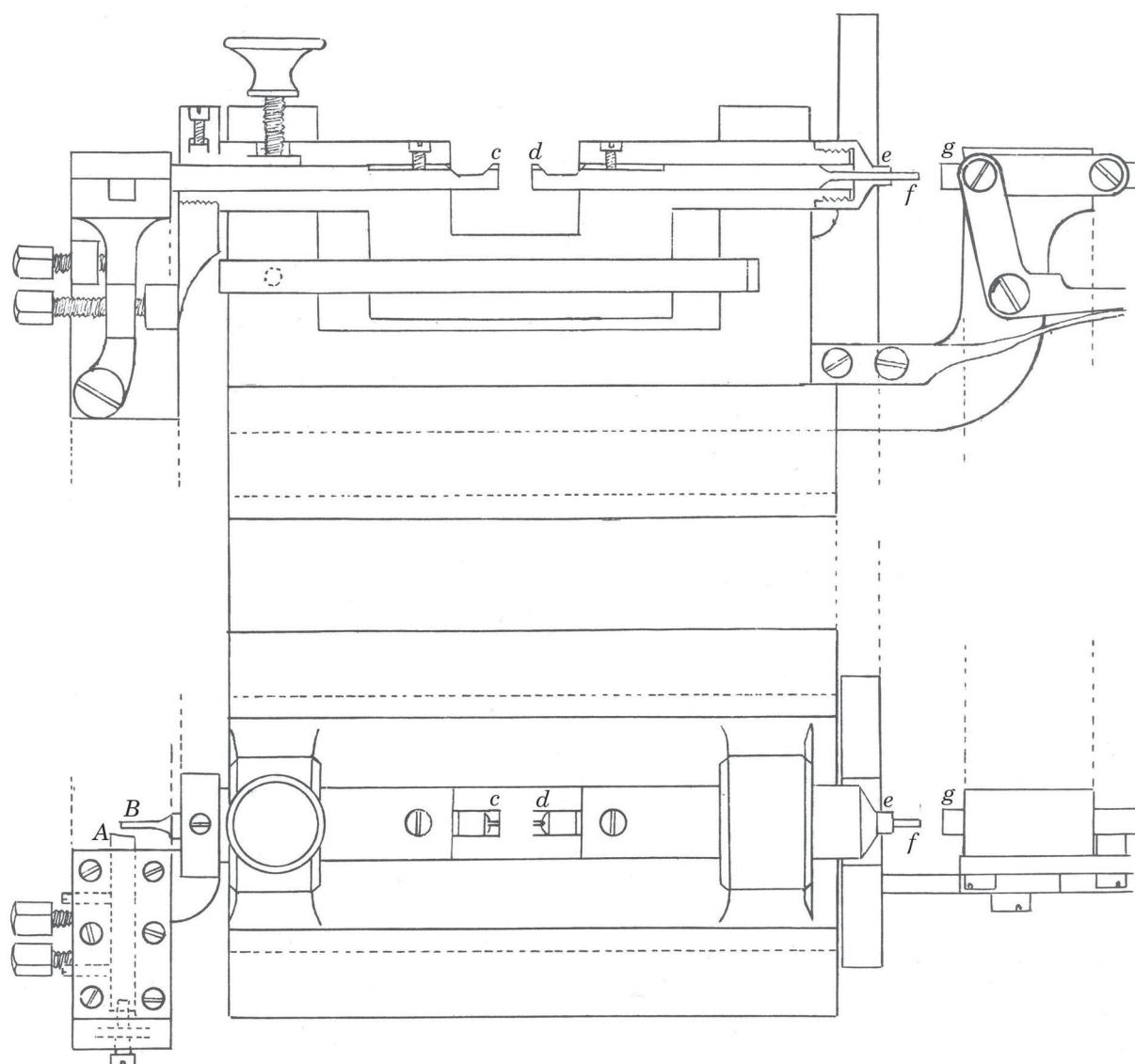


Figure 39: Chaton planting tailstock.

This first adjustment of the relative positions of **A** and **B** being done, it should be understood that if a mobile is introduced which has long pivots, the point **B** will overlap the graver **A** and the shoulder turning will be shallower than with the correctly pivoted mobile. This chaton when put in place will descend into the hole less than the normal chaton.

If, on the contrary, a mobile is introduced which has pivots shorter than the standard, the point **B** will be held behind the graver and the graver will remove more material from the chaton. The chaton, when set up in the plate, will descend further than the normal chaton and the mobile will not have too much end play, even though its pivots are too short. The shoulders of all the chatons which go in the pillar plate are turned in this manner.

The operation of jewel setting is finished, for the moment, after the bottom chatons are cemented in their positions.

In movements where the top jewel is crimped directly into the top plate or a bridge, end play is given in same manner. The jewel is then crimped in top plate using the pump headstock which we have described above (Figure 37).

If there are no jewels, which happens in ordinary movements, end play is given by placing the wheels and testing them. The plate is recessed more or less to suit, using a hand-held or preferably a fixed graver.

In all the jewelled movements, the jewels are set in the pillar plate by the process described above. If the chaton is to be fixed, which happens in a certain category of movements, it is immediately locked in place as one would do with a bare jewel. It is crimped in the pillar plate and is only removed in the event of an accident.

Assembly *en blanc*

The assembly *en blanc* which follows jewel setting is an operation divided into many steps. It is actually only the preparation for adjustment, because all the parts to be assembled are made so exactly that the workmen only has to put the pieces in their places.

One puts the spring into the barrel. Another sets up the click-and-ratchet work. Another puts on the canon pinion, and the set hands arbor⁹⁷ when there is one; the canon pinion is adjusted in advance and was put in the movement box at the same time as the center wheel. Another person assembles the escapement and checks the relative height of the pallets to the escape wheel. A special tool is used to move the pallets on their arbor and put the pallets at the correct height.

All these tasks are done by women. The movement must run freely and it is checked before sending it to the adjuster.

The adjuster starts the escapement running. He checks the functioning of the escape wheel and the balance, and then he puts on the balance spring.

In ordinary movements the balance spring is put on by the workers and only checked by the adjuster at the same time as he corrects the escapement. For these movements a special tool is used which facilitates the placement of the collet in a constant place on the balance, and it also measures the balance spring and indicates the place where it must be cut for the balance spring stud.

In keyless movements, it is at this stage that the mechanisms are assembled. For this part the supplies are prepared in such a manner that a workman can assemble quantities of mechanisms. At Elgin a single workman can install 400 mechanisms per month.

Putting on the dial, motion work and hour wheel is only done after gilding.

The adjuster observes the action of the movement by putting on an old dial which he keeps and which is used on a great number of movements. Each adjuster has at his disposal a set of these dials. The observation is done with only one hand and is only partial, the movement being checked for no more than 24 hours.

Having had its action checked, the movement is disassembled, which is only a matter of unscrewing. Steel parts, wheels, etc. which are already finished remain in the movement boxes. The screws are removed and sent back to the ebauche workshop to be used on other movements. The parts to be gilded, which have been numbered since the plate & screw department, are sent to the engraving and smoothing workshop.

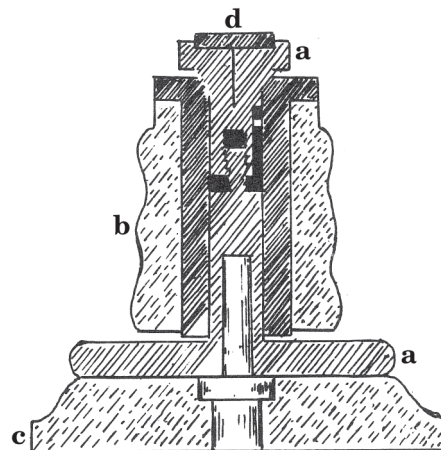


Figure 40⁹⁸

Engraving is done by hand. The outline of the lettering to be put on the bars and top plates is made in lampblack, transferred from a master engraving on a burnisher.

