Dec. 28, 1965 J. REBER, JR 3,225,586

METHOD OF REGULATING AND POISING ADJUSTMENT

Filed Jan. 22, 1962

3 Sheets-Sheet 1

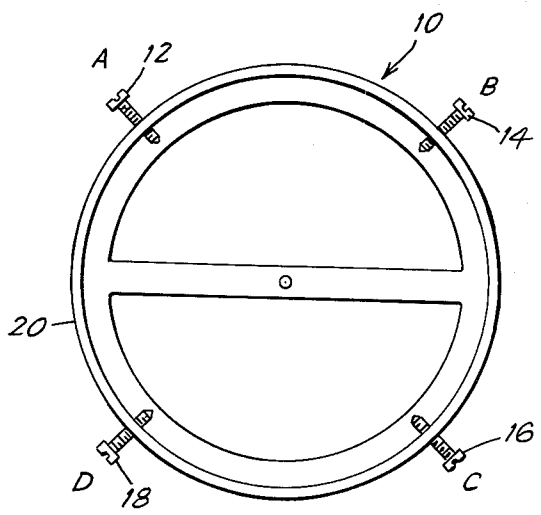

Fig. 1

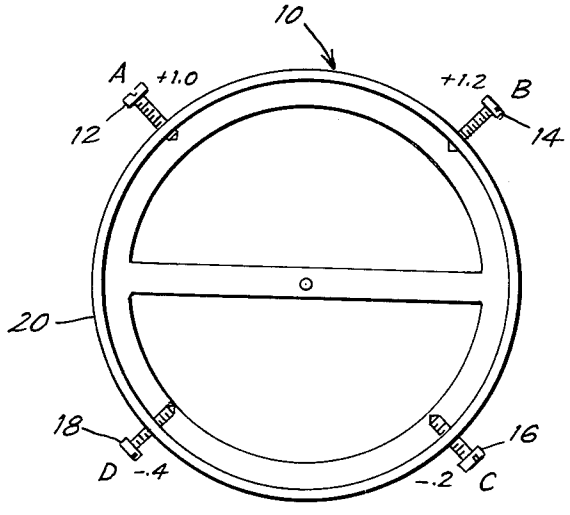

Fig. 2

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METHOD OF REGULATING AND POISING ADJUSTMENT

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Fig. 3

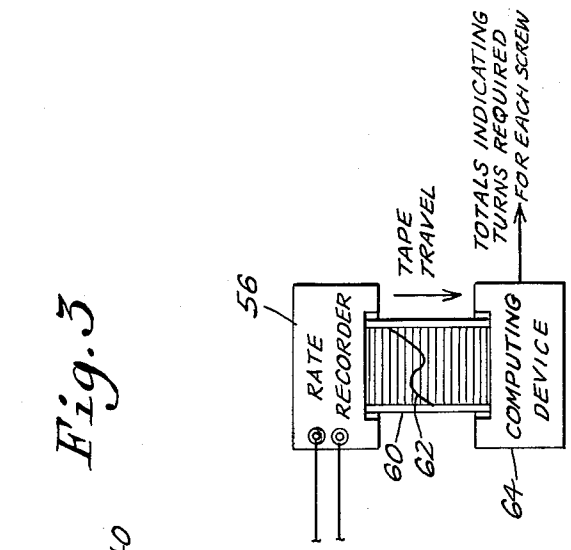
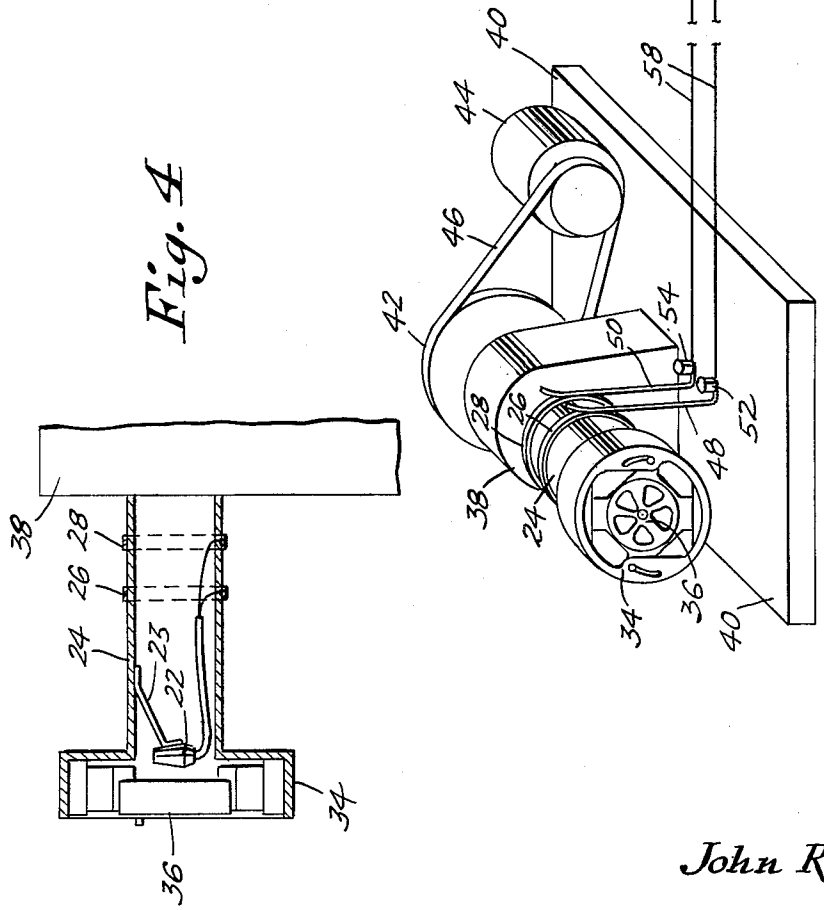


Fig. 4



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METHOD OF REGULATING AND POISING ADJUSTMENT

Filed Jan. 22, 1962 3 Sheets-Sheet 3

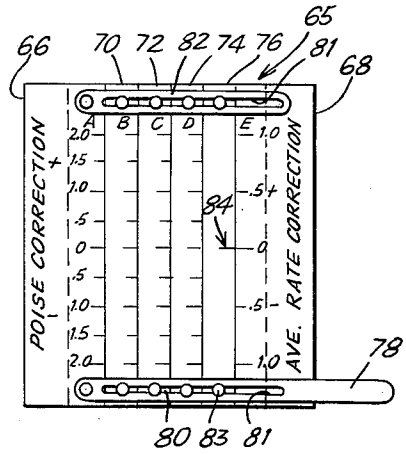

Fig. 5

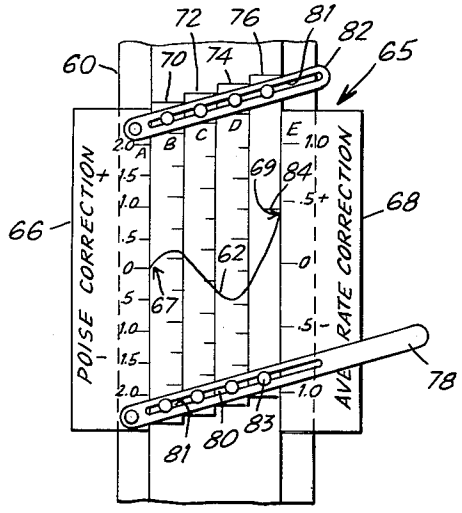

Fig. 6

86

SCREW	A	B	C	D	E	
READING	0	+.1	-.6	-.7	+.4	88
POISE CORRECTION	A-C +.6	B-D +.8	C-A -.6	D-B -.8	-92 -90	
RATE CORRECTION	+.4	+.4	+.4	+.4		94
NET CORRECTION	+1.0	+1.2	-.2	-.4		96

Fig. 7

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United States Patent Office 3,225,586
Patented Dec. 28, 1965

3,225,586
METHOD OF REGULATING AND POISING ADJUSTMENT

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Filed Jan. 22, 1962, Ser. No. 167,758
9 Claims. (Cl. 73—6)

This invention relates to the regulation of timepieces and more particularly relates to an improved method and apparatus for quickly providing the information necessary to correct both the out-of-poise and the average rate errors in a timepiece.

