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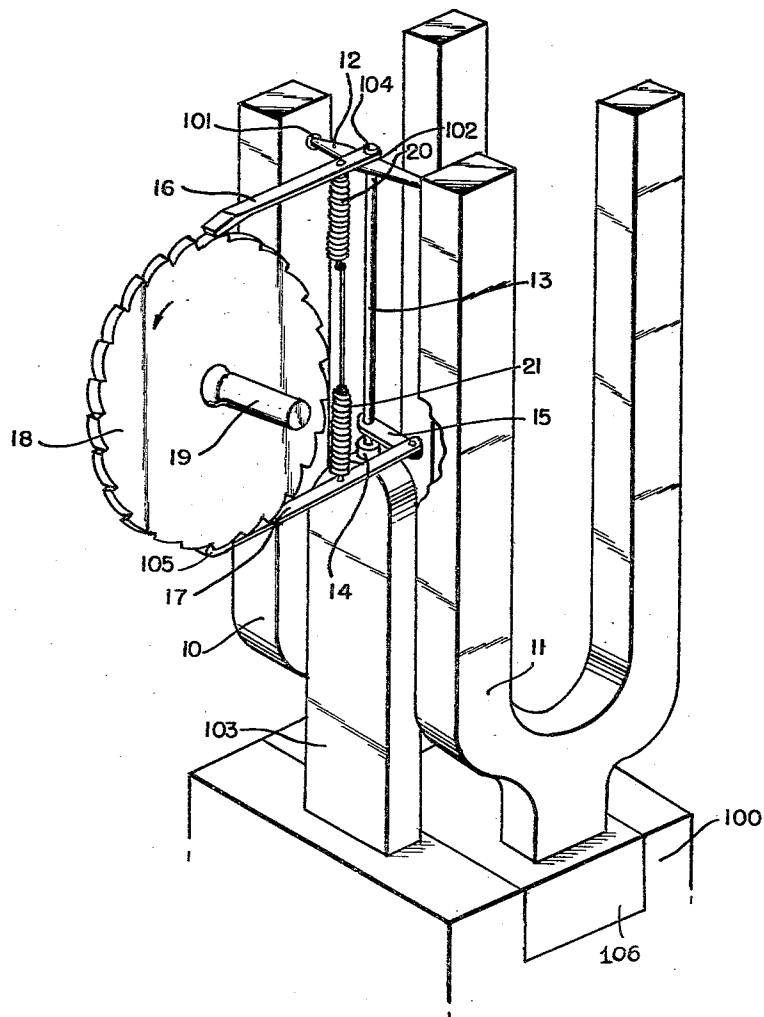
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TIMING DEVICE UTILIZING A MECHANISM

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TIMING DEVICE UTILIZING A MECHANISM

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The present invention concerns the detection of mechanical in-phase and out-of-phase conditions in mechanisms and the utilization thereof for accurate and stable timing control.

It is an object of the invention to provide two members mounted for oscillation or reciprocation at different frequencies and to convert this sequence into a stepped rotary motion or into a series of electrical pulses.

It is an object of the invention to provide means to detect the sequence of in-phase and out-of-phase conditions of two members oscillating or reciprocating at different frequencies and to convert this sequence into a stepped rotary motion or a series of electrical pulses such as for example to facilitate the use of small high frequency tuning forks or vibrating reeds as the time base of a watch or other timing device.

It is an object of the invention to provide a slow speed rotating output from a high speed oscillating or reciprocating motion.

It is an object of the invention to provide two similar oscillating tuning forks, or similar mechanical oscillating means, mounted in side-by-side relation for vibration in parallel planes, power being supplied by electromagnetic or electronic means to maintain the oscillations. The forks have slightly different resonance frequencies. As the two forks go in and out of phase a resultant is produced which is converted into an output movement or signal. It will be seen that the rate or frequency of the output movement signal decreases as the resonant frequencies approach each other and becomes zero when they are the same. The invention lies in the novel means for converting the in-phase and out-of-phase conditions of the two members into a suitable output signal or motion.

It is an object of the invention to provide an accurate and highly stable timing device.

Other objects will appear from a consideration of the drawing and the specification which are to be construed as illustrated and not as limiting.

In the drawing like numerals refer to like parts throughout.

FIGURE 1 is a cabinet projection of one form of the invention.

FIGURE 2 is a fragmentary elevation of a modified form showing the application of the invention to an electric circuit control.

