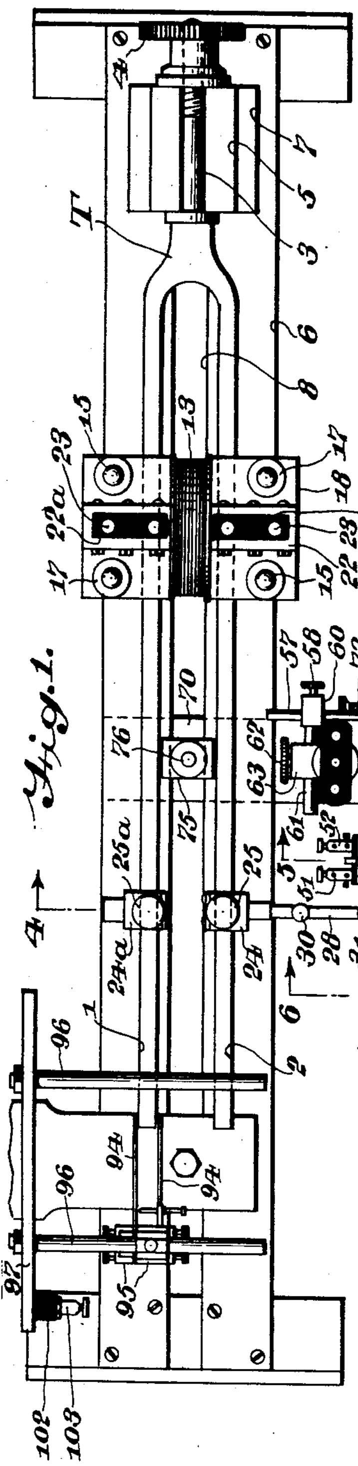
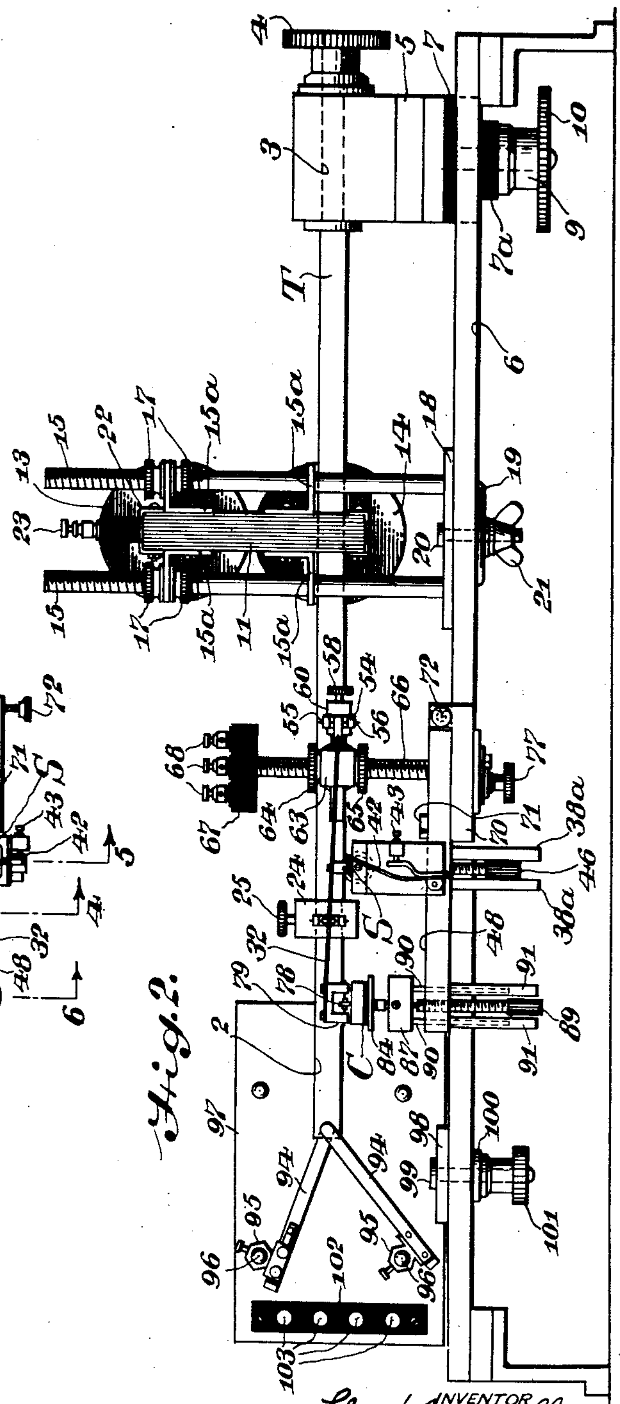
Feb. 3, 1925. 1,524,868

