2 Sheets—Sheet 1.

C. V. WOERD.

Compensation-Balance.

No. 203,976. Patented May 21, 1878.

Fig. 1.

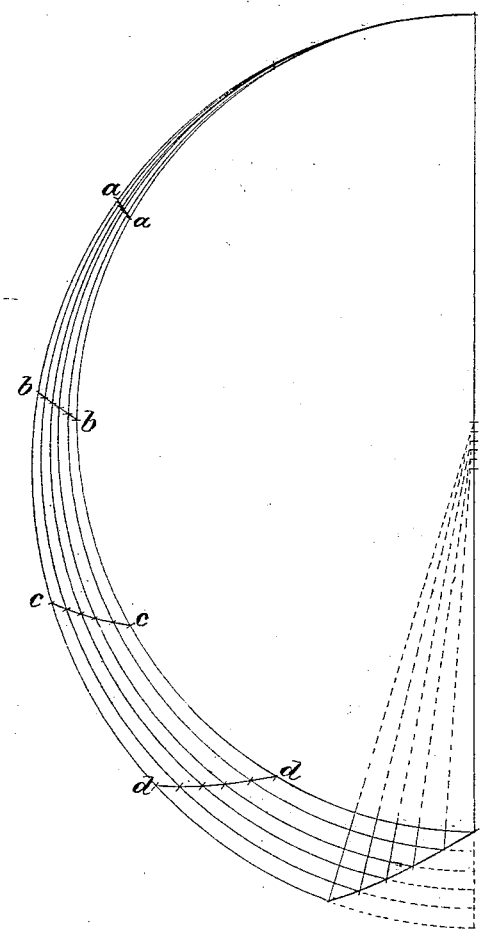
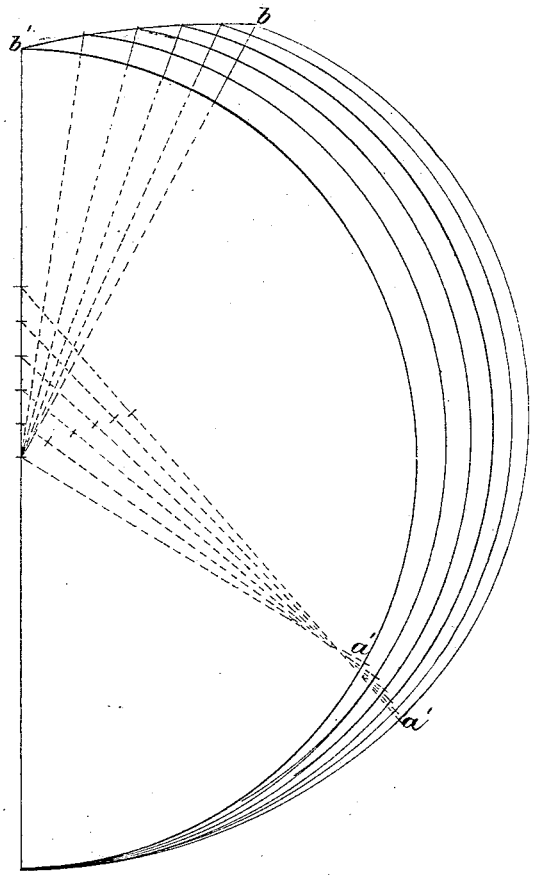


Fig. 2.



Witnesses.

Geo. W. Pierce

J. C. Mackie

Inventor:

Charles V. Woerd

by Wright & Brown

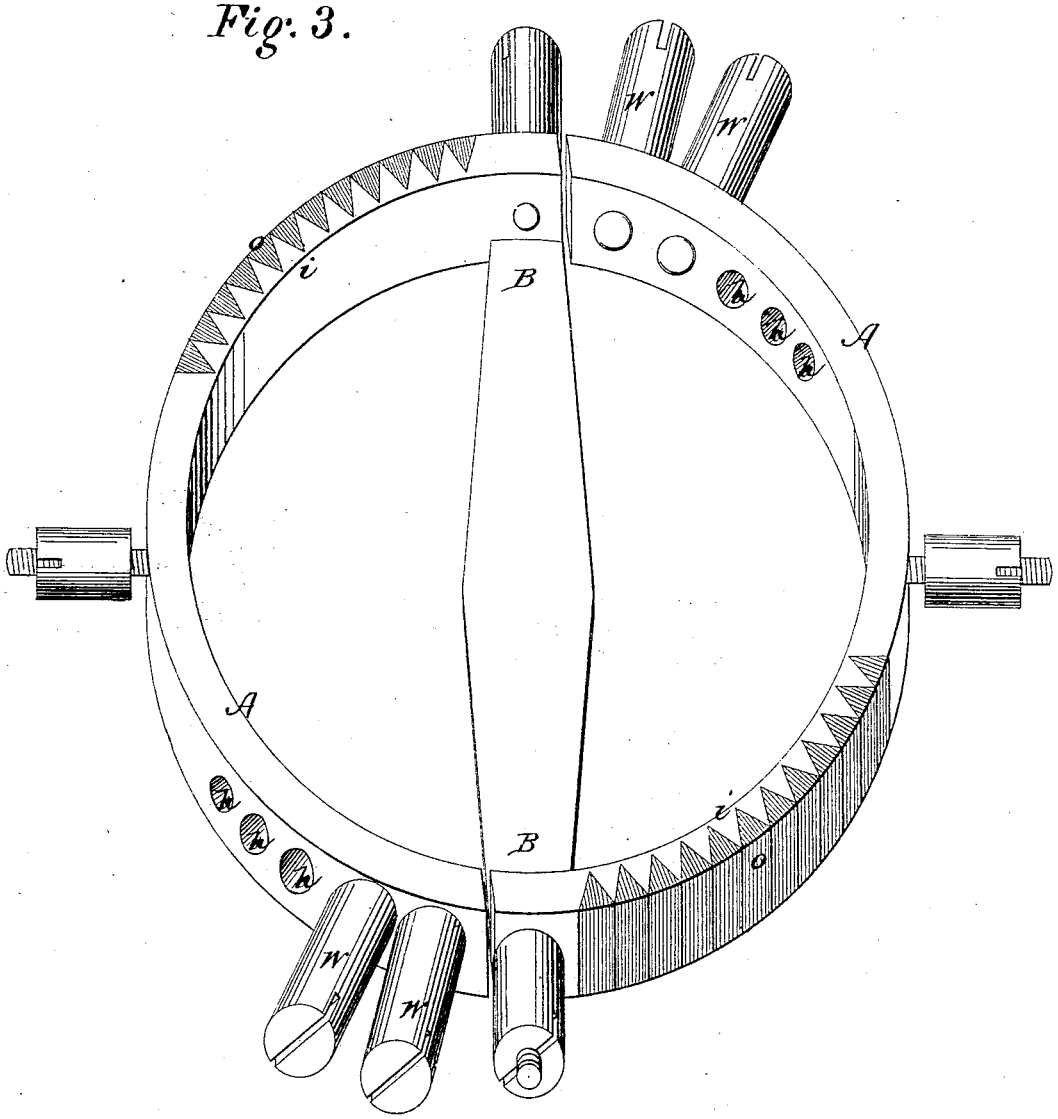
Attys.

C. V. WOERD.

Compensation-Balance.

No. 203,976. Patented May 21, 1878.

Fig. 3.



Witnesses.

Geo. W. Pierce

S. C. Thrasher

Inventor.

Charles V. Woerd

by Wright & Brown

Attys

UNITED STATES PATENT OFFICE.

CHARLES V. WOERD, OF WALTHAM, MASSACHUSETTS.

IMPROVEMENT IN COMPENSATION-BALANCES.

Specification forming part of Letters Patent No. **203,976**, dated May 21, 1878; application filed April 16, 1878.

To all whom it may concern:

Be it known that I, CHARLES V. WOERD, of Waltham, in the county of Middlesex and State of Massachusetts, have invented certain Improvements in Compensation-Balances, of which the following is a specification:

The form of compensation hitherto employed in the balances of watches and chronometers can be made perfect only for two critical temperatures, and for intermediate or extreme temperatures the compensation is imperfect. Devices called "secondary" or "auxiliary" compensation have been applied to remedy this defect in a partial degree. The effect of the temperature is to modify the elastic force of the spring, as well as to change its length and to change the form of the balance, and perfect compensation requires that the time of vibration of the balance shall be constant under all the vicissitudes of temperature to which the instrument may be subjected. This requires that an arrangement of the parts shall be made such that the moment of inertia of the balance shall maintain a constant ratio to the moment of the elastic force of the balance-spring. The law of the change of the effective elastic force of the spring is not certainly known; but sufficient is known in regard to it to make it certain that the compensation cannot be made perfect except at two temperatures. The expressions for the variations of these moments in respect to the temperature give, when graphically represented, two curved lines, and the adjustment can be made only for the two points where these curves intersect.

My invention consists in the employment of an entirely different arrangement of bimetallic laminæ from that hitherto used, said improved arrangement being such that the ratio of the moments of the balance and of the spring shall remain constant during all the temperatures to which the watch or chronometer may be subjected while in use.