97 The taper pin.

98 David's drawing was not labelled and an explanation may be useful. This cross section shows a split chuck **a** which is the same as a lathe chuck but bigger, and which can rotate on the base **c**. The piece to be engraved **d** is placed in a shaped recess on the top of **a**. The work is then gripped by raising **b** by hand; both **a** and **b** have matching conical sections like ordinary lathe chucks.

Top plates, pillar plates and cocks do not receive any marks made by a punch; this procedure is rarely used. For engraving, the parts are held in special chucks or clamps as shown in Figure 40. This tool is used everywhere and there is a clamp for each part being engraved.

The smoothers have at their disposal a machine to dress their stones. It consists of a square, cast iron platform which is charged with sand or emery, and it is planed when it becomes hollowed out. Smoothing is done with a water stone and does not present anything of particular interest except the convenient and very practical set up for the workmen. This operation is done only by men.

With gilding the labour of scratching is facilitated by using large wire brushes turning extremely quickly. Graining is done by a process about which we do not have enough details. Powdered silver is not used. Graining is done during smoothing by a chemical process which cannot be etching of the surfaces with nitric acid.⁹⁹

Gilding is done in a bath, then the pieces are well scratched with a mechanical brush and gilded a second time.

Finishing

Assembly is done in several steps that can be classified into two categories: the assembly of the movement, and running and observation.

The assembly of the movement is done by women, each of whom has one task; one assembles the barrels, another puts in certain screws, and finally others set up the train.

After assembly the cocks and top plates are sent to the jewel setting room, where the recesses for the jewel screws are made and the chatons, which had previously been cemented, are removed and cleaned perfectly with spirits of wine. The chatons are then finished; they are shaped, the sinks formed and the tops polished with a very flat stone. The top plate jewels are polished at the same time.

The assembly of the movement is completed by women who do nothing but the balance.

The *Finisher* puts in the balance and gets the movement running. And then he puts on the dial, canon pinion, hour wheel, minute wheel and the hands, and starts the movement running.

He delivers the movement adjusted and going well. The dial was fitted on a standard pillar plate. It has the feet pierced and it is rare that the finisher has to alter either the center hole or the seconds hole.

The examiner runs all the ordinary movements for 2 periods of 24 hours and returns them to the finisher for final adjustments if there is a need. When all is in order, they are delivered to the central office.

Balances

The manufacture of balances at Waltham is done with very complete tools, able to produce work of very good quality in great quantity. The balances which are manufactured there are mainly imitation compensation balances and cut compensation balances.

Part of the workshop deals with the manufacture of plain balances, mainly in gunmetal or nickel.

The number of operations which a compensation balance or imitation compensation balance passes through before being finished is about 85.

The rough balance is prepared by welding together 3 parts, as Figure 41 indicates.

A is a steel disc with a center hole, the external diameter being turned to size. **B** is a brass ring. **C** is a ring which holds the first 2 pieces in place.

The parts **B** and **C** are manufactured with great ease on a punching machine.

These parts are welded in a furnace, observing the same precautions as in the normal manufacture of balances, as we know it.

The subsequent operations are a series of turnings which initially have as a base the center hole and then the outside, and which bring the balance to its exact outside dimensions.

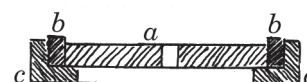


Figure 41

⁹⁹ I presume Swiss makers commonly used nitric acid and David is pointing out that the American process was something quite different.

These turnings are done very precisely and each one of them is composed of two operations. The first is on a strong machine that removes most of the material. The second brings the part to its final dimensions.

We particularly noticed a strong lathe which cuts out the steel in the center, removing the material with a graver as wide as the radius of the balance. This turning is done very quickly without any vibration, in spite of the width of the graver and the considerable effort of its work. The other lathes do not present anything of particular interest. They are all very solid and extremely well made, and they are provided with the chucks, adjustments, etc. particular to the American machines in the watch industry.

Turning being finished, the arms are formed by a cutter on a milling machine. The operation is done with 4 cuts.

The part is detached using a lathe with an intermittent movement which functions like a planing machine. The graver follows the rim of the balance and cuts a groove so cleanly that there is no need to use a file to clean the arms. A file is only used to finish the space occupied by the cutter which, considering its form, cannot make a vertical recess while cutting the bottom.¹⁰⁰

To drill the screw holes on the rim the balance is fixed in a ring, on the edge of which there are notches corresponding to the positions where the screws must go. A spring with a heel fixes this ring in the positions corresponding to the notches. The whole tool rotates on an axis passing through the center of the balance and parallel to its rim. Each hole is bored, tapped and cleaned out by a drill bit, a tap and a cutter mounted in cylinders attached to the lathe support.

To finish the balance and to smooth the interior of the arms, the rim and the outside, there are a series of machines each of which does only one operation.

The machines which smooth and even polish the sides of the arms and the interior of the rim, have a reciprocating motion and are provided with flat zinc files for the arms and round ones for the rim. These machines lap perfectly flat. The workman who does this operation has only to hold the balance on an oscillating platform and present it to the file.

Two of these machines successively treat the balance. The first smooths and removes the deep marks left by the cutter and the graver. The second does fine smoothing, even a half polishing.

Polishing the outside of the balance is done on very solid lathe which gives a last dressing to the outside of the rim by removing a small amount of brass with a steel graver. A final cut is made with a sapphire graver which almost completely polishes, and polishing is finished with a lap.

To complete the balances, the arms are given a nice appearance by polished angles, which are only partially made with the machines that we have mentioned. Most of the operations are done by hand, in particular filing the arms and the angles.

The manufacture of the brass and gold screws which load the rim of the balance is done in the same workshop. These screws are made by the same method that we saw employed for steel screws; turning by hand, the wire being in a spring chuck and protruding only the length of a screw from it. The point, the profile and tapping are done by 3 tools presented on the axis of the lathe. The screw is cut off by a fixed graver on a slide moving laterally.

The heads are slotted on an automatic machine, on which is fixed a block into which the screws are put as they are manufactured.

Polishing of the heads on the top and side is done on two different machines. That which polishes the side of the heads has an oscillating movement and the female operator has to do nothing except regulate the distance from the center of the screw to the lap.

The manufacture of plain balances is much simpler. The balance is cut out of a plate by only one blow using a tool similar to that which is used to cut out wheels. The balance is flat and of the same thickness everywhere. The shape of the rim and the arms are given by forging with a hammer. The burr thus produced is cut off by a punch.

In this state the balance, which was forged in a perfectly polished die, does not have any defects and it is simply polished with a kid-skin lap and rouge.

100 Another step, not mentioned by David, is compressing the brass to harden it. See E.A. Marsh *Watches by Automatic Machinery at Waltham* (1896, Hazlitt and 1968, Adams Brown); an interesting book describing later developments, but unfortunately inadequately.

All the operations being finished, the central hole is enlarged by holding the balance in a chuck by its outside edge.

Dials

The manufacture of dials is divided into 2 parts, the construction of the dial itself and painting.

The facilities of the Elgin and Waltham factories are complete and the workshops are noted for being very comfortable, scrupulously clean and showing all the care which particularly distinguishes the facilities of the American factories.

The points where the manufacture of dials most differ from what we do in Europe are the manner of preparing the plate and the fixing of the dial feet.

The dial plates are cut out and then pressed so that the edges of the plate, the center hole and the seconds hole are raised exactly as much as the thickness of the dial.

By this process the rigidity of the dial is increased considerably and the chances of breakage (from lapping the edge of the dial, filing to make the seconds hole, or even from drilling the center hole) are completely avoided.

Moreover, the feet are not fixed to the plate simply by soldering in holes made by a hollow punch.

