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COMPLETE SPECIFICATION

Electric Time Piece

We, BULOVA WATCH COMPANY, INC., of 75—20, Astoria Boulevard, Flushing 70, New York, United States of America, a corporation organized and existing under the Laws of the State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to electric timepieces.

It is an object of the present invention to provide an electrical timepiece having means for converting the oscillations of a vibrator such as a tuning fork or the like into rotary movements of the hands of the timepiece with means for controlling the amplitude of the oscillations so as to insure accuracy of the timepiece.

It is another object of the present invention to provide an electrical timepiece which is composed of simple and ruggedly constructed elements which are very reliable in operation.

With the above objects in view, the present invention provides a timepiece mechanism for a watch or clock comprising a tuning fork type vibrator having a pair of freely oscillatable tines, electrical means for oscillating said tines and characterized in that abutment means are provided on one or both tines for limiting the amplitude of oscillation of the tines.

The invention will be described further, by way of example, with reference to the accompanying drawings, in which:—

Fig. 1 is a plan view of the interior of a timepiece modified according to the present invention when seen from the rear of the timepiece, Fig. 1 showing diagrammatically how the electrical leads may be connected to a storage battery or the like when the timepiece is used, for example, as a clock of an automobile;

Fig. 2 is a sectional elevational view taken

along line A—B—C—D—E—F of Fig. 1 in the direction of the arrows;

Fig. 3 is a side elevational view of the structure of Fig. 1 as seen from the left side of the latter;

Fig. 4 is a fragmentary plan view similar to Fig. 1 showing a variation according to which the structure of Fig. 1 may be connected to a different source of electrical energy;

Fig. 5 is a fragmentary perspective view of a part of a pawl of the present invention as seen in the direction of arrow G of Fig. 1;

Fig. 6 is a perspective view illustrating the connection of a pawl to the tine of a tuning fork, the structure of Fig. 6 being shown in the direction of arrow H of Fig. 1;

Fig. 7 is a wiring diagram of the electrical circuit of the structure shown in the drawings;

Fig. 8 is a diagrammatic view illustrating the interaction of a pawl and ratchet wheel incorporated in a structure according to the present invention;

Fig. 9 is a diagrammatic view showing of a modified embodiment of the present invention;

Fig. 10 is a diagrammatic view of another modified embodiment of the present invention;

Fig. 11 is a diagrammatic view of yet another modified embodiment of the present invention;

Fig. 12 is a fragmentary diagrammatic view of a still further modified embodiment of the present invention; and

Fig. 13 is a fragmentary diagrammatic view of yet another modified embodiment of the present invention.

Referring now to the drawings, it will be seen that the timepiece includes a base plate 1 which is made of a circular plate having a substantially constant thickness. A vibrator 2 which is of the tuning fork type is fixed to a member 5 as by soldering or welding or the like, and this member 5, in turn, is fixed

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to the base plate 1 by a pair of screws 5a. As is clearly shown in Figs. 1 and 3, the member 5 is connected to the tuning fork 2 only at that part thereof which interconnects the tines 3 and 4, so that the latter are maintained in spaced relation to the base plate 1 and are free to oscillate.

At the free end of the tine 3 there is located a permanent magnet 6 in the form of a hollow cylinder which is open at one end and which has an end wall 6b closing the cylinder 6c, this end wall 6b carrying a magnetic bar 6a which is of very strong magnetic material, as, for example, Alnico.

The other tine 4 of the tuning fork 2 carries at its free end a balance weight 7 which may simply be in the form of a cylindrical block fixed in the manner shown in Fig. 1 to the free end of the tine 4. The tines 3 and 4 and the masses of the permanent magnet 6 and the balance weight 7 are so chosen that the tine 3 and the permanent magnet 6 on the other hand have approximately the same natural frequency so that the tuning fork will not require an undesirable large amount of damping. Also, the arrangement of the parts is such that the centers of gravity G of the permanent magnet 6 and the balance weight 7 are in alignment with the tines 3 and 4, respectively. As a result, it is possible for the tines 3 and 4 to oscillate at constant frequency while requiring an almost negligible amount of energy.

The counter weight 7 carries an abutment element 7b which is preferably made of non-magnetic material, as for example, brass. The abutment element 7b extends toward the permanent magnet 6 and is spaced therefrom a distance s.

As is well known, the tines of a vibrating tuning fork type vibrator normally oscillate toward and away from each other, i.e., inward movement of one tine from its normal rest position is accompanied by a corresponding inward movement of the other tine and outward movement of one tine is accompanied by a corresponding outward movement of the other tine. Also, the inward deflection of each tine is equal to its outward deflection, so that the amplitude of oscillation of each tine is equal to twice the deflection of each tine from its rest position to its inner deflected position.

It will be seen, therefore, that the maximum amplitude of oscillation of each tine 3 and 4 is equal to the length of the distance s inasmuch as the maximum possible inner deflection of each tine is equal to one-half s.

The purpose of the abutment element 7b and the factors influencing the selection of the distance s will be discussed below.

Also, suitable abutments 3a and 4a are carried by the base plate 1 and serve to limit the outwardmost deflections of the tines 3 and 4, respectively.

