# United States Patent [19]

**Simon-Vermot**

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[54] **REGULATING THE FREQUENCY OF AN OSCILLATORY SYSTEM INCLUDING A BALANCE AND A COILED SPRING**


[75] Inventor: **André Simon-Vermot,** Le Locle, Switzerland

[73] Assignee: **Les Fabriques d'Assortiments Reunies,** Le Locle, Canton of Neuchatel, Switzerland



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[21] Appl. No.: **271,361**

**Related U.S. Application Data**

[63] Continuation-in-part of Ser. No. 52,123, July 2, 1970, abandoned.

[30] **Foreign Application Priority Data**

July 11, 1971 Switzerland..... 10608/71

[52] **U.S. Cl.**..... **73/6,** 29/177, 58/114

[51] **Int. Cl.**..... **G04b 17/16**

[58] **Field of Search**..... 73/6; 58/114; 29/177, 178, 173



[56] **References Cited**

FOREIGN PATENTS OR APPLICATIONS

327,796 3/1958 Switzerland..... 58/114



*Primary Examiner*—Donald O. Woodiel

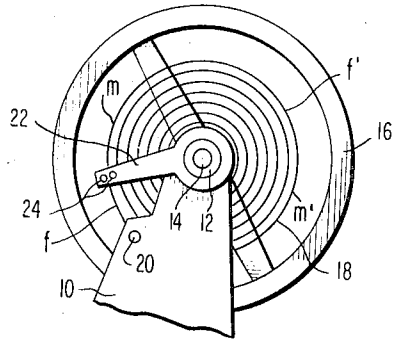
*Attorney*—Dwight H. Smiley et al.



[57] **ABSTRACT**

The regulation of the frequency of an oscillatory system including a pivotally mounted balance and a coiled spring is effected by modifying one of the cross sectional width or thickness of the spring in correlation to correction necessary to obtain the desired oscillating frequency.


**12 Claims, 4 Drawing Figures**



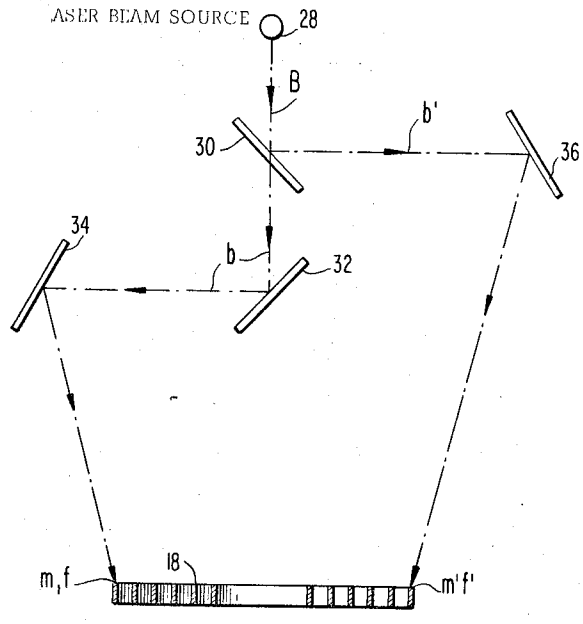



FIG. 1

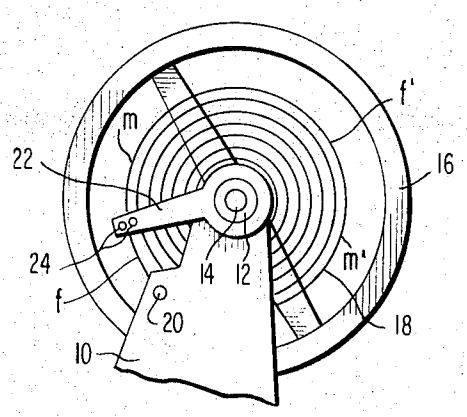
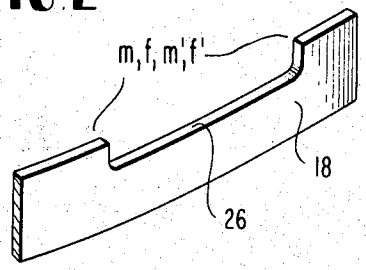