The same operation which presses and raises the edges of the dial forms the housings for the dial feet as indicated in Figure 42, representing a section of the dial at one of these points. The metal of the dial is compressed by the punch which forms the depression *a*. The material squeezed out cannot move sideways because at the same time the punch forges the groove *b*. Thus a ridge is formed which is slightly higher than the dial plate. It is the preparation for riveting. These 3 dial feet housings are stamped out by only one blow at the same time as the holes of the dial. All the respective positions are thus identical from one dial to another.

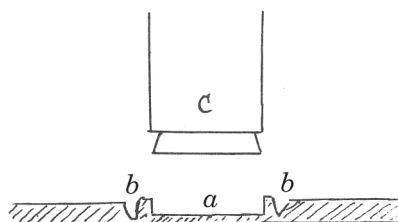


Figure 42

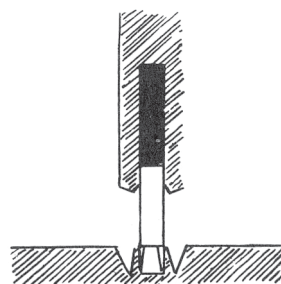


Figure 43

The dial foot is represented by *C*. It is cut to length, the end of the foot well rounded, and the part to be soldered has a groove turned by a graver, into which the ridge *b* will go.

To fix the feet, each foot *C* is set in its housing and a riveting stake of a particular form is put on the foot which, with a light hammer blow, tightens the ridge onto the foot. Figure 43 will make the operation clear. In this manner all the feet are placed in exactly the same position. The soldering which fills the groove *b* consolidates the weak points and fixes the foot so that it cannot be disturbed.

The other operations on the dial do not present anything of particular interest. Workers in one room grind and pulverise enamel in a mortar and pestle driven by the transmission,¹⁰¹ others do nothing but put enamel on the plates, and others are continuously employed at the furnaces, which are laid out in a manner to avoid the tiring reverberation. Others smooth and dress the enamel plates before delivering them to the painting workshop. Men are especially employed for this work.

In the painting workshop, which did not appear to me to employ any procedures of interest, the women are in equal numbers with the men. In this workshop, which has a large personnel in the two main establishments, the tasks are also divided up.

101 Power throughout the factories was distributed from one or two steam engines by a system of shafts, pulleys and belts, as was common in factories at that time. Waltham did not use individual electric motors until the 1930s.

Cases

In America the manufacture of cases is completely separate from the manufacture of movements, and the movement makers do not have to worry about cases or the assembly of movements into cases.

Usually the movement makers provide steel and brass guides to the case manufacturers. These guides are generally in pairs. One guide is for turning the band (the middle of the case), and it is deprived of all joints and other protruding parts which could obstruct the turner. The other guide has the joints, keys, pendant stem, hand setting piece, etc., and is for the case finisher.

The manufacturer of cases is not just an assembler of cases, but in his factory he makes all the parts necessary to completely finish the work. He has in his workshops case spring¹⁰² makers, engine turners, engravers, polishers and case finishers. This organisation, which completely fits in with the approach always followed by American establishments, has the great advantage that all the parts are manufactured under the direction of one person to produce well finished work, and one never sees in these workshops a well assembled case degraded by the workman who polishes it or who finishes it.

Waltham is the only American watch maker that deals with case manufacture. It organises this manufacture on such a scale that it is better equipped to produce quality cases in large numbers. It has two workshops, one in Waltham where silver cases are made and another in New York where gold cases are made.

Besides Waltham, a great number of case makers have adopted manufacture by machinery and the results which they produce show the advantages which they obtain both in quality and in the cost of labour. At the moment the companies which do not augment their workmen with machines and make improvements can no longer sustain themselves.

The large workshops are:

For gold: The American Watch Company (1 Bond Street, New York) and the Brooklyn Watch Case Company.

For silver: The American Watch Company (Waltham, Massachusetts) and Fahys Watch Case Company (Carlstadt, N.Y.).

There are, moreover, approximately 6 workshops making gold cases in New York, two in Boston, one in Philadelphia, two in Cincinnati and one in Chicago. But these workshops are of little importance and their existence is very much threatened by the large workshops.

The tools of the case assemblers consist of the cutting machines, shears, scales and presses necessary to prepare the raw materials as easily as possible.

The rolling mills are built according to a model little different from that which is adopted in European workshops; the main modification is to make the parallelism of the cylinders more constant. The cutting machines, shears and presses are powered by transmission, and are built according to the same principles as the machines used in the brass and sheet iron industries.

Hammers are also used; that is to say, a weight raised vertically and sliding between 2 guides. This weight is raised and dropped by a flexible belt under control of the workman. Lifting the weight is done by the transmission, by simple friction of the belt on a pulley, by tightening it between two pulleys, or using a wooden blade attached to the weight.

This tool is used to form the bezels and the backs. It is used by jewellers and it is found in different sizes in many workshops.

In the Waltham factory the manufacture of silver cases is done in 3 distinct departments.

The roughing out of the silver and the preparation of the assortments are done in a large workshop with tools for casting, rolling mills, scales, presses and hammers.

The backs are pressed and the flat edges are joined by soldering.

The working of the bands is not very advanced in the workshops which I visited; they are formed from rolled wire that is cut to length and then soldered end to end. The bands, at least for certain types, are made in 2 parts pressed to the right size and soldered together. This system has the great disadvantage of producing many clippings, but it produces a flat band which can facilitate the turning operations.

¹⁰² *secrets*. The springs to open hunting cases or the back of open face cases are often called secret springs.

The roughing of gold employs the same methods.

The lathes for bands and backs are very good. The same system is used to turn gold and silver, but each workshop has its special model different from that employed in other workshops.

All these lathes use the same method of tightening the conical split chuck. Tightening is done either inwards or outwards, and it is necessary to have a special step for each diameter.¹⁰³

Like the tools used to manufacture movements, these machines are built with great care; they have very solid beds and use tempered steel arbors and bearings.

In some workshops the slide rests are very complicated, carrying from 5 to 6 gravers which, once adjusted, can turn a great number of parts consecutively and make several turnings at the same time. In others, on the contrary, the slide rest is simple and can do only one or two operations at a time. This system seems to me to be preferable. All turnings are done using measurements or gauges, and it is easier to supervise the exactness of one or two operations made at the same time than to supervise more.

In a workshop in Brooklyn (the BWC Company) there is a very large machine on which gold bands are completely turned and finished. This machine is very solid and is extremely well designed. It carries 2 joined headstocks which can grip the band in 3 different ways to turn it and to knurl it. Between the two headstocks there are 5 carriers, similar to those of the machines to make large screws, which can be moved in and out at will. These carriers revolve and each one has 5 tools; cutters, gravers or knurling rollers. With these 25 tools one can turn from one end of the band to the other and completely finish the most complicated design. It is impossible for me to estimate the value of this machine from the point of view of its output, but opinion is that the less complicated lathes are much better.

The finishing off of the case does not offer anything in particular, other than that it is done very carefully. The methods of execution appear to me to be the same as in Switzerland, except perhaps that the use of reamers, cutters and drills mounted on tools driven by the transmission is more widespread.

The case springs and decoration are done in the same workshops as the cases.

The manufacture of case springs uses tools on a machine to rough out these parts and to deliver them to the spring fitter in very good condition. The steel wire is cut to length by a shear. It is heated and forged to the correct shape by one blow. There are complete sets of punches and dies for each case size and each form of case spring, lever and hook.

The rough springs thus obtained are cut by an automatic machine which shapes a dozen at the same time. This machine removes the dross from forging and roughs out the head while adjusting the thickness of the tail.

These rough springs are available from supply stores at a price of 10c (50 centimes) the pair.

The spring fitter only fits the spring in the band and finishes the head. He has tools, powered by the transmission, to drill, polish the blades, etc.

Engraving is done by hand and the tools are the same ones that we use.

The engine turning lathes are of various models. Many Swiss style lathes are used, set up on solid wood benches. The silver case workshop at Waltham and other workshops for gold cases have an engine turning lathe of a special design, extremely light and intended to produce only one style on each tool¹⁰⁴.

