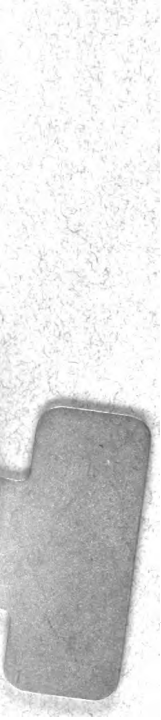
# Pamphlets and reprints

James Craig Watson



# AMERICAN WATCHES:

AN EXTRACT FROM THE

# REPORT ON HOROLOGY

AT THE

# INTERNATIONAL EXHIBITION

AT

PHILADELPHIA, 1876.

BY

JAMES C. WATSON, PH. D., LL. D.,

DIRECTOR OF THE OBSERVATORY AT ANN ARBOR, AND PROFESSOR OF ASTRONOMY IN THE UNIVERSITY OF MICHIGAN;

MEMBER OF THE BOARD OF JUDGES FOR INSTRUMENTS OF RESEARCH AND PRECISION, AND CHAIRMAN OF THE COMMITTEE OF JUDGES ON CHRONOMETRIC APPARATUS.

WITH AN APPENDIX

CONTAINING

EXTRACTS FROM A SPEECH DELIVERED AT CHAUX-DE-FONDS, SWITZERLAND, BY M. EDOUARD FAVRE-PERRET, MEMBER OF THE SAME COMMITTEE OF JUDGES, AND COMMISSIONER FROM SWITZERLAND TO THE EXHIBITION;

AND

COMPARATIVE TABLES SHOWING THE PERFORMANCE OF THE ADJUSTED WATCHES SUBMITTED FOR COMPETITION.

NEW YORK:
PUBLISHED BY ROBBINS & APPLETON,
NO. 9 BOND STREET.
BOSTON: No. 8 SUMMER STREET. CHICAGO: No. 170 STATE STREET.
LONDON: WALTHAM BUILDINGS, HOLBORN CIRCUS, E. C.
1877.

# AMERICAN WATCHES.

*Extract from the Report on Horology at the International Exhibition at Philadelphia, by* PROFESSOR JAMES C. WATSON, *Member of the Board of Judges for Instruments of Research and Precision, and Chairman of the Committee of Judges on Chronometric Apparatus.*

The most extensive exhibit of watches was that made by the American Watch Company, of Waltham, Mass. The exhibit consisted of about 2200 completed watch movements, the majority of which were provided with gold or silver cases. This represented the product of their factory for six working days. The extent of the exhibit, the conspicuous manner in which the watches were displayed, and the beauty of finish of the movements and the cases, all conspired to attract daily the attention of crowds of visitors. This was the first International Exposition at which the products of our watch manufactories were exhibited, and on account not only of the magnitude which the industry has assumed, but also on account of the excellence of the productions, it is proper here to make a brief statement of the development of this branch of our manufactures.

Until the inauguration of this new enterprise in 1850, the watches and pocket chronometers used in the United States were imported from abroad, and principally from England and Switzerland. The prevalent notion had been that the production of these delicate machines could only be made with success in those countries where labor was cheap, and where the training and secrets transmitted from one generation of watch makers to another, made possible anything like perfection in the art. It is true that several of our artisans had shown great

excellence in the finishing and adjustment of marine chronometers, so much so that it was well established that there was no lack of intelligent mechanics whose understanding of the principles of horological science, and of their application in practice, was beyond question; but when the requirement was a pocket time-keeper, even of inferior quality, the field of production looked uninviting from a commercial point of view. It was fortunate, perhaps, that the attempt finally made had been delayed so long, because an opportunity had been afforded to develop among our countrymen that ingenuity which has astonished the world in the production of machinery in a great degree automatic, or in the highest degree labor-saving in its operation. Not only this, but the fabrication by such machinery of the parts of other machines with such uniformity that the similar parts of these machines, made in any number whatever, become interchangeable, had arrived at a high degree of perfection. This system forms so important a part now of all our production of machines, for whatever purpose used, and is hence so well understood, that it is necessary barely to allude to the fact. Independently of the advantages which result from the mere perfection of the manufacture in the adjustment of the parts, essentials of the highest importance, the convenience of this system in facilitating repairs, is its most important feature in an economic point of view. This, it is well understood, is all important in the case of those machines in most general use, such, for example, as sewing machines, or agricultural machines. How much more important in the case of such delicate machines as watches, which have become the necessary companions of persons in every walk of life, and whose proper fabrication by the ordinary methods, can only be undertaken by the most experienced workmen. The development of our watch-making industry has been a part of this scheme, and there can be no doubt from the results already achieved, that this is its triumph.

Now that the results are before us, we can imagine the scheme faintly outlined, but still distinct and inviting, in the

minds of our countrymen who first conceived of the project of manufacturing watches by machinery, and thus by the application of forces other than human, overcome the commercial difficulty resulting from the difference of wages here and abroad. These were Aaron L. Dennison and Edward Howard, of Boston, Mass. The former was an expert watch-repairer, and the latter a skilled clock-maker. In 1848 Mr. Dennison suggested to Mr. Howard the project of attempting the manufacture of watches by machinery, and two years afterwards in company with Samuel Curtis, also of Boston, they established at Roxbury, Mass., a factory of this kind, and commenced the manufacture of watches which bore the name "Boston Watch Company." Subsequently they removed their establishment to Waltham, ten miles from Boston, and there having organized as an incorporated company, they erected a small factory where now stands the imposing establishment of the present American Watch Company. At the expiration of three years, the company became bankrupt, on account of unexpected obstacles encountered, and their property was purchased at an assignee's sale by R. E. Robbins, of New York, for the firm of Appleton, Tracy & Company. By an act of the Legislature of Massachusetts, a corporation was created, to be known as the *American Watch Company*, with a capital of $200,000, which was soon advanced by subscriptions to $300,000. This Company succeeded to the business already established, and has continued to develop it until it now possesses by far the largest manufactory of the kind in the world. The capital has been increased by subscriptions from time to time until now it amounts to $1,500,000.

In the hands of managers who had a mastery of the commercial machinery, and operated by mechanics whose ingenuity and intelligent application of the principles of horological art and science, made the work of a quality to merit success, this company in an untried field, and against the opposition of prejudice and cheap foreign production, have fought their way to unparalleled success. The factory is located in a quiet suburban town, free from the dust and annoyances of the city,

so that with extensive buildings, supplied with every appliance in the way of machines which it would seem that human ingenuity can devise, and surrounded by the neat cottages of the workmen, nature and art conspire to facilitate a work so delicate as the production of a watch such as modern demands require.

The factory consists of twenty-one departments, each under the proper foreman and his assistants. The whole is in charge of C. Vanderwoerd, as mechanical superintendent, whose skill as a mechanic is sufficiently attested by the machines for watch making which attracted the attention of crowds of visitors in Machinery Hall during the whole period of the Exhibition. For the sake of giving, as it were, an inside view of this establishment, it may not be amiss to particularize these departments. They are:

1. An extensive machine shop, including draughting room, where the various machines for watch making are constructed, which therefore becomes the foundation of all.

2. The press room, where the metals, brass, steel, copper, etc., are prepared for punching, and then punched into the blanks for wheels, regulators, ratchets, clicks, indexes, hands, dials, etc., the larger brass pieces, such as plates, bridges, and barrels, being punched for them from their own patterns at Waterbury, Conn., thus avoiding the freight on whole brass sheets and return chips to that great centre of brass working for New England.

3. Frame rooms, where the brass and nickel frames are made complete up to the process of stoning.

4. Dial making and enameling.

5. Dial painting.

6. Flat steel work made and finished.

7. Jewel making from the rough stone to the finished hole, using diamond and sapphire as the working materials, and ruby, chrysolite, garnet, and aqua marine for the jewels.

8. Train making, including barrels, wheels, (except scape wheels) barrel and pallet arbors, balance-staff, pinions, cannon pinion.

9. Hardening and tempering of *all* steel pieces.
10. Train finishing.
11. Screw making.
12. Setting jewels in watches.
13. Hand making.
14. Escapements, including fork, pallets, roller, scape wheel and putting them together.
15. Balance making.
16. Springing, including hair-spring and mainspring making.
17. Gilding, including stoning and frosting.
18. Assembling the parts of the watches.
19. Adjusting the movements.
20. Engraving.
21. Silver case making, in several divisions.

Supplementary to all these, there are all the needful smaller rooms, such as for blacksmithing, piping, carpenter's shop, packing, etc. The motive power is supplied by two engines of 25 and 35 horse-power, respectively, and the number of persons employed exceeds 800, half of either sex. There are many important operations in the manufacture of watches by this method where the delicate manipulation of female hands is of the highest consequence, and it ought to be mentioned here that for this labor the amount of wages paid by the Company is determined by the skill and experience required, not by the sex of the operatives.

