Aug. 23, 1960 M. HETZEL 2,949,727

ELECTRIC TIMEPIECE

Filed Feb. 14, 1956 2 Sheets-Sheet 1

Fig. 1

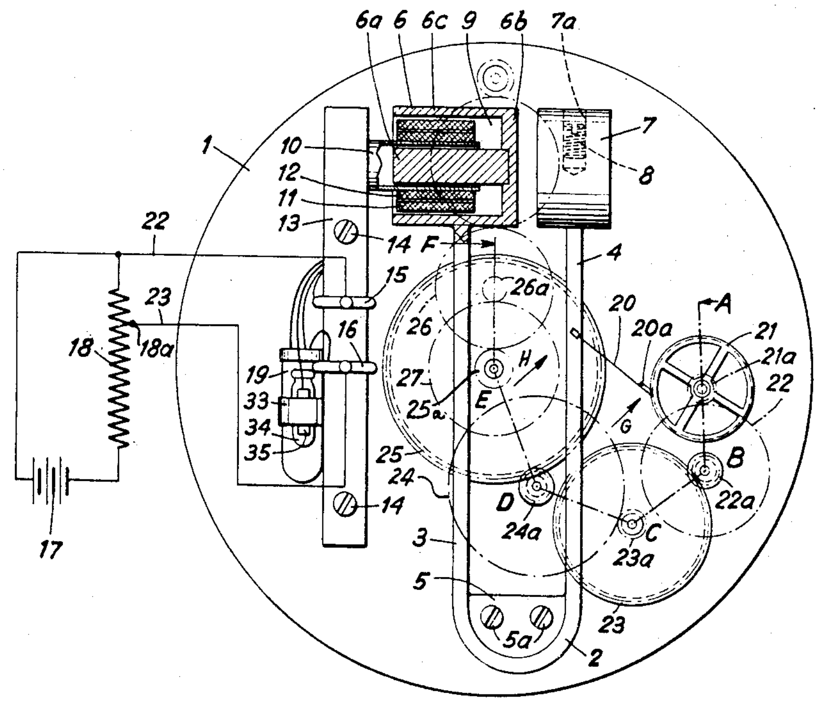
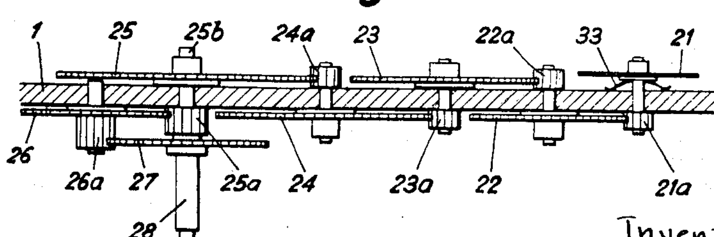


Fig. 2



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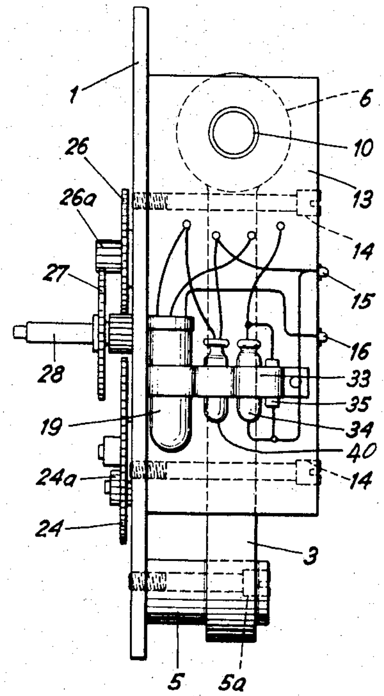


Fig.3

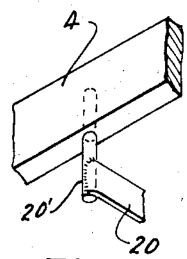


Fig.6

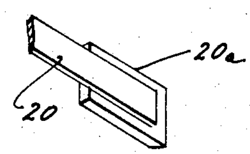
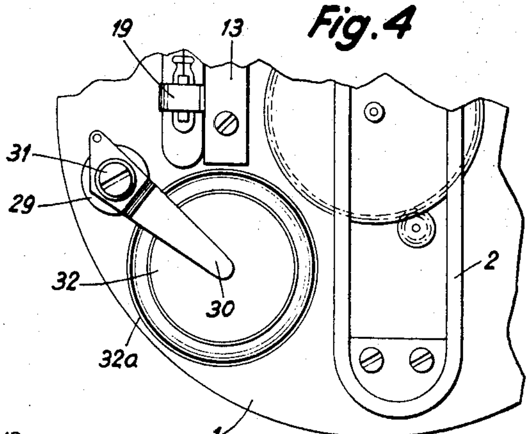


Fig.5

Fig.4



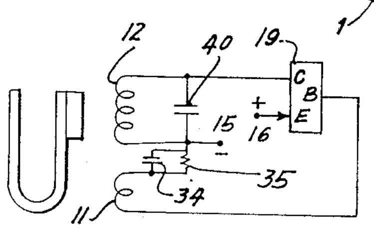


Fig.7

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ELECTRIC TIMEPIECE

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Filed Feb. 14, 1956, Ser. No. 565,452

Claims priority, application Switzerland Feb. 16, 1955

2 Claims. (Cl. 58—23)

The present invention relates to electric timepieces of the type disclosed in copending application Serial No. 436,949, filed June 15, 1954, now abandoned, and entitled "Electronic Device for the Operation of a Timepiece Movement" of which the present application is a continuation-in-part.