Some of these tools do engine turning automatically, without overlooking the middle of the backs where they leave space for an escutcheon or any other decoration which is to be engraved by hand after engine turning. In the workshop of the Brooklyn Watch Case Company one person supervises two of these machines.

Case polishing is done in the large workshops by men. The lathe used is much more solid than its Swiss counterpart and it is powered by the transmission. The methods of polishing are the same, except there is greater use of cotton mops.

103 This is what I know as a bezel chuck.

104 Perhaps similar to the lathe illustrated in Warren Niebling *History of the American watch case*, 1971, Whitmore Publishing.

VII Conclusions

The state of the Swiss watch industry

We have just examined, in as much detail as is possible in a quick study, the organisation and products of the two large American factories which hold, at this moment, the leading positions in the market of their country. These factories are the most significant and most prosperous of a group of companies which undertook this enterprise and which have sought a completely new way to manufacture watches.

It remains to examine what these experiments have produced, their cost and what result can be expected from the battle now engaged between the new processes and the old which are still employed by the manufacturers of Europe.

It is obvious to all that at this moment the American factories have the advantage. Their products are wanted everywhere, they manufacture and they sell, while the Swiss factory is idle and its agents are without business, many with unsold goods.

This state of affairs is brought about by various causes which we want to enumerate as follows:

Firstly, all the American products have the qualities of a saleable product. They have a very good reputation because the manufacturers have never delivered bad goods, everything that has left their hands being, until now, in good condition, well adjusted and running well.

Secondly, American movements are more uniform and independent of the cases, so that the whole-sale dealer and the retailer are not obliged, in order to satisfy a request, to have a stock of gold and silver watches of great value. It is enough for them to have movements and only a small number of cases which they renew as their assortment becomes depleted. Because of this uniformity, the case makers can have assortments of cases ready to finish and which they are certain to sell. They will thus deliver the case for an American movement much more promptly than a case for a Swiss movement. They will even make this case for a lower price, because the sizes are uniform and so they are better able to produce this kind in numbers, by machines which simplify the work.

Finally, these American movements are easy to repair, as we established earlier, and their sole use would save the watch merchant from having to maintain in his shop repairers who are generally very demanding.

In addition to the qualities which we have just enumerated, these movements also have the advantage of their price, which approaches more and more to that of imported goods, and which is even lower for several types because of the increased cost put on these goods by import duties.

These advantages taken together, and joined with the economies that these factories have always claimed, are the reasons why the Americans sell more at the moment.

The favour, which at this moment the American movements enjoy, does not have at its basis anything hostile to the Swiss watch. However, it contributes to highlight the defects of the Swiss watch and the objections against it which have accumulated over many years. And it is disturbing to see how the faults which are made in Swiss manufacture are pitilessly and skilfully raised by our competitors.

Nobody will dispute that a considerable number of watches unable to give good service, and even unable to run, were dispatched to the United States by Switzerland in the years when there was no competition. Each of us knows that some are dispatched even now and that many manufacturers are absolutely incapable of providing other merchandise.

Nobody will dispute either, that Switzerland sent cases to America carrying false hallmarks, with the aim of misleading the purchaser of their quality, and it is known that this fraud was made on many occasions and on a considerable quantity of goods.

Nobody will dispute also, that manufacturers labelled their inferior goods with honourable names stolen from the true manufacturer. They gained from these names the advantage of their good reputation and so misled the purchaser on the quality of the product in a way as guilty as that which was done with hallmarks.

We all know, moreover, that from time immemorial these goods of bad quality have been in much more considerable quantities than the well established merchandise able to render good service, with the result that in the United States it was always much easier to find them than the good merchandise. And that does much to explain the mediocre opinion of the public in that country.

Each one of these watches necessarily had one or more victims and sent purchasers to the American companies.

The good Swiss watch disappeared under the mass of the bad. The purchaser no longer knows if he can trust a watch maker who can slip a reject to him under the name of a manufacturer used by a counterfeiter; or even the calibre which is also used to mislead by its appearance. And so he enthusiastically obeys the advertisements which tell him to purchase an American watch.

If we consider the good Swiss watch, which is expensive and which is guaranteed by the salesman, we find that it lacks some practical qualities, qualities which are missing from all makes other than the American watch.

The movements are not uniform and cases cannot be as easily changed as with the American.^{104a} The wholesale purchaser or retailer must buy watches in gold or silver cases, which increases the cost of his assortment. And if he succeeds in obtaining movements without cases from the manufacturer, he does not find in these movements the rigorous exactness that the American guarantees, and consequently he does not get anywhere near the same assistance from the case maker as he gets when dealing with American watches.

Facilities for repairing do not exist to the same degree as with American watches. There are no regular supplies and repair shops need to have a trained repairer.

We are unfortunately obliged to add that stoppages arise even in the good watch, from the escape-ment, the train or any other source, stoppages that even defenders of the Swiss watch acknowledge are met with more frequently than in American movements. These imperfections, resulting from the inaccuracy of workmen, the carelessness of inspectors, the jolts of the voyage or any other cause, are unfortunately frequent.

However, the Swiss watch has some advantages which it can still retain for a long time.

Firstly, it has variety. We have seen the great advantages the Americans draw from their lack of variety. They will not readily give up this principle and some types of watch will remain with our manufacturers for a long time, because there will always be particular tastes to satisfy. But they will be small in number.

The main claims made for American watches have meant that everyone knows the value of these watches. The movements are known by their names, and we know what a watch maker gains by selling such a movement.

The Swiss watch is less well known and will be bought in preference by the trade which can sell it as well as the circumstances allow.

One advantage which the Swiss watch still has, is that a watch maker can advertise and sell a watch bearing a particular name that is his alone, and by advertising this watch he works to advance his own business and that of his manufacturer. By holding American watches he will be in competition with a great number of other merchants who have the same movements in the same condition, and he may not find it as beneficial in developing sales.

The American factories have refused until now to mark their movements with the names of watch makers. As long as they do not they will leave this small advantage to Swiss makers. However, they have taken a first step in this direction by removing their own name from certain models.

American competition encompasses all types of simple watches, from ordinary ones costing \$8 in America to fine pendant wound lever watches in gold costing from \$200 to \$220. These last are only made in small quantities, but the testimonies which they obtained at the Philadelphia Exhibition will make them known and certainly increase their manufacture.

We do not want to assert that this competition is likely to prohibit forever the entry of foreign merchandise into the American market. The moment has not yet arrived when we will no longer be able to export to America, but this moment will arrive one day and the difficult years we have experienced will become increasingly frequent.

We can foresee that the American factories, whose progress has been so considerable in a few years, will continue to advance. They, as we established at length, have created a completely new system. This system gives good results from the point of view of the products, but suitable methods have yet to be found so that the results are also good from the point of view of the volume of output.

104a This and earlier comments by David about cases seems to conflict with other statements. For example, Landes *Revolution in time* cites an 1818 essay which stated, in regard to Japy ebauches: "One makes an indefinite number of cases to the same size and shape, because one knows that all watches of the same calibre will fit."

When these conditions are met, the watch industry will have definitely arrived in the United States, and that country will no longer need our watches.

All will be lost. The same situation occurred in other industries. For a long time they exported products to the United States until indigenous manufacture developed and made this exportation impossible. What has occurred in the manufacture of machinery, leathers, cottons, cloths and the silk trade will happen in the watch industry.

With the strength that characterises all American companies, we can affirm that the watch factories will not need a long time to find the necessary conditions that we have signalled.

They will reach them either by decreasing the wages of their workmen or by raising the prices of their products, but they will have recourse to this latter method only when they are well known, when the practical advantages of their system are recognised and appreciated everywhere, and when the public considers and accepts their products as the best.¹⁰⁵

If the American factories lower the wages of their workmen and employees, which is extremely likely because they are still relatively high, these factories will be profitable at prices which the Swiss can no longer match.