FIG. 2



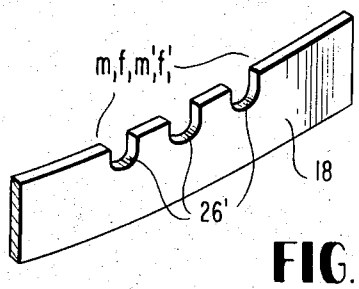
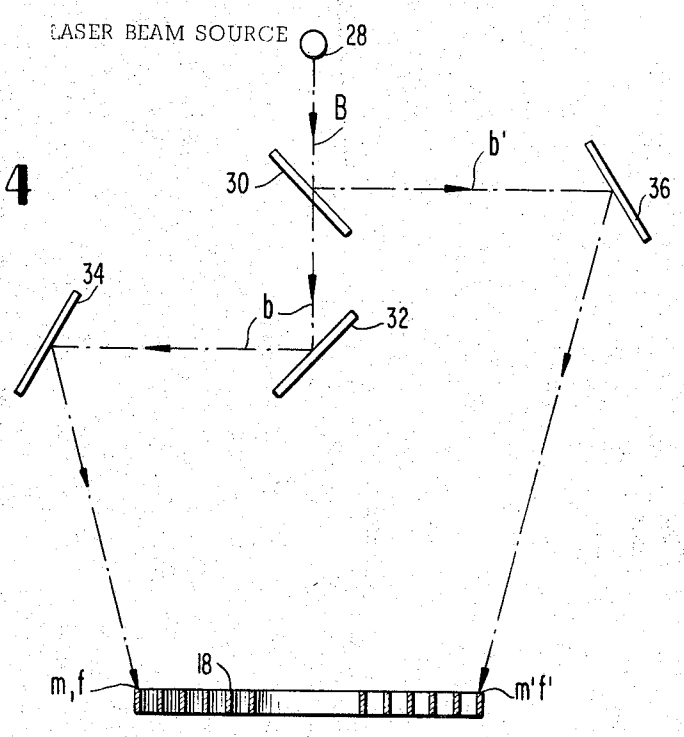




FIG. 3

FIG. 4



# REGULATING THE FREQUENCY OF AN OSCILLATORY SYSTEM INCLUDING A BALANCE AND A COILED SPRING

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of application Ser. No. 52,123, filed July 2, 1970, now abandoned.

## BACKGROUND OF THE INVENTION

In regulating or adjusting the frequency of an oscillating system of the type including a pivotally mounted balance such as a balance wheel, and a hairspring in a timepiece mechanism, the usual practice is to vary the active or effective length of the strip forming the hairspring. However, it is difficult to position with the necessary precision the point of attachment of the hairspring or to otherwise vary the effective length of the spring to obtain the exact lengths of the spring required for the desired regulation or adjustment. Alternatively, a hairspring of a determined length may be used and adjustment of the frequency is obtained by correction of the moment of inertia of the balance. The latter method is, however, rather difficult to effect accurately while maintaining the equilibrium of the oscillator.

## SUMMARY OF THE INVENTION

According to the present invention, the oscillating frequency of an oscillatory system comprising a pivotal balance and a coiled spring is regulated by modifying at least one of the width or thickness of the cross-section of the spring at selected areas of the spring, usually the outermost coil of the spring, and preferably at substantially diametrically opposite points of said coil. The cross-sectional width or thickness may be increased by galvanic deposit or by coatings of various materials such as varnish, glue or the like. Normally, however, the cross-sectional length and width or thickness of the spring forming strip is more than sufficient and the cross-section must be reduced.