L. M. KNOLL

METHOD OF AND APPARATUS FOR ELECTRICALLY OPERATING TUNING FORKS

Filed Oct. 25, 1921 3 Sheets-Sheet 1





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Filed Oct. 25, 1921 3 Sheets-Sheet 2

Fig. 3.

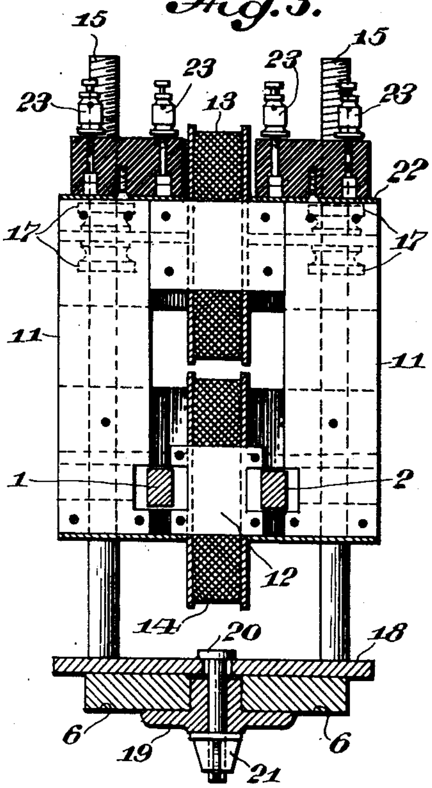

Fig. 4.

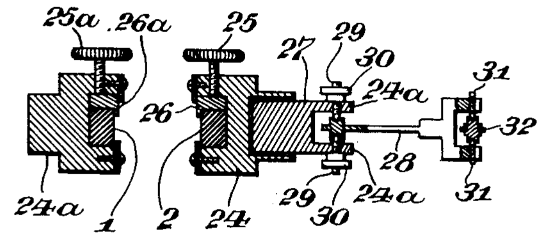

Fig. 5.

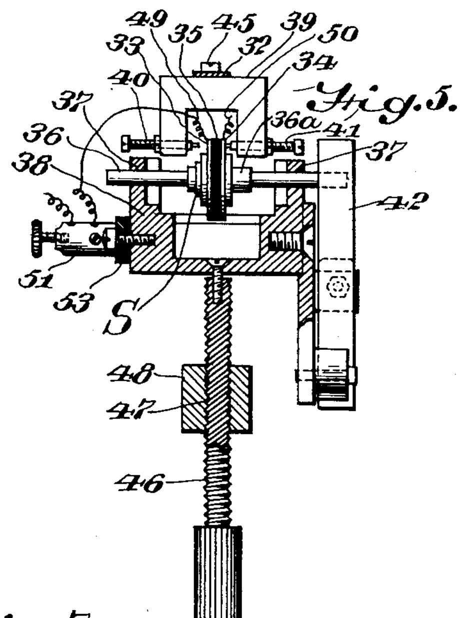

Fig. 6.

