Hamilton TECHNICAL BULLETIN

HAMILTON ELINVAR Extra

TECHNICAL BULLETIN 200

7—1719 PUBLISHED BY HAMILTON WATCH COMPANY, LANCASTER, PA. MARCH 1947

TEMPERATURE AFFECTS WATCH PERFORMANCE

Because watches are portable timepieces they are subjected to a variety of uncontrollable conditions which materially affect performance. Since it is impossible to change the conditions under which watches are used, the only alternate is to try to compensate them. And for over 200 years that has been the principal pursuit of horologists, watchmakers, and some scientists the world over. The performance of the modern fine watch is proof that these efforts were not in vain. No finer tribute can be paid the ingenuity, skill, and persistence so traditional in watchmaking.

The effects of temperature variations on the performance of watches has been the most difficult to satisfactorily compensate. The split rim bi-metallic balance wheel with a steel hairspring, despite its several shortcomings, for many, many years proved to be the most effective compensating device for the effects of temperature variations. The well known "middle temperature" error, or the inability of this balance to afford uniform compensation throughout an adopted temperature range, was and still is its most unsatisfactory characteristic. Difficulty with poising and maintenance of poise of the bi-metallic wheel has, from the watchmaker's point of view, long been an equally serious limitation.

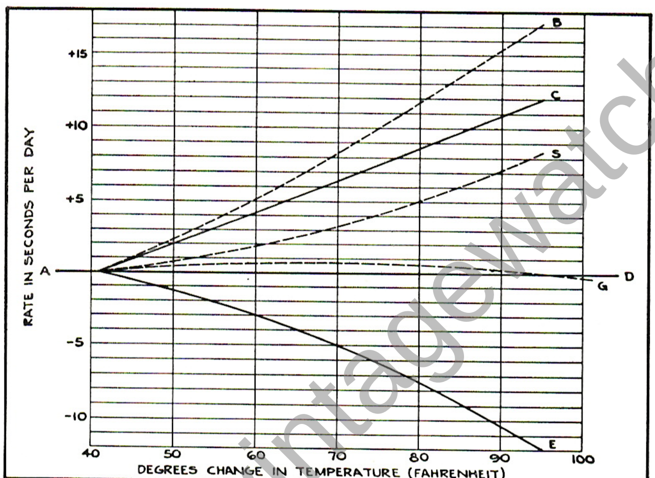


Figure 1

A graphic illustration of the "middle temperature" error characteristic of watches employing the bi-metallic balance wheel and steel hairspring. The dotted line AG shows a characteristic rate of such a watch correctly adjusted to 40° and 95° Fahrenheit. The path of this line (AG) reveals a typical deviation in rate at any given temperature between 42° and 95° Fahrenheit. Deviations result from the inability of the bi-metallic balance wheel rim segments to expand or compensate exactly for the proportional decrease of elasticity of the hairspring. Line AB represents the expansion of brass, AS the expansion of steel. AC, the approximate mean of AB and AS, indicates the gain in rate due to the effect of temperature rise on the balance wheel. AE shows loss of rate resulting from decreasing elasticity of the hairpsring subjected to the same rise in temperature. Line AD represents the ideal condition where the modulus of elasticity of the hairspring decreases in the exact ratio with the mean expansion between the steel and brass elements of the balance wheel rim.

TEMPERATURE COMPENSATION DEPENDS ON HAIRSPRING

Since the limitations of the bi-metallic balance seemed impossible to overcome, early experimenters turned again to the use of an un-cut mono-metallic balance wheel. Efforts then were focused on a search for a hairspring material that would *increase* in elasticity rather than *decrease,* as does carbon steel, with a rise in temperature. The search, therefore, was for an alloy having a modulus of elasticity directly opposite that of carbon steel. Alloy after alloy, metal after metal was tried, and even glass springs were tested without success over a period of nearly two centuries.