In the drawing, tuning forks 10 and 11 of different resonant frequencies are mounted in parallel planes on a suitable base 100 containing drive means 106 for maintaining the vibration of each fork by an electro-magnetic and/or electronic system in accordance with well-known established arts. For most applications the resonant frequencies of the two forks are determined with great accuracy at the time of manufacture and are fixed, correction being made for temperature changes as may be necessary. Forks 10 and 11 as shown in the drawing are self-correcting in that any temperature change affects them in the same manner and leaves the frequency difference the same. Where it is desired to change the output rate, the difference between the resonant frequencies may be adjusted by increasing or decreasing the effective mass or changing the physical arrangement of the material of one of the forks 10 or 11. This may be accomplished for example by an adjustment screw, differential heating means applied to one fork, or the like. These are es-

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entially adjustment means. Where stepped adjustment of definite predetermined magnitudes is desired fixed masses may be attached to one fork or a series of forks such as 11 with stepped fixed frequencies may be provided.

One tine of each fork 10 and 11 has an indentation 101 on its inner face adjacent its free vibrating end and facing the indentation in the corresponding tine of the other fork. Indentations 101 are preferably hemispherical in shape and are so positioned that they lie facing each other in a common line normal to the planes of vibration of the tuning forks 10 and 11. The distance between the forks 10 and 11 is chosen so that a short light strut 12 which is rigidly fastened at its mid-point 102 to a spindle 13 and provided with rounded ends positioned in the two indentations can be driven by the forks. Mid-point 102 of spindle 13 is such that spindle 13 both rotates and rocks in a step bearing 14 mounted to support the spindle 13 for movement of rotation and rocking on it. Step bearing 14 may have a universal ball mounting. Step bearing 14 has a mounting 103 on frame 100 which fixes the position of the bottom end of spindle 13 and at the same time allows it to rotate and rock with the bottom end of spindle 13 positioned so that the spindle 13 lies parallel to and midway between the respective tines of the forks 10 and 12.

Adjacent the bottom of spindle 13 and just above bearing 14 is provided a lever or crank arm 15 which rotates with spindle 13 but rocks very little because it is positioned so closely to bearing 14. Arm 15 is mounted parallel to strut 12.

Spindle 13 passes through strut 12 and projects above it to provide a pivotal mounting 104 for pawl 16 the free end of which falls into the notches or interdental spaces of ratchet wheel 18, permitting only counter-clockwise rotation thereof as shown by the arrow in the drawing. Mounting 104 is partly spherical in shape, so that spindle 13 may rotate freely within the end of pawl 16 mounted at 104 and the pawl 16 can have a limited rise and fall as it passes from one tooth of ratchet wheel 18.

A second pawl 17 is pivotally mounted at the end of lever arm 15 and is driven thereby. Pawl arm 17 has a claw-shaped end 105 for engaging the teeth of ratchet wheel 18 to cause counterclockwise rotation thereof. Pawls 16 and 17 engage the ratchet wheel 18 at points diametrically opposite and may be provided with suitable lateral guides to maintain their positions and may be lightly biased by springs 20 and 21 into engagement with ratchet wheel 18. Ratchet wheel 18 may be provided with an additional pawl or other suitable means to prevent rotation of ratchet wheel 18 in a clockwise direction opposite to the arrow.

Ratchet wheel 18 is mounted for rotation on shaft 19 which may function as the drive for a clock or other timing mechanism of great accuracy. Shaft 19 may also be connected to provide electric pulses for timing or the initiation of other events or control.

The operation of the device is as follows:

Tuning forks 10 and 11 are set in vibration by the application of energy in a classical manner. Each fork vibrates at its own resonant frequency and the frequencies may be chosen so that their difference produces a rotation at shaft 19 of one r.p.s. or one r.p.m. suitable for a watch or clock. When the vibrations of the tuning fork 10 and 11 are coming into phase the short strut 12 will experience principally parallel translatable motion imparted to it by the tines of forks 10 and 11 which are provided with indentations 101. At or near the instant of synchronization of the tines, when the amplitude of the translatable motion of strut 12 and pawl 16 is at or near a maximum, the pawl 16 moves sufficiently to engage a

tooth and rotate the ratchet wheel 18 by that amount. In general, the geometry of the arrangement is so chosen that wheel 18 is advanced only one tooth by pawl 16 when the translatory motion of strut 12 passes through a maximum. The pitch of the teeth of ratchet wheel 18 is selected to be about one and a half times the maximum amplitude of the movement of pawl 16 and also of the pawl 17. The translatory motion of pawl 16 will slide over a tooth face with progressively increasing movement until it drops down, engages the opposed tooth face and rotates the wheel 18. Pawl 16 progressively moves the engaged tooth and rotates wheel 18 until the translatory movement of strut 12 and pawl 16 reach a maximum, but pawl 16 cannot engage a second tooth because the pitch of the teeth is greater than the maximum movement of pawl 16.