If desired, the balance weight 7 may be

provided with a threaded bore 7a in which a screw member 8 is threadably located. The screw member 8 is shorter than the length of the threaded bore so that the screw member may be shifted toward or away from the tine 4 along a line forming an extension of the latter. In this way, the center of gravity of the balance weight 7 is shifted along this line simply by varying the position of the screw 8. As a result, the natural frequency of the tine 4 may be varied, the center of gravity of the balance weight 7, however, at all times remaining in registration with the tine 4. Inasmuch as the natural frequency of the entire tuning fork 2 is the average of the natural frequency of the two tines, it is possible to change the natural frequency of the entire tuning fork by shifting the screw 8. In this way, it is possible to regulate the time which is kept by the timepiece. Thus, if there are relatively small variations between the natural frequencies of the tines and the weight and permanent magnet, respectively carried thereby, such small variations in the natural frequencies will not influence the operation of the timepiece. When the latter is first manufactured, the relative natural frequencies of the tines and the parts carried thereby are so regulated, as, for example, by filing off a part of one tine, that the timepiece keeps perfect time to within plus or minus three minutes per day, for example. By shifting the screw member 8 in the balance weight 7 it is possible to provide a very fine adjustment which will enable the timepiece to keep accurate time within this range of plus or minus three minutes per day.

In the chamber 9 within the drum magnet 6, there is located a tubular carrier 10 which is fixed to a support 13, the latter in turn being fixed to the base plate 1 by means of screw members 14, as is shown in Figs. 1 and 3. The tubular member 10 freely surrounds the core 6a without contacting the latter, and the tubular member 10 carries a pair of coils 11 and 12, the coil 12 having approximately five times as many turns as the coil 11. The core 6a has sufficient clearance within the tube 10 to avoid contacting the latter during oscillations of the tines 3 and 4 of the tuning fork. Thus, the coils form with the permanent magnet 6 of a transducer which, together with the tuning fork 2, forms a tuning fork oscillator.

At the left face of the support 13, as viewed in Fig. 1, and as is shown in Fig. 3, there is fixed a resilient strap 33 which serves to mount on the support 13 a condenser 34, a resistance 35, a transistor 19, and a capacitor 40. Furthermore, the support 13 carries a pair of insulated electrical terminals 15 and 16 which are electrically connected to the lines 22 and 23 which in turn are connected to a source of electrical energy. According to the embodiment of the invention shown in Fig. 1, the

source of energy is the storage battery 17 of an automobile. In general the voltage of such an automobile battery is too great for the purposes of operating a timepiece of the type disclosed, so that this battery is not connected directly to the timepiece. The lines 22 and 23 are connected in the manner shown in Fig. 1 to the resistance 18, and the end 18a of the line 23 forms with the resistance 18 a voltage divider, this voltage divider being located outside of the timepiece, although it could of course be located within the casing of the timepiece and fixed to the base plate 1, if desired.

When the above described electronic circuit is connected to the source of energy, the electrical circuit is closed and the oscillations of the tuning fork are started and are maintained by the source of energy. The tuning fork starts oscillating as soon as the circuit is closed because it is quite sensitive and picks up any vibrations which are present in the surrounding atmosphere or in the base plate 1. With an arrangement as described above it is possible to obtain the frequency of fork vibration constant of 2×10^{-7} , while for a timepiece of the type described above a frequency of fork vibration constant of 10^{-5} is adequate. The oscillations of the tuning fork must be converted into a rotary movement in order to be useful in the timepiece, and this conversion can take place by the transmission means illustrated in Figs. 1, 2, 5 and 6.

A pawl 20 is fixed to the tine 4 of the tuning fork 2, this pawl 20 being in the form of a relatively light leaf spring. As is evident from Fig. 6, a pin 20¹ is fixed to and extends downwardly from the tine 4, as viewed in Fig. 1. That is, the pin 20¹ is fixed to the face of the tine 4 which is directed toward the front of the timepiece and extends toward the front of the timepiece. The tine 4 is formed with a relatively shallow bore which does not extend more than one quarter of the way through the tine 4 and into which the pin 20¹ is pressed, so that in this way the natural frequency of the tine 4 is hardly influenced to any appreciable extent at all. The leaf spring 20 is fixed to the pin 20¹ as by being soldered thereto, in the manner shown in Fig. 6, and at its free end leaf spring 20 carries the tooth member 20a made of a very hard material such as glass or hardened steel. Also, precious or semi-precious stones such as rubies or sapphires are particularly suitable for this purpose. As is evident from Fig. 5, the member 20a is wider than the leaf spring 20 and extends beyond the latter, and this member 20a is fixed to the leaf spring 20 by a suitable adhesive material, for example. The member 20a is so thin that it need not be provided with a special bevel or the like to form a tooth.