Until Dr. Charles Edward Guillaume, a French physicist who had been experimenting with nickel-iron alloys, discovered and announced that certain of the nickel-iron alloys exhibited the desired characteristic of increasing elasticity with temperature rises, the search proved fruitless. Hairsprings formed with Guillaume's first alloys, however, were far from satisfactory. The springs were very soft, easily deformed, and what was even worse, possessed a very low degree of elasticity. Guillaume then sought to produce a harder alloy and one with a coefficient of thermo-elasticity which was virtually zero over a wide range of temperatures—a characteristic which, if realized, promised to practically eliminate "middle temperature" error, and insure the use of the highly desired un-cut mono-metallic balance wheel. That Guillaume was successful is now horological history. His alloy was appropriately named "Elinvar," a manufactured term compounded from *el*asticity *invar*iable. In recognition of this achievement, Dr. Guillaume was granted the Nobel Award in Physics and thus received international recognition as a scientist.

ELINVAR AFFORDS FREEDOM FROM EFFECTS OF TEMPERATURE

Remarkable freedom from the effects of temperature changes was but one advantage Elinvar revealed. The alloy exhibited a high resistance to rust or corrosion, a serious weakness of the steel hairspring. The effects of magnetism, a serious weakness of watches with steel hairsprings, was virtually eliminated with Elinvar and the mono-metallic balance wheel.

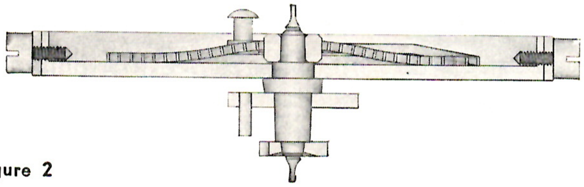


Figure 2

The effect of magnetism on the steel hairspring is shown in this cross section of a balance assembly employing a bi-metallic balance wheel.

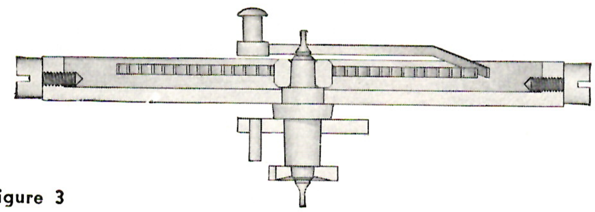


Figure 3

Cross section of a balance assembly employing an un-cut mono-metallic balance wheel and an Elinvar hairspring.

The significance of this characteristic can be appreciated by comparing the illustrations in Figure 2 and Figure 3. When a watch with a steel hairspring and bi-metallic balance becomes magnetized, the hairspring is attracted toward the balance arm which, even though it may not touch the balance arm and stop the watch, results in erratic timing.

Watches equipped with Elinvar hairsprings and mono-metallic balances, although they are affected while in a magnetic field, even stopped if the magnetic field is strong enough, will resume running upon removal from the magnetic field with minor effects on the rate.

HAMILTON RESEARCH ON ELINVAR

Hamilton technical men who had closely followed the reports of Dr. Guillaume's work soon decided to experiment with Elinvar. After five years of painstaking research and exhaustive tests of Elinvar hairsprings with mono-metallic balances, Hamilton announced that the famous Grade 992 railroad model, henceforth, would be equipped with mono-metallic balance and the ELINVAR hairspring.

Elinvar met with immediate success. Railroad men, time inspectors, and watchmakers the country over welcomed the improved timekeeping of an already fine watch. The practical advantages of the solid rim mono-metallic balance wheel, Elinvar's resistance to rust, and the virtual elimination of the effects of magnetism were quickly recognized by watchmakers and generously applauded.

The success of Elinvar in the 992 naturally stimulated demand for its use in all new Hamilton watches. This was done but only as rapidly as thorough tests of experimental models of each size and grade watch could be completed.

Almost simultaneous with the initial application of Elinvar hairsprings and solid mono-metallic balances to Hamilton watches, Hamilton metallurgists began what soon became a major research project on other nickel-iron alloys of the Elinvar group. To many a watchmaker, the research might have seemed unnecessary, even useless. But Hamilton technicians have long known that an original invention—no matter how successful—is only the beginning. The wisdom of that philosophy was demonstrated some years later in an unexpected manner. World War II began to hazard European sources of Elinvar. Then the uniform quality of the alloy began to vary. To a less farsighted company such a situation might have been serious; to Hamilton it was simply the signal to convert nearly ten years of research knowledge and experience to practical use.

