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TUNING FORK GENERATOR

Original Filed June 16, 1928

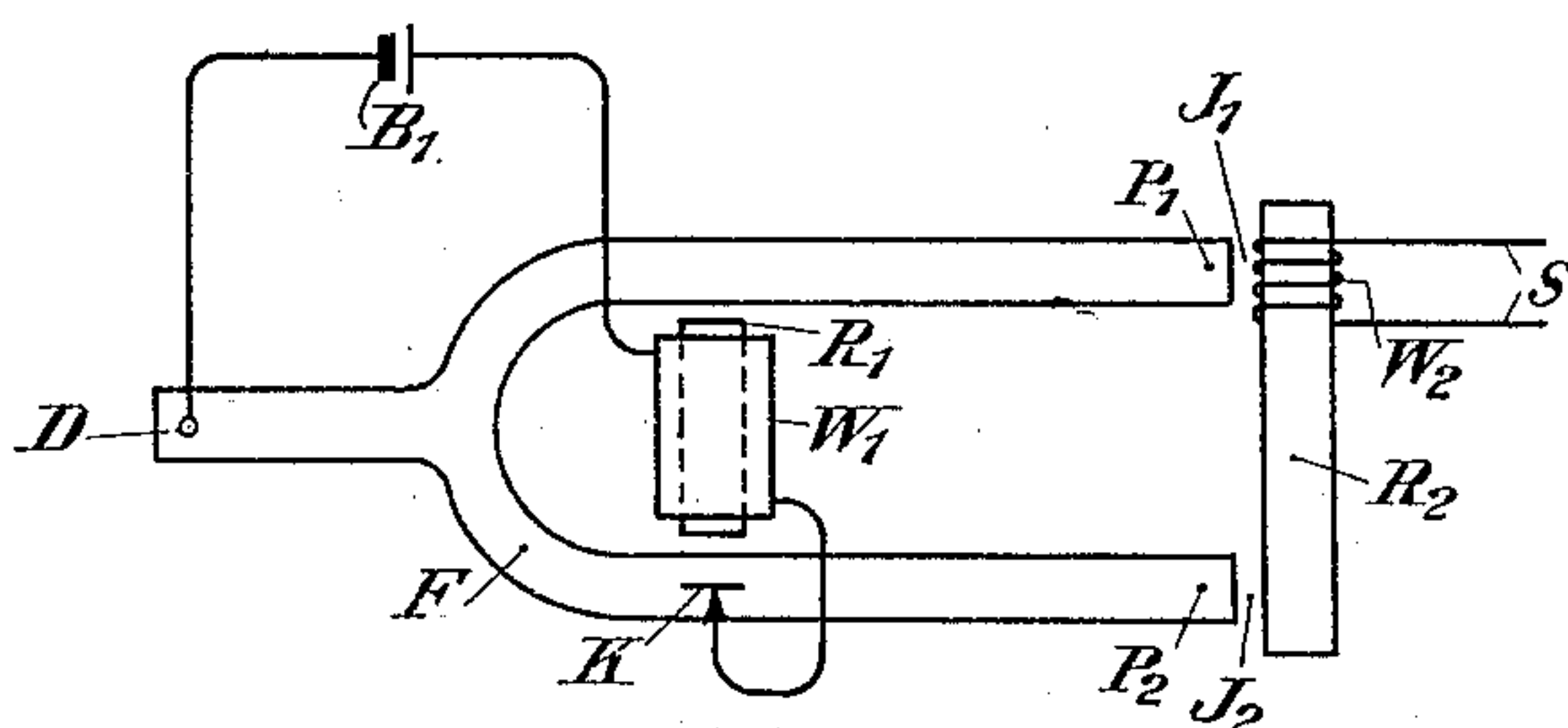


Fig. 1

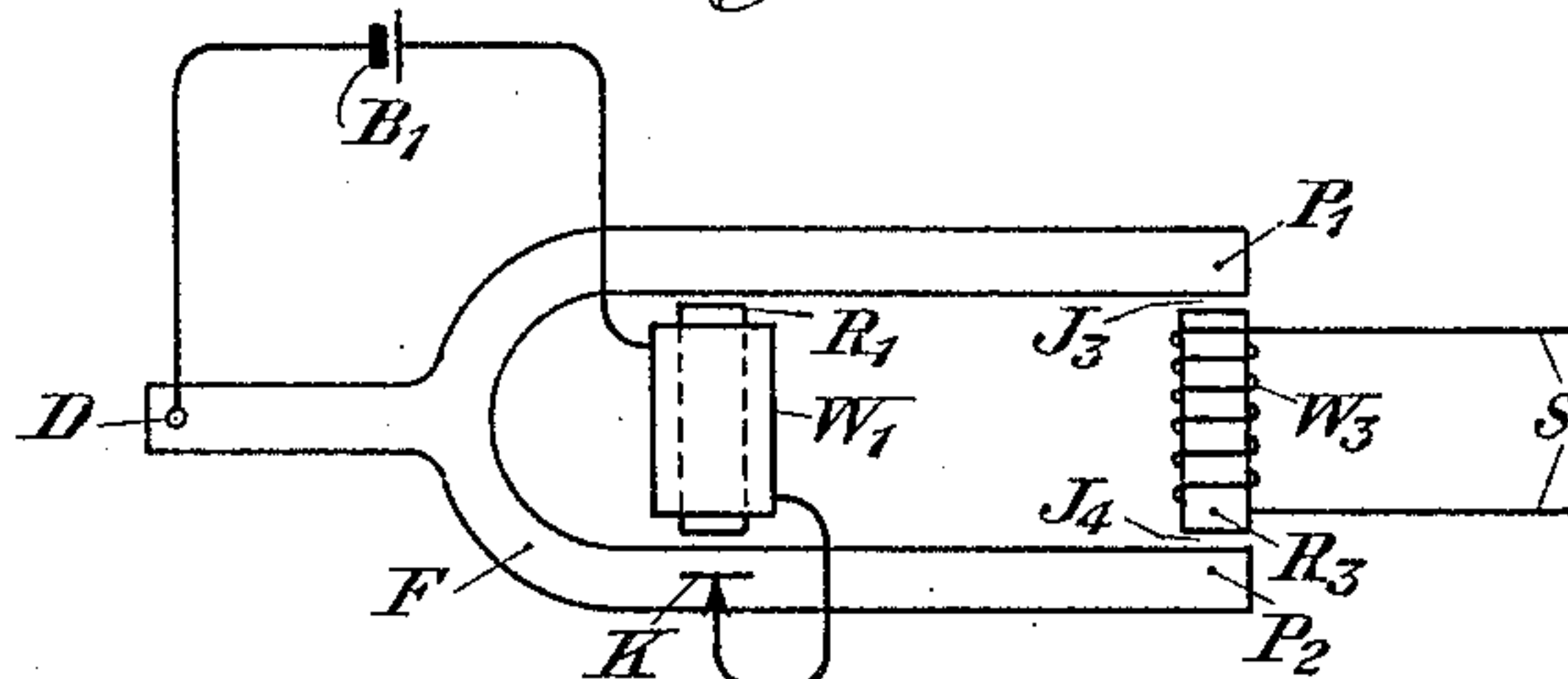


Fig. 2

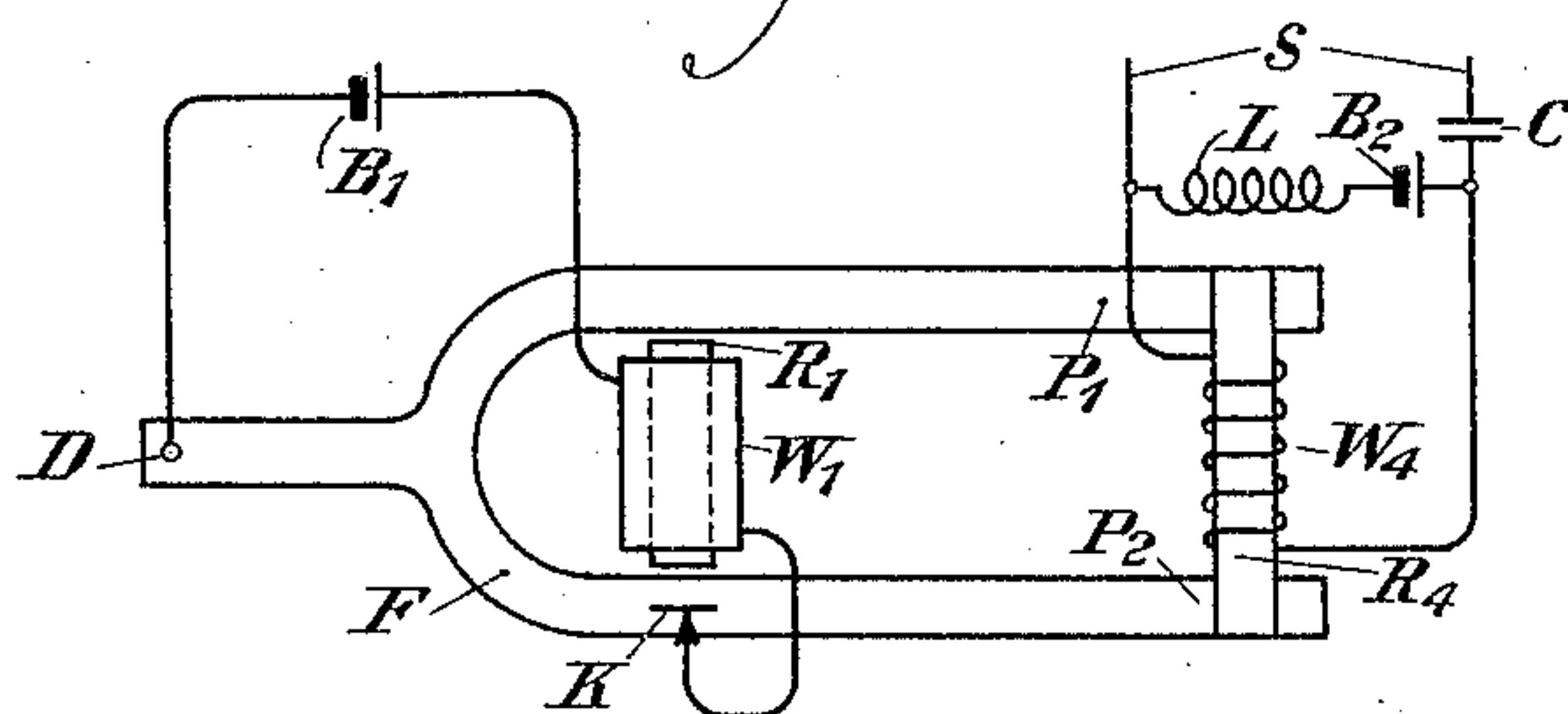


Fig. 3

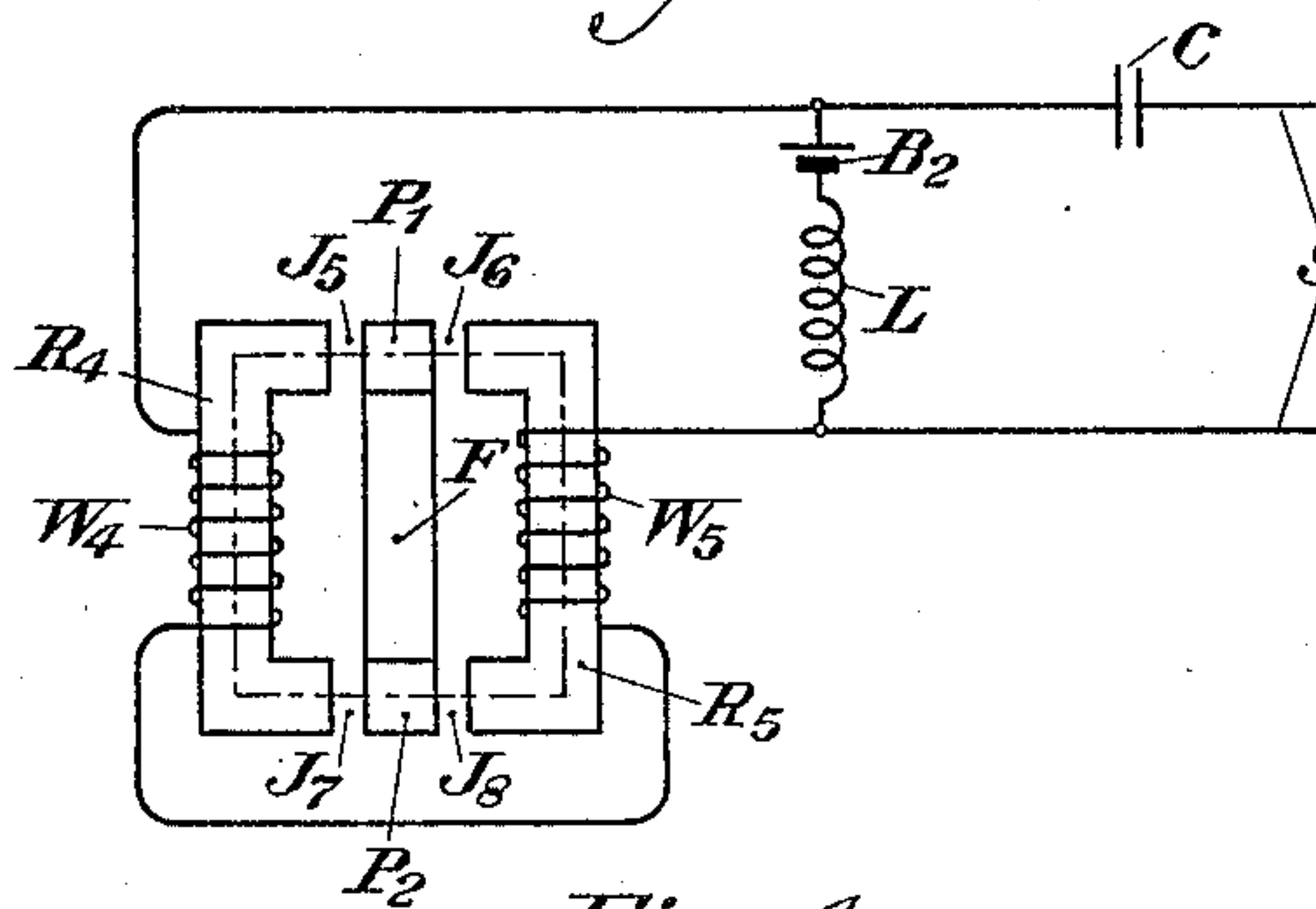


Fig. 4

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TUNING FORK GENERATOR

Original application filed June 16, 1928, Serial No. 286,042. Divided and this application filed May 15, 1930. Serial No. 452,642.

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 No. 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 drawing, 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 Figs. 3 and 4 show how to produce an alternating current from a tuning fork energized from a local source, so arranged that the driving flux may have substantially no effect upon the circuit in which the current is generated.

Referring to Fig. 1 of the drawing, 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 magnetic alloy.

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 away 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 contact 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 dimensions 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 . An alternating current is thus produced by virtue of the continuous change in the number of effective turns of the coil of wire W_2 even though the flux through the core R_2 were to remain constant.

In the usual arrangement for generating an electromotive force by a tuning fork, the flux threading a coil of wire is variable while all of its turns remain in the path of the threading flux. This is illustrated in Fig. 2. 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 is intermittently changed so that the reluctance of the magnetic circuit, which is treaded 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 the arrangements of Figs. 1 and 2 it will be evident that the wave shape of the electromotive forces produced in windings W_2 and W_3 , respectively, are conditioned not only upon the vibration of the fork, but to an equal extent upon the variations of the driving current in winding W_1 . Figs. 3 and 4 represent a top view and an end view, respectively, of an electrically driven tuning fork arrangement for producing an alternating current by virtue of the vibration of the associated tuning fork. In this arrangement, the flux produced by the electrical driving apparatus is divided and split up into two substantially equal parts which are made to oppose and neutralize each other in the generator windings, thereby preventing the fluxes produced by the winding W_1 of the electrical driving apparatus from affecting the current generating action as will be apparent from the following description. This represents one of the important features of this invention.

The circuit arrangement for maintaining the tuning fork in continuous vibration after it is started, is shown in Fig. 3 in which reference characters similar to those of Fig. 1 have been employed to designate similar parts. The arrangement disclosed by Figs. 3 and 4 is designed to minimize the effect

that the flux established by winding W_1 may have upon the nature of the current generated by the system and flowing through the output circuit S , as suggested herein-
 5 above. Here, two similar yokes of magnetic material R_4 and R_5 are placed adjacent to the prongs P_1 and P_2 of the fork F . The yokes R_4 and R_5 are so placed with respect to the prongs P_1 and P_2 that gaps J_5 and J_6
 10 are established between these yokes and prong P_1 , and gaps J_7 and J_8 are similarly established between these yokes and prong P_2 . The free ends of the prongs P_1 and P_2 will periodically alter the cross-section and
 15 mean length of the effective magnetic path designated in Fig. 4 by the dot-and-dash line, thereby periodically changing the reluctance of this magnetic path.

Coils W_4 and W_5 are wound, respectively,
 20 on yokes R_4 and R_5 and are connected in series relationship. A battery B_2 , connected in series relationship with a choke coil L , supplies current to the windings W_4 and W_5 for their energization, the choke coil L being
 25 interposed so as to prevent the alternating current generated by the system from becoming shunted through the battery B_2 . A condenser C , preferably of large capacity, is connected in series with the output cir-
 30 cuit S in order that none of the direct current from battery B_2 may reach output circuit S , this condenser, nevertheless, permitting the alternating current generated in windings W_4 and W_5 to readily flow there-
 35 through.

As the fork F vibrates, the reluctance of the magnetic path, including yokes R_4 and R_5 and gaps J_5 , J_6 , J_7 and J_8 becomes periodically changed, as has been stated herein-
 40 above. Accordingly, electromotive forces are generated in windings W_4 and W_5 . Since these windings are series aiding, the electromotive forces generated thereby will be additive in effect and will result in the
 45 transmission of a current of corresponding frequency through condenser C to the output circuit S . Very little of this current can be shunted through the circuit of battery B_2 by virtue of the presence of the
 50 choke coil L .

The magnetic circuit established by the driving apparatus, i. e., that magnetic circuit produced by winding W_1 shown in Fig. 3, will be substantially without effect upon the
 55 voltages generated by windings W_4 and W_5 and therefore without effect upon the wave shape of the corresponding current transmitted through the output circuit S . The magnetic field established by winding W_1
 60 which flows through the prongs P_1 and P_2 also divides between the yokes R_4 and R_5 . By making the reluctance of these two magnetic paths equal, the magnetic field established by winding W_1 will pass through
 65 these yokes in equal amounts. In other

words, the fluxes in the yokes R_4 and R_5 due to the magnetic field established by winding W_1 are substantially equal and the directions of the fluxes through yokes R_4 and R_5 are in mutually opposite directions. Accord-
 70 ingly, these fluxes will tend to produce mutually neutralizing electromotive forces and hence be substantially without effect upon the generation of the electromotive forces
 75 impressed upon 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 in-
 80 vention 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 two U-shaped cores
 85 of iron, the ends of which face each other, a tuning fork placed so that each prong will be between the adjacent ends of both of said U-shaped cores, each prong of the tuning
 90 fork being spaced by equal gaps from the adjacent ends of both said U-shaped cores, two coils of wire wound on said U-shaped
 95 cores and arranged in series relationship so that their magnetic effects which produce alternating currents will be additive, and
 100 means for producing a driving flux for said tuning fork which threads said U-shaped cores equally in order that the effect of said flux will be negligible.

2. The combination of a tuning fork,
 105 means for driving the tuning fork, two electromagnets having U-shaped cores of iron positioned on opposite sides of the two planar surfaces bounding the faces of the
 110 fork, each end of each U-shaped core being closely adjacent to one of the prongs of the fork, each end of each U-shaped core being spaced from the corresponding prong by a
 115 small gap, all of said gaps being substantially equal, and a source of direct current connected in series with the windings of said
 120 electromagnets.

3. The combination of a tuning fork,
 125 means for producing a flux for driving the fork, two U-shaped iron cores on opposite sides of the prongs of said fork each having a coil of wire wound thereon, the ends of
 130 each U-shaped iron core being separated from both prongs by equal gaps, said U-shaped iron cores being equally threaded by the driving flux, and a source of direct current connected in a circuit in series with the
 135 coils of wire wound on said U-shaped iron cores.

4. Electrical generating apparatus com-
 140 prising the combination of a tuning fork, a core of iron having a coil of wire wound thereon which is positioned between the prongs of the fork, the axis of said core being
 145 perpendicular to the prongs of the fork,

a source of direct current, and two similarly shaped iron bars both equally spaced from the ends of both of the prongs of the fork and parallel to the core upon which said coil is wound, each of said iron bars also having a coil of wire wound thereon which is energized by said source of direct current.

5. The combination of a tuning fork, means for producing a flux for driving said tuning fork, two similarly shaped bars of iron both equally spaced from the ends of both prongs of the tuning fork, each bar of iron having a coil of wire wound thereon, equal portions of the driving flux passing through the bars of iron upon which the coils are wound, and means for supplying direct current to said coils of wire.

6. The combination of two U-shaped cores of iron the ends of which face each other, a tuning fork placed so that both of its prongs will be adjacent to both ends of each of said U-shaped cores, each prong of the tuning fork being spaced from and between the corresponding ends of both U-shaped cores by equal gaps, means for driving the tuning fork, a source of direct current, and coils of wire wound about said cores of iron and connected in series relationship with respect to said source of direct current.

7. In an electrically driven tuning fork generator, means for preventing the driving flux from affecting the wave shape of the generated current, said means comprising two separately excited generator coils mounted on individual cores, said cores being so disposed as to cause the interfering flux to divide into two equal amounts which thread them in mutually opposite directions.

8. In an electrically driven tuning fork generator having a driving magnet and a separately excited generator arrangement including two separate cores, means to prevent the driving flux from affecting the wave shape of the generated current, said means consisting of means for causing the driving flux to separate into two parallel paths formed by the two generator cores, the component fluxes of the driving flux setting up equal and mutually opposite electromotive forces in said generator cores.

9. In an electrically driven tuning fork having separately excited generator windings, two cores upon which the generator windings are wound, said cores forming parallel opposing paths for the stray magnetic field emanating from the driving means of the tuning fork and forming series-aiding paths with respect to the generator flux.

10. In a tuning fork generator driven by a magnet, the combination of an iron core bridged from one of the tines of the fork to the other and separated from these tines by air-gaps, a second iron core similarly bridged from one of the tines of the fork

to the other and similarly separated therefrom by air-gaps, each of said iron cores diverting some of the driving flux there-through, a winding mounted on each of said iron cores, each winding having a number of turns such that the electromotive force caused by the driving flux passing through one of the iron cores will equal the electromotive force caused by the driving flux passing through the other iron core, a source of direct current, said windings being connected in series with each other and with said source of direct current so as to produce a second flux which results in the generation of an alternating current as the second flux is varied by the motion of the tuning fork.

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

ANDREW L. MATTE.