This member 20a of the pawl cooperates with the teeth of ratchet wheel 21 so that the oscillations of the tine 4 transmit turning

impulses to the ratchet wheel 21 through the pawl 20. In this way the ratchet wheel 21 is turned through a predetermined angle at every oscillation. As is evident from Fig. 2, the ratchet wheel 21 and the pinion 21a are fixed to a common shaft which extends through the base plate 1. In addition, this common shaft extends through an opening of a dished spring 33 which bears against part of the ratchet wheel 21 and urges the latter away from the base plate 1, so that dished spring 33 acts as a brake retarding the turning movement of the ratchet wheel 21. The spring 23, the ratchet wheel 21, as well as the pawl 20 and member 20a are carefully designed and chosen so that at each oscillation the turning movement transferred to the ratchet wheel 21 by the leaf spring 20 will result only in a turning of the ratchet wheel in the desired direction through a distance of one tooth. In other words the arrangement is such that the ratchet wheel 21 cannot overrun or turn freely beyond the distance through which it is turned by the pawl. Furthermore the frictional resistance provided by the spring 33 is such that during the return movement of the pawl 20 the ratchet wheel 21 also does not turn and the tooth member 20a runs over a tooth of the pawl to engage in the next space between the teeth. In this way a turning movement is imparted to the ratchet wheel 21 which compels the latter to turn through a member of revolutions which have a direct relation to the rate of oscillation of the tuning fork 2.

Inasmuch as the tuning fork oscillates at a constant rate, the ratchet wheel 21 also turns at a constant speed and in one direction. A gear train is provided to transmit the turning of the ratchet wheel 21 to the hands of the clock, and this gear train includes in addition to the pawl the pinion 21a, the gear 22 meshing with the pinion 21a and turning together with the pinion 22a which meshes with the gear 23 which turns together with the pinion 23a. The pinion 23a meshes with the gear 24 which turns the pinion 24a, the latter meshing with the gear 25 which turns together with the pinion 25a. The gear 25 is fixed as by a press fit to the shaft 25b to which the pinion 25a also is fixed, and this shaft 25b extends all the way up to the unillustrated face of the clock which carries the numbers.

The frequency of oscillations of the tuning fork and the number of teeth of the ratchet wheel 21 as well as the different transmission ratios between the several driving and driven gears are so chosen that the shaft 25b makes one complete revolution in an hour. Thus, the minute hand is fixed to the shaft 25b.

The speed of the minute gear 25 is reduced to one twelfth in a known way. Thus, the gear 25a meshes with a gear 26 which turns together with the pinion 26a, the latter in turn meshing with a gear 27 affixed to the sleeve

28 freely turnable on the shaft 25b. These gears 25a, 26, 26a, and 27 give to the sleeve 28 a speed of rotation which is one twelfth that of the shaft 25b, so that the sleeve 28 turns through a complete revolution in twelve hours, and thus the hour hand is fixed to the sleeve 28.

If, for example, the tuning fork oscillates at 175 cycles per second, then the various pinions and gears can have the following numbers of teeth to provide the desired transmission to enable accurate time to be kept from the tuning fork.

		Number of
15	Pinion or Gear	Teeth
	Ratchet wheel 21	- - - 360
	Pinion 21a	- - - 6
	Gear 22	- - - 30
	Pinion 22a	- - - 6
20	Gear 23	- - - 36
	Pinion 23a	- - - 6
	Gear 24	- - - 42
	Pinion 24a	- - - 6
	Minute wheel 25	- - - 50
25	Pinion 25a	- - - 10
	Gear 26	- - - 30
	Pinion 26a	- - - 8
	Hour wheel 27	- - - 32

A consideration of the above numbers of teeth will show that the minute wheel makes one revolution an hour and the hour wheel makes one revolution in twelve hours.

With the above described embodiment of the timepiece the source of energy is located outside of the timepiece and is in the illustrated example the battery of an automobile. However, the timepiece of the invention, which may be a wrist watch instead of an automobile clock, may carry its own source of energy within its own housing. Thus, Fig. 4 shows an arrangement where the base plate 1 is provided with a depression which receives a miniature battery 32 which may have a terminal voltage of 1.35 volts, and this battery 32 is maintained within the depression 32a of the base plate 1 by an electrically conductive springy member 30 which is affixed by a screw 31 to a block 29 of insulating material, this block being fixed in a known way as by a screw or the like to the base plate 1. The force of the spring 30 keeps the battery 32 in position within the recess 32a. The casing of the battery 32 which engages the electrically conductive base plate 1 forms the negative pole of the battery while the positive pole thereof is formed by the cover of the battery which engages the member 30. This member 30 is insulated from the base plate 1 by the block 29, although if desired the member 30 can also be insulated from block 29 and screw 31 in any suitable way as by suitable washers and a suitable sleeve into which the screw 31 extends. With the arrangement of Fig. 4 the electrically conductive springy member 30 is connected with a suitable lead to the positive

terminal 16 carried by the support 13 while the negative terminal 15 is in this case connected electrically with the base plate 1.

A wiring diagram illustrating the electrical circuit is shown in Fig. 7. Thus, referring to Fig. 7 it will be seen that the tuning fork together with the permanent magnet are shown diagrammatically at the left. Furthermore, the transistor 19 is shown with its emitter, base, and collector terminals respectively indicated by the letters E, B, and C, respectively. The terminal 16 is connected electrically with the emitter connection E, while the collector connection C is connected with one end of the coil 12 which has approximately five times the number of convolutions of the coil 11, as was pointed out above, the other end of the coil 12 being connected to the negative terminal 15. In parallel with the coil 12 is located the capacitor 40 which serves to prevent undesired oscillations. Furthermore, the condenser 34 and resistance 35 are interconnected between the coils 11 and 12, in the manner shown in Fig. 7, and the coil 11 is connected electrically to the base connection of the transistor 19, in the manner shown in Fig. 7.

