April 19, 1932. A. L. MATTE 1,854,267

TUNING FORK GENERATOR

Original Filed June 16, 1928

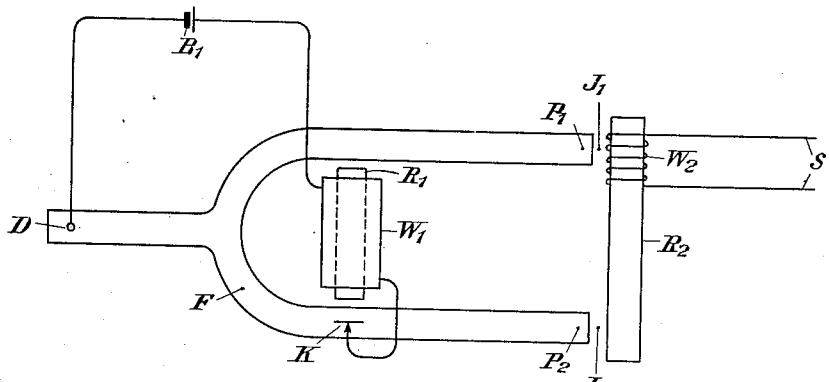



Fig. 1

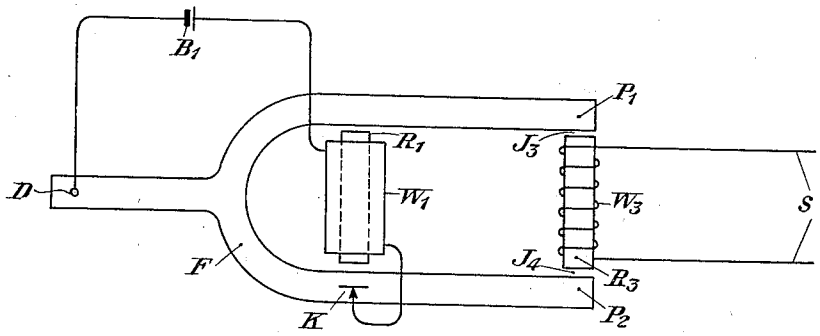



Fig. 2

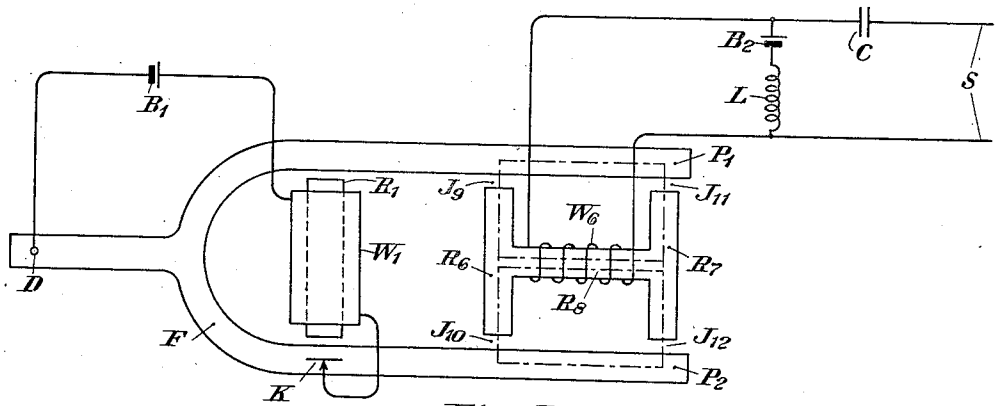



Fig. 3

INVENTOR
A. L. Matte

BY

ATTORNEY

Patented Apr. 19, 1932

1,854,267

# UNITED STATES PATENT OFFICE

ANDREW L. MATTE, OF SUMMIT, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK

## TUNING FORK GENERATOR

Original application filed June 16, 1928, Serial No. 286,042. Divided and this application filed May 15, 1930. Serial No. 452,641.

This invention relates to tuning forks and tuning fork generators, and more particularly to arrangements for producing current of the frequency of vibration of a tuning fork or of some harmonic of its frequency of vibration.

This is a division of a copending application, Serial Number 286,042, filed June 16, 1928.