It is not the purpose of this report to give a description of the details of the processes, and only such allusion to them will be made as may be necessary to make clear the matters under consideration. As regards the individual machines employed, in number the aggregate of the various kinds amounting to thousands, each of its kind performs some special work, either in forming or finishing pieces, and it performs those operations always in the same manner. Sometimes the functions of the machine are performed automatically, but generally the human operator is present to direct its movements; nevertheless the result is always to do its work, even if

it be a very trifling performance, to thousands of pieces alike, so that the great desideratum of the production of interchangeable parts for movements of the same caliper is effected. While the system adopted affords practically a perfect interchangeability of the parts, yet it must be understood that the polishing and finishing of the parts leaves often microscopic differences which might be of importance in the case of fine movements. When therefore the parts of these watches are assembled, the exact sizes of the jewels are measured by means of the requisite gauges, the finest of which measures the seventeen-thousandth part of an inch. In this way systematic provision may be made for that freedom only in the operation of the parts of the movements which is essential to the proper performance of their functions under the conditions of temperature and other adventitious circumstances under which they are to operate.

Each watch of this character is numbered and the exact sizes of all its pivots and jewels are accurately recorded. Hence, should any part of the watch fail, the factory can supply, upon receipt of the number of the movement, an exact duplicate of the required part.

The exhibit contained specimens of all the varieties of movements manufactured by this Company. Of full plate movements there are seven distinct grades. These again are divided into varieties such as stem-winding and key-winding, or by varying the balance, making it in nickel, steel, gold, or bi-metallic of brass and steel for compensation, and also by varying the number of jewels. Of three-quarter plate movements there are four distinct grades, subdivided similarly into varieties. The total annual product of the factory is upwards of 100,000 watch movements and 50,000 silver watch cases. The gold cases required are made by Messrs. Robbins & Appleton, in New York. The principal market for this product is in the United States, but already a considerable demand for these watches has been created and is now being supplied in England, Germany and Russia. The value of the annual product of these two establishments exceeds $2,000,000.

In the examination of the quality of the watches produced by the American Watch Company, it became necessary to consider first the mechanical contrivances by which the parts are executed, and then the manner in which these are brought together in the completed movement. While introducing so much that is novel in the way of machinery and processes of execution, there has been no attempt, in respect to the parts of the movements, at innovations which are not of recognized merit. There are certain well-established principles in reference to the proper construction of the train which have resulted from the application of the laws of mechanics, such as relate to the form of the teeth of the wheels, the leaves of the pinions, and the proper numbers for each. It is well established also, that for the purposes of a watch to be carried in the pocket, the lever escapement is to be preferred. The results of careful experiments show that when the lever escapement, the duplex escapement, and what is known as the chronometer escapement, are equally well constructed, and placed in movements with equally good trains and equally well sprung, the performance is substantially the same. There being, therefore, no objection to the lever escapement, as regards the time keeping properties, and there being good reasons for its adoption in preference to the two others named, when the manner in which the watch is to be carried, is considered, the propriety of this form of construction, even for the finest watches, is put beyond question. There is one innovation upon what was, in this country and in England, until recently regarded as an essential principle of watch construction, which the company ventured upon at the outset. This consisted in dispensing with the fusee and chain, and using in preference the going barrel, thus reducing very much the size and the complexity of the watch. The Swiss manufacturers long ago ventured, so to speak, to adopt to a considerable extent, this form of construction, but the poor quality of the watches which the careless greed of manufacturers and importers flooded upon the markets of the world, did much to strengthen the idea, among the dealers as well as among the purchasers, that a good watch

must be provided with a fusee and chain, so that the ultimate force with which the power of the main spring acted upon the escapement should be as nearly constant as possible. Hence the popularity of the English lever watches in this country, and hence the tenacity with which in England they still adhere to the notion that no reliance can be placed upon any other form of construction.

But wisely the pioneers in the introduction of this industry into our country, decided to adopt the going-barrel, so as not only to reduce the size and expense of the watch, but also to obviate the great expenses for repairs made necessary by the frequent breaking of the chain. And besides, in the case of the breaking of the mainspring, the recoiling of the barrel, from the sudden removal of the pressure, creates the risk of injury to the teeth of the great wheel and to other important parts of the movement. Yet, in spite of these discouragements, the necessity of a fusee and chain seemed so apparent to those not versed in the knowledge of the action of the balance spring as regulating the movement of the watch, that this notion so well fortified, did much to oppose the introduction of the watches in which these parts were wanting. Certain it is that many scientific sceptics upon this point had to be convinced by actual trials before yielding their assent to the possibility of the construction of an accurate time-keeper upon the simpler system. It is indeed true that the force of the mainspring is not constant, but if the difference be not too great, the isochronal property of the hair-spring in proper or even approximate adjustment, is quite sufficient to regulate the movement of the watch within the limits required. If the mainspring be of considerable length, and the number of turns when wound such that only comparatively a few turns are unwound during twenty-four hours, there will be very little variation of the force actually transmitted to the train, so that if the watch is wound regularly, the small differences which would result are counteracted so completely by even an approximate isochronal adjustment of the balance spring as to become practically insensible.

The safety of these simpler movements from any injury which might result from the breaking of the mainspring, is most effectually provided for in all the watches made by this Company, by a device known as "Fogg's Patent Safety Pinion," invented in 1865. The arbor is tapped with a triple left-hand thread upon which the pinion screws. This pinion is toothed into the great wheel upon the barrel, and the action of the wheel upon it is in the direction of the tightening of the screw. Whenever, therefore, the mainspring breaks, the recoil of the great wheel unscrews the safety pinion from the arbor, and thus instantaneously releases the whole movement from the effect of the reaction.

It is well known that the teeth of the wheels should be epicycloidal in form, and the attempt is always made, in a properly constructed movement, to secure this form in the final process of finishing. Often, however, in the manufacture under the old system, partly on account of the difficulty of securing the proper form, and partly on account of the peculiar æsthetic notions of workmen who conceived a dislike to epicycloidal teeth because they had in mind the resemblance of their form to that of the bishops' mitres, this important principle was disregarded. Another obstacle arises from the difficulty of producing in miniature with precision what it is possible to draw only upon a magnified scale. But by the application of the machines constructed for this purpose, not only in this instance, but in many other similar cases in the production of the various parts, is the difficulty obviated, and the requirements of theory rendered possible in practice. The forms of the cutters and polishers of the machines which cut the gearing are kept true by means of a machine which gives the true epicycloidal form, so that by proper attention to the depthing when the train of wheel-work is put together in the watch movement, the perfection of smooth and continuous action is secured. It is right here that the superiority of the American system comes into important operation. While it is possible by the ordinary methods, by patient work to produce the wheels and pinions, with the requisite degree of perfection, yet manifestly,

on account of the necessary expense, this cannot be done in the case of the common grades. But by the method under consideration, the action of the machines is precisely the same for all grades. There may be degrees of finish, but the form is unchanged, and the cheapest movements have this excellence in common with the best. The difference of the cost of watches not specially adjusted, will therefore depend upon differences in the number of jewels, the finish of particular parts, and the character of the balance.

The excellence of the train being beyond question, the next and the important consideration, is the character of the work in the construction of the parts connected with the escapement. These are all constructed by processes quite similar to those already mentioned, and hence attention may be directed particularly to the hair-spring and the balance. It is well known that it is upon the proper performance of these parts that the accurate time-keeping property of the movement depends. Any imperfection here will make manifest in a striking degree any imperfections in the train, and even when everything else is perfect, a failure here renders the movement practically worthless for the purpose for which it was intended. The balance spring must be of the very best material, must be evenly coiled, and must be so tempered as to secure a maximum degree of elasticity, and a continuance of this quality undiminished. There will then be a relation between its elastic force, the length to be brought into action, and the weight of the balance which it is to control, to be determined so as to make the vibrations of this balance isochronous whether they be long or short. An examination of the process employed in springing the movements showed that this is accomplished by means of instrumental appliances with all the precision necessary, even in the case of the commonest grades of movements. For higher grades, not including those specially adjusted, to be considered hereafter, the process gives results of wonderful accuracy. The symmetry of the action of the spring as its coils are caused successively to contract or expand, is carefully tested by an indicator constructed for that purpose, and

the condition that the centre of torsion shall be coincident with the axis of the balance staff, is thus secured in advance. The elastic force of the spring for different degrees of winding is next determined, and thereupon it is possible to select a balance from an assortment of compensated balances prepared so as to fulfill the requirements for poise and compensation by identical processes, such that the conditions for isochronism are very approximately realized without any special adjustments after actual trials of the running movement. In this way movements which are of low price, and adapted to the general market, are produced which perform often equal to the most carefully adjusted. An actual trial, by timing tests, of movements of this grade has shown generally only small errors in the several adjustments for temperature, isochronism and position, and in some instances they have been within the limits attainable by special attention to these adjustments in the usual way. Thus often for a very moderate price indeed, may be obtained a movement of a very high order of excellence, such that if it had been adjusted by the usual method, on account of the attention required from the adjuster, its cost would have been necessarily increased ten fold.