It will be seen from the above that the reciprocation of the pawl 20 is brought about by the oscillation or vibration of the vibrator 2, the length of the stroke of reciprocation of the pawl being a function of or dependent upon the amplitude of oscillation of the tuning fork. It will also be understood that the arrangement of the parts is such that normally each reciprocation of the pawl brings about an angular rotation of the ratchet wheel which corresponds to the pitch of each ratchet tooth. Thus, the stroke length of the pawl must not only be sufficiently great so that the pawl will, during successive reciprocations, engage different teeth, but also, the stroke length of the pawl should not be so great that the pawl engages, during successive reciprocations, non-successive teeth. If the latter were to occur, i.e., if, during successive reciprocations, the pawl were occasionally to engage alternate teeth, that particular reciprocation of the pawl would be accompanied by a double angular displacement of the ratchet wheel. Since, in practice, a timepiece particularly of the watch type is often subjected to shocks, the amplitude of oscillation of the tuning fork, may become sufficiently great, at least temporarily, so as to cause the pawl to engage, during successive reciprocations, non-adjacent or non-successive ratchet teeth. This, in turn, would bring about inconstant and inaccurate activation of the timepiece mechanism.

As may best be seen in Fig. 8, the pawl should move in a direction T tangential to the ratchet wheel at the point of engagement between the tooth 20a and the ratchet wheel, in such a manner that the tooth 20a reciprocates with a stroke the length of which is greater than the distance P and smaller than

twice this distance, the distance P representing the pitch of the ratchet teeth. It is clear that if the tooth $20a$ does not reciprocate with a stroke the length of which exceeds the distance P , the tooth $20a$ would not, during successive reciprocations, engage successive teeth but would instead simply remain in engagement with the same tooth. Also, it will be seen that if the tooth $20a$ reciprocates with a stroke the length of which exceeds the distance $2P$, the tooth $20a$ would engage non-consecutive or alternate teeth. If this were to occur then each reciprocation during which the stroke length of the tooth $20a$ exceeded the distance $2P$ would bring about a double angular displacement of the ratchet wheel 21.

It will be readily understood that the stroke length of the tooth $20a$ in the direction T is a function of or dependent upon the amplitude of oscillation of the tine 4. Thus, in order for the tooth $20a$ to reciprocate with a stroke length equal to at least P , the tine 4 will have to oscillate with a certain minimum amplitude. The above described electrical means shown schematically in Fig. 7, are capable of oscillating the tine 4 at at least such minimum amplitude.

Also, it will be understood that in order for the stroke length of the tooth $20a$ not to exceed $2P$, the maximum amplitude of oscillation of the tine 4 may not exceed a certain maximum amplitude. Preferably, the above described electrical means will not oscillate the tine 4 above this maximum amplitude, but shocks to which a timepiece is very often exposed may be sufficient to cause the tine 4 to oscillate above this maximum amplitude. However, the abutment element $7b$ carried by the balance weight 7 prevents the tines 3 and 4 from oscillating above an amplitude corresponding to the distance s , as set forth above. Accordingly, the distance s is so selected that the tines 3 and 4 may oscillate at a maximum amplitude which corresponds to reciprocation of the tooth $20a$, in the direction T , with a stroke length less than $2P$. In this way, the tooth $20a$ cannot, during oscillation of the tuning fork, skip any of the teeth $21a$ of oscillation of the tuning fork and consequently each reciprocation of the pawl 20 brings about an angular movement of the ratchet wheel 21 which corresponds to the pitch P of the ratchet wheel $21a$.

In practice, the electrical means for oscillating the tuning fork are so constructed and arranged that the tines are oscillated at such amplitude as will bring about reciprocation of the tooth $20a$ in the direction T with a stroke length equal to approximately $1.5P$. Thus, in Fig. 8 the forwardmost position of the tooth $20a$ is shown in solid lines whereas the normal backwardmost position is shown in dotted lines.

In the embodiment illustrated in Fig. 9, the tuning fork 102 having tines 103 and 104

is adapted to be mounted on the base plate of the timepieces mechanism by means of the member 105, the latter being screwed onto the base plate by means of screws $105a$. The tines 103 and 104 respectively carry a permanent magnet 106 and a balance weight 107, the respective centers of gravity of these members being in registration with the respective tines. The tine 104 carries a pawl 120 having a tooth $120a$, as described above. The instant embodiment differs from the above described one in that the abutment element $107b$ instead of being carried by the balance weight 107 is carried by the permanent magnet 106. As described above, the element $107b$ may be made of non-magnetic material, such as brass. If desired, however, the element $107b$ may be made of magnetic material but be magnetically insulated from the permanent magnet 106 by means of a partition element $107b^1$ which is made of non-magnetic material. The right free end of the element $107b$, as viewed in Fig. 9, is spaced a distance s from the balance weight 107, and the function and mode of operation of the device is identical to that of the above described embodiment.

