SHORT TALKS TO WATCHMAKERS

BOOK TWO

Subject

Temperature Adjusting

Continued

By

C. T. Higginbotham

Consulting Superintendent

South Bend Watch Co.

Compliments of

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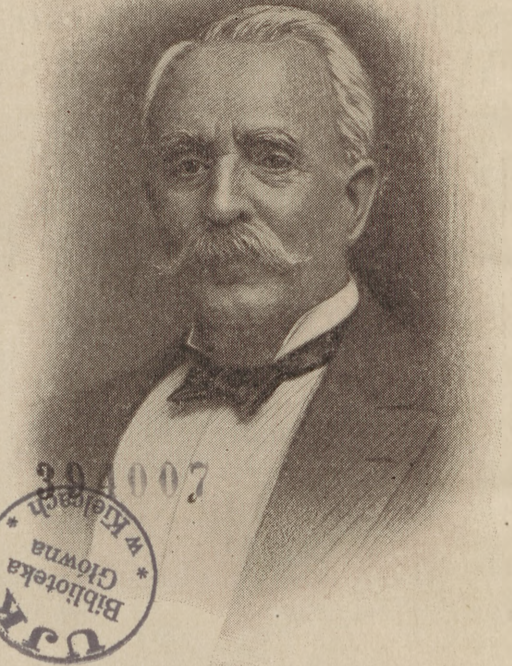


CHARLES T. HIGGINBOTHAM

Mr. Higginbotham probably has a more thorough and broader experience in the science of making high grade watches than any other man in the United States.

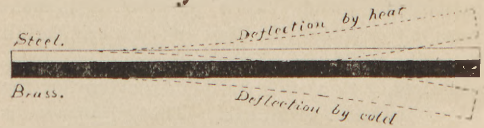
Although sixty-five years of age, he takes an active part in all matters that concern the production of a movement that is gaining a reputation as a most accurate and durable timepiece—the South Bend.

THE adjustment of watches is commonly classed under three heads: Isochronism, temperature and position. Strictly speaking the first embraces the other two, but as commonly understood it means simply adjusting the hairspring and balance to each other so that the latter shall perform its long and short arcs in the same time while the watch is in a horizontal position. Then position adjustment steps in to equalize the time of vibration for all the other positions. Finally temperature adjustment produces a uniformity in the time of the vibrations in heat and cold. This adjustment is entirely distinct from the other two so far as the means used to secure it are concerned. It is of this adjustment that the present article treats. Before attempting it, the structure, properties and action of the balance should be carefully studied.

STRUCTURE.—The chronometer, or more properly speaking, compensation balance is composed of two metals; brass and steel. The arms are of steel; the rim of steel and brass laminated; the inside steel, the outside brass. The proportional expansion of metals, as has been explained in book one, is called the coefficient of expansion. Brass, being an alloy, its coefficient of expansion varies according to the proportion of the different metals composing the alloy. Zinc has about three times greater coefficient of expansion than steel, consequently, the larger the per cent. of zinc the greater the expansion. Brass used in balances has its component metals so proportioned that it is capable of being brought to a very hard condition and still possess about twice the coefficient of expansion of steel.

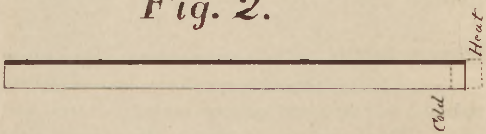
If we secure together a strip of brass and a strip of steel, and submit it to heat or cold, the brass expanding or contracting more than the steel, will cause the bar to deflect as shown by

Fig. 1.



the broken lines in Fig. 1. Should either metal be too greatly in excess of the other no deflection will take place. The metal having the greater mass will completely overcome the other carry-

Fig. 2.



ing it forward in a direct line just as though the bar was composed of a single metal. See Fig. 2. It follows then that in order to secure the best action in the rim the metals must bear a certain proportion to each other in dimension and also in density and structure. The proper proportions are $\frac{2}{5}$ steel $\frac{3}{5}$ brass. This is to say, the sectional area of the rim should show these proportions.