In order to accurately regulate a timepiece, it is necessary to correct for both the average rate error and the position rate error and this is normally accomplished by observing the timepiece while it is operated in a plurality of positions. According to the older custom, the operation of a timepiece in a number of positions was observed over a relatively long period of time and corrections then made to correct the observed errors. The time necessary to carry out this procedure was generally relatively lengthy, depending to a certain extent upon the skill of the watchmaker. It was not unusual, however, for a period of several days or a week to be consumed in the regulation of a timepiece in this manner and many watchmakers still rely upon this procedure.

A more common method of regulating a timepiece today, however, entails the use of a rate recording machine which permits a quick ascertainment of the rate error of the timepiece in any position in which it is placed. In using such a machine, the watchmaker normally checks the rate error in a series of positions and then corrects for this error with a speed again dependent upon the skill of the individual watchmaker.

According to the present invention, it has now been found that it is possible to use a rate recording machine of a type presently available in conjunction with process steps and additional apparatus in order to obtain an almost instantaneous record not only of the position and average rate errors under test, but also of the specific adjustment which must be made to the timepiece in order to correct these errors. With such an arrangement, it will be appreciated that the skill of the watchmaker is almost entirely eliminated from the rate correction process and that the time required for carrying out the process is reduced to a fraction of that heretofore necessary. The advantages of such an arrangement will be immediately apparent to those skilled in the art, particularly in view of the fact that the method of this invention may be carried out with conventional rate recorders in conjunction with quite simple additional equipment which is economical in nature and well within the reach of the average watchmaker.

A large number of watchmakers presently have a watch rate recorder of the general type illustrated in U.S. Patent No. 2,113,825, one commercial variation of which is available as the "Watchmaster" rate recorder. Very briefly stated, this type of recorder utilizes a drum which is rotated at a speed controlled by a time standard, with the drum carrying a record medium such as a sheet of paper. A watch to be tested is placed under a microphone and the ticks of the watch cause electrical impulses in the microphone circuit. These impulses are used to periodically energize a magnet and cause a stylus to peck against the drum once for each tick of the watch under test. In addition to this movement, the stylus is caused to move axially of the drum. The rate of rotation of the drum is controlled by the time standard in such a manner that when the watch under test and the time standard are running at the same rate, the successive

pecks of the stylus create a straight line on the paper, the straight line being parallel to the axis of the drum. If the watch under test runs faster than the time standard, then the stylus strikes the drum before it has completed a full revolution since the last peck of the stylus. The line of dots made by the stylus in such a case extends along the drum as a spiral, the pitch of the spiral being less with greater differences in the rates of operation of the watches. If the unknown watch runs slower than the time standard, the dots lie along a spiral, but if the direction of drum rotation is such that the fast watch produces a right-hand spiral then the slow watch produces a left-hand spiral. When the paper is removed from the drum and laid flat, the line of dots which form along the spiral on the drum becomes a straight line, sloping up or down toward the right, depending upon whether the watch tested was fast or slow.

A "Watchmaster" rate recorder may be used in performing the method of the present invention (although other recorders may also be used) in the following manner. The watch to be tested is mounted adjacent a microphone in such a manner that both the microphone and the watch may be rotated at a constant speed in the plane of the balance wheel of the watch. The rate of rotation of the watch under test and its associated microphone is preferably chosen such that one rotation is completed in the time that it takes the "Watchmaster" rate recorder to complete a line of marking across the paper. It has been discovered that when this is done, a sinusoidal trace or curve is created in super-position on the straight line created through normal use of the "Watchmaster" rate recorder. Thus, if no average rate correction is necessary, a pure sine wave would result. In the normal case, however, where some average rate is necessary, the sine wave is skewed upwardly or downwardly by the deviation in the straight line caused by the need for correction of the average rate.