If the other alternative is chosen and prices are increased, the advantage will still remain with the Americans with respect to cases, repair, uniformity of quality, etc., and the same advantages will have to be brought to Swiss manufacture.

These two alternatives have the same result for the Swiss watch factories, not only to lose the American market, from which they will be excluded sooner or later by the force of events, but also to be excluded from other regions of the world.

We must adopt the whole of the American procedures.

We are in a good position to do it, since the experiments have been done. American manufacture is established and is functioning as of now, and we only need to emulate the best one possible, but making significant modifications to suit the particular circumstances which we have in Switzerland and which do not exist in America. Everything indicates that it is necessary to move in that direction if we want to preserve the watch industry in our country and not see it disappear in the face of foreign competition.

Just as machinery, fabrics, furniture and weapons can no longer be manufactured with any chance of success, except in establishments provided with improved machines, in few years the watch industry will have to change in the same way.

If the existing factories in the United States have a few prosperous years, we will re-experience what occurred in 1863 to 1866. New factories will emerge in the United States and these factories will make the situation increasingly difficult for European manufacturers.

It is in Switzerland that these new factories must be built, and if they are not created here they will be created in the United States. Nothing will remain for us after a few years, because America already sends watches to all our markets; to Russia, to England, to South America, to Australia and to Japan.

An exact copy of what America has done is not what we recommend. We do not demand that all workmen are united under the one roof, nor that we manufacture ebauches, assortments, balances, dials, hands, springs, etc. under only one management. We only recommend that we take particular features of these factories, like the system of manufacture, and that we apply them as well as possible to Swiss manufacture.

Recommendations

We recommend:

1. *The adoption of Swiss sizes* so as to give to the Swiss watch, in as brief a time as possible, one of the distinctive qualities of the American watch, the complete independence of the movement from the case.

These sizes would be independent of the calibre and would fix the diameters and the heights of the ebauches. Moreover, they would fix for key winding watches:

105 The only weakness in David's analysis is that he does not appear to have predicted the third alternative, the enormous improvement in automatic machinery and interchangeability.

The exact position of the barrel, the position of the seconds pivot, and if possible the position of the case screw and the pin.¹⁰⁶

For movements with pendant winding, they would fix:

The position of the stem, the position of the seconds pivot, and if possible the position of the case screw and the pin.

Within the framework of these fixed elements, which would make it possible to manufacture cases independently from the movements, many different calibres could be designed.

We leave aside the question of whether we should adopt American sizes or if it would be advisable to adopt sizes nearer the basic sizes generally adopted in Switzerland.

2. Secondly, we recommend *the grouping of watch manufacturers* around a small number of calibres, to improve the construction of these calibres and especially to push the mechanical manufacture of the movement as far as possible.

Each group of manufacturers would adopt only one calibre or a very small number of calibres and would bind themselves to one of the ebauche factories currently existing in Switzerland.

The ebauche factory, having adopted a product, is required by its group of manufacturers to provide this calibre or small number of calibres in sufficient quantities, by adopting the American system for everything that relates to the parts of the ebauche, its assembly, the escapement, jewel setting and finishing. This work would be done in factories because it is the most practical way to organise such work. The ebauche factory will order pinions, assortments, balances, dials, in a word all the supplies currently provided from firms, who will be given the means to improve on the methods that America employs. These makers of pinions, assortments, balances, dials and other supplies will engage to work exactly according to the standards which will have been given to them. If later we see some advantage in also making these supplies in the ebauche factory we will do it, but we believe that they can be made outside the factories as long as the suppliers agree to it, and that way we will find a great simplification in the initial organisation.

It is absolutely necessary that this grouping of watch manufacturers takes place, because it is only in this situation that we will be able to obtain improvements from mechanisation in the ebauche factories. A machine can rapidly make a great number of very good, similar parts; that is its role. The reduction of the number of calibres is fundamental to the mechanical system of organisation and we can achieve nothing as long as we do not reach agreement on this point.

The manufacturers constituting a group will thus receive improved movements from the ebauche factories and enjoy the same qualities as those from American workshops; that is, uniformity of manufacture, exactness of proportions, uniform running, simple assembly and simple repair.

These movements could be accompanied by repair parts similar to those which the American factories deliver. Each manufacturer will take care to finish its movements. That is, it will deal with adjustment, engraving, assembly and testing and that each one will finish its products as it considers suitable for the market with which it is occupied.¹⁰⁷

The ebauche factory will be able, as are the American factories, to deliver movements of different qualities in the same calibre.

3. Thirdly, we recommend *the study of a standard calibre* which would be proposed as the Swiss calibre and which would unite all qualities from the point of view of good running of the watch and simple manufacture. It is intended that this calibre would be produced in great numbers and would be made by all those who do not have particular reasons to prefer another calibre. The movements would essentially be sold for their quality and would be offered in competition with the American full plates which are sold in spite of their defects.¹⁰⁸

106 Swiss watches were often attached to the case by a pin on the edge of the top plate, entering a hole in the case band, and a single screw on the opposite side of the band.

107 The personalisation of ebauches, requiring their manufacture separate from the *établisseurs*, has always been a feature of Swiss organisation.

108 Restricting the number of calibres seems to be the only recommendation that was not heeded.

4. The requirements to develop *mechanical manufacture* are of two different categories.

There is firstly the need to find finance and to organise the groups around the ebauche factories. We do not look at these points which will be examined when it is required to begin a company of this kind which is allowed by the principal interests.

Secondly, we must examine the best techniques of execution. On this point we have much invaluable information from the United States and it is not necessary to search elsewhere. It is necessary to use the men and the machines of that country and thus to avoid the great waste of time and the considerable expenditure of experimentation.

We will gain much time if we succeed in getting one of the men who knows the basics of the organisation of these factories and their tools, and we can hope to find amongst the important personnel of these establishments advisers willing to co-operate with us.

The principal machines are known by people independent of the factories, and the construction of these machines has tended to become a speciality of companies whose services the watch factories themselves use, as is done in Europe. It will be necessary to get the essential tools from them because they are built in a superior way to that which is practised in our country. It will even be necessary to send mechanics to visit workshops in the United States and to work there, and afterwards their knowledge could be used to teach Swiss mechanics. It will also be necessary to develop tool workshops for the watch industry within the excellent mechanics workshops which Switzerland has for other industries.

We attach to this report the addresses of American mechanics who deal with watch tools and some information leaflets. We recommend, as being the best, the American Watch Tool Company of Waltham. Secondly George Hart in Newark.

5. We cannot ignore *the powerful assistance of advertising*. We have established the importance it has in both the expenditure and the success of the American factories, and it is absolutely necessary we do not leave the exclusive benefits of it to them.

The simple announcements that Swiss houses have published, on their own account until now, are no longer enough and they only have a slight impact beside the profusion of American announcements. They do not replace advertisements. The large number of names, addresses, qualities and different kinds of watches disperses the attention of the public. They usually appear in watch making journals and are not put before the public in the many other papers. Finally they were used to advertise bad merchandise as much if not more than good products, and the public has every right to be wary of them.

We believe that through an energetic organisation, which would take the form of an *association of manufacturers*, we could obtain the means of creating effective advertising for the Swiss watch of good quality. We would cease being tacitly responsible to foreigners for the frauds which are done in Switzerland on case hallmarks, quality and the names and denominations of movements. Finally, we could probably reduce entertainment expenses abroad to a certain extent.

This association would be founded by the manufacturers of time pieces¹⁰⁹. These manufacturers would undertake to observe a certain number of principles relative to the control of cases, the construction of movements, the designation of their particular merchandise by one or more names, trademarks, etc.

This association would create an *Office of adjustment and manufacturing control* which would issue certificates of quality in several categories. These certificates would show, at the head, the names of the houses taking part in and sharing the expenses of the office, and only they would have the right to present their products to it.