The combined thickness of the rim of an 18s balance should be about 127 hundredths of a millimeter.

PROPERTIES.—The less the thickness of the rim the more active; which is to say the greater its deflection; but if it is made too thin it would be deflected by centrifical force—the tendency of metals to fly from the center when in circular motion—when the balance is in rapid motion and the timekeeping qualities of the watch be more or less impaired. The joint between the metals must be perfect. Blow holes are fatal to uniform action. For this reason the old method of soldering the two

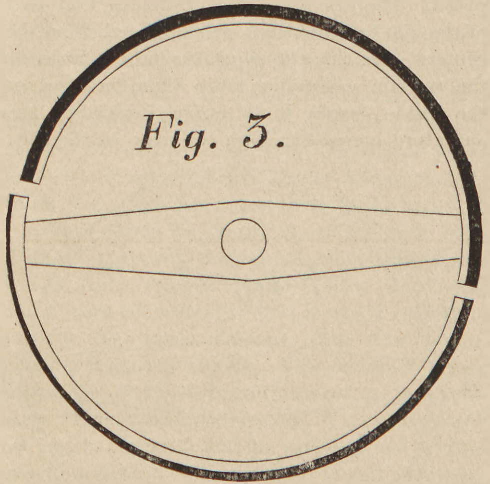


Fig. 3.

metals together with silver solder has been superceded by making a smelted joint. The metals must be of uniform thickness and temper throughout; otherwise the deflection of both sections of the rim will not be uniform with the result that deflection from heat or cold would throw the balance out of poise. See Fig. 3. In this case the brass and steel are correctly proportioned at one side which would of course produce the proper deflection, while at the other side the steel is greatly in excess of the brass for the greater portion of its length with a result that the deflection of the rim at that side would be slight as compared with the opposite side.

ACTION.—The action of heat expands the metals of which the balance is composed. The arm elongates, throwing that part of the rim to which it is attached out from the center. The rim also elongates but the brass on the outside expanding more than the steel on the inside causes it to curve inwardly; this curvature increasing from the arm to the cut.

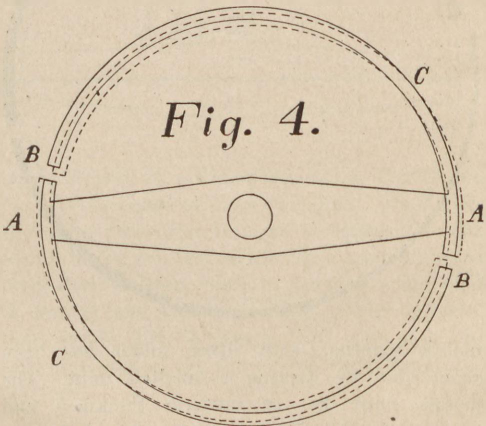


Fig. 4 will illustrate just how this curvature takes place. The full lines show the normal

condition of the balance; the broken lines the effect of heat. It should be understood that in this drawing, as in the preceeding ones, the effects illustrated are somewhat exagerated, which is necessary in order to show the action clearly. It will be seen by reference to Fig. 4 that under the influence of heat the rim recedes from the center at A, approaching the center to a much greater extent at B, while at C it maintains a uniform distance.

To fully understand the conditions described above it is well to study this drawing, Fig. 4, carefully. If all the metal embraced by the balance were concentrated at A the result would be that it would recede from the center when heated and approach the center when cooled, while if it were concentrated at B the opposite condition would be produced, which is to say, it would approach the center when heated and recede from it when cooled. Now if all the metal were concentrated at C it would maintain exactly the same distance from the center whether heated or cooled. This feature is taken advantage of to secure adjustment to temperature. This adjustment is called "Compensation" by which name it will be referred to in this article in future. I desire here to call attention to a peculiar condition produced by the deflection of a laminated balance rim:—A CUT COMPENSATION BALANCE CAN ONLY BE ABSOLULELY TRUE IN ONE TEMPERATURE. This can be readily understood by reference to Fig. 4.

Position of screws.