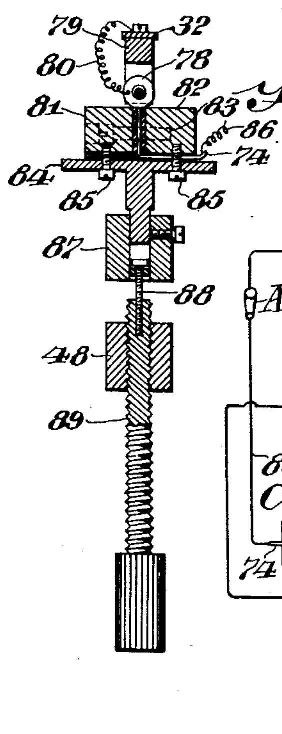

Fig. 7.

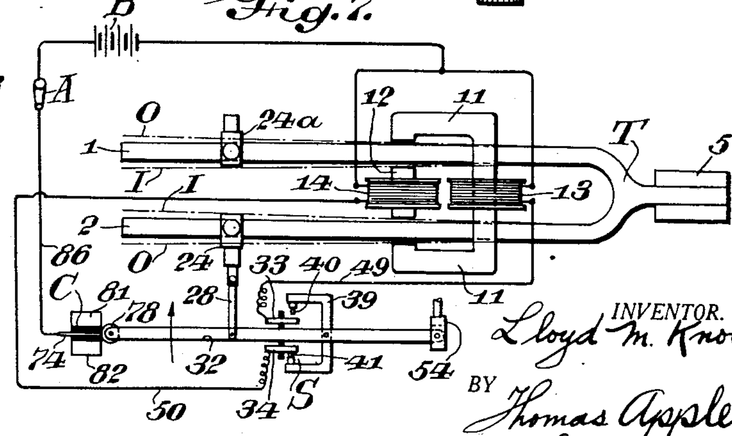

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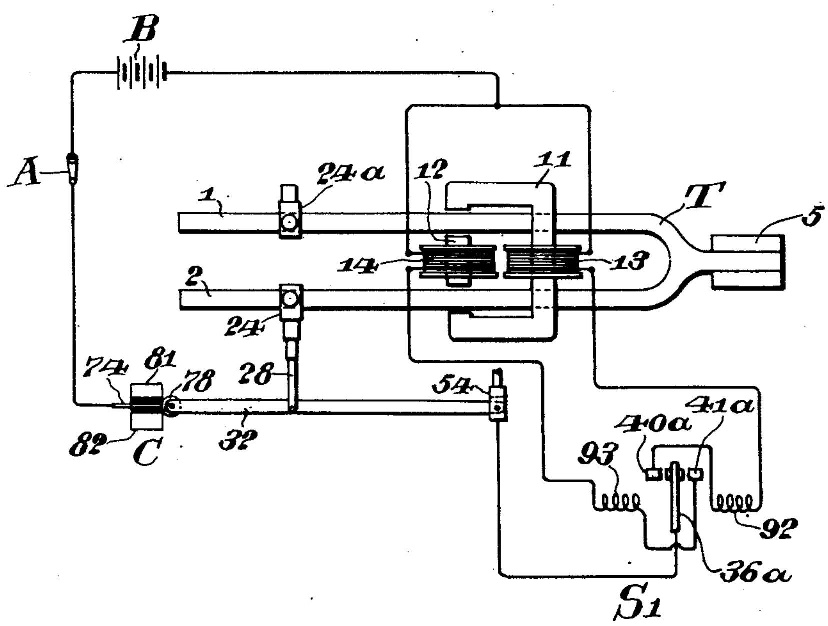
Fig. 8.



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Patented Feb. 3, 1925. **1,524,868**

UNITED STATES PATENT OFFICE.

LLOYD M. KNOLL, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR OF ONE-FOURTH TO THOMAS APPLEBY, OF PHILADELPHIA, PENNSYLVANIA.

METHOD OF AND APPARATUS FOR ELECTRICALLY OPERATING TUNING FORKS.

Application filed October 25, 1921. Serial No. 510,406.