The results of the examination of all the grades so far considered were, as stated in the report for an award, that for watches not specially adjusted, and including all the ordinary and medium grades as to price, this Company is enabled to produce in the case of such movements, better watches than are produced by the other methods in use, and that these products are worthy of special commendation.

This Company also exhibited watches, the parts of which were also made by machinery and highly finished, and which had been specially adjusted for isochronism, for position of the balance, and for temperature. One of these, selected at random, was taken down and all its parts minutely examined. The workmanship throughout was found to be excellent, and the materials the very best. The plates were of nickel, the wheels of gold. The holes were jeweled and capped, and the springs of excellent quality, and the balance spring of the

form known as the Breguet spring. The workmanship being of a quality to warrant a movement of the highest order, it remained to determine by actual trial the accuracy of the adjustments, and the regularity of the motions from day to day. The limited time available, in the course of the examinations, for a work of this kind, made it difficult to give to these trials proper attention; but the requisite astronomical instruments being in position and available near the United States Government building, (being there as a part of the National exhibit) ten of these movements were taken from among those on exhibition, and subjected to trials. The first trials for errors of position were made for seven of these movements by Mr. Theodore Gribi, a member of the Swiss Commission, whose services as mechanical expert were of great value to the writer of this report in the course of the examinations in the department of horology. The trials made by Mr. Gribi were during days when the ranges of temperature were considerable, the average temperature in the building during the middle of the day often exceeding 100° Fahrenheit. The results of Mr. Gribi's comparisons during a period of ten days, as computed by him, are as shown by the following table:

| No. of Watch. | Dial Up and Dial Down. | Variation Between | | | Sum of the Four Variations. |
|---|---|---|---|---|---|
| | | Pendant Up and Pend'nt Down | Hanging and Lying. | Pendant Up and Pendant to Right | |
| | s | s | s | s | s |
| 670087 | 2.36 | 8.35 | 0.11 | 3.77 | 14.59 |
| 670061 | 1.40 | 1.50 | 2.65 | 3.23 | 8.78 |
| 670082 | 0.73 | 0.98 | 0.30 | 0.01 | 2.02 |
| 670083 | 1.76 | 0.44 | 7.01 | 5.01 | 14.22 |
| 670092 | 0.88 | 7.31 | 3.18 | 5.19 | 16.56 |
| 670044 | 3.74 | 1.45 | 0.28 | 0.46 | 5.93 |
| Mean, | 1.81 | 3.34 | 2.25 | 2.94 | 10.34 |

The numbers given show the difference of rate corresponding to a period of 24 hours.

The movement numbered 670052, which was also compared by Mr. Gribi, is, for reasons which will subsequently appear, omitted from this table.

Subsequently, during the trial of the Marine Chronometers, these movements were subjected to further trials to determine their errors, and especially the errors of compensation for temperature. The results derived by the reporter from his observations in connection also with the comparisons made by Mr. Gribi, were communicated to the Centennial Commission in explanation of the award recommended by the Judges for the production by this company of first-class pocket chronometers. These results are as shown by the following table:

| No.of Watch. | Variation for $\pm 1^{\circ}$ of Temperature. | Difference between Long and Short Arcs of Vibration. | Maximum Error of Position. |
|---|---|---|---|
| | s | | |
| 670075 | $\mp 0.034$ | | |
| 670099 | $\mp 0.188$ | | |
| 670095 | $\pm 0.024$ | s | s |
| 670061 | $\mp 0.014$ | 2.5 | 1.4 |
| 670087 | $\mp 0.038$ | 0.4 | 8.3 |
| 670083 | $\pm 0.012$ | 2.2 | 0.5 |
| 670052 | $\pm 0.064$ | 1.3 | 6.7 |
| 670044 | $\mp 0.052$ | 0.6 | 1.4 |
| 670082 | $\mp 0.064$ | 0.1 | 0.8 |
| 670092 | $\pm 0.240$ | 0.4 | 7.0 |
| The mean of all gives..... | $\pm 0.07$ | 1.07 | 3.7 |

These numbers refer to the variations of the rate corresponding to a period of 24 hours.

In the reduction of the observations for the movement numbered 670052, included in the above table, it was assumed that an abnormal error, shown by Mr. Gribi's comparisons, was due to an error of observation, but subsequently it was found that the movement was not in proper running order, on account of clogging pieces of lint adhering to the escapement, and that it needed overhauling; and hence in the subsequent trials another movement was taken.

The results thus obtained were sufficient to show that the claim of the production of first-class pocket chronometers was well founded, and they served as the basis for the award to the company for that class of movements. Although sufficient to warrant the award made, it is true that they do not depend upon a series of observations sufficiently extended to be com-

pared fully with the results for the trial of first-class pocket chronometers at the Swiss observatories where such trials are regularly made. And besides, in the temperature trials there was some uncertainty as to the position in which the watches had been placed in the refrigerator during a portion of the 48 hours that they were kept in the cold. In order then, to put the movements to a severer test, they were taken to the Observatory at Ann Arbor, and there subjected by the reporter to a rigorous trial. The whole period of this final trial was eleven weeks, which is five weeks longer than the first-class pocket chronometers are tested at the Swiss observatories. The trial began on September 9th, and ended on November 26th, 1876, and the results for the successive weeks are shown by the following tables:

# TABLE

*SHOWING THE PERFORMANCE OF THE WATCHES DURING A TRIAL OF ELEVEN WEEKS.*

| W'K OF TRIAL. | *First.* | *Second.* | *Third.* | *Fourth.* | *Fifth.* | *Sixth.* | *Seventh.* | *Eighth.* | *Ninth.* | *Tenth.* | *Eleventh.* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Range of Temperature..... | 57° to 69° | 60° to 72° | 47° to 69° | 43° to 53° | 35° to 50° | 39° to 66° | 40° to 61° | 49° to 65° | 31° to 99° | 40° to 77° | 55° to 69° |
| Mean Temperature..... | 62°.1 | 66°.5 | 53°.1 | 48°.7 | 43°.4 | 54°.8 | 48°.8 | 56°.3 | 61°.8 | 52°.7 | 61°.4 |
| Position..... | Horizontal Dial Up. | Horizontal Dial Up. | Vertical. Pendant Up | Vertical. Pend. Down | Vertical. Pend. Right | Vertical. Pend. Left. | Horizontal Dial Up. | Horizontal. Dial Up. | Horizontal. Dial Up. | Horizontal. Dial upad'n | Horizontal Dial Up. |
| Number of the Chronometer. | WEEKLY SUMS OF RATES. | | | | | | | | | | |
| | s | s | s | s | s | s | s | s | s | s | s |
| 670044 | — 5.65 | — 4.80 | +27.55 | +52.10 | +42.05 | +18.20 | + 2.05 | — 3.50 | + 1.40 | +11.35 | — 5.55 |
| 670089 | + 3.05 | + 3.35 | +47.40 | +70.60 | +114.85 | +66.85 | +11.90 | +13.50 | +12.65 | + 6.40 | +10.05 |
| 670082 | —13.65 | — 7.60 | + 9.10 | +15.85 | + 9.65 | —10.25 | — 7.90 | —11.30 | —11.30 | —16.75 | —21.95 |
| 670095 | —20.85 | —16.95 | —18.15 | + 7.85 | + 1.40 | +25.75 | —20.90 | —16.50 | — 8.55 | —18.90 | —20.00 |
| 670087 | —14.15 | —17.20 | + 6.35 | +79.20 | +67.40 | — 1.95 | — 8.45 | —14.35 | — 3.55 | — 9.50 | —18.85 |
| 670083 | + 1.70 | + 7.80 | + 5.15 | +57.60 | +71.95 | +42.45 | +19.05 | +27.95 | +23.40 | +10.20 | +18.20 |
| 670090 | + 7.45 | + 6.45 | +36.55 | +27.30 | +42.50 | — 1.75 | +24.90 | +17.80 | +29.45 | +34.00 | +29.80 |
| 670061 | —27.70 | —39.50 | + 1.25 | —20.95 | —45.80 | —32.50 | —47.60 | —49.40 | —35.70 | —36.05 | —55.45 |
| 670099 | —20.25 | —26.15 | +20.20 | +66.15 | +69.85 | +53.25 | — 6.25 | —18.05 | —10.50 | — 0.35 | —22.65 |
| 670092 | —15.90 | —11.35 | —59.43 | —31.62 | —63.05 | —62.15 | —32.45 | —31.55 | — 9.30 | —22.35 | — 7.20 |

These watches are all stem-winders. The duration of the trial in each position was such as to indicate unmistakably the total effect of irregularities of motion due to the change of position, and through considerable changes of temperature.