In the embodiment illustrated in Fig. 10, the tuning fork 202 having tines 203 and 204 is adapted to be secured to the base plate of a timepiece by means of a member 205, the latter being screwed onto the base plate by means of screws $205a$. The tine 204 carries a pawl 220 having a tooth $220a$ adapted to cooperate with the ratchet wheel in the manner described above. The tines 203 and 204 each carry a permanent magnet 206, the respective centers of gravity of which are in alignment or registration with the respective tines, so that the instant embodiment differs from the above described one in that two permanent magnets are provided, there being no balance weight corresponding to element 7 of Fig. 1. In the instant embodiment the electrical means for oscillating the tuning fork include both permanent magnets 206, suitable electrical components being associated with each other. One of the permanent magnets 206 carries an abutment element $207b$ which is spaced from the other permanent magnet a distance s , the function and operation of the device being identical to the above described ones.

In the embodiment illustrated in Fig. 11, the tuning fork 302 includes a pair of tines 303 and 304, the axis of symmetry of the tuning fork being indicated by the line $X-X$. As in the above described embodiments, a member 305 serves to mount the tuning fork onto the base plate of a timepiece, as, for example, by means of screws $305a$.

The tines of the tuning fork are inclined toward each other and converge toward each other as they approach their free ends so that the tuning fork 302 has the substantially triangular configuration indicated in Fig. 11.

A pair of permanent magnetic drums 306 are

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fixed at their end faces respectively to the outer faces of the free ends of the tines, it being understood that one of the drums 306 may be replaced by a suitable balance weight of the type described in connection with the embodiments illustrated in Figs. 1 and 9. The arrangement of the parts is such that the center of gravity of each magnet is spaced a distance D_G from the axis of symmetry X—X. This distance is so selected as to be substantially equal to the distance D_T which is the distance that each point T is spaced from the axis of symmetry X—X. The point T of each tine is that point about which the tine oscillates or pivots. In practice, the point T of each tine will be located in the lowermost third of the tine.

As a result, the frequency of oscillation of the tuning fork is maintained constant at a desired value and only a minimum amount of energy is required to maintain the vibrations or oscillations.

The tine 304 carries a pawl 320 having a tooth 320a which is adapted to cooperate with a ratchet wheel, in the manner described above, and one of the tines carries the abutment element 307b which is fixed to the inner face of the free end portion of the tine. As is clearly shown in Fig. 11, the free end of the abutment element 307b is spaced a distance c from the inner face of the free end portion of the other tine so as to limit the maximum amplitude of oscillation of the tuning fork.

In the embodiment illustrated in Fig. 12, each of the tines 403 and 404 carries a permanent magnet 406, it being understood that one of the permanent magnets may be replaced by a suitable balance weight. The instant embodiment differs from the above described ones in that each of the permanent magnets 406 carries an abutment element 407b, these elements being spaced from each other a distance s and cooperating with each other in such a manner that when the amplitude of oscillation of the tines is equal to the maximum permissible amplitude, the abutment elements will engage each other thereby preventing the tines from oscillating at an amplitude greater than this maximum amplitude.

In the embodiment illustrated in Fig. 13 the tines 503 and 504 each carry a permanent magnet 506, it being understood that one of the permanent magnets may be replaced by a suitable balance weight. In the instant embodiment, each of the permanent magnets 506 either carries or is formed with an abutment portion 507b which may be substantially frusto-conical or dome-shaped as shown in Fig. 13. The respective inwardmost parts of the portion 507b are spaced from each other a distance s , thereby limiting the maximum amplitude of oscillation of the tines.

Additionally, it will be understood that any suitably shaped abutment means may be pro-

vided for limiting the maximum amplitude of oscillation of the tines. For example, the abutment means may be connected to or be integral with the tines proper. Also, it is not essential that the abutment means be located between the free end portions of the tines, and they may be so arranged as to be located physically exteriorly of the space between the tines.

WHAT WE CLAIM IS:—

1. A timepiece mechanism for a watch or clock comprising a tuning fork type vibrator, having a pair of freely oscillatable tines, electrical means for oscillating said tines and characterized in that abutment means are provided on one or both tines for limiting the amplitude of oscillation of the tines.

2. A timepiece mechanism for a watch or clock as claimed in Claim 1 wherein the abutment means limit the deflection of the tines in one direction.

3. A timepiece mechanism for a watch or clock as claimed in either of the preceding claims wherein the abutment means limit the inward deflection of the tines.

4. A timepiece mechanism for a watch or clock as claimed in Claim 1, 2 or 3 wherein said abutment means comprises an abutment element carried by one of the tines between the tines and adapted to engage the other tine.

5. A timepiece mechanism for a watch or clock as claimed in Claim 4 wherein the abutment element is carried by the one tine in the region of its free end.

6. A timepiece mechanism for a watch or clock as claimed in any preceding claim wherein the tines are so constructed and arranged that the abutment means are constituted by abutments which are part of or are formed integrally with one or both tines.

7. A timepiece mechanism for a watch or clock as claimed in any of the preceding claims wherein the abutment means comprise two cooperating abutment elements, one of which is carried by one of the tines and the other of which is carried by the other tine.