In general, the vibration of a tuning fork may be made to generate an alternating current in two distinct ways. First, the vibration of the tuning fork may be made to change the reluctance of a magnetic path or circuit to thereby generate an electromotive force in a coil overwound on some portion of this magnetic path or circuit. Second, the flux of a magnetic path or circuit may remain virtually constant, yet the fork may be made to vibrate so that the change in the position of its tines or prongs may divert some of the flux from a number of turns of the coil in which an electromotive force is to be generated. The difference between these two methods will be readily apparent if one recalls that the electromotive force generated when a coil is threaded by a magnetic field is dependent upon the rate of change of the linkages formed by the turns of the coil and the enclosed lines of magnetic induction. Thus, an electromotive force may be produced either by changing the amount of flux enclosed by a given number of turns of wire or by changing the number of turns of wire enclosing a given number of lines of magnetic induction. The principles underlying the two methods enumerated hereinabove will be employed in connection with the invention to be subsequently described.

One of the primary objects of this invention is to generate an alternating current by the continuous action of a tuning fork, the tuning fork being electrically driven.

Another object of this invention is to prevent the electrical driving means of the tuning fork generating arrangement from affecting or interfering with the generating action.

While this invention will be pointed out with particularity in the appended claims, the invention itself, both as to its further objects and features will be better understood from the detailed description hereinafter following when read in connection with the accompanying drawings, in which Figure 1 shows how the number of effective turns of a coil of wire may be periodically changed; Fig. 2 shows how the flux threading a coil of wire may be periodically changed; and Fig. 3 shows another embodiment of an electrically driven tuning fork generator for rendering the effect of the driving flux substantially negligible in the circuit producing the generated current. Figs. 1 and 2 are included herein to show different types of electrically driven tuning fork generators. Fig. 3 shows the tuning fork generator which is claimed as novel in this divisional application.

Referring to Fig. 1 of the drawings, there is shown a tuning fork F having two tines or prongs $P_1$ and $P_2$. The tuning fork may be mounted very solidly on a rigid, heavy base which is supported on a soft, diffused bed such as may be provided by pads of rubber. This fork may be made, preferably, of ordinary soft steel although it will be clear that it may be made of any well-known alloy, particularly one which exhibits magnetic properties and which is easily maintained in mechanical vibration.

A coil of wire $W_1$ wound on a core of iron $R_1$ is placed between the tines or prongs $P_1$ and $P_2$ a considerable distance from the free ends of these tines or prongs. The current that may flow through the winding $W_1$ is supplied by a local source of direct current such as is designated as $B_1$. One terminal of the source $B_1$ is connected to a contact D, while the other terminal of this source is connected to the winding $W_1$. When the con-

tact K is closed, current will flow from the source $B_1$ through the winding $W_1$ and over the curved portion of the tuning fork F between contact K and the fixed contact D.

The tuning fork F may be started by pulling the prongs $P_1$ and $P_2$ together, i. e., inwardly. After being started, it is driven continuously, the energy for its continuous operation being supplied from the source $B_1$. The contact K provides a make-and-break circuit which periodically interrupts the direct current flowing from the source $B_1$. Thus, after the prongs $P_1$ and $P_2$ have been drawn together, the contact K will be opened so that no current may flow from the source $B_1$ through the winding $W_1$. As these prongs become released, soon the contact K will become closed and current will then flow from the source $B_1$ through winding $W_1$. Accordingly, that winding will become excited and its core will become threaded with a dense magnetic field. The prongs $P_1$ and $P_2$ will then be attracted, thereby opening the circuit including the source $B_1$ and the winding $W_1$ at the contact K. Later, contact K will be closed and another pulse of current will surge through the winding $W_1$ and the prongs $P_1$ and $P_2$ will be attracted, i. e., drawn inwardly again. And, so it continues.

Another core of magnetic material is placed adjacent to the free ends of the prongs $P_1$ and $P_2$, this core being so spaced from the free ends of these prongs that gaps $J_1$ and $J_2$, respectively, are established. A coil of wire $W_2$ is wound about a portion of the core $R_2$ adjacent to one of the prongs such as $P_1$. Coil $W_2$ has a plurality of turns of wire so spaced that the length of the coil in the direction of its axis is about equal to, and no greater than, the corresponding dimension of the adjacent prong $P_1$. The winding $W_2$ is connected to an output circuit S.