COMPENSATION balances are provided with several more holes in the rim than are needed for the screws used. This is done to afford means for changing the position of the screws in order to effect compensation. For convenience of reference we shall number the holes at each side of the balance beginning at the arm with number 1.

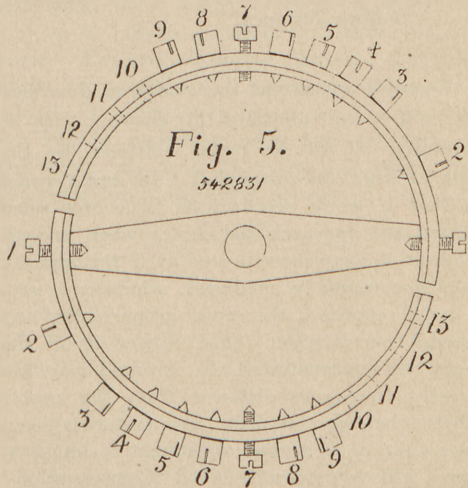
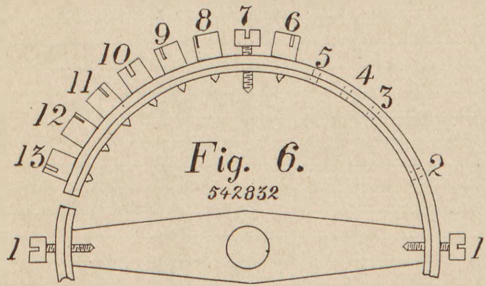


Fig. 5 is a balance having 26 holes tapped for screws in the rim. Holes 1 to 9 inclusive hold screws, while 10 to 13 inclusive are vacant. This condition we call:—"All screws back." In Fig. 6, which has the same number of holes, 2 to 5 inclusive are vacant, while 1 and 6 to 13 inclusive hold screws. This is called:—"All screws forward." Holes 1 and 7 receive the

meantime screws, which are never changed to other holes.

We shall take two watches with balances screwed up exactly as shown in Figs. 5 and 6. These are two regular South Bend Watches with the balances simply screwed up for this particular test. We shall give the rates and errors with the screws in position as shown in Figs. 5



and 6, and also the rates and errors shown by certain changes in position of the screws. Let it be understood that when we say, for instance:—Move No. 9 to No. 10 it means that a pair of screws are to be moved; this is to say Nos. 9 at opposite side of the rim. It will be observed that Fig. 6 shows but half a balance. This method is for economy of space and will be used in all subsequent drawings.

The student having equipped himself with temperature cabinets should make trials of several watches for the sake of practice in timing before attempting adjustment. For this purpose he should rule a few rate papers. These are papers conveniently ruled for keeping records of watches under trial; those illustrated

Temp 90 and 40				
Date	Time	Dif	Var	Error
Jan				
6	9 30	00		
7	9 30	-14	-14	
8	9 30	-14	00	Und. 14
		00		
2		00	00	
		+14	+14	Und. 14
		00		
3		-7	-7	
		00	+7	Und. 14
		00		
4		-3	-3	
		+8	+11	Und 14
		00		
5		+3	+3	
		+20	+17	Und. 14
		+.5		
6		+4	+3.5	
		+21.5	+17.5	Und. 14
		-1.5		
7		+1.5	+3	
		+18.5	+17	Und 14
		+1		
8		00	-1	
		+13	+13	Und 14

Fig. 7 A.

South Bend No. 542831.				
Temp 90 and 40.				
Feb., 1910.				
Date	Time	Dif.	Var.	Error &c.
2	9 30	00		
3	9 30	-9	-9	
4	9 30	+28	+37	Und 46
Alteration			9 to 10	
6	9 27	00		
7	2 27	-6.5	-6.5	
8	9 27	+30.5	+37	Und 43.5
Alt		10 to 11		
10	9 21	00		
11	9 21	-3.5	-3.5	
12	9 21	+33	+36.5	Und 40
		11 to 12		
14	9 29	00		
15	9 29	00	00	
16	9 29	+37	+37	Und 37
		12 to 13		
18	9 18	00		
19	9 18	-4	-4	
20	9 18	+26	+30	Und 34
8 to 12		6 to 10	5 to 9	4 to 6
22	9 20	00		
23	9 20	-7	-7	
24	9 20	-9.5	-2.5	Und 4.5
		3 to 4		
26	9 22			
27	9 22	-1.5	-1.5	
28	9 22	+1	+2.5	Und 4
		4 to 5	2 to 3	
Mar				
1	9 16	00		
2	9 16	-.5	-.5	
3	9 16	-2	-1.5	Over .5