8. A timepiece mechanism for a watch or clock as claimed in any one of the preceding claims wherein the electrical means include a magnet carried by one of the tines at its free end.

9. A timepiece mechanism for a watch or clock as claimed in Claim 8 wherein the other tine carries at its free end a balance weight.

10. A timepiece mechanism for a watch or clock as claimed in Claim 8 wherein the other tine carries another magnet, which last-mentioned magnet also forms part of the electrical means for oscillating the tines.

11. A timepiece mechanism for a watch or clock as claimed in Claim 8, 9 or 10 wherein the center of gravity of each magnet or balance

weight is in alignment with the particular tine which carries it.

12. A timepiece mechanism for a watch or clock as claimed in any of Claims 8 to 11 wherein the center of gravity of each magnet or balance weight is spaced from the axis of symmetry of the vibrator a distance substantially equal to the distance which the turning or pivot point of each tine is spaced from this axis of symmetry.

13. A timepiece mechanism for a watch or clock as claimed in any of Claims 8 to 12 wherein the tines converge toward each other with the free end portions of the tines, however, extending substantially parallel to each other.

14. A timepiece mechanism for a watch or clock as claimed in any of Claims 8 to 13 wherein the magnets or balance weight are affixed to the outer faces of the substantially parallel free end portions of the tines, and the abutment means for limiting the amplitude of oscillation of the tines include at least one abutment element affixed to the inner face of the free end portion of one of the tines.

15. A timepiece mechanism for a watch or clock as claimed in any of Claims 8 to 14 wherein the abutment element or elements are carried directly by the magnets and/or the balance weight.

16. A timepiece mechanism for a watch or clock as claimed in any of the preceding claims wherein the abutment element is or elements are made of non-magnet material, as, for example, brass.

17. A timepiece mechanism for a watch or clock as claimed in any of Claims 8 to 15 wherein the abutment element or elements are made of magnetic material and are magnetically insulated from the magnets, as, for example, by means of a partition element or the like which is made of non-magnetic material and is interposed between the abutment element and the magnet by which the same is carried.

18. A timepiece mechanism for a watch or clock as claimed in any of Claims 8 to 15 wherein the abutment element or elements are integral with the magnets and/or balance weight.

19. A timepiece mechanism for a watch or clock as claimed in Claim 9, or any Claim appendant thereto, wherein shifting means are provided whereby the center of gravity of the balance weight can be shifted along a line which is a projection of the tine which carries the balance weight so that the natural frequency of the tines and consequently that of the vibrator can be adjusted.

20. A timepiece mechanism for a watch or clock as claimed in Claim 19 wherein the shifting means include a screw which engages a threaded hole the axis of which extends

along the line which is a projection of the tine.

21. A timepiece mechanism for a watch or clock as claimed in any of the preceding claims wherein the vibrator is connected to a motion transmitting device by means of which oscillation of the tines is converted to rotation for driving the timepiece mechanism.

22. A timepiece mechanism for a watch or clock as claimed in Claim 21 wherein the motion transmitting device includes a driving member mounted on one of the tines in such a manner that the driving member reciprocates during oscillation of the tines, with the length of the stroke of reciprocation of the driving member being dependent upon the amplitude of oscillation of the tines.

23. A timepiece mechanism for a watch or clock as claimed in Claim 22 wherein the abutment means for limiting the amplitude of oscillation of the tines are so constructed and arranged that the maximum amplitude of oscillation of the tines corresponds to an amplitude at which the stroke length of the driving member is not greater than a predetermined maximum length.

24. A timepiece mechanism for a watch or clock as claimed in Claims 7 and 23 wherein the electrical means are capable of oscillating the tines with an amplitude which is at least equal to that amplitude at which the stroke length of the driving member is at least equal to a predetermined minimum length.

25. A timepiece mechanism for a watch or clock as claimed in Claim 24 wherein the reciprocating driving member is operatively associated with a turnably mounted member, the interaction between the driving member and the turnably mounted member being such that reciprocation of the former is converted to rotation of the latter when the length of the stroke of reciprocation is at least as great as said predetermined minimum length but preferably is not greater than said predetermined maximum length.

26. A timepiece mechanism for a watch or clock as claimed in Claim 25 wherein the driving member is a pawl and the rotatably mounted member is a ratchet wheel, the latter causing rotation of the hands of the timepiece.

27. A timepiece mechanism for a watch or clock as claimed in Claim 26 wherein the minimum stroke length of the pawl in a direction tangent to the ratchet wheel at the point of engagement thereof with the pawl is equal to a distance slightly greater than the pitch of the ratchet teeth and wherein the maximum stroke length of the pawl in this tangential direction is slightly less than twice the pitch of the ratchet teeth.

28. A timepiece mechanism for a watch or clock as claimed in Claim 27 wherein the abutment element or elements are in the form of pins or rods.

29. A timepiece mechanism for a watch or

- clock as claimed in Claim 28 wherein the distance between the free end of the pin or rod-like abutment element and the opposite tine or the distance between the free ends of the pin or rod-like elements is so selected that the maximum amplitude of oscillation of the tines corresponds to an amplitude at which the driving member reciprocates with a stroke the length of which does not exceed said predetermined maximum length.