The reduction of cross-section may be effected mechanically, as by grinding, and this reduction may be by reduction of thickness of the spring forming strip but such reduction is difficult to accurately control and can adversely effect the strength of the spring. Accordingly, it is preferred to modify the width of the spring forming strip by producing notches or the like in at least one edge of the strip. Such notches may be continuous or elongated but greater accuracy is obtained by providing a plurality of smaller notches which do not tend to materially affect the strength of the spring. As there is some difficulty in producing the notches by grinding techniques after the balance system is assembled, the notches preferably are formed by laser beams.

## BRIEF DESCRIPTION OF THE DRAWING

FIG. **1**, a plan view of an oscillating system, the frequency of which has to be regulated;

FIGS. **2** and **3** are fragmentary pespective views of a hairspring after the modifications have been effected, and

FIG. **4** is a diagrammatic view of laser beam apparatus for effecting modification of the spring forming strip.



## DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawing, specifically to FIG. **1**, an oscillatory system of the type as usually incorporated in a timepiece movement, comprises a support **10** for a bushing **12** journalling an arbor **14** pivotally supporting a balance wheel **16** and to which the inner end of a hairspring **18** is anchored. The outer end of the hairspring **18** is anchored to a stud or pin **20** carried by the support **10**, and a regulator arm **22** is mounted on the support coaxially with the arbor **14** and carries pin means **24** engaging the outer spring convolution. The pin means can comprise a single pin but usually it comprises a pair of pins which straddle the outer convolution of the spring **18**.

According to the invention, modification of the cross-section of the outer coils of the spring **18** is effected at substantially diametrically opposite points of the spring, modification for major adjustment being effected at points $m$ and $m'$, between the pin means **24** and the point of attachment of the inner end of the spring **18** with the arbor **14** and balance **16**, and modification for finer adjustment being effected at points $f$ and $f'$, at least one of which is between the pin means **24** and the attachment of the outer end of the spring to the stud **20**.

The points of modification $m$, $m'$ and $f, f'$ preferably are on the outermost coil of the spring and are diametrically opposed to preserve the equilibrium of the assembly and the symmetrical operation of the spring. The cross-sectional width or thickness may be increased by galvanic deposit or by coatings of various material such as varnish, glue or the like. Normally, however, the cross-sectional width or thickness of the spring forming strip is more than sufficient and must be reduced.

The reduction of cross section may be effected mechanically, as by grinding, and this reducdion may be by reduction of thickness of the spring forming strip but such reduction is difficult to accurately control and can adversely affect the strength of the spring. In contrast, the width of the spring forming strip may be modified without affecting the strength of the spring by producing notches or the like in at least one edge of the strip. Whereas there may be some deleterious effect if the notches are too deep, they may be relatively wide or elongated longitudinally of the spring without adverse effect, and for fine regulation and increased accuracy a plurality of smaller notches disposed longitudinally of the spring may be employed. Obviously there may be some difficulty in producing the notches by grinding techniques after the balance system is assembled so that the notches preferably are formed by laser beams.

The notches may have a depth of 10 to 20 percent or more of the width of the strip constituting the spring **18** depending upon the correction necessary; and may comprise a single continuous or elongated notch **26**, FIG. **2**, or a plurality of smaller or narrower notches **26'**, FIG. **3**. The longer notches **26** may be provided at the points $m$, $m'$ for basic correction, for example, and the smaller notches **26'** provided at the points $f, f'$ for finer correction. The notches may be provided in either or both edges of the spring forming strip.