After the printing of the first certificates, only additions would be printed. A charge would be levied on these certificates to cover as far as possible the cost of verification.

No certificate would be issued to a watch unless it bears the name of the manufacturer in an obvious place decided by regulation.

The watch merchants would be allowed to set up an association and consequently to present their names to the Office of Control to be reproduced on the certificates. The members of the association would preserve their complete freedom, only engaging to put on or to have put on

109 *montres destinées à marquer l'heure*. Simple watches as opposed to chronographs, repeaters, etc.

their name on watches which would pass inspection. The cost of the certificate would be proportional to the quality or the value of the watch. There will be no certificates for watches below a certain degree of quality.

The association would take a distinct name and would take the steps necessary to protect its certificates against falsification. Measures would be taken to make this organisation, and the guarantees which it would provide to purchasers, known abroad. The advertisements would achieve a certain importance and would be used to support serious products. The association would be represented in the principal markets and take into its hands the interests of the manufacturers.

6. The effects of this association will be completed by the resolution of the study, which is being made at the moment, into the question of *the control of silver and gold*; if this solution is applied sufficiently energetically to put an end to the abuses which are made and which continue with impunity under the current system.

We generally agree that much larger penalties are necessary, and we hope for a rigorous law this year that will put an end to those practices by dishonest persons which give such a poor reputation to our country.

7. We recommend, moreover, *the introduction of patents*. So many things have been said on this subject, including opinions emanating from qualified people, that we do not want to discuss this question even generally.

We will only say, from the point of view of the watch industry and what is done in the American factories, that the patent is a powerful incentive to efforts to improve, as happens daily in those factories.

We do not say that the Swiss leave their country because they do not have the protection that they wish for their inventions, but we can affirm that the use of patents excites in the United States and elsewhere much research, and we can expect a similar effect if something similar were introduced here.

It is right that a man should be recompensed or reap a reward from that which his hard work has led him to discover, and that the company openly recognises the service that he has done.

Excesses are harmful as elsewhere, and wise legislation on this matter can only be good in an industrialised country.

8. *The schools of horology* and the schools of art intended for apprentices must be developed and access must be made increasingly easy for all. Their influence is important for the progress which our industry needs to achieve. It is essential that the pupils of these schools are educated in the use of the tools and machines employed by the companies of whose improvements we have spoken, and that they are given the concepts of these new systems of manufacture.
9. We support the steps being taken at the moment to popularise the use of *the metric system* in the watch industry, and we hope that the instruments declared practical by the jury of the Intercantonal Society will help Swiss watch makers in the practice of American exactitude, and that the 100th of a millimetre will be successfully adopted for a long time, as were its predecessors, the antique douzieme and the English screw plate.
10. An especially significant detail to study, and one that can bring some simplification to manufacture and facilitate repair, is *the screw*. The number of different screws in the watch industry is infinite, and it is by no means necessary. If we specified a number of suitably proportioned screws, which would suffice for all our needs, the manufacture of screws would be greatly simplified and the price of very good quality screws would be acceptable. The question of screw pitches is also extremely important for the manufacturer and the repairer, and it is with great satisfaction that we have heard that this question is being studied by a section of the watch industry in Geneva. This will be a small improvement which could be followed by many others.

All the points which we have touched on and which we draw to your attention, leaders and gentlemen, show that the painful foreboding, communicated to the public in these last years by some well informed people, has a serious base.

No longer can we hide our presentiments, or even the facts, by surrounding them with the uncertainty which arises in us. They are very serious realities, as menacing as can be imagined for the industry of our country.

We have shown you the means by which we believe we can prevent being overrun by this powerful and bold competition from overseas, and we believe it our duty to particularly insist on the imminence of this danger.

We can affirm that there will need to be a considerable united effort and much work to regain lost time. And if we do not regard the situation as hopeless, it is because we think that the serious application, in the near future, of the various measures which have been proposed can improve this situation considerably.

Let us not forget that the most significant of these measures can only have effect if they are adopted and supported by a great number of the interested parties. The association, or at least the union, of the vital forces in Swiss industry is absolutely necessary if we are to preserve in our country the industry which has for so long made us prosperous. This is why, in concluding, we fervently hope that this union is possible, and that we will soon see emerging, from the various centers of our industry, active relationships defending our interests against threats.

Second report, March 1877

Second Report to the Intercantonal Committee of Jura Industries on the manufacture of watches in the United States, by Mr J. David, engineer (March 1877).

At the meeting of the 22nd of January last, in Neuchâtel, where I had the honour to read my report to you, it was agreed that the discussion would not be published in journals, so as not to wake the indiscreet attention of foreign manufacturers and not to give them weapons against us by too openly making the truth known to them. It was agreed that all communications concerning the Swiss watch industry and American competition should be addressed to your office which would act, as needed, to forward these communications to the sections of the Intercantonal Society or to give them a suitable answer.

It is from observing this convention, in my eyes extremely significant, that I come here today to communicate to you my opinion of the various articles which have appeared lately and which seem to me to require a response on my part.

These articles express the same unfortunate spirit that we see reigning in our watch making areas.

One wants to ignore of the importance of the competition. One puts forward all the reasons that he can find to reassure himself of the future. One does not want to admit the truth because, despite the large numbers, it does not burst forth in all its obviousness at present. One disputes the definite and worrying information that informed people from time to time thrust at the public. One sticks happily to reassuring information without weighing it and examining it closely. One wants above all to live quietly. One pushes far back from himself the idea that serious reporters, not only in our small field of the watch industry but generally in all industries, produce similar results from their investigations. And one patiently awaits the end of a crisis which perhaps will never end or which undoubtedly will be renewed in the near future.

We thus find an almost complete quietude in a country which should be seeking by every means possible to shift its industry out of the rut in which it is stuck, and to cure it of an extremely serious disease which it has caught and whose symptoms are already too obvious.

The articles in the journals which I read express this sad tendency exactly, this tendency of all people to reassure each other by treating as pessimists and alarmists the people who can foresee a little from the current circumstances. That is why I want to raise them, by seizing this occasion to draw the attention of interested parties to the various points which I have already developed. And it appears increasingly important to me that they are studied without delay.

The *National* of 27th February contains an extract of an article by A. Lange and Sons published in the *Deutsche Uhrmacher Zeitung*.

In this article, Messrs Lange on the whole support what Mr. Favre-Perret said and the limitations they express refer only to the fine watch, the production of which has, until now, not been affected by American competition. However, care has been taken to present this article to the Swiss reader in a more reassuring form, so as to turn his thoughts away from the conclusions of Mr. Favre-Perret.

When examined closely, we see that Messrs Lange compare American products with their own products; that is, watches of a quality much higher than average and which are not an article of great production able to feed a population, which is the purpose of this activity in Switzerland.

Messrs Lange speak about movements of \$200 which, after having been made in factories by machines, must be finally adjusted with much labour by skilful workmen. This assertion can be allowed as correct, although things could have changed since the investigation of Messrs Lange, of which we do not know the date. But this necessity to improve at great expense only applies to the good movements of the three or four premier qualities, which are only produced in very small numbers, and which do not count beside the enormous production of the ordinary, less expensive movements that nevertheless keep time sufficiently well and which have been substituted at this moment for our Swiss movements.

A person affirmed last October that the production of movements of first quality, those which are sold for \$150, did not exceed 15 pieces per annum at the large Waltham factory.

A very detailed document concerning the production at Waltham during the last months of 1876, does not mention *any* movement of first quality in a production of 95,000 movements per annum. This manufacture is thus an *hors-d'oeuvre*, simply a matter of assortments and self-esteem, but we must believe that it is being studied and that it will grow suddenly in a very awkward way for our manufacturers of fine watches. For the moment they are still safe, but whoever has seen the energy and ability developed by the American industry will not be able to say that this manufacture is impossible by means of machines. All that one can say is that it has not been organised today.

Here, according to this document, are the proportions in which various qualities of movements were made by Waltham during the last months of 1876.