FROM RESEARCH A NEW HAIRSPRING MATERIAL

The tempo of research was accelerated. And finally, during 1939, a pilot steel mill was set up in the Metallurgical Laboratories. Alloys were compounded, ingots poured and forged, the resulting bars swaged and wire drawn to desired dimensions. Springs were formed and tested. More "heats" were made, more springs were tested. The goal was to produce a better alloy and a better hairspring than Europe had ever produced. For so big an undertaking, success came quickly. From the pilot stage to regular manufacture is normally the orderly process of expansion . . . except when a war upsets the transition and imposes new and what, at that time, seemed to be impossible demands for production.

This bulletin it not another story of Hamilton's wartime production and yet it is, for without the new hairspring material and the "know how" of Hamilton's technical men in quickly adapting it to Hamilton chronometers, watches, and fuses, it is not likely that Hamilton's war production would have been so significant a contribution to Victory.

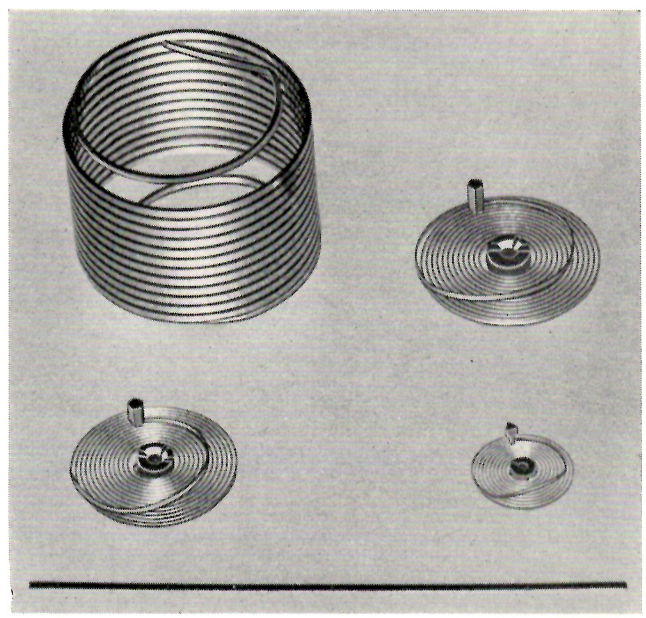


Figure 4
Hamilton Made Hairsprings Employed in War Products.
Top row: Hairspring for the Hamilton Marine Chronometer and the 35 size Navigation watch. Second row: 16 size Railroad and Navigation watches, and the 6/0 size strap watches. Bottom: Time Fuze Spring.

Before war production completely commanded manufacturing facilities, Hamilton was able to release a small number of its now famous 992B railroad grade watch—the first to be equipped with the new hairspring. While the hairspring was of a highly finished white metal as contrasted with the dark blue original Elinvar spring in the old 992, and as such was noticed by some watchmakers and railroad time inspectors, it was the performance of the watch that quickly captured the attention of the trade. War, however, soon stopped production of civilian watches and made it necessary to suspend plans to employ the new spring in all Hamilton movements. Hamilton's war timepieces all employed springs made from the new alloy. The now famous performance of Hamilton's war watches and chronometers under rigorous service conditions confirmed, as few other tests could, the real merits of the new alloy for hairsprings.

The employment of the new spring in the company's normal civilian watches was naturally high on the list of war to peace conversion jobs. As rapidly as engineering and tooling could be completed for each different size spring, production was started and as inventories of each size permitted, the new hairsprings were assembled in new watches.

NEW HAIRSPRING NAMED HAMILTON ELINVAR EXTRA

The new hairspring alloy, while it is a member of the Elinvar family, is decidedly not a simple iron-nickle alloy. It is as different from the once famous Elinvar as one brother is from another. A few family characteristics of the alloy are evident but the inherent qualities and even the appearance differ markedly. The new alloy, therefore, is named *Hamilton Elinvar Extra:* Hamilton, because it is Hamilton made; Elinvar, because it is a member of the Elinvar family of alloys; and Extra, because it has "extra" qualities not possessed by any other watch hairspring.