In the foregoing table the watches are arranged in the order of their merit, as indicated by the range and fluctuations of the rate in all the changes of temperature from the beginning to the end of the trial; not taking into the account the errors arising from the change from the horizontal to the vertical position.

During the seventh week the watches were placed in different positions, with the dial up, in respect to the magnetic meridian, but no sensible errors which might be attributed to the action of magnetic forces, were indicated.

In the ninth week of the trials the watches were kept during two days at a mean temperature of 36°.7, and then transferred to a warm room in which they were kept for two days at a mean temperature of 95°.1.

During the tenth week, the watches were kept three days with the dials down, in order to find the difference of rate between the dial up and the dial down.

By a comparison of the rates from day to day during the periods in which the position remained unchanged, the mean daily variation of the rate of each chronometer was obtained, and the variation of the rate, assumed to be uniform through a considerable range of temperature, corresponding to a variation of one degree of the thermometer, was derived by a comparison of the rates at the extremes of temperature to which they were subjected. In order to exhibit more fully the character of these movements the following tables are subjoined, the numbers in which have been derived from the data obtained in the course of the final trials now under consideration:

# TABLE

*SHOWING THE MEAN DAILY RATE, AND THE MEAN DAILY VARIATION OF THE RATE, CORRESPONDING TO A PERIOD OF TWENTY-FOUR HOURS, IN DIFFERENT POSITIONS, ETC.*

| Number of the Chronometer. | Mean Daily Rate. | Mean Temperature. | Mean Daily Variation. | Mean Variation for ±1° | Before and after Oven. | Difference between Hanging and Lying. | Difference Hanging and Pendant Left. | Difference Hanging and Pendant Right. | Difference Dial Up and Dial Down. | Sum of these Four Variations. |
|---|---|---|---|---|---|---|---|---|---|---|
| | s | ° | s | s | s | s | s | s | s | s |
| 670090 | +2.76 | 59.5 | ±0.12 | ∓0.098 | 0.0 | −2.98 | −5 30 | −0.11 | −1.30 | 9.69 |
| 670089 | +1.15 | " | 0.14 | ∓0.038 | 0.5 | −5.75 | +2.71 | +9.25 | −1.77 | 19.48 |
| 670082 | −1.75 | " | 0.20 | ∓0.041 | 0.0 | −1.83 | −2.69 | −0.31 | −1.55 | 6.38 |
| 670095 | −2.47 | " | 0.21 | ∓0.014 | 0.7 | +0.26 | +6.23 | +2.53 | +0.10 | 9.12 |
| 670083 | +2.34 | " | 0.26 | ∓0.089 | 0.5 | +1.27 | +5.48 | +8.67 | −3.25 | 18.67 |
| 670044 | −0.38 | " | ±0.27 | ∓0.094 | 0.2 | −3.28 | −1.16 | +1.10 | +3.85 | 9.39 |
| 670092 | −2.57 | " | 0.30 | ±0.214 | 0.7 | +3.91 | −0.74 | +1.52 | −1.25 | 7.42 |
| 670087 | −1.82 | " | 0.31 | ∓0.005 | 0.1 | −2.69 | −1.13 | +8.23 | −0.20 | 12.25 |
| 670099 | −2.47 | " | 0.39 | ∓0.164 | 0.3 | −4.34 | +5.01 | +5.44 | −0.37 | 15.16 |
| 670061 | −6.08 | " | 0.54 | ∓0.014 | 0.4 | −4.63 | −4.75 | −6.87 | +0.45 | 16.70 |
| **Mean of all** | ±2.38 | 59.5 | ±0.27 | ±0.077 | 0.3 | ±3.09 | ±3.52 | ±4.40 | ±1.41 | 12.42 |

In this table the watches are arranged in the order of their mean daily variations of rate.

In trials of this character, one of the conditions of competition often imposed in advance is that the difference between hanging and lying shall not exceed a certain limit, and the result has been an attempt to accomplish this at the sacrifice of the adjustments in other positions. The movements under consideration were not adjusted specially in reference to any such condition.

# TABLE

*SHOWING THE MEAN DAILY RATE IN DIFFERENT WEEKS, AND THE VARIATIONS OF RATE FOR CHANGES OF POSITION.*

| Number of the Chronometer. | Difference Pendant Up and Pendant Down. | Difference Pendant Right and Left. | Difference of rate between First and Eleventh Weeks. | Difference before and after Vertical Positions. | Mean daily rate for Weeks in which position was horizontal. For temperature 60° Fahr. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Before exposure to Heat. | | | | After exposure to Heat. | | |
| | | | | | First. | Second. | Seventh. | Eighth. | Ninth. | Tenth. | Eleventh. |
| | s | s | s | s | s | s | s | s | s | s | s |
| 670090 | —1.76 | —5.18 | +3.19 | +0.87 | +1.26 | +1.56 | +2.44 | +2.17 | +4.39 | +4.68 | +4.44 |
| 670089 | +3.14 | —6.40 | +1.00 | +0.51 | +0.50 | +0.74 | +1.25 | +1.78 | +1.74 | +1.38 | +1.49 |
| 670082 | +0.79 | —2.38 | —1.19 | —0.74 | —1.87 | —0.83 | —1.58 | —1.77 | —1.54 | —2.02 | —3.07 |
| 670095 | +3.65 | +3.64 | +0.12 | —0.81 | —2.95 | —2.33 | —3.13 | —2.31 | —1.20 | —2.85 | —2.84 |
| 670083 | +7.09 | —3.19 | +2.36 | +0.01 | +0.44 | +1.69 | +1.71 | +3.66 | +3.50 | +2.35 | +2.72 |
| 670044 | +3.06 | —2.27 | +0.01 | —0.61 | —0.63 | —0.12 | —0.72 | —0.83 | +0.37 | —0.71 | —0.66 |
| 670092 | +4.94 | —2.30 | +1.24 | +0.53 | —2.73 | —3.04 | —2.48 | —3.69 | —1.74 | —1.23 | —1.33 |
| 670087 | +9.94 | —9.33 | —0.67 | —0.18 | —1.85 | —1.92 | —2.10 | —2.35 | —0.37 | —1.93 | —2.58 |
| 670099 | +5.81 | —0.43 | —0.34 | —0.66 | —2.54 | —2.67 | —2.74 | —3.21 | —1.22 | —1.45 | —2.99 |
| 670061 | —3.23 | +2.69 | —3.96 | —1.40 | —3.93 | —5.55 | —6.96 | —7.11 | —5.08 | —5.45 | —7.90 |
| Mean of all | ±4.34 | ±3.72 | ±1.41 | ±0.57 | ±1.87 | ±2.04 | ±2.51 | ±2.89 | ±2.12 | ±2.40 | ±3.00 |

In this table the watches are arranged in the order of their mean daily variation of rate.

The means given at the bottom, show the average accuracy of the performance of the whole group.

Those who are familiar with investigations of this character will understand, without further explanation, what the numbers in these tables indicate; but for the purpose of making the results clear to the general reader, it is necessary to consider them more fully, commencing with the first of those which immediately precede.

The mean daily rate, as shown in the second column, is the average rate by which each watch gained or lost on mean solar time during the whole period of the trials, and the next column shows the average temperature during the same period. The fourth column exhibits the mean variation of the rate from day to day, excluding the differences which resulted from the changes of position. The amount of this mean daily variation for a particular chronometer is a fair index of the perfection of its manufacture, except so far as relates to the special adjustments next to be considered.

In reference to the numbers given in the fifth column for the variation of the daily rate corresponding to a variation of one degree in the mean temperature, it should be stated that they represent this coefficient as derived from the differences corresponding to a range of temperature from 36°.7 to 95°.1 Fahrenheit, disregarding the effect due to the irrationality of the compensation, for which, in marine chronometers, a secondary or auxiliary compensation is frequently applied to the balance. In reducing the rates to a mean temperature, whenever such reductions were required, a small correction was introduced on this account, whenever its amount was clearly indicated by the observations.

The numbers given in the column headed "before and after the oven," exhibit the change of the daily rate found by comparing the rates on the days preceding and following the placing of the watches in a heated room, and show how far they are affected by sudden and violent changes of temperature.

In order to understand the significance of the numbers in the succeeding columns which relate to the differences due to changes of position, it is necessary to call attention again to the character of the final adjustments of a first-class pocket

chronometer. The general nature of these adjustments and the methods by which they are approximated to by this Company in the case of even the cheaper grades of movements, have already been alluded to, but for our present purpose further consideration of this subject will not be out of place.