We indicate the quality of the movement by its price as it is given in the lists circulated publicly and by its actual sale price to the ordinary dealers with the American company.¹¹⁰

	List price range dollars		Dealer price range dollars (list less 53%)		Dealer price range in francs (\$1.00 = fr4.80)	
22.5% key wound brass 18 & 20 size	9.50	13.00	4.50	6.15	21.50	29.50
16% key wound brass 18 & 20 size	13.00	23.00	6.15	10.80	29.50	51.80
39% key wound brass 18 & 20 size	14.00	21.00	6.60	9.85	31.60	47.35
11% pendant wound brass 18 & 20	19.00	30.00	8.95	14.10	42.80	67.65
9% key wound brass 18 & 20 size	27.00		12.70		60.90	
6% key wound brass 18 & 20 size	30.00	40.00	14.10	18.80	67.70	90.20
0.1% key wound brass 18 & 20 size	34.00	44.00	16.00	20.65	76.80	99.25
4.5% pendant wound brass 18 & 20	37.00	49.00	17.40	23.00	83.45	100.50
0.1% pendant wound nickel 18 & 20	41.00	53.00	19.30	24.90	92.50	109.55

We can determine from these figures the categories of products in which the American movement competes.

If we consider this competition from the point of view of sending Swiss products to the United States, we must reduce all these prices, so that they can support 25% import duties and a minimum of 5% for sundries, to arrive at the same price as the American movements. We thus arrive at the following figures:¹¹¹

Movements sold by Americans Dealers, price range in francs which need to be produced in Switzerland for about (francs):	
key wound brass 18 & 20 size	21.50	29.50	16.40	22.40
key wound brass 16 size	29.50	51.80	22.40	39.35
key wound brass 18 & 20 size	31.60	47.35	24.00	35.95
pendant wound brass 18 & 20 size	42.80	67.65	32.50	51.40
key wound nickel 16 size	60.90		46.25	
key wound brass 18 & 20 size	67.70	90.20	51.45	68.55
key wound nickel 18 & 20 size	76.80	99.25	58.35	75.40
pendant wound brass 18 & 20 size	83.45	100.50	63.40	76.35
pendant wound nickel 18 & 20 size	92.50	109.55	70.30	90.85

In these approximate tables, I do not take account of the *agio*¹¹² which is variable.

It is obvious from these figures that Switzerland can fight with regard to the prices; and if at this moment we do not sell and we see American products preferred to ours, it is because, as we have often said, these American products enjoy qualities which give them a great superiority over similar products from Europe.

110 David presents this and the following table in a different order; the watches were listed by type. I have changed the order to suit his argument.

111 There are a few discrepancies between the two tables, both in the descriptions and the prices, but the prices are close enough for the purposes of the argument.

112 *agio*, the difference in the cost of mercantile paper and cash.

These qualities are: the uniformity of the movements, the uniformity of all the supplies, and the uniformity of running. These are very much appreciated by the consumer, who is willing to pay for a more expensive movement that is guaranteed to be of good quality and who is tired of the bad experiences that he has had with Swiss watches.

As long as Switzerland does not adopt the principles which govern manufacture in the United States, and as long as she does not equip her watches with the essential qualities that American factories have given to their watches, we will see those factories gain ground to our cost.

Messrs Lange go on to say that America does not make watches for ladies and that she has delegated one of her factories to get small watches from Switzerland and then apply its special trademark to the top plates. I have no doubt that this ridiculous suggestion is totally incredible to those who have seen what serious work is done in these factories. (It could happen in some particular circumstances, but in any case on a very small batch, and it would be expensive for the company.) It is not a serious argument to propose against the American factories and their importance.

These factories make all the parts for a lady's watch, but in the United States they make them in the style of a watch that they call size 10 and which corresponds to our 16 lignes, and they currently produce this movement in quite large numbers.

We saw above (page ¹¹³) that this 10 size watch represents 17% of Waltham's production, approximately 16,000 watches per annum based on the figures for the end of 1876. A pendant wound watch of the same size produced by Waltham has had much success.

The factory at Elgin also makes a size 10 key wound watch and will soon have a pendant winder for ladies to put beside that of Waltham.

As long as these factories do not see the need for a smaller movement they will not make it, but we must be careful that we don't believe or say that they cannot do it. They have not begun such manufacture because they have enough work with their other articles and they do not at the moment see the need to undertake a new piece.

All is possible, and they will make 13 and 14 lignes pendant wound watches when they judge the time is ripe. We note that they rigorously follow the principle that we have attributed to them, of making only a very small number of calibres for which they are well equipped and getting from their machines all the work that they can do.

Must you continue to raise a point in Messrs Lange's communication which can contribute to deceiving the reader on a significant aspect of watch manufacture in the United States? These men say that anyone initiated into the mysteries knows well that the adjustment of watches cannot be done by mechanical procedures. This assertion is correct for precision adjustment, but it is not for ordinary adjustment of which the number is, as we said, very considerable and whose precision is perfectly comparable to the precision of good Swiss ordinary adjustment.

Without pretending that adjustment is done in these factories by completely mechanical procedures, so much so that the adjuster is useless, we can affirm that adjustment is produced mechanically by the fact that the inexorable regularity which governs the manufacture of all the movement parts simplifies the work of the adjuster so much that this operation is not comparable to that which we know in Switzerland.

If we take, for example, the Waltham factory, which produced 95,000 movements per annum in a bad year like 1876, this production included approximately 8 different calibres and 35 different models.

Among these models there are:¹¹⁴

P.S. Bartlett, 18 size, 4 holes jewelled ¹¹⁵	19,800
Broadway, 18 size, no jewels	12,000
Wm. Ellery, 10 size, no jewels	7,800
Wm. Ellery, 18 size, 4 holes jewelled	4,600

113 No number is given in the ms and there is no place, other than below, where numbers of 10 size watches are mentioned. Perhaps some of the sizes specified in the tables on page 78 are wrong.

114 15.6% of the identified watches are 10 size lady's movements.

115 This jewelling is additional to the escapement. 4 holes jewelled is a 15 jewel watch; 7 for the escapement (including the impulse pin and the pallets) and 8 for the 4 holes in both the top and pillar plates. A Broadway has 7 jewels.

Also note that David distinguishes the type of hole jewelling; in chatons or simply fixed in the plates.

P.S. Bartlett, 18 size, pendant wound, 2 holes jewelled	4,300
American Watch Co., 14 size, no jewels	4,200
Appleton Tracy, 18 size, 4 chatons	3,600
Wm. Ellery, 18 size, no jewels	3,600
P.S. Bartlett, 10 size, 4 chatons	3,600
Home Watch, 18 size, no jewels	3,300
Wm. Ellery, 18 size, pendant wound, 2 holes jewelled	3,300
Martyn Square, 18 size, no jewels	3,000
Total:	73,100

The 21,900 other pieces being represented very unequally between the 23 types not listed above and forming groups of 2000 to 2500 movements identical in all their parts¹¹⁶.

By realising these are significant figures, we can see that the work of the adjuster is singularly simplified if, for several consecutive weeks, he works on the same movement containing exactly the same elements (the same motive force, the same wheels, the same escapement, mass produced balances of exactly the same weight and dimensions, and identical balance springs made especially for these movements). With balances and balance springs which, we can admit, are rigorously uniform, and with movements identical to each other, we can see that balance springs can be matched in advance to balances according to rules found by experiment, and that by using special tools the balance spring can be fixed to its balance and to its stud so that the length of the spiral is exactly the same for the same series of balance springs and matched balances.

All these operations are simple. They are done by conscientious workers and the adjuster receives the work all prepared and only has to make very slight final retouches as indicated by the running of the watches.

In all these operations the secret lies in this complete exactitude which makes it possible, from the beginning to the end of construction of the movement, to avoid the labour and difficult tasks to which the Swiss manufacturers devote most time and expense.

