the end stone, so that the rounding off shall be barely perceptible to the eye. First remove a narrow ring around the outer edge and try. If not enough, take off a little nearer to the center of the pivot. If too much is taken off, we shall have to flatten the end again, which will shorten the pivot. Therefore we take off but little at a time, and as equally as possible off each pivot. Always remove any "feather-edge" that may appear at the corners of the pivots, with an oil-stone slip.

(84.) Having substantially equalized the vibrations, any remaining error can be easily compensated for by the isochronizing of the spring, which should *follow*, not precede, the adjustment to positions. Most workmen test that adjustment by *timing* the watch in different positions, and make the alterations of the pivots according to the errors found in the time, instead of by the differences in the vibrations as above directed But it is clear that if the spring were isochronal, there would be no change of time in the different positions, even if the frictions and arcs of vibration were different. Hence that test is of no use, except before the spring is isochronized, and even then it is a mere waste of time and labor, because the same information can be gained instantly by simply observing the extent of the arcs of vibration in the different positions. For, if the arcs are the same, the times will be the same. And when we have equalized the arcs, we may be certain that they will be performed in equal times, without taking the trouble to try them.

(85.) *Faulty methods.* Other methods of adjusting to positions are often followed by "the best workmen." Some throw the balance out of poise in such a way as to equalize the vibrations in different positions. For instance, if the watch goes faster in the hanging position, or XII up, than when horizontal, they make it go slower by increasing the arc of vibration, thus: Allowing the balance to come to rest, they make that side which is at the top when the figure XII is up heavier, by drawing out one or two screws in the rim or otherwise. Or, if it loses in that position, they make the bottom heavier, so that the motion will be lessened. Now in an adjusted compensation balance this would probably destroy the adjustment for heat and cold. Even with an unadjusted balance this plan may be unsuccessful, for a greater vibration may be either quicker or slower, according to the spring--and the change of vibration may produce the opposite effect to that designed. Or, if the spring be isochronal, it will have no effect upon the time except the injurious one caused by the want of poise.

(86.) Others bend the hair-spring to one side, instead of leaving it free and concentric with the balance axis, as it should be. For instance, if the watch loses with XII up, but goes correctly with III up, the spring is bent towards the figure XII, so that when that side is upwards, the spring will partly support the balance and lessen the friction in that position. Workmen who follow this method adjust only for the two horizontal positions and two vertical positions, viz.:—XII up and III up. And they calculate that, by thus adding a side pressure of the pivot to the friction upon its end, they will increase the friction while in the horizontal positions, and so make it equal in the horizontal and vertical positions. Now it is sufficient to say that either of the two preceding methods is entirely wrong in principle, being directly destructive of the isochronism of the spring, and injures the watch in *all* positions for the sake of a little apparent improvement in one or two. No good workman will practice either of them, nor will he need to do so if he properly understands his business.

(87.) The arc of vibration should be the same in each of the four vertical positions. If it is not, there may be different causes. The balance may be out of poise; the balance jewel holes may not be round, not evenly polished inside, or too large for the pivot—allowing the balance to fall towards the lever, escape wheel, etc., or away from them, and interfere or change the action of the parts. The change of the arcs when held in the different positions will guide us to the cause. Inasmuch as the greater the friction is, the smaller the arc will be, we know in which position to remedy the inequality of the friction, and we may also ascertain the effect of our alterations by simply noting the change in the arcs. It is desirable to equalize the frictions in the different positions as nearly as possible, as it leaves less to be accomplished by isochronizing the spring, and there is a limit to the amount of irregularity which this adjustment can compensate for. Besides, the more perfect all the parts of the watch are, the finer the performance which we may hope to obtain from the spring.

PART IV.

THE ISOCHRONAL ADJUSTMENT.

(88.) We have now reached that portion of our subject which relates to the final adjustments of the hair-spring for the purpose of insuring that the vibrations of the balance, whether they be great or small, shall always be accomplished in equal times, when the spring is said to be isochronized or adjusted to isochronism. In my previous articles I have given general directions for fitting springs, which, if followed, will prevent any very great errors of time from varying arcs of vibration, and which, moreover, must be attended to before the last finishing touches, presently to be described, can be proceeded with. The isochronal adjustment of the hair spring is, without doubt, the most delicate and least understood operation the watchmaker is called upon to perform. Many who talk and write most glibly about it do not appear to know even the meaning of the term. And upon considering their ideas we are forced to the conclusion that unless their practice is better than their theories, it is not worth much; or else, if they do really understand the subject, they are purposely trying to lead others off upon a wrong tack, in order to keep their knowledge to themselves. But to this there are, of course, honorable exceptions.

(89.) I do not propose to advance any new theories, but to regard it in a very practical light, as a merely mechanical problem, requiring no profound knowledge, either scientific or mathematical, but which may be satisfactorily solved by any watchmaker of ordinary skill and patience. And I shall endeavor to give all necessary instructions for doing so. Even if the workman does not intend to undertake the isochronal adjustment, it is important that he should know how to discover whether the watches he buys and pays an extra price for as isochronized, are so or not, for there is as much swindling of ignorant dealers on "isochronal hair springs" as on "compensation balances, adjusted for heat and cold," of which not one out of a hundred so called are adjusted at all.

(90.) *Action of non-isochronal springs.* If the hair-spring is not isochronal, the watch will vary from correct time whenever the extent of the motion of the balance, or the "arc of vibration," as it is termed, is changed. In a watch having a going-barrel the vibrations are largest or longest when first wound up, and become smaller as the motive power becomes weaker, so that during every hour of the 24 the watch may keep a perceptibly