One of the objects of the present invention is to provide an electrical timepiece capable of being connected to the storage battery of an automobile to be operated thereby or capable of carrying its own source of electrical energy.

Another object of the present invention is to provide an electrical timepiece with a means for converting the oscillations of a tuning fork or the like into rotary movements of the hands of the timepiece.

An additional object of the present invention is to provide an electrical timepiece with a means for adjusting the natural frequency of one of the tines of a tuning fork of the timepiece so as to regulate the latter.

Also, it is an object of the present invention to provide a structure capable of accomplishing all of the above objects and at the same time composed of simple and ruggedly constructed elements which are very reliable in operation.

With the above objects in view the present invention mainly consists of an electrical timepiece which includes a base plate which carries a tuning fork having a pair of tines spaced from the base plate. A permanent magnet is carried by one of the tines and is adapted to cooperate with an electrical circuit for maintaining the oscillations of the tuning fork, and a balance weight is carried by the other of the tines, the natural frequency of the latter tine and balance weight being approximately equal to the frequency of the first mentioned tine and permanent magnet. A pawl or the like is connected to one of the tines and cooperates with a ratchet wheel which in turn cooperates with a gear train for converting the oscillations of the tuning fork into a rotary movement capable of being used for moving the hands of a timepiece.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

Fig. 1 is a plan view of the interior of a timepiece 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 forms a clock of an automobile, for example;

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;

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Fig. 5 is a fragmentary perspective view of 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; and

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

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 constant thickness. A tuning fork **2** is fixed to a member **5** as by soldering or welding or the like, and this member **5** is in turn fixed to the base plate **1** by the pair of screws **5*a***. As is evident from Figs. 1 and 3, the member **5** is connected to the tuning fork **2** only at the 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 **6*b*** closing the cylinder **6*c***, this end wall **6*b*** carrying a magnetic bar **6*a*** which is of a very strong magnetic material such as Alnico, for example.

The other tine **4** of the tuning fork **2** carries a balance weight **7** at its free end, this balance weight **7** simply being 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 balance weight **7** are so chosen that the tine **3** and permanent magnet **6** on the one hand and the tine **4** and balance weight **7** on the other hand have approximately the same natural frequency so that the tuning fork will not require an undesirably large amount of damping.

The balance weight **7** is provided with a threaded bore **7*a*** in which a screw member **8** shorter than the length of the threaded bore is threadedly located so that this screw member may be shifted toward or away from the tine **4** along the line forming an extension of the latter, and by this shifting of the screw **8** it is possible to vary the natural frequency of the tine **4**. Inasmuch as the natural frequency of the entire tuning fork is the average of the natural frequencies 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 for example by filing off a part of one tine, that the timepiece keeps perfect time to within plus or minus three minutes, 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 time piece to keep accurate time within this range of plus or minus three minutes per month, for example.

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 the screw members **14**, as is evident from Figs. 1 and 3. This tubular member **10** freely surrounds the core **6*a*** 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 convolutions as the coil

11. The core 6a has sufficient clearance within the tube 10 to avoid contacting the latter during the oscillations of the tuning fork. Thus, the coils form with the permanent magnet 6 a transducer which together with the tuning fork 2 forms a tuning fork oscillator of the same general type as that disclosed in the above mentioned copending application.

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 capacitance 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 circiut 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 a frequency constant of 2×10^{-7}, while for a timepiece of the type described above a frequency 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 20′ is fixed to and extends downwardly from the tine 4, as viewed in Fig. 1. That is, the pin 20′ 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 20′ 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 20′ 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 the 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 33, 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 number 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.

Pinion or gear:	Number of teeth
Ratchet wheel 21	360
Pinion 21a	6
Gear 22	30
Pinion 22a	6
Gear 23	36
Pinion 23a	6
Gear 24	42
Pinion 24a	6
Minute wheel 25	50
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 **32***a* 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 **31**. 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 capacitance **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 understood that each of the elements described above, or two or more together, may also find a useful application in other types of electrical timepieces differing from the types described above.

While the invention has been illustrated and described as embodied in electrical timepieces operated from tuning fork oscillators, it is not intended to be limited to the details shown, since various modifications and structural

changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. In an electric timepiece, in combination, a base plate; a tuning fork carried by said base plate and having a pair of tines spaced from said base plate; a permanent magnet carried by one of said tines, electrical coils disposed to cooperate with said permanent magnet for maintaining the oscillations of the tuning fork; a balance weight carried by the other of said tines and formed with a bore, said other tine and balance weight having a natural frequency substantially equal to the natural frequency of said one tine and permanent magnet; a member located within and shiftable along said bore of said balance weight for adjusting the natural frequency of said other tine and balance weight, and means including a pawl connected to the other tine of said fork and a ratchet wheel engageable by said pawl to convert the oscillations of said fork into a rotary movement.

2. In an electric timepiece, in combination, a base plate; a tuning fork carried by said base plate and having a pair of tines spaced from said base plate; a permanent magnet carried by one of said tines; electrical coils fixedly mounted on said base plate in cooperative relation to said permanent magnet for maintaining the oscillations of the tuning fork; a balance weight carried by the other of said tines and formed with a threaded bore; a screw member shorter than said bore located within and threadedly engaging said balance weight in said bore thereof, so that by turning said screw member along said bore the natural frequency of said other tine and balance weight may be regulated, and means including a pawl connected to the other tine of said fork and a ratchet wheel engageable by said pawl to convert the oscillations of said fork into a rotary movement.

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