As the tuning fork F vibrates, a magnetic field is intermittently established by winding $W_1$, as has been explained hereinabove. A portion of its magnetic flux will flow through the rounded portion of the fork F (which is at the left of the winding $W_1$). Another portion of this magnetic field will flow over the prongs $P_1$ and $P_2$ and over the iron bar or core $R_2$. As the fork F vibrates, the magnetic field passing through the bar $R_2$ will intermittently cut more or less of the turns of wire of coil $W_2$. In other words, as the fork vibrates, the number of effective turns of the winding $W_2$ will be continuously changed and, consequently, an electromotive force of varying magnitude will be established across its terminals. Consequently, an alternating current may flow through the circuit S, the frequency of which will have a component equal to the frequency of vibration of the fork F. Even if the flux density through the core $R_2$ were to remain substantially constant as the fork F vibrates, an alternating current would be produced by virtue of the change in the number of effective turns of the coil of wire $W_2$ threaded by that flux.

Fig 2 shows a different arrangement embodying some of the principles of this invention, in which the flux density threading a coil of wire is varied while all of its turns remain in the path of the threading flux. In this arrangement, a core of iron $R_3$ is placed between the prongs $P_1$ and $P_2$ of the fork F so that gaps $J_3$ and $J_4$ are respectively established between prongs $P_1$ and $P_2$ and the ends of the core $R_3$. The driving circuit for maintaining the fork F in vibration after it is started is the same as has been described in connection with the arrangement of Fig. 1, similar reference characters designating similar parts.

As the fork vibrates, the size of the gaps $J_3$ and $J_4$ are intermittently changed so that the reluctance of the magnetic circuit, which is threaded by the flux produced by winding $W_1$ and which passes through the prongs $P_1$ and $P_2$, is similarly changed. When prongs $P_1$ and $P_2$ are at their extreme outer positions, i. e., when prongs $P_1$ and $P_2$ are the greatest distance apart, the reluctance of the magnetic path is a maximum. On the other hand, when these prongs are at their extreme inner positions, i. e., when these prongs are at their least distance apart, the reluctance of the magnetic path is a minimum. Since the winding $W_3$ is in the path of a periodically varying magnetic flux, the voltage across the terminals of winding $W_3$ will also vary periodically, this voltage changing from a maximum positive value to a maximum negative value. Accordingly, an alternating current may flow through the circuit S which is connected to the winding $W_3$. In this arrangement, it will be apparent that while the effective number of turns of the coil $W_3$ remains constant, an alternating current may be produced by virtue of the periodical change of the reluctance of the magnetic circuit threading the winding or coil $W_3$.

In both Figs 1 and 2, it will be apparent that the wave shape of the generated electromotive force is influenced by the driving flux. The invention defined by the attached claims provides means for obviating this effect.

Fig. 3 shows another electrically driven tuning fork arrangement for deriving alternating current from the associated continuously vibrating tuning fork, this arrangement involving a Wheatstone bridge of a magnetic type. Here the core or cores associated with the generating coil are so arranged as to effectively form a magnetic Wheatstone bridge, the generating coil being placed in one of the diagonals of the bridge and the electrical driving apparatus in the other diagonal. Accordingly, the flux

produced by the electrical driving apparatus is prevented from interfering with the action of the generating coil.

The magnetic apparatus placed between the prongs $P_1$ and $P_2$ of fork F is in the form of a flattened spool, the bases of which are formed by bars $R_6$ and $R_7$ and the connecting cross-piece of which is a bar $R_8$, all of these bars being made of magnetic material. The cross-piece $R_8$ is shown midway between bars $R_6$ and $R_7$. Gaps $J_9$ and $J_{10}$ extend between prongs $P_1$ and $P_2$, respectively, and bar $R_6$, and gaps $J_{11}$ and $J_{12}$ extend between these prongs, respectively, and bar $R_7$. A winding $W_6$ is wound upon the connecting bar $R_8$, this winding being supplied with energizing current from a battery $B_2$ which is connected in series relationship with choke coil L. Choke coil L prevents generated alternating currents from passing through battery $B_2$, while condenser C prevents the current of battery $B_2$ from flowing through the output circuit S. The apparatus employed herein for maintaining the tuning fork in continuous vibration after it is started is the same as has been employed in connection with the arrangement of Fig. 1, the same parts being designated by the same reference characters.