The parts of the escapement being supposed to be of proper construction and in proper adjustment in the movement, the attention will finally be directed to the balance and to its controlling spring. In reference to the balance it is often erroneously supposed that the office of the compensation by means of a bi-metallic segmental rim of brass and steel is to counteract simply the effect of the expansion of the balance itself by an increase of temperature, whereas in fact the change of rate arising from the loss of the elastic force of the balance spring, by an increase of temperature, is five times greater than that resulting from the expansion of the balance. And still further there is a change of rate due to the elongation of the spring from the same cause. The compensation of the balance must provide for all these changes, and they amount to a change of the rate to the extent of more than one minute in twenty-four hours for a change of only ten degrees in the temperature. This, however, is now so well understood, that within limits which are always possible to good workmanship, the compensation can be readily effected, and the poise of the balance with reference to the axis of its staff successfully arranged. But when the attention is finally directed to the adjustment of the balance spring, the difficulties to be encountered require the highest knowledge and the most skillful manipulation on the part of the adjuster. On account of the change in the amount of the friction in different positions, and on account also of different degrees of viscosity of the oil at different times, and on account further of inequalities of motion communicated by the train, the arcs through which the balance will vibrate, will be subject to considerable fluctuations even under the most favorable circumstances. When we add to these the interferences which are constantly operating as the watch is carried about in the pocket of the wearer, it becomes of the highest

importance that the isochronism of the spring shall be as perfect as possible. The property of an isochronal adjustment, it is well known, is that the vibrations of the balance shall be performed in the same time whether they be long or short. This will require, in general, for a balance of a given weight and diameter, a certain determinate length of the spring in action, and a form such that this action shall be symmetrical in reference to the motion of the balance each way from the point of quiescence. When this adjustment is once secured, it is evident that any change of the acting length of the spring will destroy this important provision; and here comes in one of the difficulties in the adjustment of a pocket chronometer which is to be carried in different positions. In the case of a marine chronometer there is provision made that the instrument shall perform its functions always in the same position, and hence, when the balance is once poised, regulated to time, and the isochronal adjustment of the balance spring completed by comparing the times of vibration, or the daily rate, in long and short arcs, obtained by varying the acting power of the mainspring, the desired result is accomplished. But in the case of a watch, even if the poise be perfect, the isochronal adjustment made perfect for a horizontal position, will be found to be in error in other positions because of the modification of the action of the spring as its position is changed. It becomes a very difficult matter, therefore, to secure the perfection of the adjustments for a variety of positions when an extreme limit of precision is sought. It has already been mentioned how these adjustments are by instrumental appliances effected in all the watches made by this company, when once the required relation of the parts has been established; but the production of movements of the highest degree of excellence requires that further and special adjustments be made.

The elastic force of the spring as its coils are contracted or expanded from the state of quiescence, must change its value in a ratio depending upon the weight and diameter of the balance, for the case of isochronal action, and this relation is

found by careful trials. The weight of the balance is not affected by the temperature, but its diameter is thus changed, and here again a source of error creeps in. It is the accumulation of all these errors, infinitesimal almost in each vibration, which, in the course of the twenty-four hours, gives a finite error in excess or defect, and thus alters the rate of the watch. If the acting part of the spring be too short the tension as it is wound will be too great, and in the course of long arcs of vibration the rate will gain, while in short arcs it will lose. But if the acting part be too long the tension due to the elastic force will be too small, and the watch will lose during the long arcs of vibration and gain in the case of the short arcs. Any bend in the spring changes the effective length in action, and hence the final isochronal adjustments are effected by modifying the terminal curves of the spring without unpinning it from the collet or the stud.

It is evident further that when once these adjustments are effected, it is of the greatest consequence that the conditions remain unchanged. Hence the importance of a spring properly and permanently tempered. It has been established by experiment that the effect of the process of tempering the spring is to leave it, before it has been put into use, in a condition such that the relations of its molecules do not become permanent until it has been for some time in continuous vibratory motion, and further that the effect of such motion is to produce in the outset an increase of its strength and elasticity, and hence an acceleration of the rate of the movement which it controls.

The use of the flat spring in these chronometers requires that, for the best and most permanent adjustment, a terminal curve for the spring be brought out of and over the plane of its coil. This is not essential for a spring whose action shall be always in the same position, but when the positions are to be different the form of this terminal curve performs an important office in the adjustment. Sometimes both ends of the spring are turned into such terminal curves, and theoretically there would seem to be good reason for this arrangement;

but the difficulties of finding, in practice, the proper forms for two such terminal curves, is a sufficient warrant for confining the attention to a single curve, as in the Breguet form of the spring adopted in the construction of the watches under consideration.

The accuracy of the adjustments depending upon the positions in which the watches were placed, are sufficiently indicated in the several columns of the Tables. A reference to the table showing the weekly sums of the rates, will indicate the time allotted in the trials to each position in which the movements were tried. It will be observed that the periods were such as to make prominent the irregularities depending upon these changes of position, and further that the trials extended to six positions, besides tests for the influence of possible magnetic action. It is hardly necessary to add that the tables establish conclusively the excellence of all the adjustments. And it should be borne in mind, in a just determination of the merits of these movements, that they were subjected to great vicissitudes before they received the long trial of eleven weeks. They had been taken from the factory to the Exhibition before its commencement. They were not regularly wound and kept running, but only so kept during the progress of three distinct trials separated by considerable intervals, and they were exposed to great changes of temperature. After the partial trials at Philadelphia they were allowed to remain unwound and at rest, then they were again wound and started, carried to Ann Arbor, and after an allowance of only three days to assume their regular rate, the final trials began. These extended over the long period of eleven weeks, and through considerable ranges of climatic temperature, circumstances such as to test severely their running qualities. In order to do full justice to the exhibit, it would have been better to have extended the trials to a much larger number of movements, because in the case of so small a number involved in the means taken, a single watch going badly, or not very closely adjusted for errors of temperature and position, affects the mean results much more than if the number were greater.

The limitation of the number was not the fault of the exhibitors, but was determined by the convenience of the reporter, who could not undertake, in connection with the other duties devolving upon him, the trial of a greater number.

It would be of benefit to the Company if their finest productions could be subjected to trial every year in some astronomical observatory. Nothing has done more to stimulate the Swiss manufacture toward excellent workmanship and the most careful adjustments possible, than the competitive trials which have been made for a series of years at the Observatories at Neuchatel and Geneva. In this way, by comparison of results, can some idea be formed of the progress made and the degree of perfection attained. The trials of the first-class pocket chronometers at the Swiss observatories extend over a period of six weeks. They are tried in five positions and in the oven. The second grade of pocket chronometers are subjected to trial for four weeks, in two positions, hanging and lying, and in the oven. It will be seen by reference to the parts of this report which refer to the English, Swiss and German exhibits, that the labors of the judges were very much facilitated by the certificates issued from the observatories, showing the results of the actual trials of the adjusted movements which were on exhibition. And in a determination of the progress which has been made in America, there was thus provided a standard of acknowledged excellence. It is not the purpose of this report to make direct comparisons of the productions of different manufacturers. The reader who is curious in such matters will find, in most cases, the requisite data under the heads of the report relating to the exhibits in question. But in order to convey to the general reader an idea of what the system of manufacture under consideration has made possible in a newly developed industry in this country, it is proper to state here that the reporter has compared the results of the trials as heretofore given with those furnished for all the first-class fully adjusted watches in the International Exhibition, and that it is clear beyond question that the chronometers numbered 670044, 670082 and 670095 are alto-

gether superior to any others exhibited. The tables already given show clearly the excellence of their adjustments, and the smallness of the mean daily variation of their rates. The best of these, taking everything into account, is No. 670044, for which the mean daily rate was only thirty-eight one hundredths of a second, and for which the difference of mean daily rate between the first and eleventh weeks of the trial was only one hundredth of a second. The steadiness of the rates of these watches is best shown by placing in juxtaposition the average daily rate during several weeks separated by considerable intervals, and during which the determining conditions were very different, as already stated. The following are the results:

| Week ending. | Mean daily rate of | | |
|---|---|---|---|
| | No. 670044. | No. 670095. | No. 670082. |
| | s | s | s |
| 1876. July 20. | —0.50 | —3.60 | —2.80 |
| Sept. 18. | —0.63 | —2.95 | —1.87 |
| Oct. 30. | —0.72 | —3.13 | —1.77 |
| Nov. 26. | —0.66 | —2.84 | —3.07 |

These numbers, for the sake of comparison, are reduced as nearly as possible to the temperature 60° Fahrenheit.

The performance of No. 670044 is extraordinary, considering the vicissitudes to which it was subjected and the long period of nineteen weeks during which its rate is considered. The mean daily variation of the rate is greater than that of each of the other two, but this may be due to the imperfect elimination of the error of the eccentricity of the second's dial, in the daily comparisons. Its temperature correction is also apparently somewhat larger, but that all the essentials for good performance were present, is best attested by the steadiness of the rate from week to week as it was under trial.