To all whom it may concern:

Be it known that I, LLOYD M. KNOLL, a citizen of the United States, residing in the city and county of Philadelphia, State of Pennsylvania, have invented new and useful Improvements in Methods of and Apparatus for Electrically Operating Tuning Forks, of which the following is a specification.

My invention relates to a method of and apparatus for electrically operating tuning forks.

The principal objects of my invention are to provide a simple and improved means for securing constancy of frequency in tuning forks when minute time intervals of precise duration are desired for precision measurements and other purposes; to provide a method of and apparatus for supplying energy to tuning forks with a minimum of interference to their free vibration; to provide a tuning fork whose prongs will continuously complete each cycle of vibration regardless of the number of times the fork is stopped or the duration of its periods of rest; to provide a driver for a tuning fork, which produces driving impulses having positive action and a nicety of regularity; to provide electrical contacting mechanism whose contacts are uniformly positive and of an unvarying resistance nature; and to provide a self-starting tuning fork.

My invention further resides in the method and apparatus hereinafter described and claimed.

When a predetermined rate of vibration having a constancy of frequency is desired, for precision measurements and other purposes, it has been usual to employ tuning forks electrically driven by means of electromagnets. Heretofore when such arrangements were used a periodic but non-harmonic force was impressed upon the prongs of the tuning fork due to the usual arrangement of electrical contacts on the prongs and their co-acting contacts, usually mounted on resilient supports, which permitted the driving impulses to be applied to the prongs during a portion of time when the motion of the prongs is opposed by the magnetic field, thus damping the free vibration of the fork and introducing frequency variations. The length of the gap between the contacts also required careful adjustment if constancy of frequency was to be even approached, in order that the amplitude of vibration of the prongs might somewhat approach that at which the period of vibration of such arrangements has a stationary value and is consequently least affected by small changes of amplitude.

My invention permits the actuating force to be applied momentarily to the prongs at or near their position of rest regardless of the amplitude of their vibration and therefore offers minimum damping to the free vibration of the fork whose frequency will then more closely approach constancy.

The nature, characteristic features and scope of my present invention will be more fully understood from the following description taken in connection with the accompanying drawings forming a part thereof, in which;—

Figure 1 is a plan view of a tuning fork provided with my driving mechanism.

Figure 2 is a side elevation.

Figure 3 is a sectional end elevation showing the arrangement of driving magnets.

Figure 4 is an elevational section view taken on line 4—4 of Fig. 1.

Figure 5 is an elevational view, partly in section, taken on line 5—5 of Fig. 1, showing the selector mechanism.

Figure 6 is a sectional elevation taken on line 6—6 of Fig. 1, through the contact closing mechanism.

Figure 7 shows the electrical circuit in diagrammatic form.

Figure 8 shows a modification of the circuit connections employing an electromagnetic selector.

Referring to Figs. 1, 2, and 3, a tuning fork T comprising prongs 1 and 2 and threaded shoulder 3, is secured by means of thumb-nut 4 to a slotted standard 5. This arrangement facilitates removal of the tuning fork with a minimum of disturbance to the surrounding parts.

An insulator 7, of hard rubber or the like, and shaped to fit in groove 8, is provided between standard 5 and base 6. A block 7^a of similar material is also placed below the base so that together they electrically insulate the tuning fork from base 6 and yet permit of longitudinal adjustment of the fork whenever the pressure between insulator 7, base 6 and block 7^a is released by turning thumb-nut 10 in proper direction on stud 9 of standard 5.

Actuating magnets 11 and 12, energized by coils 13 and 14 respectively, are placed intermediate the ends of tuning fork T. These magnets embrace prongs 1 and 2 and are mounted, for vertical adjustment, by means of angle brackets 15ª of non-magnetic material, threaded posts 15, and thumb screws 17, on base-plate 18. This plate is secured to base 6 by means of clamping plate 19, bolt 20 and wing-nut 21, permitting longitudinal and transverse adjustment of the electromagnets 12 and 13 with respect to prongs 1 and 2.

