If there is any doubt about the close coiling, pull the pieces again. Then screw the nut up tightly, to insure the coils being in a true plane, and heat the whole slowly and evenly, to blue the springs, and cause them to "set" in that form. When cool the springs are finished, if they are to be left soft.

(19.) But if they are to be hardened and tempered, they are placed either singly, or in a mass as made, between two flat pieces of brass, provided with steady-pins to prevent shifting or sliding, and tightly screwed together, then made red hot and treated as before described for helical springs, except that the polishing is done by passing a wire through the center of each to hold it while rolling it on a polishing block of bell metal with red-stuff or "sharpe." Some use a stick with a conical end to hold the spring upon, and scour it with a tooth brush. The stick is held in the left hand, its point in the center of the spring, which is stretched down over it into a shape similar to that of a hoop skirt, and kept in that position by the thumb resting upon it. The insides of the coils are polished by sharpening a piece of peg wood and forcing the spring into the same shape, while resting it on a flat piece of cork, rubbing it by moving the stick in both an oscillating and lateral direction, very carefully, to avoid bending the coils. The edges are polished by rubbing the spring around on a piece of smooth paper, by means of a cork pressed gently upon it. In all cases the polishing powder should be plentifully supplied. Springs should not be polished any more than necessary to obtain a clean smooth surface, lest some parts should be reduced more than others and cause irregular action. It is then blued in the bluing-pan, which is simply a flat brass disc on which the spring is laid and held down in close contract with it by a piece resembling a three-arm watch balance, on the end of a lever pivoted so that it is pressed down by a spring, but can be instantly raised by the finger on the other end of the lever. In Fig. 1, *a* is the cover, attached to the lever which is pivoted at *b* to the upright standard rising from the bottom piece, and held down by the spring *c*. When the desired color is reached the finished spring is thrown off to cool. See coloring, (12 to 16). In making the very finest quality of flat springs, a flat plate is sometimes taken and a spiral groove cut in its surface having the exact shape the spring is desired to take, in which it is placed and set by heat. But few watchmakers have the tools for cutting such a groove truly, or are capable of using them.

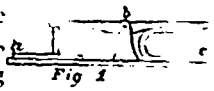

Fig 1

(20.) *Making the terminal curve.* Some workmen make the elbow of the Breguet spring before hardening and tempering, in which case a thin strip of brass must be placed between the main body of the spring and the supplemental coil above, and the whole then screwed together for hardening. But I do not advise to make any terminal curves till the last thing, but simply make the plain cylindrical or spiral spring, and ascertain its adaptability to the balance and proper place for the elbow or the commencement of the curve, before expending any labor on that part of the spring, which will be treated of under the head of isochronism. When, however, the springs are heated in animal charcoal, (10), if the required size and number of coils, place for elbow, and shape of curves are known, it would be well enough to form the spring before hardening.

(21.) These directions are not designed as a complete guide for making springs—although I have told enough, I think, to enable any who wish to experiment successfully, and some things not before published—but to give a clear idea of the process of making them as a basis for better understanding of subsequent operations. Furthermore, the workman who proposes to fit a helical spring in a chronometer will generally find it necessary to make one to suit. Hence instructions upon that operation must include the making of the spring, as already described. But flat or spiral springs can be bought ready made, of almost every strength and quality, so that a suitable one can be readily selected from a fair stock of them, and thus save time and labor.

(22.) *Diameter of springs.* The proper diameter for a hair-spring is a matter of calculation in new chronometers and watches,—helical springs being generally one-third and spiral springs one-half the diameter of the balance. But a certain length in proportion to its thickness is indispensable to its free action, and if it is found that there is not room for that length of a helical spring, the coils being of the above-named diameter, then a spring with large coils must be made, to secure the necessary length of wire. But the repairer should generally be guided by the old spring, if it yet remains, remembering that the new spring, when finished, will have expanded a little larger than the grooves in the block, or its first size when hardened. If your wire is not of the same stiffness as that of the old spring, more or less coils than the old one had must be used, to get the same strength of spring. But generally the old spring should be copied in all respects, unless there is good reason to believe that it was never satisfactory.

(23.) *Number of coils.* Helical springs have usually from nine to eleven coils, but it is well to make thirteen, to allow for testing the temper at the ends, etc., after which the superfluous length can be broken off. A rather long spring is better than a short one, especially if it is somewhat soft, as the angle of flexion, and the consequent danger of setting by use, are less. A spring should be thin and hard, rather than thicker and lower tempered, both being of the same strength. For the former will maintain the motion of the balance longer (without additional impulse from the hand or the movement), and consequently a watch with such a spring will be less affected by difference in the motive power, or friction, poor oil, jarrings, etc. The less the number of coils the harder the temper should be, and, conversely, the softer the spring the longer it must be. Hardened springs, are less liable to be affected by magnetism than soft ones, and are to a great extent, but not entirely, free from the deterioration or loss of force to which all springs are more or less subject by constant action, even when the flexion does not approach the limits of their elasticity. The well-known phenomenon of hardened springs slightly accelerating on their rates, for a few months after being fitted, is an example of this change of condition. In this case the springs lose a portion of their excessive initial hardness, and gain in pliability and elasticity. After attaining their greatest degree of elasticity they remain nearly constant, while the deterioration of soft springs is comparatively rapid.

(24.) As for the proper number of coils for spiral springs, the custom is to use from nine to twelve in English lever watches, generally about ten, in the Swiss, eleven. For a duplex, eight or nine suffice. The Swiss, in their cheap watches, often use fifteen to eighteen coils—as the springs, being of a soft wire, must necessarily be long to prevent bending by use. But this only preserves them for a time, and in a few years they frequently need re-springing in order to do even decent service.