CHARACTERISTICS OF ELINVAR EXTRA

To the owners of new Hamilton watches, Hamilton-Elinvar-Extra Hairsprings means even finer performance of an already fine watch. Specifically it means uniformly fine performance regardless of the normal temperature variations to which the watch is subjected—performance that is not permanently impaired by magnetism.

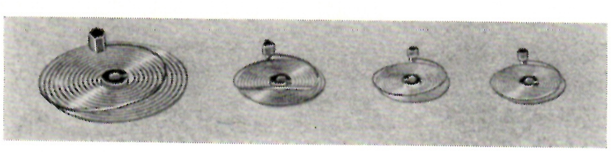


Figure 5
All Hamilton Watches Are Now Equipped with the new Elinvar Extra Hairsprings. Left to right: 10 Size, 14/0, 21/0, and 22/0.

To the watchmaker Hamilton Elinvar Extra means:

(1) Rates not affected by normal temperature variations.
(2) Rates which are not permanently affected by magnetism.
(3) Exceptional isochronal properties.
(4) Ease of position adjusting.
(5) Maximum spring resiliency.
(6) Rugged spring structure—not affected in any way by normal handling.
(7) Little trouble from oil on Elinvar Extra springs (*Because the coils on Elinvar Extra have more space between them and because the spring is highly resilient, an accidental deposit of oil is not likely to cause coils of the spring to stick together.*)
(8) Permanent mirror finish.
(9) Rustproof hairsprings.

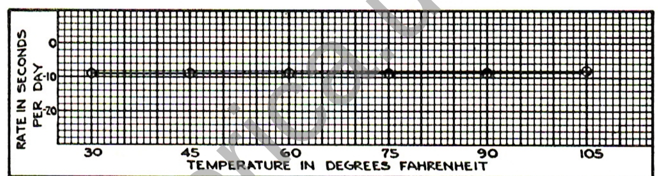


Figure 6
A typical temperature rate curve of a 16 Size 992B Hamilton Watch employing a Hamilton Elinvar Extra Hairspring.

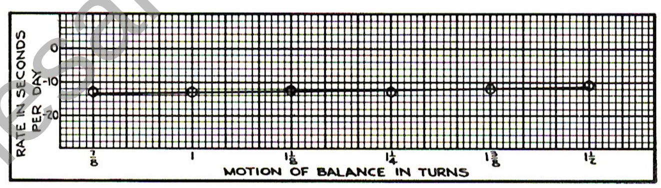


Figure 7
A typical isochronal rate curve of a 16 Size 992B Hamilton Watch employing the Hamilton Elinvar Extra Hairspring.