In order that the eddy currents, due to the frequency of the exciting currents in coils 13 and 14, may be reduced to a minimum electromagnet cores 11 and 12 are of the laminated type, being built up of thin sheet iron laminations. Two insulating blocks 22ª, of hard rubber or other insulating material, are mounted on the top of core 11 by means of inverted channel 22. These blocks carry the terminal binding-posts 23 for the electromagnet coils 13 and 14.

Selector S and the contact closing device C are driven, as shown in Fig. 1, directly by the vibrating prong 2 of the tuning fork T through a bracket 24 which is slidably mounted at a suitable position near the free end of prong 2 and adjustably secured by means of clamp 26 (Fig. 4) and thumb-screw 25. Pivot bracket 27 is insulated from and mounted in bracket 24 (Fig. 4) and provided with jaws 24ª in which lever 28 is pivotally mounted by means of adjusting screws 29 and lock-nuts 30. One end of lever 28 is bifurcated and contains screws 31 for pivotal connection with lever 32. Motion will thus be transmitted from the tuning fork prong 2 to selector and contact closing lever 32. A similar adjustable bracket 24ª is mounted on prong 1 for symmetry of the mechanical action or balance of the tuning fork.

A selector S is provided for the purpose of selecting the proper electromagnet through which the driving current shall flow depending upon the direction of motion of the prongs 1 and 2 at the instant the driving current and magnetic impulse is applied. The action of electromagnet 12 (Figs. 1, 3 and 7) is to draw the prongs 1 and 2 together when their motion is toward each other, while that of electromagnet 11 is to force the prongs apart when their motion is outward or away from each other. The driving impulse, however, is applied only momentarily while the prongs pass through their normal position of rest as will be readily understood from the description of the contact closer C hereinafter described.

The selector S may consist, as shown in Figs. 1, 2, 5, and 7, of two contacts 33 and 34 separated by insulating washer 35 and insulated from shaft 36, upon which they are mounted, by means of insulating bushing 36ª. Shaft 36 (Fig. 5) is slidably mounted in bearings 37, of supporting bracket 38, so that it may follow the motion of lever 32, bracket 39 and contact-screws 40 and 41. In order that the contacts 33 and 34 may alternately retain a certain contact pressure against their respective contact screws 40 and 41, an adjustable tension spring 42 (Figs. 2 and 5) is provided which bears upon shaft 36. The tension of spring 42 is regulated by means of adjusting screw 43 (Fig. 2). Contact screws 40 and 41 may be platinum tipped and are mounted in a bracket 39 which is secured to lever 32 by means of screw 45. Contacts 33 and 34 are also of platinum or platinum covered to secure a low resistance electrical contact between them and their co-acting screws 40 and 41.

Bracket 38, (Fig. 5) is provided with legs 38ª (Fig. 2), slidably engaging corresponding sockets in base plate 48, to prevent rotation of bracket 38 and retain its alignment with the base plate. Vertical adjustment of bracket 38 is provided by means of supporting and adjusting screw 46 operating in a tapped hole 47 in base-plate 48, so that contacts 33 and 34 may be properly positioned with respect to contact screws 40 and 41. Electrical connection with contacts 33 and 34, respectively, is provided by means of flexible conductors 49 and 50 terminating in binding-posts 51 and 52 mounted on insulated selector terminal block 53. Bracket 38 may be of metal and adjusting screws 40 and 41 in electrical contact therewith so that their circuit will be completed through lever 32 to contact closer C.

Lever 32 is pivotally mounted in bracket 54 by means of pins 55 and 56 (Fig. 2). Bracket 54 is provided with a stem 57 (Figs. 1 and 2) and held by means of a thumb-screw 58 in a holder 60 which is also provided with a stem 61 secured by thumb-screw 62 in a bracket 63. Bracket 63 is adjustable vertically by means of thumb-nuts 64 and 65 on a vertical threaded support 66 which is secured to base-plate 48. The upper end of support 66 carries a terminal block 67, of insulating material, upon which are mounted binding-posts 68 for convenience of connecting the various elements with a source of electrical energy.