A portion of the magnetic flux derived from winding $W_1$ flows through bar $R_6$ and another portion of this flux flows through bar $R_7$. Assuming that gaps $J_9$ and $J_{10}$ adjacent to bar $R_6$ are substantially equal and that gaps $J_{11}$ and $J_{12}$ adjacent to bar $R_7$ are also substantially equal, then more flux may, perhaps, thread bar $R_6$ than $R_7$. But since bar $R_8$ is interposed between the midpoints of bars $R_6$ and $R_7$, the ends of bar $R_8$ will be at substantially equal magnetic potentials so that substantially no flux produced by winding $W_1$ may flow therethrough. Accordingly, none of the flux derived from winding $W_1$ will thread bar $R_8$ and, consequently, no electromotive forces will be established at the terminals of winding $W_6$ by virtue of the flux from winding $W_1$. In other words, the action of the winding $W_6$ in the production of electromotive forces will be substantially unaffected by the driving mechanism and circuit.

It will be understood that while the terminals of bar $R_8$ are shown in a position midway between the terminals of bars $R_6$ and $R_7$, respectively, bar $R_8$ need not be so placed, for it may be placed in any position with respect to bars $R_6$ and $R_7$ so that its terminals are at substantially equal magnetic potentials.

As the prongs $P_1$ and $P_2$ of the fork F vibrate, gaps $J_9$ and $J_{10}$ as well as gaps $J_{11}$ and $J_{12}$ will be periodically changed in length so that the reluctance of the magnetic path followed by the flux arising from the flow of current from battery $B_2$ through choke coil L and through winding $W_6$ will be similarly changed. Accordingly, periodical electromotive forces will be generated by winding $W_6$ and these periodical electromotive forces will result in an alternating current of corresponding frequency which will become transmitted through condenser C and the output circuit S.

While this invention has been shown in certain particular embodiments merely for the purpose of illustration, it will be understood that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. The combination of a tuning fork, means for driving the tuning fork, and means independent of the driving means for generating current always having the natural frequency of vibration of the tuning fork, said means including a coil of wire having an iron core which is midway between and parallel to the prongs of the fork.

2. The combination of a tuning fork, a solenoid for generating current always of the natural frequency of vibration of said tuning fork, the axis of the core of said solenoid being parallel to and midway between the prongs of said fork, and means including an electromagnetic structure independent of the solenoid for driving said fork, said electromagnetic structure and said solenoid being effectively perpendicular to each other and so spaced that said solenoid will be substantially free from the distorting effect of the flux of said electromagnetic structure.

3. In an electrically driven tuning fork arrangement provided with a single generator coil for producing current always having a frequency equal to the natural frequency of vibration of the tuning fork, means for preventing the driving flux from distorting the wave shape of the generated current, said means consisting of an I-shaped soft iron core the stem of which supports the generator coil and lies parallel to the prongs of the tuning fork.

4. The combination of a tuning fork, electromagnetic means for driving the tuning fork, and means independent of the driving means for generating current always having the natural frequency of vibration of the tuning fork, said generating means including a coil of wire wound on a core associated with points in the flux paths of the driving means which are at the same magnetic potential with respect to said flux from said driving means.

5. The combination of a tuning fork, electromagnetic means for driving the tuning fork, and means independent of the driving means for generating current always having the natural frequency of vibration of the tuning fork, said generating means in-

cluding a magnetic system having parallel magnetic paths for the passage of flux from said driving means and a core for a generating coil associated with points in said parallel paths which are of the same magnetic potential with respect to the driving flux in said paths.

In testimony whereof, I have signed my name to this specification this 13th day of May, 1930.

ANDREW L. MATTE.