When the tines having indentations 101 are instantaneously in phase the strut 12 moves in translation only and spindle 13 rocks in its bearing 14 without rotation. Arm 15 accordingly does not rotate and any movement of pawl 17 is negligibly slight and due only to the small distance of lever 15 above step bearing 14. As the tines acting on strut 12 move progressively out of phase, the translatory motion of strut 12 decreases to a small value or zero and its movement of rotation increases until it reaches a maximum when the tines are in opposite phase, that is, completely out of phase. Strut 12 rotates spindle 13 and lever arm 15 through an increasing angle. Lever arm 15 reciprocates pawl 17 through an increasing distance and its hook engages a tooth on wheel 18 progressively and ultimately rotates the wheel an amount determined by the throw of lever 15. Here again the pitch of the teeth on wheel 18 is about one and a half times that of the maximum travel of the end of pawl 17 as well as that of pawl 16, so the hook on pawl 17 is not able to move far enough to engage a second tooth. However, the wheel 18 has been advanced far enough so that pawl 16 will be able to engage the next consecutive tooth on its side of wheel 18. The pawls 16 and 17 are so positioned, and the length of their travel and the pitch of the teeth on ratchet wheel 18 are so chosen that each leave the toothed wheel so that the other can engage one tooth and move the wheel through an angle corresponding to half a tooth pitch.

The toothed wheel 18 is driven round half a tooth at each in-phase condition of the forks 10 and 11 and an additional half tooth at each out-of-phase condition of the forks. As the frequency difference between the forks 10 and 11 can be very small and thus the time intervals between phase changes relatively long, it is practical to make the toothed wheel 18 and its shaft 19 rotate at a speed as low as one revolution per minute without an unduly large number of teeth and with great accuracy.

It is desirable to have the movements of the pawls 16 and 17 equal in magnitude. The end of lever arm 15 would foul the nearer tine of fork 11 if it were made with a length half that of strut 12. The lever arm 15 may be made half the length of the strut 12 by off-setting the indentations 101 on projections on all the tines of the forks 10 and 11 or curving the tines to allow clearance for the end of lever 15. All the tines are curved so as not to change the effective frequency difference of the forks. Again, fork 11 may be lowered slightly which would cause a slight tilt in strut 12, spindle 13 and the lever 15, giving the needed clearance. This construction may be used without detriment to the action of the device.

If a series of electrical pulses is required instead of the rotation of shaft 19, the pawls 16 and 17 can be replaced by insulating members which operate electrical contacts. The insulating member employed in place of pawl 16 would act to close repeatedly a pair of normally open contacts during the in-phase condition. The insulating member replacing pawl 17 would act to open repeatedly a pair of normally closed contacts during the

out-of-phase condition. The first closing of the contacts by pawl 16 would energize a relay which has its own hold-in circuit such as that provided by wires 69 and 70 in FIG. 2. The hold-in circuit contains the normally closed contacts actuated by pawl 17. The relay once energized remains energized from near the in-phase condition to near the out-of-phase condition and would be de-energized during the other half of the cycle. Additional relay contacts could be employed to transmit the resultant output tuning pulses.

In FIGURE 2, reciprocable insulated arms 16' and 17' replace pawls 16 and 17 of FIGURE 1, respectively. Arm 16' acts to close a normally open pair of contacts 40 carried by flexible metal members 41 and 42. Member 41 is biased to open position by tension spring 43 as well as by its own resiliency. Resilient metal member 42 is arrested by stop 44 to assure that the contacts 40 are normally open until member 41 is acted upon by arm 16' and contacts 40 are closed. It will be seen that the flexibility of members 41 and 42 provide a wiping action at contacts and reliability of performance.

In the same way, arm 17' acts to open normally closed contacts 50 carried by flexible metal members 51 and 52. Member 51 is biased to closed position by compression spring 53 as well as by its own resiliency. Stop 54 limits the movement of member 51 under the action of bias spring 53. As the forks 100 and 103 approach synchronism and strut 12 moves arm 16' increasingly in translation, the reciprocating movement of the arm 16' increases until it deflects member 41 against the action of bias spring 43 sufficiently to close contacts 40. Upon the closing of the contacts 40, a current flows from battery or other source of voltage 55 through a circuit which, in the example shown in FIGURE 2, comprises wire 56, contacts 40, wire 57, relay coil 58, wire 59, normally closed contacts 50 and wire 59 back to the other side of voltage source 55.