A simplified system for producing the notches **26, 26'** by laser radiation is shown in FIG. **4** as comprising a source **28** for producing a laser beam $B$ and directing the beam to a transparent mirror **30** which splits the

beam into two beams $b$ and $b'$. The transmitted beam $b$ is directed by mirrors or reflectors **32, 34** to a point, such as $m$ or $f$, on the edge of an outer coil or convolution of the spring **18,** and the reflected beam $b'$ is directed by a mirror **36** to the diametrically opposite point, such as $m'$ or $f'$ of an outer coil or convolution of the spring **18.** The mirrors, particularly mirrors **34** and **36,** may be adjustably mounted to enable focusing the respective beams at the exact points of the spring coils. Preferably, the laser beams have a $\lambda$ of about 0.696 m$\mu$, frequently clearing about 25–150 $\mu$s with a frequency of repetition up to 20 times per second.

The correcting modification may be made either on the outer coil of the hairspring or on a coil near the outer coil. The correction also may be effected on two or more of the outer coils. The notching of the strip forming the hairspring somewhat weakens the corrected coil or coils and in order to avoid an undesired contact of the outer coil, for instance under the action of a shock, it may be necessary to displace the outer coil either radially in the plane of the hairspring or vertically out of this plane, that is, to move the outer coil away from the adjacent coil. The method described is useful for effecting a basic and/or fine adjustment of the frequency at the time of assembly or subsequently thereto. Also, it is compatible with the use of a conventional regulator for a fine adjustment of the frequency by the use of service personnel such as a watch-repairer.

The frequency of the assembly is determined by the following equation

$$T = 2\pi \sqrt{I/C}$$

wherein

$$C = Ee^3 h/12 L$$

$I$ being the moment of inertia and $E$ being the elasticity constant of the spring strip, $e$ its thickness, $h$ its depth and $L$ its length.

Normally, the frequency is adjusted by an adjustment of $L$, but in some instances, the fine adjustment also is effected by an adjustment of $I$. According to the present invention the adjustment of the frequency of the oscillating system is adjusted by modifying

$$e^3h/12$$

and in particular $h$.

I claim:

**1.** A method for regulating the frequency of an oscillating system of the type including a balance and a hairspring the outermost coil of which is fixed at an outer point of attachment, comprising: modifying one of the cross-sectional width or thickness of the strip forming the hairspring over at least one portion of at least one of the outer coils, the modification introduced into said cross-section being correlated with the correction in the desired oscillating frequency of said system sought to be obtained.

**2.** A method according to claim **1,** wherein said modification of section is a diminution.

**3.** A method according to claim **2,** wherein said diminution of said modified section of the strip forming the hairspring is effected by grinding.

**4.** A method according to claim **2,** wherein said diminution of said modified section of the section of the strip forming the hairspring is effected by laser radiation.

**5.** A method according to claim **2,** wherein said diminution is effected by reducing the width of the strip forming the hairspring.

**6.** A method according to claim **2,** wherein said diminution is effected by reducing the thickness of the strip forming the hairspring.

**7.** A method according to claim **1,** wherein said modification of said cross-section is effected by correction at two symmetrical, diametrically opposed places of one of the outer coils of the hairspring.

**8.** A method according to claim **7** wherein said corrections are effected simultaneously by laser radiation.

**9.** A method according to claim **1,** wherein the outer coil is displaced from its position occupied prior to said modification of said cross-section in a direction away from the coil adjacent thereto for avoiding contact with the adjacent coil.

**10.** A method in accordance with claim **9,** wherein said displacement is effected in a vertical direction with respect to the plane of said coil.

**11.** A method in accordance with claim **9,** wherein said displacement is effected in the plane of said coil.

**12.** A method according to claim **1,** wherein said system comprises a regulator having pin means, and modifying the section of the strip forming the hairspring over a portion of the outer coil between said pin means of the regulator and the outer point of attachment of the hairspring.

* * * * *

# UNITED STATES PATENT OFFICE

# CERTIFICATE OF CORRECTION

Patent No. 3,782,169 Dated January 1, 1974

Inventor(s) Andre Simon-Vermot

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the Heading:

Change priority date to --- July 11, 1969, No. 10608/69

**Signed and sealed this 17th day of September 1974.**

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

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