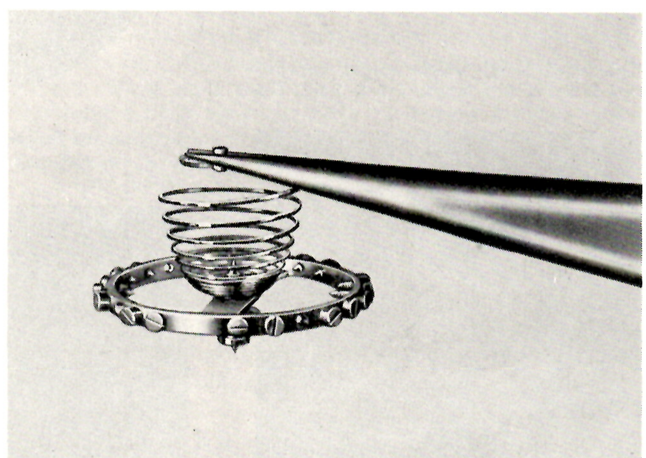


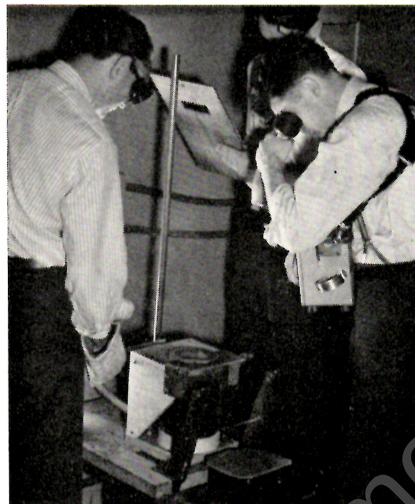
Figure 8
The exceptional resiliency and rugged nature of Hamilton Elinvar Extra hairsprings virtually eliminates problems of spring distortion in the normal handling of the part.

In short, Hamilton Elinvar Extra means a new and greater freedom from the traditional balance and hairsprings' problems and limitations which have so long inhibited the best work of the watchmaker.

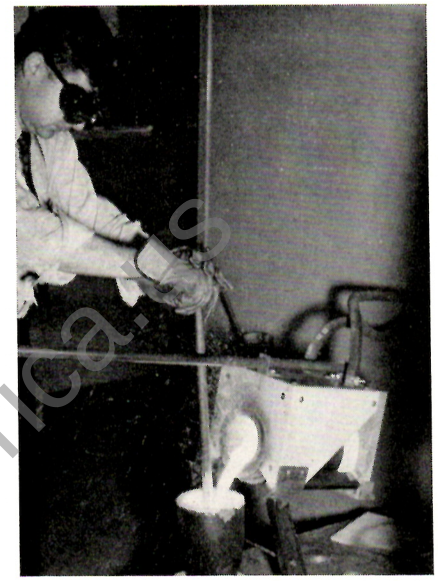
HAMILTON ELINVAR EXTRA REQUIRES CRITICAL CONTROL AND INFINITE CARE IN PROCESSING

The photographs below highspot the carefully controlled processing steps required in the production of Hamilton Elinvar Extra hairsprings. Only the very purest metals can be used and each metal in the alloy must be weighed with laboratory accuracy. Precise control of time and temperature of each "heat" is imperative. From beginning to end, infinite care is vital to the quality of Hamilton Elinvar Extra hairsprings. In the making of the new hairsprings, as in the thousands of other operations that go into the making of a fine watch, accuracy begets accuracy. That is why Hamilton Elinvar Extra is completely Hamilton made.

1. Each metal employed in the alloy for Elinvar Extra is weighed on laboratory type scales.

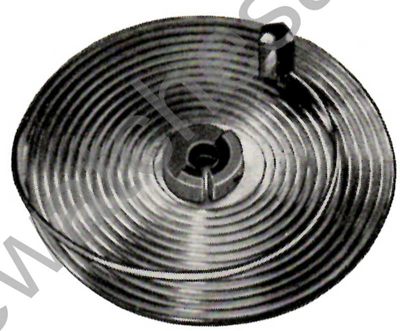


2. Metallurgists frequently check temperatures against processing time in making a "heat" of Elinvar Extra.

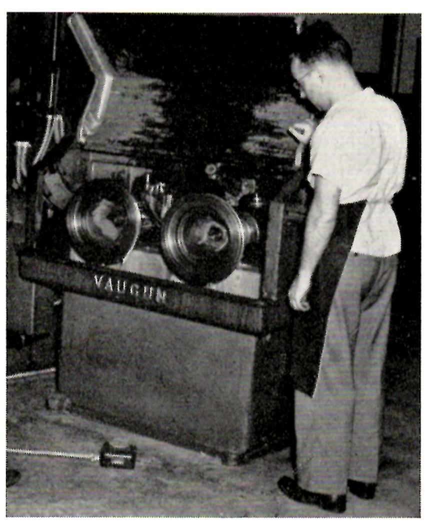


3. At a carefully pre-determined time, the "heat" is poured into an ingot mold.

4. The ingot (left) which weighs approximately 5 lbs. is then forged into a bar. The "hot top" (center) is waste.



5. After the forged bar is turned on a lathe, it is swaged and processed into wire of various sizes.



6. Hairsprings are formed in a tool like this, then heat treated, colleted and studded.