Base-plate 48 is mounted, for swinging adjustment, on base projection 70 by means of screw 71. This plate may be moved to the right or left by means of adjusting screws 72 and 73. This adjustment is provided so that the selector contacts 33 and 34 may be properly positioned with respect to contact screws 40 and 41, and also to permit the stationary contact 74 of the contact closer C to be properly positioned with respect to the rest position of prong 2.

Base projection 70 is secured to base 6 by means of clamp plate 75, screw 76 and thumb-nut 77, in such manner as will permit longitudinal adjustment, with respect to base 6, of the selector and contact closing mechanism carried by base plate 48.

Contact closer C is provided for the purpose of closing the circuit through the electromagnet momentarily selected by the selector S as the prong 2 passes through its position of rest. This contact should be of short duration so that driving energy will be supplied to the prong without interfering with its free vibration. To accomplish this result there is provided a contact wheel 78 (Fig. 6) rotatably mounted in bracket 79 which is secured to lever 32. Positive electrical connection between lever 32 and contact wheel 78 is provided by means of a flexible conductor 80. A thin sheet of platinum 74, or other suitable conductor, is bent in the shape of an L and mounted between, but insulated from, two blocks 81 and 82. These blocks are secured together by means of a screw 83, and are insulated from bracket 84 to which they are fastened with screws 85. A terminal connection 86 is made to stationary contact 74. Bracket 84 is mounted on base plate 48 by means of sleeve 87, screw 88, and adjusting screw 89, in such manner as will provide for rotary and vertical adjustment of the stationary contact 74 with respect to contact wheel 78 and base plate 48. Sleeve 87 is provided with two legs 90 slidably engaging sockets 91 which tend to retain the sleeve in proper alignment with base plate 48 and yet permit vertical adjustment of the sleeve. It will thus be seen that as the contact wheel 78 rolls from right to left, or conversely, in synchronism with prong 2, it will make a momentary contact with the stationary contact 74 and cause driving energy to be applied to prongs 1 and 2 of the tuning fork as the prongs pass through their rest position.

When the selector S, as hereinbefore described, is used, the circuit connections may be made as shown in Fig. 7, where B represents a source of electrical energy applied to the driving magnets 12 and 13 through selector S and contact closer C. The prongs 1 and 2 are indicated as having returned from their outward swing, as indicated by line O, to their rest position, leaving the selector contacts 34 and 41 in closed position and the contact closer contacts 74 and 78 momentarily closed to supply current from source B through conductor 86, contact closer C, selector S, and conductor 50 to electromagnet 14. The prongs will then continue to their maximum inward swing as represented by the line I and will draw lever 32 in the direction shown by the arrow, thus opening selector contacts 34 and 41 and closing contacts 33 and 40 preparatory to the next succeeding closure of the contact closer contacts 74 and 78 as the prongs and lever 32 again assume the rest position and cause energy to be applied to electromagnet 13 which draws the prongs apart. This action will continue as long as proper energy from source B is applied. It will be seen that when switch A is open and the prongs are at rest there will always be one set of contacts on the selector S in closed position and that when the actuating energy from source B is again applied, by closure of switch A, the first motion of the prongs 1 and 2 will be in the direction that would have followed their last motion, after the driving energy was withdrawn, had not said energy been withdrawn. It will thus be seen that the direction of motion of the prongs is not reversed by stoppage of the driving energy and that each excursion of the prongs will eventually be completed regardless of the number of interruptions, periods of rest and their duration occasioned by opening switch A. The contact closer contacts will remain in closed position whenever the prongs 1 and 2 are at rest and thus the operation of the fork may be started by merely closing the circuit at switch A.