The flow of current in relay coil 58 attracts relay armature 60 against the bias of compression spring 61 and operates the relay by opening normally closed contacts 62 and thereafter closing, sequentially, normally open contacts 63 and 64. Contacts 63 may be spaced to close before contacts 64. Control terminals 65, 66, 67 and 68 may be connected to provide any desired control sequence or function. Terminals 65 and 66 provide a circuit which is opened periodically before a circuit containing terminals 65 and 68 or terminals 65 and 67 is closed. It will be seen that a large number of operation sequences can be built up by suitable selection of contacts such as 62, 63, 64 and others to give circuits which break before make, "break before make before make," break after make, and the like by particular arrangements and connections in a plurality of circuits.

As forks 10 and 11 move out of phase and strut 12 rotates the reciprocating action of arm 17' increases until it moves member 51 and opens contacts 50, breaking the holding circuit of relay coil 58 which comprises battery 55, wire 69, contacts 63, arm 60, wire 70, coil 58 and contacts 50. When the circuit of coil 58 is broken at contacts 50, armature 60 is no longer attracted and bias spring moves armature 60 to break contacts 64 and 63 and to close contacts 62 together with their corresponding control circuits connected to terminals 65, 66, 67 and 68. The entire sequence is periodically repeated with a frequency determined by the beat frequency of tuning forks 10 and 11.

While there have been described above what are presently believed to be the preferred forms of the invention, variations thereof will be obvious to those skilled in the art and all such changes and variations which fall within the spirit of the invention are intended to be covered by the generic terms in the appended claims, which are variably worded to that end.

Multiple event circuits by which selected events may be caused to occur in a desired sequence are disclosed

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in U.S. Patent No. 2,169,988 to Earl F. Norrito, granted August 15, 1939 for Multicircuit Jack. Holding circuits for relays are disclosed in U.S. Patent Nos. 2,267,410 to J. W. McNary, granted December 23, 1941 for Control System Interlock; 2,305,450 to G. R. Stibitz, granted December 15, 1942 for Relay; and 2,307,712 to A. J. Schenk, granted January 5, 1943 for Central Station Dispatching Control System for Conveyors.

I claim:

1. A timing device for producing a timed signal output comprising a pair of tuning forks having different resonant frequencies mounted in substantially parallel relation, means to drive said forks at their respective resonant frequencies and output means connecting said forks, said output means having a member mounted for movement in translation when said forks vibrate in phase and for rotation when said forks are not in phase.

2. The combination set forth in claim 1, said output means having a pair of arms, one of said arms being operative to produce an effective output when said member experiences primarily translatable motion and the other of said arms being operative to produce an effective output when said member experiences primarily rotational movement.

3. In combination, a first mechanical vibrating system having a resonant frequency, a second mechanical vibrating system having a different resonant frequency, a member mounted for movement both in translation and in rotation, said first system having means acting on one part of said member, said second system having means acting on another part of said member, the resonant frequencies of said systems being so chosen that they move into and out of phase in a predetermined period with high stability, said systems acting on said member to cause it to experience increasing translatable movement as said systems move into phase and increasing movement of rotation as the systems move out of phase, and output means connected to said member.

4. The combination set forth in claim 3, said vibrating systems comprising a pair of tuning forks mounted for vibration in substantially parallel phases, said member extending between corresponding tines of said forks so

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that the tines act thereon to produce said translatable movement and said movement of rotation.

5. The combination set forth in claim 4, said output means comprising a spindle supporting said member and constructed to rotate therewith, a first arm pivoted on said member, a lever mounted for rotation by said spindle, a second arm mounted for movement by said lever, said first arm being actuated principally by translatable movement of said member and said second arm being actuated by movement of rotation of said member, said spindle and said lever.

6. The combination set forth in claim 5, said first and second arms being pawls, a ratchet wheel mounted for rotation between said pawls, the maximum movements of said pawls being substantially equal, the pitch of the teeth of said wheel being approximately one and a half times the maximum movement of a pawl.

7. The combination set forth in claim 5, an actuating coil, an electrical circuit comprising said actuating coil, a pair of normally open contacts, a pair of normally closed contacts and a voltage source, one of said arms being constructed to act on said pair of open contacts to close them periodically and the second said arm being constructed to open said pair of closed contacts periodically, said arms acting alternately with respect to said pairs of contacts.

8. The combination set forth in claim 3, a control electric circuit having a pair of normally open contacts and a pair of normally closed contacts, said member being constructed to close said normally open pair of contacts by one of said movements and to open said normally closed pair of contacts by the other of said movements of said member, sequentially and periodically with a frequency determined by the difference of the frequencies of said first and second systems.

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