Of the accompanying drawings, forming a part of this specification, Figure 1 is a diagram representing, on an enlarged scale, the motion of one of the segments of the rim of a compensation-balance under a decrease of temperature, when the laminæ are arranged in parallel connected strips, as hitherto. Fig. 2 is a diagram representing the motion of one of the segments when the laminæ are arranged according to my invention. Fig. 3 represents an enlarged view of the balance complete, constructed in accordance with my invention.

In said drawing, A A represent the segments of the rim of a compensation-balance. These segments, instead of being bimetallic throughout their entire length—that is to say, composed throughout of parallel strips of steel and brass, as heretofore—are bimetallic only a portion of their length, and these bimetallic portions are located as close as posble to the inner or fixed ends of the segments.

i and *o* represent said bimetallic portions or laminæ, *i* being the inner portions, which are of steel, and are integral with the segments A, and *o* being the outer portions, which are of a composition of higher expansibility than ordinary brass. I prefer to employ for said composition equal parts of copper and zinc.

The parts *o* and *i* are arranged in the form of intermeshing teeth, as shown in Fig. 3, the steel segments being grooved or serrated along the portions *i* to receive the parts *o*, which are fused solidly to the steel, and the parts *o* are turned down or cut away on the perimeter of the balance, so that the fine edges of the steel teeth separate the parts *o* into successions of prisms. The number of teeth in the bimetallic portions will depend upon the thickness of the segments A, and the length of the bimetallic portions should in general be equal to about one-sixth of the circumference of the balance.

By this arrangement of bimetallic laminæ the following advantages are obtained: First, the action is different from that of continuous or parallel bimetallic laminæ, in that the difficulties arising from the constrained and irregular action of the parallel laminæ are avoided, and that freedom of movement of the compensating-weights which is necessary to fulfill the actual requirements of the adjustment for temperature is provided for; secondly, it is always possible to find the number of teeth in the bimetallic part of the rim, and thus the proper relative proportions between the parts *o i*, which, in connection with the proper compensating-weights, will make the motion of these weights correspond with the requirements of the balance-spring for tautochronous vibrations at different temperatures.

In order to lighten the steel rim and keep the effective weight of the balance as near the extremities of the segments A as possible, I drill one or more holes, *h*, in the segments, between the bimetallic parts and the compensating-weights, so that the desired effect may be produced by a limited arc of the two metals. This provides also for a delicate adjustment of the poise of the balance.

The movement of the compound laminæ under a decrease of temperature in the form of bimetallic compensation hitherto used is shown in Fig. 1. The inner curve represents the rim of the balance at a middle or normal temperature. The outer curves represent its successive positions at diminished temperatures, and the oblique lines *a a*, *b b*, &c., show the motion of the compensating-weights placed at different positions on the rim. The curves described by these weights do not in any case change the moment of inertia of the balance in the required ratio, and the compensation is therefore imperfect.

The motion of the rim of the balance, when constructed in accordance with my invention, is shown in Fig. 2. The inner curve shows the normal position at a middle temperature, and the other curves show its motion under successively diminished temperatures. The curved line *a' a'* shows the path of the extremity of the bimetallic arc or portion *o i*, and *b' b'* shows the curve described by the compensating-weight at the outer extremity of the segment.

The proper number of teeth in the bimetallic parts to correspond with the thickness of the continuous steel rim, to be easily found in the actual adjustment, will give to this curve the form which is required in order that the rate of change of the moment of inertia of the balance shall be always sensibly the same as that of the moment of the elastic force of the balance-spring, so that the compensation may be made practically perfect. The forms and relation of the curves in the two cases will be similar when the temperature is increased from the normal temperature considered.

The rim of the balance is cut very close to the extremities of the arms B, to form the outer ends of the segments A, and the compensating-weights W are placed near the outer ends of the segments. The holes *h* are made in order to keep the resultant action as far as possible from the bimetallic parts of the rim.

I claim as my invention—

1. A compensation-balance, in the segments of which a highly-expansive metal is combined with steel for the regulation of the compensation, according to the methods herein stated, and in the form and manner shown and described.

2. In a compensation-balance, the bimetallic portions or laminæ *o i*, arranged in the form of intermeshing teeth at or near the inner ends of the segments A, substantially as and for the purpose specified.

3. In a compensation-balance, the segments A, composed of a single metal, excepting at their inner ends, where they are provided with the more highly expansible portions *o*, arranged as shown and described.

4. A compensation-balance having steel segments A, which are serrated at their inner ends, and provided between the serrations with a more highly expansive metal fused to the steel, and arranged in a series of prisms, as set forth.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

CHAS. V. WOERD.

Witnesses:

GEO. W. PIERCE,

C. F. BROWN.