Fig. 7 B.

in Fig. 7A and 7B will be found convenient for this purpose. The first column to the left is for the date; the next for the time when comparison was made; the next for the difference in time between the watch and the clock or other standard of comparison; the next for the gain or loss as compared with the previous comparison; the column at the right for the temperature error. The temperature at which the watch was run or other matter may also be inserted in this column if desired. We also enclose in the booklet a sample rate paper as used in the adjusting department of the South Bend Watch Company. This paper is very elastic in its possibilities. It can be used for isochronal, temperature and position adjustments as well as or many other kinds of rates.

Rules to be observed in trials.

SEE that the watch is in perfect order; clean and freshly oiled. If the oil is at all thick or viscid the cold temperature will make it more glutenous and retard the motion of the balance.

Be sure that the balance has a sufficient amount of endshake. The plate and cock, being composed of brass or nickel, contract more in the cold than the staff and as a consequence may retard the motion of the balance if the endshake is too close.

Always take the time when the second hand of the watch is at 60 regardless of where the second hand of the clock may be. This for two reasons:—First, should there be any error in the

spacing or in the centering of the dial it would thus be eliminated so far as any difference when the comparison was taken. Second, it lessens the liability of mistakes in timing as will become apparent later on.

In timing, carry the tick of the clock or chronometer mentally, keeping the gaze steadily fixed on the watch. A marine chronometer is excellent to use as a timer for the reason that it beats half seconds, but a little practice will enable anyone to estimate half seconds very closely from a clock beating seconds. Practice counting first. Beginning when the second hand of the clock is at 60, say, half—one—half—two—half—three—half—four—half—five—and so on. In timing watches begin to count when the hand of the watch is approaching the 60, and about 10 to 15 seconds from it. Let us assume that the hand of the watch being timed is approaching the 60 and the hand of the clock approaching the 30 when the count is begun. We begin:—Five—half—six—half—seven—half—eight—half—nine—half—thirty—half—one—half—two—half—. At this moment the second hand of the watch reaches the 60. It follows then that the watch is either 32½ seconds slow or the difference between that and 60 which is 27½, fast. A glance at the minute hands will determine whether it is fast or slow; it will also determine the number of minutes it is out in case it should be one or more.

Run the watch both in high and low temperatures in a horizontal position with the dial up. There are two reasons for this:—It is easily compared without disturbing; but more important still it avoids the introduction of any position errors that might exist in the watch.

The watch may be run in its own case or it may be run in any close shutting receptacle which while not necessarily air tight should at least prevent the free ingress of air.

Run the watch for 24 hours in each trial, timing it as nearly at same hour as possible. A few minutes earlier or later will make no difference but should there be a greater amount it might, in which case it is better to repeat the trial.

Run the watch in the high temperature first; then, after timing, wind it but do not set it. It is best not to run the risk of disturbing the rate by setting between the trials. The difference in time will show the variation.

After removing from the cold cabinet do not open the receptacle or case containing it for at least an hour. This gives it time to attain the temperature of the air in the room which is necessary as a preventative from rust. If the watch should be opened immediately upon being removed from the cold cabinet it would "sweat" as it is called; that is, the moisture from the air would condense upon the steel parts and possibly produce rust.

Figuring rates and making alterations.