It has been found that the amplitude of the curve as measured from the straight line is indicative of position error in seconds/day or in terms of balance wheel poise error in gram cm. when balance motion is known. By providing for a notation of the amount of balance motion and by utilizing a balance wheel assembly employing four balance screws which are of equal and constant weight and which are positioned equally from one another, the amplitude of the curve or trace may be expressed in revolutions of each group or pair of opposed screws. The interpretation of the trace may be accomplished in a very simple fashion through the use of a unique reader provided by the present invention or, alternatively, the information which constitutes the curve itself may be very readily fed to a computer which would itself perform the necessary manipulations and calculations.

As a result of the invention, it will therefore be appreciated that it is possible to provide average rate and position corrections to a watch through the use of conventional equipment in conjunction with relatively simple additional equipment constructed according to the present invention.

It is accordingly a primary object of the present invention to provide an improved process and apparatus for correcting the rate of a timepiece.

It is another object of the invention to provide an improved method and apparatus which permits almost instantaneous correction of the rate of a timepiece to eliminate average rate error and out of poise error.

It is another object of the invention to provide an improved method and apparatus of the foregoing type which is simple in nature and does not require expensive or difficult to acquire equipment.

It is another object of the invention to provide an

improved apparatus for adjusting the rate of a timepiece which is susceptible of use with conventional and readily available rate recording devices.

It is another object of the invention to provide a simple device for use in carrying out the process of the instant invention which permits rapid interpretation of a recording obtained according to the invention.

It is still another object of the invention to provide an improved method and apparatus for correcting the rate of a timepiece which is equipped with a balance wheel having four identical balance screws mounted at equi-spaced positions about its periphery for radial adjustment.

These and further objects and advantages of the invention will become more apparent upon reference to the following specification, drawings and appended claims wherein:

FIGURE 1 is a plan view of a four-screw balance wheel of the preferred type for use with the apparatus and method of this invention;

FIGURE 2 is a plan view of the balance wheel of FIGURE 1 showing the changes in the relative positions of the balance screws after adjustment according to the method of this invention;

FIGURE 3 is a perspective depiction of apparatus which may be used in carrying out the method of this invention;

FIGURE 4 is a partial vertical section of the microphone and clamping arrangement of the timepiece rotating device shown at the left of FIGURE 3;

FIGURE 5 is a plan view of a tape reader constructed according to the invention, illustrated without a tape inserted therein;

FIGURE 6 is a plan view of the tape reader of FIGURE 5 showing a tape inserted therein and showing adjustment of the various scales of the reader to provide the desired information according to the invention; and

FIGURE 7 illustrates a table or computation form which may be used in conjunction with the tape reader of FIGURES 5 and 6 in order to provide the final adjustment information according to the method of the invention.

The same reference numerals denote the same parts throughout the several views of the drawings.

It is obvious that it is impossible to manufacture balance wheels which, when assembled in a watch without any adjustments, will produce an "on-time" rate and display no poise error. If this were possible, the balance wheel could consist of nothing more than a simple rim with no screws nor devices for poising and/or timing adjustment. Unfortunately, the necessity for maintaining a timing accuracy of at least one part in several thousand makes this an impossible task. Consequently, it is necessary to perform such operations as balance poising.

Although the out-of-poise condition of a balance wheel assembly is usually thought of as resulting from a "heavy" spot on the balance wheel rim, it is in reality a lack of concentricity between the axis through the balance axis pivots and the center of gravity of the balance wheel. Consequently, it is only necessary to provide weight adjustment along any two arbitrarily chosen mutually perpendicular axes in the plane of the balance to move the center of gravity to coincide with the balance axis. Thus, it is not necessary to provide a large number of screws so that one of them is bound to fall on or very near the so-called "heavy" point.