Figure 8 shows a modification of circuit connections employing an eletromagnetic selector S^1, having a contact-carrying armature 36^a, electrically connected to lever 32, and actuated by means of electromagnets 92 and 93. Stationary contact 41^a is connected to selector magnet coil 93 and prong actuating magnet-coil 14 in such manner that as the driving current is momentarily applied to electromagnet 14 it will also pass through selector coil 93 and cause the armature 36^a to be drawn over into contact with contact 40^a in readiness for the next succeeding closure of the contact-closer contacts 74 and 78 at which time the energy will be applied to driving magnet 13 and selector magnet 92, armature 36^a will then be drawn back into contact with selector contact 41^a. This operation will continue as long as energy from source B is applied.

The motion of the prong 1 may be electrically conveyed to any desired mechanism by means of a set of contacts arranged on springs 94 (Figs. 1 and 2) in such manner that they will be opened and closed with each swing of the prong 1. These contacts are shown mounted on their carrying springs 94 which are securely held in brackets 95 and electrically insulated therefrom. When desired a set of these contacts may be actuated by each prong and two sets of mechanisms operated simultaneously and in synchronism. For this purpose two contact carrying studs 96 are provided affixed to plate

97. This plate is supported by base-plate 98 which is secured to base 6 by means of clamping plate 100, screw 99, and thumb-nut 101. A terminal block 102, of insulating material, may be secured to plate 97 for convenience of mounting terminal binding-posts 103 which are connected to contact springs 94.

A second set of circuit closing mechanisms similar to C, S, and S^1 (Figs. 1, 2, 5, 6, 7 and 8) may be operated by means of bracket 24^a and prong 1 for the purpose of electrically transmitting the vibrations of the fork T to any desired apparatus. Such an arrangement will also aid in maintaining symmetry of the mechanical action or balance of the tuning fork.

While I have shown but one set of driving magnets and one tuning fork driven thereby, it will be understood that a plurality of driving magnets may be used. It is to be further understood that any desirable number of tuning forks may also be operated in synchronism by means of one master driving fork as herein shown.

It will also be understood that the driving impulses conveyed to driving magnets 13 and 14 may also be used for such purposes as would the impulses obtained by means of a source of energy connected to springs 94, thus, in many cases, eliminating these springs and their associated contacts and supports and thereby simplifying the apparatus.

While I have illustrated one practical apparatus embodying my invention I do not wish to be limited to the exact details of construction so illustrated and described as changes may be resorted to without departing from the spirit and scope of my invention, as defined by the appended claims.

Having thus described the nature and objects of my invention, what I claim as new and desire to secure by Letters Patent is:—

1. The method of obtaining free vibrations in tuning-forks consisting in applying driving energy momentarily to the vibratory member only as said member passes its normal position of rest.

2. The method of obtaining free vibrations in electrically operated tuning-forks consisting in applying driving energy momentarily to the vibratory member only as said member passes its normal position of rest.

3. The method of obtaining vibrations undamped by the driving energy in tuning-forks consisting in applying driving energy to the vibratory member only as said member passes its normal position of rest.

4. The method of obtaining vibrations undamped by the driving energy in electrically driven tuning-forks consisting in applying driving energy to the vibratory member only as said member passes its normal position of rest.

5. The method of driving a tuning-fork consisting in supplying actuating energy to its vibratory members alternately to move them in opposite directions.

6. The method of driving an electrically operated tuning-fork consisting in supplying actuating energy to its vibratory members alternately to move them in opposite directions.

7. The method of driving an electrically operated tuning-fork consisting in supplying harmonic energy to its vibratory members alternately to move them in opposite directions.

8. The method of driving a tuning-fork consisting in alternately selecting each direction of motion of the vibratory members and applying actuating energy alternately to the selected members.

9. The method of driving a tuning-fork consisting in alternately selecting each direction of motion of the vibratory members and momentarily applying actuating energy alternately to the selected vibratory members as they pass through their normal position of rest.

10. In combination, a tuning-fork, a pair of driving electromagnets acting on said tuning fork, selector mechanism for alternately selecting a path through each of said electromagnets, a circuit closing device, and a source of energy.

11. In combination, a tuning-fork, a pair of driving electromagnets acting on said tuning fork, selector mechanism for alternately selecting a path through each of said electromagnets, circuit closing mechanism actuated by said tuning-fork, and a source of energy.