- 10 30. A timepiece mechanism for a watch or

clock substantially as hereinbefore described with reference to and as illustrated in Fig. 9, Fig. 10, Fig. 11, Fig. 12 or Fig. 13 of the accompanying drawings.

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Agents for the Applicants.

Reference has been directed in pursuance of Section 9, subsection (1) of the Patents Act, 1949, to Patent Nos. 761,609 and 746,465.

FIG. 1

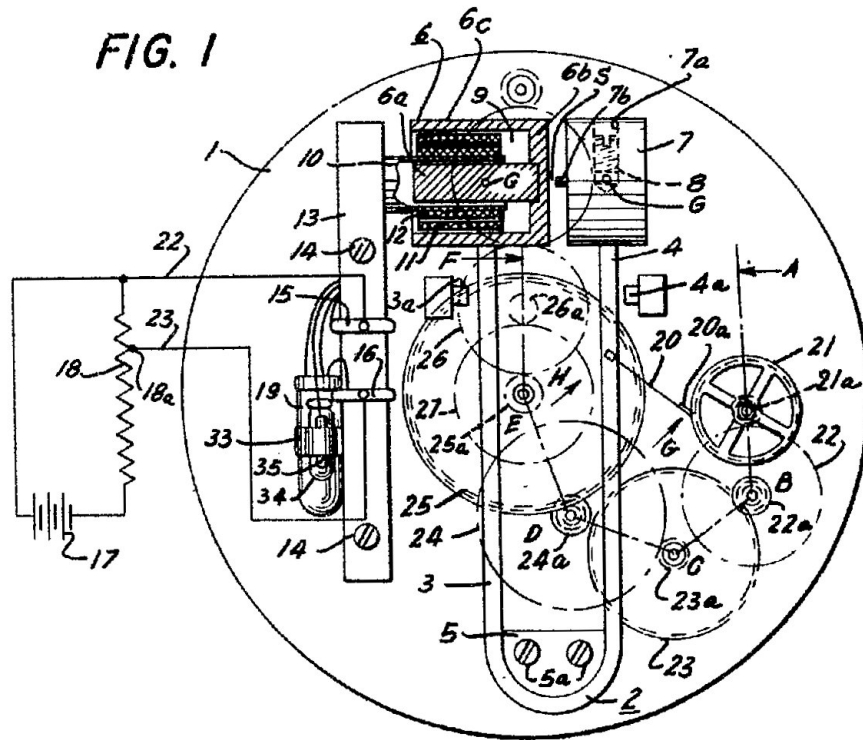
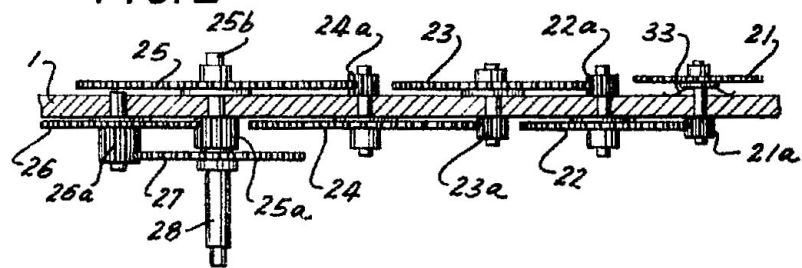