In FIGURES 1 and 2, a balance wheel assembly is shown generally at **10** in which a minimum of balance or meantime screws are employed. These balance or meantime screws **12–18** are of known weight and are shown located equally about the circumference or rim **20** of the balance wheel. Rotation of these balance screws will cause them to advance a relatively small amount in a radial direction to produce a sensitivity which depends on thread pitch and screw weight. Since the screw always advances the same amount for a given angular rotation, good predictability is provided. By adjusting one or more of these screws, an out-of-poise condition existing in the balance wheel assembly may be corrected, as will be more fully explained hereinafter.

In order to make the necessary poise adjustment of a balance wheel, the amount by which the various meantime screws are to be adjusted must be known.

According to this invention, it has been found that the rate of timekeeping error of a balance wheel timekeeper with an out-of-poise balance wheel varies sinusoidally as the oscillating balance wheel is rotated with the timekeeper at a constant speed in the plane of the balance wheel. In addition, it has also been found that the amplitude of the trace or curve produced is dependent upon the constants of the rate recorder, the amplitude of balance wheel oscillation and the unbalancing moment causing the out-of-poise condition. Using these relationships, it has been found that when a uniformly rotating microphone to which a timepiece is attached is moving at such a speed of rotation that one revolution of the microphone is completed in exactly the same time that a rate recorder completes its timing cycle, the trace produced by the rate recorder can be interpreted to determine the adjustment necessary for each meantime screw.

The pickup and recording device for indicating the amount of adjustment necessary for a balance wheel assembly is more clearly shown in FIGURES 3 and 4 and consists of a rotating microphone **22** supported by a holder **23** within a tubular housing or shaft **24**. Insulated slip rings **26** and **28**, which are carried on the exterior surface of the shaft, are connected to the microphone by leads **30** and **32**. A quick-acting, locating chuck assembly **34** is secured to one end of the shaft **24**. This chuck assembly is used to orient the timepiece **36** which has, for example, a balance wheel assembly such as shown in FIGURES 1 and 2, in a predetermined position with the axis of the balance parallel to the axis of rotation of the chuck. The shaft **24** is rotatably mounted within a bearing support **38** which is in turn mounted on a base support **40**. A pulley **42** is mounted on the other end of the shaft **24**. A variable speed motor **44**, the speed of which may be synchronized with a recorder, is mounted on the base **40** and is connected to the pulley and shaft arrangement through a belt **46**.

The insulated slip rings **26** and **28** are connected through brush contacts **48** and **50** to terminals **52** and **54**, respectively. These terminals are in turn connected to a rate recorder **56** by leads **58**. The recorder **56** may be of any suitable type and preferably is of the type shown in U.S. patent No. 2,113,825.

The recorder **56** contains a tape **60** which is being rotated about a drum (not shown) at some predetermined speed such as five times per second. As the watch ticks, the microphone **22** picks up the sound and causes a dot or mark to be made on the tape. A plurality of these dots or marks form the trace **62**. The trace thus produced on the tape may then be fed into a computing device **64** which may be of a mechanical or electro-mechanical type. This computer indicates the necessary corrective adjustment for each of the four meantime screws **12–18** which will bring the average rate and positioning error of the watch **36** within acceptable limits.

A variety of procedures and types of computing equipment, ranging from the relatively simple to the complex, can be adapted for indicating the corrections necessary from the data presented by the tape **60**. For example, a single electronic detector-computer could be built to perform all the operations, making it necessary for an operator only to perform the actual balance screw adjustments. On the other hand, the same operation can also be performed using equipment that can be inexpensively constructed and made available to the average watch-

maker or watch repairman. The latter alternative is the one described herein and the description itself will indicate to those skilled in the art that automation is readily available.