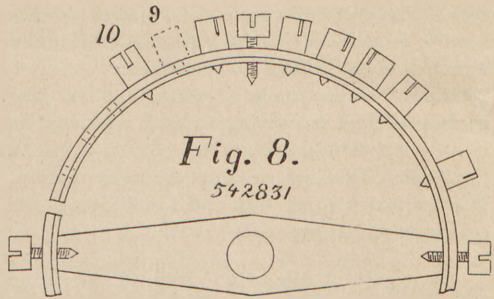
IN making out rates we generally use signs and abbreviations in order to economize space and to save time. The plus sign is used to signify when the watch is fast of the clock and the minus sign to indicate when it is

slow. The plus sign may also be used to indicate what is termed over compensation and the minus sign to indicate under compensation. A watch with the balance made of a single metal and having a steel hairspring will, if regulated in mean temperature, gain in the cold and lose in the heat. This we call under compensation. When a watch gains in the heat and loses in the cold we say it is over compensation.

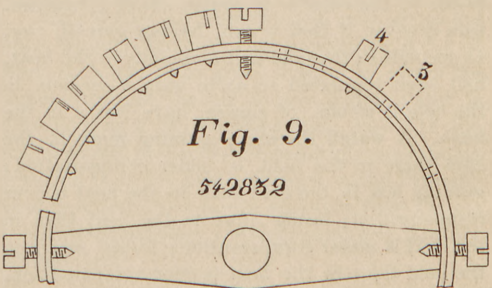
An important rule to be observed in figuring rates is:—When the signs indicating the cold and the heat rate are alike subtract the lesser from the greater; the remainder is the error. When the signs are opposite add the two together and the sum will be the error. A watch running in both termperatures on a fast rate but faster in the cold is of course under compensation because if that watch, having gained, say, 15 seconds in the cold and 5 seconds in the heat, had been regulated so as to gain 5 seconds in the cold it would, of course, have lost 5 in the heat. A watch therefore gaining more in the cold than in the heat is under compensation; gaining less in the cold than in the heat is over compensation; losing more in the heat than in the cold is under compensation; losing more in the cold than in the heat is over compensation.

Moving the screws.

WHEN a watch is under compensation one or more of the screws should be moved forward as indicated on Fig. 8 where the dotted line under No. 9 shows that the screw has been moved forward to No. 10.



When the watch is over compensation one or more screws should be moved back as shown on Fig. 9. Moving a screw forward or back on a rim a certain distance does not always produce the same result. There are many causes for variation, one of which I desire to call particular

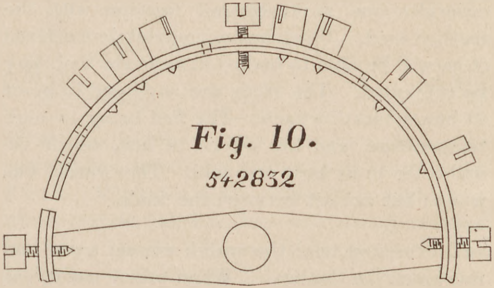


attention to which is the varying curvature of the rim as illustrated in Fig. 4. It will be readily seen that a limited movement forward or back at C would produce little or no change in compensation as compared with the same amount of movement at B for the reason that the part of the rim at C changes its distance from the center of the balance very slightly, if at all.

Rate papers

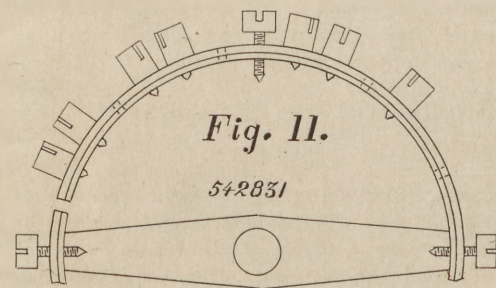
FIG. 7A is a rate paper giving 8 suppo-sititious trials of watches in which the rates widely differ although the errors are alike. Let the student study this paper carefully and make himself familiar with the method used. When he has completely mastered it he will be able to make out any rate that may be presented. The trials are supposed to be of 24 hours duration each. The first being in high temperature and the second in low, which we will refer to as heat and cold. The watch was wound but not set between the trials.