12. In combination, a tuning-fork, a pair of driving electromagnets acting on said tuning fork, selector mechanism actuated by said tuning-fork for alternately selecting a path through each of said electromagnets, circuit closing mechanism actuated by said tuning-fork, and a source of energy.

13. In combination, a tuning-fork, a pair of driving electromagnets acting on said tuning fork, electromagnetic selector mechanism alternately selecting a path through each of said electromagnets, circuit closing mechanism actuated by said tuning-fork, and a source of energy.

14. In combination, a tuning-fork, a pair of driving electromagnets acting on said tuning fork, circuit closing mechanism actuated by said tuning-fork, electromagnetic selector mechanism actuated by said circuit closing mechanism, and a source of energy.

15. In combination, a tuning-fork, a pair of driving electromagnets acting on said tuning fork, selector mechanism alternately selecting a path through each of said electromagnets, a circuit closing device

actuated by said tuning-fork, manually operated means for closing the main circuit, and a source of energy.

16. In combination, a tuning-fork, a pair of driving electromagnets acting on said tuning fork, selector mechanism alternately selecting a path through each of said electromagnets, a circuit closing device actuated by said tuning-fork, means for closing the main circuit, a source of energy, and means for electrically conveying the vibrations of said tuning-fork to remote apparatus.

17. A system for electrically operating a tuning-fork comprising a pair of driving magnets, means operated by said tuning-fork for momentarily closing the main circuit, means operated by said tuning-fork for alternately selecting a path through each of said pair of driving magnets, means for prematurely closing the main circuit, and a source of energy.

18. A system for electrically operating a tuning-fork comprising a pair of driving magnets independently connected, means operated by said tuning-fork for momentarily closing the main circuit, means operated by said tuning-fork for alternately selecting a path through each of said pair of driving magnets, a switch for closing the main circuit, and a source of energy.

19. A system for electrically operating a tuning-fork comprising a pair of driving magnets independently connected, means operated by said tuning-fork for momentarily closing the main circuit, electromagnetic means for alternately selecting a path through each of said pair of driving magnets, and a source of energy.

20. A system for electrically operating a tuning-fork comprising a pair of driving magnets independently connected, means operated by said tuning-fork for momentarily closing the main circuit, electromagnetic means operated by the driving energy for alternately selecting a path through each of said pair of driving magnets, and a source of energy.

21. In combination, a tuning-fork, a pair of electromagnets, one of said electromagnets arranged to force the vibratory members of said tuning-fork toward each other, and the other of said electromagnets arranged to force said vibratory members apart, means for applying harmonic actuating energy to said electromagnets, means for momentarily selecting the proper electromagnet to which energy is to be applied, and a source of energy.

22. In combination, a tuning-fork, a pair of electromagnets, one of said electromagnets arranged to force the vibratory members of said tuning-fork toward each other, and the other of said electromagnets arranged to force said vibratory members apart, means for alternately applying harmonic actuating energy to each of said electromagnets, and a source of energy.

23. In combination, a tuning fork, a pair of electromagnets, one of said electromagnets arranged to force the vibratory members of said tuning-fork toward each other, and the other of said electromagnets arranged to force said vibratory members apart, means for alternately applying harmonic actuating energy to each of said electromagnets only as said vibratory members pass through their normal position of rest, and a source of energy.

24. In combination, a tuning-fork, an electromagnet, means for applying harmonic actuating energy to said electromagnet for driving the vibratory member of said tuning-fork only as said vibratory member passes through its normal position of rest, and a source of energy.

25. In combination, a tuning-fork, an electromagnet, means for applying harmonic actuating energy to said electromagnet for driving the vibratory member of said tuning-fork only as said vibratory member passes through its normal position of rest, means for electrically conveying the vibrations of said tuning-fork to remote apparatus, and a source of energy.

In testimony whereof I have hereunto affixed my signature this twenty-fourth day of October 1921.

LLOYD M. KNOLL.