FIGURES 5 and 6 show a tape reader 65 constructed according to the invention and having two outer stationary edges 66 and 68. Located between these stationary edges are a series of parallel, transparent, engraved movable scale indicator strips 70–76. These scale indicator strips are connected together so as to move in unison by means of slide bars 80 and 82 which have a slot 81 cut along their length. Secured to each end of the indicator strips 70–76 are slide pins 83 which are slidably positioned within the slot 81. Bar 80 is extended at its right end to form a handle 78.

The stationary edge 66 has a "poise correction" scale "A" located on its face while the stationary edge 68 has an "Average Rate Correction" scale "E" located on its face. The movable indicator strips 70–74 have scales "B"–"D" located on their faces, while the movable indicator 76 has an index mark 84 located on its surface.

In FIGURE 6, the tape 60 is shown inserted in the tape reader 65 under the transparent indicator strips 70–76. The lefthand edge or end 67 of trace 62 on the tape is aligned with the "0" mark on the poise correction scale A while the pointer 84 located on the indicator 76 is aligned with the right end 69 of trace 62 by manipulation of handle 78. With the reader 65 now properly adjusted, a reading can be taken from the reader 65 and placed on a computation form or table 86 shown in FIGURE 7, as will be more fully explained hereinafter. Once the form 86 is complete, an operator may apply the indicated corrections to the balance wheel of the watch under test.

The overall operation of the assembly will be better understood by going through the steps of an actual adjustment operation which may be described in the following manner.

A watch or timepiece 36 is assembled and has a balance wheel 10, such as the one shown in FIGURE 1, located therein. Due to a number of reasons, the balance wheel will more likely be out-of-poise, thus preventing the assembled watch from keeping accurate time. To determine the amount of adjustment of the various balance screws 12–18 that will be necessary to correct the poise of the balance wheel, the watch 36 is placed in the chuck 34 of the pick-up and recording device shown in FIGURE 3 with the pivot axis of the balance wheel parallel to the axis of rotation of the chuck, and with the meantime screw B up when the balance is at rest. The winding of the mainspring is such as to produce approximately a ⅝ turn motion.

The motor 44 of the pick-up device is then turned on and its speed adjusted to insure that a complete cycle of the microphone and watch is synchronized with a complete recording cycle of the rate recorder 56. That is to say, the chuck completes one revolution as the recorder traverses the tape once. The rate recorder 56 is then turned on, thus producing a recording or trace 62 upon the tape 60. This trace, which begins at the left-hand edge of the tape and terminates at the right-hand edge represents the variation of rate of the timepiece as it is rotated through one complete cycle of revolution of the chuck 34.

As is well known, a timepiece having a properly adjusted balance wheel will not exhibit any change in frequency or rate as it is operated in different rotational positions in the plane of a balance wheel. The timepiece having a balance wheel which is out-of-poise will exhibit a change in frequency or rate, however, as it is rotated and, in the apparatus of this invention, will produce a trace that is a sinusoidal curve. This curve represents the rate-position characteristic of the balance wheel timepiece superimposed on a straight-line curve which, in turn, represents the average vertical rate of the balance wheel timepiece. It is known that the amplitude of the trace is dependent upon the constants of the rate recorder 56, the unbalancing moment of the balance wheel 10, and the amplitude of the balance wheel oscillation. The maximum amplitude of the trace 62 thus is proportional to the difference in rate between the maximum rate and the average rate of the balance wheel while the slope of the straight line function, which is independent of the unbalancing moment of the balance wheel, is dependent upon the constants of the rate recorder and the mean rate of the balance assembly.

To construct the "Watchmaster" tape recorder shown in FIGURES 5 and 6, it is necessary to relate the above-named relationships one with another in the following manner.

Knowing the constants employed in construction of the rate recorder and in the design of the balance wheel, the aforementioned rate and poise constants can be computed. Obviously, however, these computations are only approximate and simply serve as a guide. Consequently, initial experiments must be conducted to precisely establish the constants of the balance wheel model in use within the particular watch. That is to say, the reader 65 is calibrated for a given balance assembly and for a given balance motion. In order to accentuate the rate error, it is desirable that this motion be relatively low, ⅝ turn being a preferred figure, although other motions could obviously be used.