The ebauches, the pinions, the assortments, the planting of wheels and the escapement, the finishing, the adjustment, the final assembly, everything is done successively by exact operations, and the watchmaker only intervenes in each step to adjust or quickly finish what the inexperienced worker or the machine could not do completely.¹¹⁷ The details, which I have given in that part of the report entitled "procedures of manufacture", clearly show that it is this exactitude which governs all manufacture and I have indicated how, by rational steps, this exactness is obtained. The procedures described are not extraordinary nor inapplicable, and there is no reason why Swiss manufacturers flinch from their application.

The *Journal du Locle* printed a letter which said: "It is probable that America has not yet found how to set jewels mechanically, etc." This reflection was with regard to a movement in which only the balance was jewelled, and the correspondent admitted it was probably far from being the truth.

In America all the jewels are set by mechanical procedures, even in the best qualities.

In Switzerland, the vexatious conditions in which the workmen are placed, by the variety of calibres, prevents them and will continue to prevent them for a long time from making use of simple procedures for jewel setting.

Some makers without jewel setters have simplified their work and decreased their toil by particular processes and tools, but as they keep all that secret they do not have imitators.

In the United States, the most ingenious procedures were originally worked out by the mechanics who run the factories; they are procedures without which, it is admitted, one cannot work practically.

These procedures, that I described in detail in my report, have as principal advantages: To place the jewel exactly in its place. To place it exactly at its height. To center the plate exactly and to

116 Although superficially it seems that 23 lots of 2000 is vastly greater than 21,900, this is not the case. A lot contains parts for one *calibre* and those parts may be used for several grades or different types.

117 Not true, because the critical components (pivots and jewels), which are also the components most likely to break, were *not* interchangeable. David has previously said this, but to say so here would not have helped his argument.

avoid the workman having to forge his pieces by centring them with a pin¹¹⁸, which gives the ordinary Swiss work such a bad appearance.

I do not believe that there are many examples of good American movements in public hands. Reasons of economy always make people buy ordinary movements, which is wrong, because if the good American movements are still too expensive to be on a par with our Swiss movements, one can be sure that it will not always be so, and it is now that we must focus our attention on their manufacture where we have much to learn, not only in jewel setting but for many other important parts.

It would be good if some samples were bought of higher quality than have been acquired up to now. The Intercantonal Committee could perhaps fill this gap. It could circulate these samples among the interested parties, and their examination would assuredly challenge the many doubts which have been raised and which are based only on a lack of palpable evidence.

A correspondent from Geneva wrote on February 16 to the *Jura Bernois* and the author, who I have been told is very well informed, advanced the following assertion: "the factory at Elgin is idle, and we know from a good source that Waltham employs only half of its workmen".

I know, contrary to that source, that it is absolutely certain that Elgin has not ceased work for many months and that at the moment it is fully occupied. Many people have said "it works day and night - it cannot fill its orders".

Last October this factory produced 225 movements per day working 10 hours per day. If it now works 12 hours per day, it must produce at least 250 movements; that is to say about 77,000 movements.

The Waltham factory must work beautifully well if it arrives at no less an alarming production with only half its workmen. It produced:

October 1876	6,500	movements worth to the factory about	\$63,000
November 1876	8,450	"	\$85,390
December 1876	8,200	"	\$83,910
January 1877	7,900	"	\$78,800
February 1877	8,600	"	\$74,000
In 5 months	39,650	"	\$385,300

In 12 months this rate of production would produce 95,000 movements worth approximately \$915,000.

At the moment the Springfield Illinois factory, of which I also have recent details, employs 150 workmen and produced between 50 and 65 movements per day, which is approximately 15,000 to 20,000 movements per annum.

Thus we have, for only these three factories, a total of 187,000 movements per year, worth about \$758,000, taking as a base the lowest price at which Waltham sells its products to its principal dealers.¹¹⁹ This production is not to be scorned or ignored, especially if we take into account that there are yet other factories and it is well known that production is following a rapidly ascending path. When the business revival occurs, that everyone is waiting for, these factories will be able to produce much more.

Included in the production details of Waltham given above, are the quantities exported to England:

October 1876	800	movements worth approximately	\$5,000.
November 1876	1,650	"	\$11,300.
December 1876	1,500	"	\$9,500.
January 1877	1,900	"	\$11,900.
February 1877	2,500	"	\$15,700.
In 5 months	8,350	"	\$53,400.

This production, calculated for one year on the average of these 5 months, gives about 20,000 movements representing a value of \$128,000; but it is higher than that because the table shows us that exportation to England increased by 350 movements per month over these 5 months.

118 *d'éviter que l'ouvrier ait à forger ses pièces en les centrant à la cheville*. Perhaps drawing a hole to move its center and then closing it with a punch.

119 This figure is lower than the previous estimate because David is presuming *all* movements are of the cheapest grade and all are sold at the maximum possible discount.

The Elgin factory is in strong competition with Waltham in England and I am assured that its exports to that country are very significant.

If we compare the figures which we have just given to the official figures for Swiss exports to the United States, supplied by the American consul in Basle, we see our figures decreasing even more quickly than their figures increase, and we foresee the time is near when our exports will be reduced to *zero*.

February 1875, Swiss watch exports to America were worth Fr. 743,600.

February 1876, Swiss watch exports to America were worth Fr. 401,900.

February 1877, Swiss watch exports to America were worth Fr. 170,250¹²⁰.

These figures say more about the competition which we face than all the other information. The consolatory remarks, which are printed for the public in journals, risk creating a peace for which we will pay dearly and they have no weight beside the facts.

I could go much further in correcting the errors which are being spread, but I am satisfied for the moment to have touched on the most obvious.

If I insist, gentlemen, in drawing your attention to the present situation and its inevitable consequences for our country, it is because I strongly believe that this situation is extremely serious and that it will continue to worsen if we does not act vigorously.

Our industry races towards the greatest danger and it is up to us to face the truth courageously and not give in to a false sense of safety by cherishing illusions which are no longer possible.

I particularly insist on the fact that all those who recently observed the American industry can only confirm what has already been known in Europe for many years.

The reports which we have from Messrs Reuleux, Bally and the delegates from the Industrial Society of Mulhouse all testify to the energy and the intelligence of American industry. These gentlemen saw, in all the mechanical arts, a numerous class of serious and sober workers who shame old Europe. They are eagerly occupied developing production, improving quality, reducing hand work and spreading their sales. They will not give ground to anyone, they will free themselves from European imports, and they will reap the advantages of the riches which they have all around them.

These gentlemen admit that the American industrialist, because he sticks to one speciality which he makes on a large scale, is in the process of becoming superior to his competitor in Europe, who scatters his forces over a great number of similar articles. And it is only by a great effort that Europe will preserve even a part of the activity which she still undertakes.

This sad forecast applies to the large-scale industries of Europe which are well tooled and which make continual progress. We can apply this forecast to our watch industry which is not yet in such a favourable position to fight and which is suddenly in the presence of a courageous and well armed adversary.

Let us put to one side the bad council of our offended self-esteem and engage in the fight, benefiting from all the advantages which we still have and from the methods that our competitors have discovered.

Let us take *their* tools, imitate *their* workmen and *their* methods, but especially *let us group together* to obtain the kind of progress that the individual industrialist, in his tiny room with his own efforts, cannot achieve.¹²¹

120 Although using the exchange rate of \$1.00 = Fr4.80 is probably too crude, the figures in dollars are \$155,000, \$83,700 and \$35,500. These figures are for single months; Landes *Revolution in time* gives approximate annual figures for 1854-1882.

121 My emphasis.

Possibly the most important document in the history of modern watchmaking.

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In 1876 Jacques David, who later became the director of the Longines Watch Company, visited the American watch factories. The reports he wrote were so sensitive publication was suppressed and they were not printed until 115 years later.

Now, 126 years after it was written, this extraordinary manuscript has at last been translated into English.