In the first trial the watch was set exact and was placed in the heat. When taken out it was 14 seconds slow. It was placed in the cold without resetting and when taken out was still 14 seconds slow, not having varied during the trial. Referring to column 4 we have carried out for the heat trial, minus 14, for the cold trial, 00. The loss being in the heat we have marked it, Und. 14. In the second trial it did not vary in the heat but gained 14 seconds in the cold which we find marked, plus 14, in the 4th column. This watch was also, Und. 14. In the third trial the watch lost 7 seconds in the heat and when taken from the cold was found to be correct, it having gained the 7 seconds, which it had lost previously, consequently the 4th column is carried out, minus 7 and plus 7 making 14. In the 4th trial the watch lost 3 seconds in the heat and was found to be 8 fast when taken from the cold, it having gained, not only the 8 seconds, but also the 3 seconds it has lost previously, making a gain of 11 seconds. In the 4th column it is carried out, minus 3 and plus 11, making 14. In the 5th trial the watch gained 3 seconds in the heat and was fast 20 in the cold having gained the difference, 17 seconds. The 4th column is carried out, plus 3 and plus



17, subtracting 3 from 17 leaves 14 and as the greatest gain was in the cold it is under 14. In the 6th trial the watch was .5 (five-tenths) seconds fast when placed in the heat; when taken out it was 4 seconds fast, having gained 3.5. When taken from the cold it was 21.5; a gain of 17.5; the difference being Und. 14. In the 7th trial the watch was slow 1.5 when placed in the heat and fast 1.5 when taken out which was carried out plus 3 in column 4. It was 18.5 when taken from the cold, the difference, plus 17 being carried out in column 4. These rates subtracted leave Und. 14. In trial 8 the watch was fast 1 second when placed in the heat and correct when taken out, having lost 1 second, carried out minus 1. It was 13 seconds fast when taken from the cold. These two added make Und. 14.

Fig. 7B is a rate paper made from actual tests of South Bend full plate watch No. 542831. In 24 hour trials, the temperatures being 90 and 40, degrees F., the balance being screwed up as shown in Fig. 5. In the first trial it was set correct. When taken from the heat it was slow 9 seconds. When taken from the cold it was fast 28 seconds. Adding 9 and 28 gives 37, the amount it gained in the cold. Adding 9 and 37 we have its error, 46 seconds and as it lost in



the heat and gained in the cold it was under compensation. The 9th screw was moved to number 10 as shown in Fig. 8, this reduced the error to 43.5, amounting to 2.5 seconds. It will not be necessary to explain in detail all the trials which follow but it is desirable to call attention to the varying effect produced by moving the screws on different parts of the rim. Moving from 9 to 10, as has been seen made a difference of 2.5 seconds; 10 to 11, of 3.5 seconds; 11 to 12, of 3 seconds; 12 to 13, of 3 seconds. In making changes it is well to avoid jumping a screw over 1 or more other screws for the reason that it is liable to make the balance more difficult to poise from the change of weight. For this reason it is desirable to move the screws in sequence as shown in the alteration between the 5th and 6th trials, where 8 is moved to 12, 6 to 10, 5 to 9 and 4 to 6. This alteration made a difference of 29.5 seconds reducing the error to Und. 4.5. Moving 3 to 4 made a difference of .5 only. This slight change was occasioned by the slight curvature of the rim as illustrated in Fig. 4. Moving from 4 to 5 and from 2 to 3 made a difference of 4.5 seconds, bringing the watch from Und. 4 to over .5. This left the screws in the position shown in Fig. 11.

Variation in the position of screws.

DESPITE all the care that it is possible to use in the manufacture of balances or the springing of watches no entire lot will come out the same, after compensation, so far as the position of the screws in the balance are concerned. Fig. 6 shows a balance in watch number 542832 with all screws forward. It showed a compensation error ~~Und.~~ 34 seconds. Moving 6 to 4 reduced it 3 seconds. Moving 4 to 3 as shown in Fig. 9 made no change. Finally, when compensation was secured the screws occupied the position shown in Fig. 10.