The actual calibration is accomplished in the following manner. A test watch is mounted in the chuck, is adjusted for approximately a ⅝ motion and the chuck is then rotated to produce a trace of the type indicated in FIGURE 3. All four screws of the balance are then adjusted by trial and error until the right end of a given sine wave is on the same horizontal line as its beginning, indicating a zero average rate error. Each of the four screws is then adjusted outwardly ¼ turn, the chuck again rotated and a chart again produced by the rate recorder. The change in position of the termination of a single cycle of the sine wave is noted. The four screws are then backed out an additional quarter turn and the procedure repeated. This process is repeated a number of times in order to obtain an average conversion factor between the reading of the rate recorder curve and the turns of the screws. The scale E is then marked using this proportionality factor and the tape reader is calibrated for average rate error.

In determining the calibration constant for the position rate error, the timepiece under test is adjusted to produce a horizontal straight line on the rate recorder by a trial and error technique. After this has been accomplished, successive ¼ turns of one screw are made while noting the change in amplitude of the trace which is created by these changes in screw position. An average value is obtained for a proportionality factor and all four scales A, B, C and D are then marked using this factor.

The production of a rate recorder tape from the timepiece under test has previously been described. This tape is now used in order to determine the correct adjustment of the meantime screws in the following manner. The tape 62 is inserted into the reader 65 so that the left-hand edge 67 of the trace 62 is aligned with the zero point of the poise correction scale A. The handle 78 of the reader is then operated so that the pointer 84 of slide 76 is lined up with the right-hand end 69 of the trace 62. Since the slides 70–76 are ganged together, movement of the handle 76 also causes the slides 70–74 to be moved. The point where the trace 62 crosses each engraved scale is then read and recorded under the proper column on line 88 of the computation form 86 (FIGURE 7.)

The poise correction necessary is then computed on line 90 of the computation form 86 by following the various subtraction steps indicated on line 92. The average rate correction as indicated by scale E is then placed in the blocks of line 94. The columns of lines 90 and 94 are then added vertically and the sum entered on line 96.

The sum of line **96** represents the net correction required for each balance screw of the balance wheel.

FIGURE 2 shows how these various corrections are then made to a balance wheel assembly. The meantime or balance screw **12**, which corresponds to screw "A" of the form **86**, is rotated one complete turn in the counterclockwise or positive direction. The diagonally opposite screw **16**, which corresponds to screw "C" of the form **86**, is rotated .2 of a revolution in the clockwise or negative direction. Screws **14** and **18** are likewise corrected according to the amount indicated by the form **86**.

It will now be appreciated that with the method and apparatus of this invention, it is possible to accomplish average and position rate error elimination through but one cycle of operation of a conventional rate recorder wherein the results of such a cycle of operation are provided in the form of the amount of adjustment to be made to specified meantime screws of the balance wheel. Operator error is almost completely eliminated and rate correction is brought within the purview of even the neophyte watchmaker. The apparatus utilized in accomplishing such rate regulation consists partially of conventional rate recording machines in conjunction with extremely simple and rudimentary computing apparatus. It will be apparent that while certain additions and subtractions are present in the method as described, calculating or computing machinery of a very simple nature may be provided to eliminate even these manual steps.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. An apparatus for determining the position and average rate corrections for the balance wheel of a timepiece comprising chuck means for holding said timepiece, a microphone associated with said chuck means for sensing the ticking of said timepiece, means for rotating said chuck means and said microphone, trace rate recording means coupled to the output of said microphone, said rate recorder having a timing cycle equal to one revolution of said chuck means and said microphone so that the trace produced by said recorder represents the position error and the average rate error of said timepiece, and means for computing from said trace the adjustment to be made to said timepiece to correct its rate error.