No. 670089 is hardly of inferior rank to the three here specially mentioned, although the sum of its position errors is greater than the general average.

The results thus developed show clearly enough that there is no lack, in this country, of mechanics skilled in the most abstruse principles of horology, and able to execute their work

in accordance therewith. But it is a lamentable fact that the great majority of those who are to care for these productions after they are put into use, are in total ignorance of the fundamental principles upon which the performance of a watch depends. It would be of inestimable benefit to the public, from an economic point of view, if there could be established in this country schools of horology where young men desiring to become experts in the repairing even of watches, could be enabled to acquire that knowledge and experience which is essential to the proper performance of this kind of work. In every industrial or intellectual pursuit in life, it is desirable that men should be thoroughly educated in the principles underlying their profession, and in none more so than in that which we are considering. It is true that we find occasionally men in this profession also, imbued with the desire to know the why and the wherefore, who have sought to acquire, and often have acquired such education; but too often indeed do we find men professing to be accomplished watch repairers who are in profound ignorance of the principles upon which the peculiar functions of these instruments are correctly performed, and who are liable to undo in a moment what has been achieved by the patience and skill of an accomplished manufacturer. The reader will already have in mind, from what has been under special consideration, that the greatest care is necessary in respect to fully adjusted watches. For needed repairs they should be entrusted to men who fully understand that the relations of the balance and the hair-spring should never be disturbed, even to the minutest bending or lengthening of the spring, or disturbance of the weights of the balance.

It is apparent, therefore, how important it is to the possessor of a good watch that it shall not be liable to be ruined by the ignorant manipulation of some professed watch repairer who undertakes to clean it. The desire to regulate such a watch to run in conformity with a worthless clock, with pretended compensation of the pendulum, has often been the source of mischief to the machine which should regulate

instead of being regulated. And further, it should be borne in mind, that the use of watches has now become so general that the expenses of cleaning and repairs must amount to millions of dollars annually. These expenditures result partly from necessity, partly from the worthlessness of movements palmed off by irresponsible dealers upon a confiding public, and partly from the ignorance of those who undertake the repairs. It is one of the merits of the system of watch manufacture under consideration, that it reduces to a minimum the expenses to be incurred and the dangers to be encountered.

The general reader unacquainted with the results which are obtained from clocks and chronometers of the best construction, by those who are concerned with the accurate determination of time, may perhaps expect closer results than those indicated in the foregoing tables, especially when recalling to mind some of the extravagant statements often made as to the running qualities of watches in the hands of wearers whose comparisons have been made at long intervals, and often with uncertain standards, thus obtaining accidental coincidences. The trial of the movement from day to day, with exact standards of comparison, will necessarily reveal those errors which are compensated or concealed when the intervals of comparison are very long.

The fullness of this report on this particular exhibit has been made necessary on account of the disposition manifested by certain foreign manufacturers to arrogate to themselves and their country the sole possession of that knowledge and skill which can render possible the higher achievements of horological art. While conceding, as they have been compelled to do, by the inexorable logic of the facts before them and the world, the superiority of the American system of manufacture in the case of all but the specially adjusted watches, they have been disposed to cling to the latter as of their exclusive control, and to look with suspicion upon any results which went to show the possibility of excellent production in these higher grades also. The final adjustment of a watch for position, for isochronism, and for temperature, requires only that the maker

shall be able to produce the best quality of springs, of the desired form, and to make a balance of proper proportions, it being supposed that the escapement and the train have been properly constructed. The adjuster must understand the methods of springing, must know how to secure the poise of the balance, and how to modify the acting part of the spring so as to secure isochronal action in different positions and at different temperatures. It cannot be supposed that the science and skill which have achieved wonders in all of what might be called the inferior operations, should find an insurmountable barrier here. The results of the trials of the very few watches selected for that purpose, from among those of the exhibit under consideration, show that such is not the case. And the manufacturers may claim superiority for their finest productions, for the very simple reason that the machine to be adjusted finally for all the errors which interfere with accurate time keeping, is a better machine when constructed upon their system than when constructed upon the old system, and the better machine being equally well adjusted with the inferior one, in respect to these isochronal functions, must, in the nature of things, be of a perfection more enduring, and must satisfy better all the conditions for the highest productions of horological art.

# APPENDIX.

## I.

*Extracts from a speech delivered in the Amphitheatre of the Primary College of La Chaux-de-Fonds, Tuesday, the 14th of November, 1876, by M. Edouard Favre-Perret, Member of the International Jury on Watches of the Exhibition at Philadelphia, and one of the Swiss Commissioners to the United States.*

GENTLEMEN: I must, to start with, announce to you that you have not an orator before you, but a manufacturer, and as such I ask your indulgence. I shall give you information which, unluckily, is not cheerful, on the condition of Swiss watch making compared with the American competition. I shall tell you of facts simply, such as I have seen them, such as I have understood them. Frankness is here more necessary than anything else, for it is not by palliating the bad side of a difficult situation that we can succeed in improving it.

It is evident, gentlemen, that I do not present you with an entire report of my observations at the Exhibition at Philadelphia. These will find space in my report which I shall address to the Federal Council. I shall confine myself to speaking about American watch making, and in comparing it with our own and that of our neighbors. I shall speak to you more about figures than about anything else. Figures, you know, have their own eloquence. For a long time we have heard here of an American competition, without believing it. The skeptics—and there were many of them—denied the possibility of a competition at once so rapid and so important. To-day we are forced to believe the proofs of it, and to acknowledge the existence of a formidable manufacture. We have had the proofs of it under our own eyes; we have seen the American factories, and we have been able to satisfy ourselves exactly as to their power. * * * * * *

Well, gentlemen, we are on the same road as regards the United States. For a long time America has been the principal market for our watches—our milch cow, so to speak. To-day we must earnestly prepare to struggle with the Americans on the fields where hitherto we have been the masters. Some of you have known Mr. Dennison, who was, we may say, the father of American watch-making. Mr. Dennison travelled

through the canton of Neuchatel, studying our mode of manufacturing, seeking to inform himself of everything, and carefully noting the weak parts in our industry. After his return to the United States he founded a factory at Boston, "The Boston Watch Company." This was in 1854. The capital—scarcely $100,000—was subscribed by capitalists more than by practical business men. In the beginning the company turned out only the rough skeleton movement and attended to the finishing all other parts, such as trains, balances, jewels, etc., etc., were imported from Switzerland. Little by little, however, the factory extended its operations and produced other parts. Notwithstanding all this progress, this mode of doing things not suiting the American character, so little inclined to let capital remain almost unproductive, the capitalists abandoned the factory, and it failed in 1856.

Another American, whom you have also known, gentlemen, when he had business relations with us, scented a good speculation, and bought in the entire factory, tools included, for $75,000. Then a year after he incorporated it at $145,000 in a new company, "The American Watch Company," with a capital of $200,000. Soon this capital became insufficient, and it was increased to $300,000 before the war of secession. This war, which seemed calculated to destroy such an enterprise, was, on the contrary, the cause of its prosperity. America put on foot a million soldiers, and as every one wanted his watch, there was great animation in the watch business. At this juncture, which might have been a lucky one for our industry, we failed to comprehend our real interests. Instead of sending good watches to the Americans, the worst trash was sent. Had mere skeleton movements been sent in cases they would have been thought good enough The Americans, however, went to work on an entirely different plan. The company increased their plant, and turned out a better ordinary watch than the Swiss watch. At the end of several years, and with the aid of patriotism, the American watch enjoyed a good reputation, while our own was discredited everywhere. * * *

The capital was increased to $750,000, and the operations of the new company grew to immense proportions. During the following years business went on so well that every where new watch factories sprung up. Every one wanted to make watches. To-day you can count about eleven factories. The Waltham Company give employment to about 900 workmen, and make about 425 movements per day. The Company again increased their capital in 1872; it amounts to-day to $1,500,000, besides $300,000 as reserve fund, or a capital of 9,000,000 francs. This watch factory is a real power; there is none like it in Europe. We have seen it in all its details, and we have admired its splendid organization. Their tools work so

regularly, that all parts of the watch may be interchanged by a simple order on a postal card, without necessitating the forwarding of the adjoining piece. * * * *

In 1860 the American companies produced only 15,000 watches; in 1863, 100,000. To-day they produce 250,000, and this figure can be easily doubled in case the crisis, which so severely prevails there as well as here, should come to an end. For we must not forget that if several factories have been closed during the crisis, the tools as well as the workmen, are still there, all ready to resume work again. Nor must we leave out of sight the exorbitant customs duties and freight, which amount to about 25 or 30 per cent, which take away from us every possibility of being able to stand the fight. And now that we know the figures of production in the United States, we can easily, with the aid of official reports, give an account of what is that country's consumption of watches. We have sent to the United States:

| | |
|---|---|
| In 1864 | 169,000 watches. |
| In 1865 | 226,000 watches. |
| In 1866 | 262,000 watches. |
| In 1867 | 207,000 watches. |
| In 1868 | 209,000 watches. |
| In 1869 | 206,000 watches. |
| In 1870 | 330,000 watches. |
| In 1871 | 342,000 watches. |
| In 1872 | 366,000 watches. |
| In 1873 | 204,000 watches. |
| In 1874 | 187,000 watches. |
| In 1875 | 134,000 watches. |

In 1876 we shall barely send there 75,000 watches, or since 1872 a deficit of 300,000 watches. What a loss for Switzerland, and particularly for Neuchatel! For this deficit concerns principally our own Canton, and it is very easy to convince oneself of the fact. In 1875 Chaux-de-Fonds turned out 106,000 watches or movements. In preceding years she turned out double that amount. The deficit, therefore, amounts, for La Chaux-de-Fonds alone, to 4,000,000 francs; for Locle, Neuchatel, etc., it reaches the same figure in proportion.

We have stated that the shipment of our goods has largely decreased. Shall we attribute its cause to the crisis? Certainly in many respects we may do so; it cannot be denied. But the American competition contributes still more largely to it.

The Americans have already commenced to send their manufacture to Europe. In England they sell annually from 20,000 to 30,000 watches. The American watch commences to

drive from the English market the Swiss, and even the English watch. The Americans commenced by creating a demand for their goods in the Indies and in Australia; and then, thanks to some powerful exporting houses, they invaded England. At Moscow and St. Petersburg they have already established important branch offices. They do not keep it secret, but loudly advertise it; their aim is to drive us first out of their own country, and then to compete with us on our own soil, if our sluggishness and our blind confidence leave the field free to them. I sincerely confess that I personally have doubted that competition. But now I have seen—I have felt it—and am terrified by the danger to which our industry is exposed. Besides, I am not the only one to think so; the "Société Intercantonale" have sent a delegate to make inquiries, and his report perfectly agrees with mine. Up to this very day we have believed America to be dependent upon Europe. We have been mistaken. The Americans will send us their products since we cannot send them our own. * * *

We ask ourselves whether the Americans can maintain their prices? I answer yes, they can, for if they obtain a good profit on their superior quality of goods, they can afford to be satisfied with a smaller profit on the lower grades of watches. In America everything is made by machinery; here we make everything by hand. We count in Switzerland about 40,000 workmen making on an average each per annum 40 watches. In the United States the average is 150 watches. Therefore the machine produces three and a half to four times more than the workman. It remains for us to solve the situation. But how can we get out of the corner into which we have been driven? To-day, even without machines, we cannot dispose of the 1,600,000 watches which our people can manufacture. How will it be if we establish machines which will thrice increase our production? We must either diminish the number of our hands and make machines, or else cling to our system and be resigned to see our industry decline.

Gentlemen, I do not pretend to point out the remedy. I simply call your attention to the evil—that is all. It remains for you to find the cure. However, I believe it will be good to do for our mechanicians what we have done for our watchmakers; that is, to create schools. You must not despair; you must not desert the field; we must, on the contrary, organize for resistance, and to reconquer the lost ground. If America closes her gates to us by customs duties and exorbitant expenses, we are at least left the resource of energetically fighting against her in European markets.

[Here the orator gave an extract from the report of Mr. Hirsch (Director of the Observatory) to the Council of State, after the Exhibition of 1867. This report already signalized the danger confronting our industry. Resuming, he said]:

Had the Philadelphia Exhibition taken place five years later we should have been totally annihilated without knowing whence or how we received the terrible blow. We have believed ourselves masters of the situation, when we really have been on a volcano. And to-day we must actually struggle if we do not want to encounter, in all the markets, that rival manufacture. Did we not sneer at Besançon at the outset? And now Besançon suffices for France, and besides she exports her surplus of manufacture. We ask ourselves if, in reducing the prices of watches, we can increase their sale in the same proportion? And if the sales do not increase what will become of us? We shall have an enormous stock of goods and a permanent stagnation. The customs duties, you know, amount to about 25 per cent. For a long time hopes have been entertained that they might be reduced. We cannot count on it. America needs all her resources, especially in her present situation; and whether Democrats or Republicans be in power, we cannot hope for a reduction in import duties. We must therefore make up our minds to lose the American market!

It has been said, and it has been complacently repeated, that the Americans do not make the entire watch, and that they are dependent on Switzerland for several parts of the watch. This is a mistake. The Waltham Company make the entire watch—from the first screw to the case and dial. It would even be difficult for them to use our productions, so great is the regularity, so minute the precision with which their machines work. They arrive at the regulation of the watch—so to say—without having seen it. When the watch is given to the adjuster, the foreman delivers to him the corresponding hair-spring, and the watch is regulated. (Sensation among the audience.) Here is what I have seen, gentlemen! I asked from the director of the Waltham Company a watch of the fifth grade. A large safe was opened before me; at random I took a watch out of it and fastened it to my chain. The director having asked me to let him have the watch for two or three days, so as to observe its motion, I answered, "On the contrary, I persist in wearing it just as it is, to obtain an exact idea of your manufacture."

At Paris I set my watch by a regulator on the Boulevard, and on the sixth day I observed that it varied 32 seconds, And this watch is of the fifth American grade; it cost 75 francs (movement without case). At my arrival at Locle I showed the watch to one of our first adjusters, who asked permission to "take it down"—in other words to take it to pieces. I, however, wished first to observe it; and here is the result which I noted: Hanging, daily variation, 1½ seconds; variation in different positions, from 4 to 8 seconds; in the "heated

room" the variation was but slight. Having thus observed it, I handed the watch to the adjuster, who took it down. After the lapse of a few days he came to me and said, word for word, "I am completely overwhelmed; the result is incredible; one would not find one such a watch among fifty thousand of our manufacture."

This watch, gentlemen, I repeat to you, I took at hazard—out of a heap as we say. You understand from this example that the American watch may be preferred to the Swiss. I have finished, gentlemen, and I have told you of things such as I have seen them. It remains for us to profit from this sad experience, and to improve our manufacture. Competent men are not wanting among us; they must go to work at once.

## II

*Results of the Trials of Swiss Watches submitted for Competition at the International Exhibition.*

For the purpose of enabling the reader of the foregoing reports to understand clearly what is regarded as the standard of excellence in the adjustment of pocket chronometers, and the relative merits of the watches, the following results of the trials made at the Swiss Observatories of the best pocket chronometers exhibited by Swiss manufacturers, at the International Exhibition at Philadelphia, are given.

The variations for one degree of temperature are for degrees of the Centigrade scale, which is used in Switzerland. Ten degrees Centigrade are equivalent to eighteen degrees Fahrenheit.

The column headed "mean daily variation" shows the average variation of the rate from day to day, excluding variations resulting from changes of position.

The numbers given refer to variations of the rate, from the causes named, corresponding to a period of 24 hours.

## I. POCKET CHRONOMETERS, OF THE FIRST CLASS, SUBJECTED TO TRIAL FOR SIX WEEKS AT THE OBSERVATORY AT NEUCHATEL.

| Maker. | Number. | Mean daily Rate. | Mean Daily Variation. | For var'n of +1° Temper't're | Before and after Oven. | Difference Hanging and Lying. | Hanging and Pend't Left. | Hanging and Pend't Right. | Dial up and Dial down. | Diff. betw'n first and last Week. | Difference extreme rates. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | s | s | s | s | s | s | s | s | s | s |
| Breting frères, | 47811 | −2.12 | ±0.29 | +0.01 | 0.5 | +1.14 | −0.68 | +1.02 | −0.76 | 0.72 | 3.2 |
| H. L. Matile, | 10045 | +2.58 | ±0.51 | −0.01 | 1.6 | +2.64 | +1.82 | +0.62 | −1.19 | 1.09 | 5.7 |
| H. Grandjean & Co. | 34060 | +6.26 | ±0.45 | −0.22 | 0.8 | +2.46 | −3.96 | −0.06 | −2.51 | 3.09 | 9.0 |

## II. POCKET CHRONOMETERS OF THE SECOND CLASS SUBJECTED TO TRIAL FOR FOUR WEEKS AT THE OBSERVATORY AT NEUCHATEL.

| Maker. | Number. | Mean Daily Rate. | Mean Daily Variation. | Variat'n for +1° Temper't're | Before and after Oven. | Diff. betw'n Hanging and Lying. | Diff. betw'n first and last Week. | Diff. betw'n Extreme Rates. |
|---|---|---|---|---|---|---|---|---|
| | | s | s | s | s | s | s | s |
| Borel & Courvoisier | 54025 | +2.21 | ±0.16 | +0.08 | 0.8 | 1.16 | | 2.9 |
| | 54059 | | ±0.20 | −0.02 | 0.7 | 0.19 | 2.2 | 4.0 |
| | 60008 | | ±0.21 | −0.14 | 0.3 | 2.23 | | 6.0 |
| | 54023 | | ±0.26 | −0.03 | 4.3 | 0.95 | 4.5 | 6.3 |
| | 54045 | | ±0.69 | −0.21 | 0.7 | 4.44 | 3.7 | 9.8 |
| H. L. Matile, | 10697 | −3.84 | ±0.70 | −0.31 | 0.5 | 0.52 | | 7.9 |
| | 10661 | +4.09 | ±0.86 | −0.18 | 0.1 | | | 11.6 |
| Jacot frères, | 199313 | −1.40 | ±0.33 | +0.01 | 0.8 | 2.74 | | 4.6 |
| | 199315 | −4.78 | ±0.42 | +0.44 | 1.5 | 3.59 | | 14.7 |
| | 199311 | −2.47 | ±0.45 | −0.05 | 1.9 | 3.34 | | 6.6 |
| | 199307 | −1.03 | ±0.45 | −0.28 | 1.2 | 0.94 | | 8.4 |
| | 199309 | +0.88 | ±0.53 | +0.37 | 0.4 | 0.88 | | 9.9 |
| | 199310 | −4.12 | ±0.67 | +0.19 | 4.5 | 3.40 | | 10.6 |
| | 199308 | −2.37 | ±0.80 | −0.19 | 0.2. | 0.17 | | 6.1 |
| | 199314 | +1.35 | ±0.80 | +0.21 | 0.9 | 2.52 | | 9.2 |
| | 199312 | +5.43 | ±1.38 | −0.07 | 0.0 | 4.96 | | 10.7 |

*III. POCKET CHRONOMETERS, OF THE FIRST CLASS, SUBJECTED TO TRIAL AT THE OBSERVATORY AT GENEVA.*

| Maker. | Number. | Mean Daily Variation of Rate. | Variation for +1° Temperature. | Error of Position. |
|---|---|---|---|---|
| | | s | s | s |
| H. R. Ekegrén, | 16779 | ±0.30 | +0.18 | 4.08 |
| | 16726 | ±0.37 | +0.32 | 2.45 |
| | 16753 | ±0.41 | +0.28 | 2.50 |
| | 16779 | ±0.48 | +0.16 | 2.30 |
| | 16710 | ±0.49 | +0.14 | 1.50 |
| | 16642 | ±0.50 | +0.27 | 2.30 |
| | 16766 | ±0.53 | +0.09 | 4.06 |
| | 16519 | ±0.56 | +0.13 | 3.70 |
| | 16518 | ±0.65 | —0.16 | 1.90 |
| | 16903 | ±0.66 | +0.01 | 3.40 |
| Patek, Philippe & Co., | 49027 | ±0.38 | —0.33 | 5.89 |
| | 47776 | ±0.39 | +0.11 | 2.09 |
| | 42952 | ±0.42 | +0.11 | 1.48 |
| | 47417 | ±0.49 | +0.07 | 1.60 |
| | 45201 | ±0.49 | +0.21 | 1.63 |
| | 44035 | ±0.54 | +0.13 | 5.79 |
| | 49062 | ±0.55 | +0.26 | 1.82 |
| | 49111 | ±0.61 | +0.64 | 2.40 |
| | 49264 | ±0.66 | +0.10 | 1.79 |
| | 41659 | ±0.72 | —0.01 | 2.20 |

Besides the manufacturers here mentioned, Louis Audemars, James Nardin, Maurice Stahl, and A. Huguenin & Sons exhibited pocket chronometers which had not been subjected to trial at an observatory.

The English pocket chronometers had not been subjected to timing tests, and were not submitted for trial. The best German watches exhibited were not of a grade for competition with the chronometers under consideration.

In determining the relative merits of the watches whose performance has been indicated in the tables which have been given. the reader will need to bear in mind that the interval of time over which the trials extended, must be considered in reference to the steadiness of the rate from day to day or from week to week. Since the trials of the first-class Swiss pocket chronometers extend over only a period of six weeks, while the American watches were subjected finally to a trial of eleven weeks, it is proper, for the sake of comparison, to repeat here the results already given for the steadiness of rate for a corresponding period. By referring to the tables given in the report we find these results to be:

*AMERICAN WATCH COMPANY'S,*

| Number. | Mean Daily Rate. | Mean Daily Variation. | Diff. between first and seventh Week. | Diff. between first and eleventh Week. |
|---|---|---|---|---|
| | s | s | s | s |
| 670044 | —0.38 | ±0.27 | 0.09 | 0.01 |
| 670095 | —2.47 | ±0.21 | 0.18 | 0.12 |
| 670082 | —1.75 | ±0.20 | 0.29 | 1.19 |
| 670089 | +1.15 | ±0.14 | 0.75 | 1.00 |
| 670087 | —1.82 | ±0.31 | 0.35 | 0.67 |
| 670099 | —2.47 | ±0.39 | 0.20 | 0.34 |
| 670092 | —2.57 | ±0.30 | 0.25 | 1.24 |
| 670083 | +2.34 | ±0.26 | 1.27 | 2.36 |
| 670090 | +2.76 | ±0.12 | 1.18 | 3.19 |
| 670061 | —6.08 | ±0.54 | 3.03 | 3.96 |

By means of the data given in this appendix the reader will be able to verify the statement made in the report, that the American Watch Company's watches numbered 670044, 670095 and 670082 were the best on exhibition at the International Exhibition at Philadelphia.

# INTERNATIONAL EXHIBITION.

## PHILADELPHIA, 1876.

The United States Centennial Commission announce the following report as the basis of an award to the AMERICAN WATCH COMPANY, Waltham, Mass., for watches:

### REPORT.

The movements made by this Company are constructed upon what is known as the "American System" with interchangeability of parts for the several grades manufactured, and by the use of machinery devised and perfected in their factory, and by them first brought into use for the purposes of watch-making. There can be no doubt that the application of machinery, to a great extent automatic, constructed so as to act upon scientific principles, must result in the production of the parts of watch movements with precision and uniformity. This superiority will always be the more marked in the ordinary and medium grades of movements as to price, so that this Company is enabled to produce in the case of such movements better watches than are produced by the other methods in

use. We have examined a large number of watch movements of these grades, with plain or compensated balances, which had uniformly good trains, and were well sprung, so that their time keeping properties must be of the highest order for watches not specially adjusted. We have also examined the operation of the machinery for the production of the parts, and the instruments used in springing the watches, and for other adjustments, and we have been convinced of the certainty of the processes which they employ, and we consider them justly entitled to special commendation.

This Company also exhibited watches, the parts of which were also made by machinery and highly finished, and which had been adjusted for isochronism, for position of the balance and for temperature. Since these watches had not been subjected to trials in an astronomical observatory, and the requisite astronomical instruments were in position and available at the United States Government Building, we asked for and received ten movements from the exhibit to be submitted to the requisite tests. These tests were as follows: 1st. For temperature, 48 hours in the refrigerator and 48 hours in the heated room· 2d. For errors of position and isochronism. The tests were during a period of ten days. The results showed the excellence of the several adjustments, the small errors outstanding being far within the limits considered as the proper standard of excellence in the adjustment of first-class pocket chronometers.

All of the watches made by the American Watch Company are provided with Fogg's safety pinion, invented in 1865, which obviates the possibility of injury to the movement from the breaking of the mainspring, which is an improvement.

JAMES C. WATSON,
ED. FAVRE-PERRET,
Judges.

APPROVAL OF GROUP JUDGES.

JOSEPH HENRY, (Sir) WILLIAM THOMSON,
J. E. HILGARD, E. LEVASSEUR,
F. A. P. BARNARD, H. K. OLIVER,
J. SCHIEDMAYER, P. F. KUPKA.
GEO. F. BRISTOW,

A true copy of the record.

FRANCIS A. WALKER,
Chief of the Bureau of Awards.

Given by authority of the United States Centennial Commission.

A. T. GOSHORN,
Director General.

J. L. CAMPBELL, Secretary. J. R. HAWLEY, President.

# AMERICAN WATCH COMPANY,

WALTHAM, MASSACHUSETTS, U. S. A.,

MANUFACTURERS OF

# Watch Movements and Watch Cases.

---

## AGENCIES:

ROBBINS & APPLETON,
*No. 9 Bond Street, New York.*

ROBBINS, APPLETON & CO.,
*No. 8 Summer Street, Boston, Mass.*

ROBBINS & APPLETON,
*No. 170 State Street, Chicago, Ill.*

ROBBINS & APPLETON,
*Waltham Buildings, Holborn Circus, London, E. C.*

---

***Orders and inquiries from the Trade to be addressed to the nearest Agency.***
***No Goods retailed either by the Company or its Agents.***

---

## WALTHAM WATCHES SOLD BY ALL RESPECTABLE JEWELERS

AND GUARANTEED BY THE COMPANY.