FIG. 2



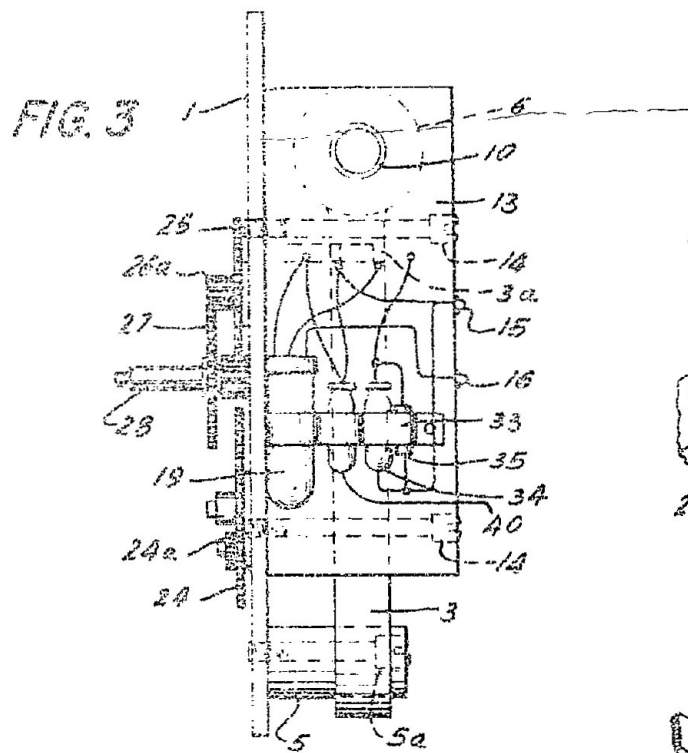


FIG. 6

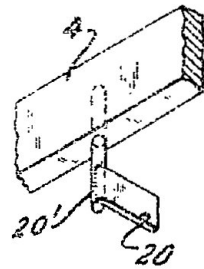


FIG. 5

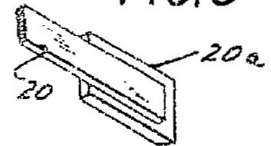


FIG. 4

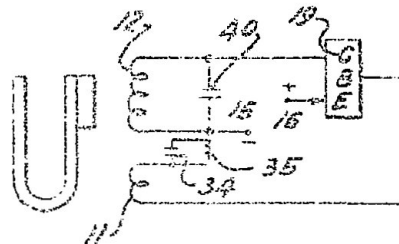
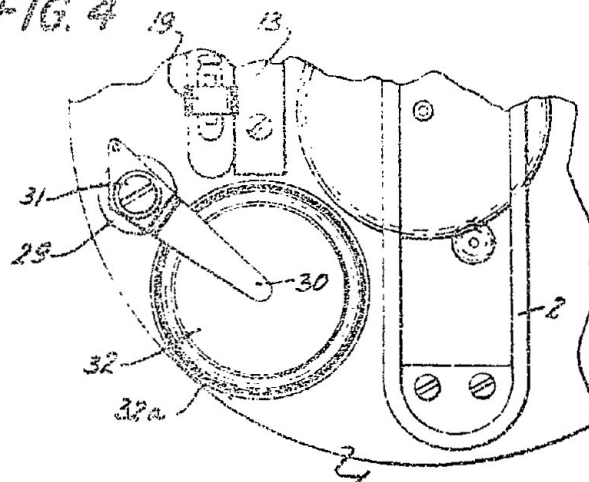


FIG. 7

830,518

COMPLETE SPECIFICATION

3 SHEETS

This drawing is a reproduction of the Original on a reduced scale.

SHEETS 2 & 3

6

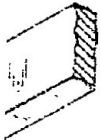


FIG. 5

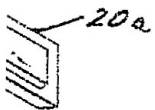


FIG. 8

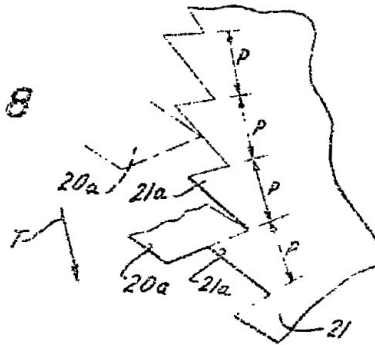


FIG. 9

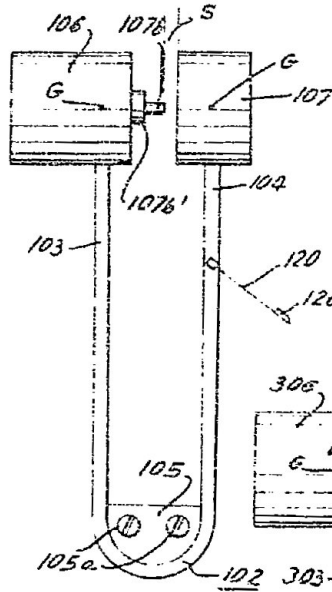


FIG. 10

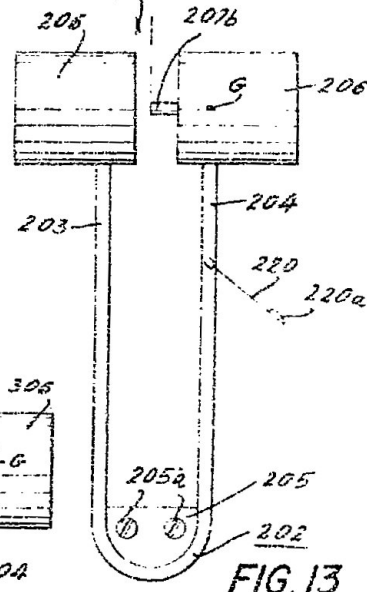


FIG. 11

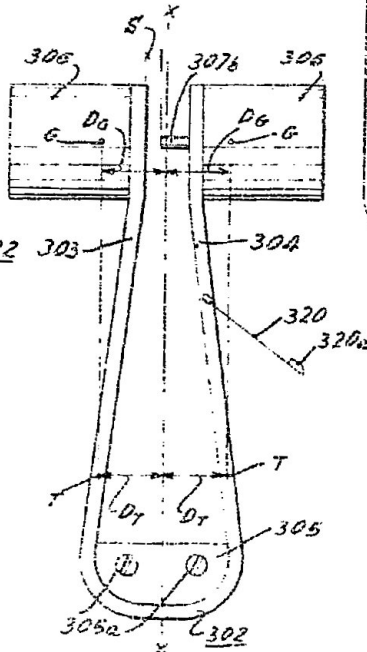


FIG. 13

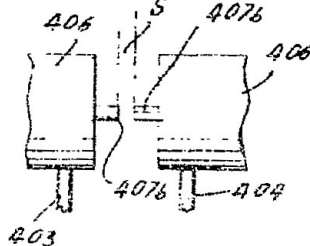
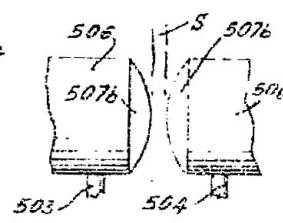


FIG. 12