2. An apparatus for determining the position and average rate corrections for the balance wheel of a timepiece comprising rotatable shaft means, chuck means located on one end of said shaft means, drive means associated with the other end of said shaft for rotating said shaft, microphone means associated with said chuck means for sensing the ticking of said timepiece, rate recording means coupled to the output of said microphone, said rate recording means having a timing cycle equal to one revolution of said chuck means so that the trace produced by said recorder represents the position error and the average rate error of said timepiece, and means for computing from the output of said recorder the adjustment to be made to said timepiece to correct its rate error.

3. A method for determining the adjustment to be made to four balance wheel adjustment screws which lie on diametral lines disposed perpendicular to one another in order to correct the rate of a timepiece regulated by said balance wheel for average rate error and for position error comprising the steps of moving a record medium at a rate controlled by a time standard, applying indicia to said record medium at a position determined by the rate of the timepiece being tested so that the position of said indicia is representative of the relation of the rate of said timepiece to the rate of said time standard, continuously rotating said timepiece so that each discrete indicia represents a different position of said timepiece and the collective indicia present a trace in the form of a sine wave superimposed on a straight line wherein the slope of said straight line represents the average position rate of said timepiece and the amplitude of said sine wave represents position error, disposing said record medium adjacent a series of parallel scales at least four of which are movable, and simultaneously moving said four scales to positions which permit the desired information to be obtained therefrom as a function of the intersection of said sine wave and said scales.

4. Apparatus for determining position and average rate corrections for a timepiece having a rate regulating device oscillating in a given plane comprising means for rotating said regulating device in said plane at a constant speed, translating means coupled to said timepiece for sensing the oscillating frequency of said regulating device during said constant speed rotation, and recorder means coupled to said translating means for producing a sinusoidal record having an amplitude indicative of position error and a slope indicative of average rate error for said timepiece.

5. Apparatus for determining position and average rate corrections for a timepiece having a balance wheel oscillating in a given plane comprising means for rotating said balance wheel in said plane at a constant speed, microphone means coupled to said rotating means adjacent to said timepiece for sensing the oscillating frequency of said balance wheel during said constant speed rotation, and recorder means having a rotatable chart and movable stylus coupled to said microphone means for recording the oscillating frequency of said balance wheel, said chart being rotatable at a constant reference frequency and said stylus marking said chart in response to signals from said microphone means to produce a sinusoidal record having an amplitude indicative of position error and a slope indicative of average rate error for said timepiece.

6. Apparatus according to claim **5** wherein said chart is mounted on a rotatable drum and said stylus moves across said drum, and means for driving said stylus in synchronism with the speed of said balance wheel rotating means.

7. A method of making average rate and position corrections to a timepiece having a rate regulating device with adjustable poising means and oscillating in a given plane comprising, rotating said rate regulating device in said plane at a constant speed, sensing the oscillating frequency of said regulating device during said rotation, comparing the output of said sensing means with a reference frequency signal, deriving from said comparison a record indicative of average rate and position errors of said timepiece, and adjusting said poising means to compensate for said errors.

8. A method of making average rate and position corrections to a timepiece having a balance wheel with adjustable poising means and oscillating in a given plane comprising rotating said balance wheel in said plane at a constant speed, sensing the average rate and position variations in oscillating frequency of said balance wheel during said rotation, and adjusting said poising means to compensate for said variations.

9. A method of making average rate and position corrections to a timepiece having an oscillating balance wheel with adjustable poising screw means movable in mutually perpendicular planes passing through the axis of rotation of said balance wheel comprising, rotating said balance wheel at a constant speed in its plane of oscillation, deriving signals from the ticks of said timepiece

during said rotation, comparing said tick signals with a reference signal, deriving from said comparison a sinusoidal record having an amplitude indicative of position error and a slope indicative of average rate error for said timepiece, and adjusting said screw means to compensate for said errors.

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ISAAC LISANN, *Primary Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,225,586 December 28, 1965

John Reber, Jr.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 59, strike out "axis"; column 5, line 60, after "edge", second occurrence, insert a comma; column 6, line 69, for "7.)" read -- 7). --.

Signed and sealed this 13th day of December 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents