

July 16, 1935.

S. B. SMITH ET AL

2,008,263

FREQUENCY CONTROL MEANS

Filed Nov. 1, 1932

Fig. 1

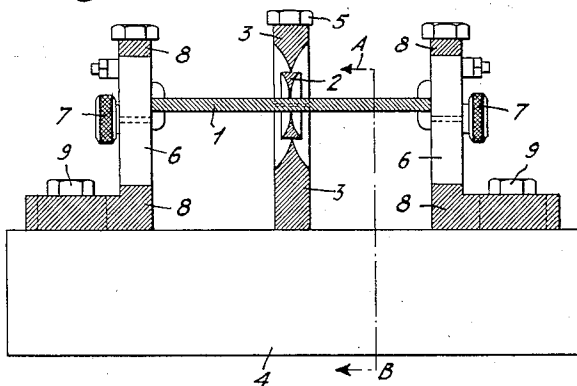


Fig. 3

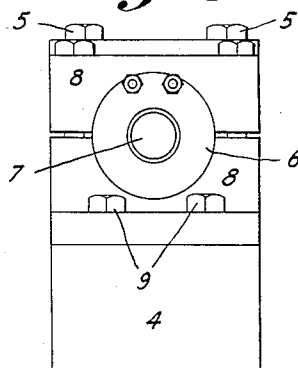


Fig. 2

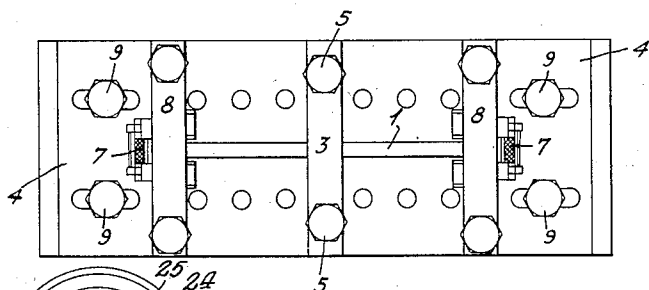


Fig. 4

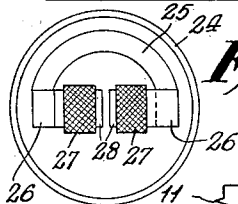
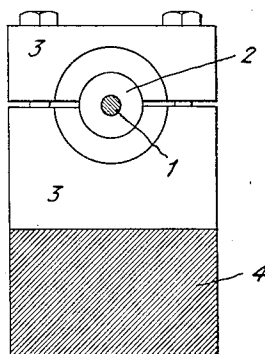
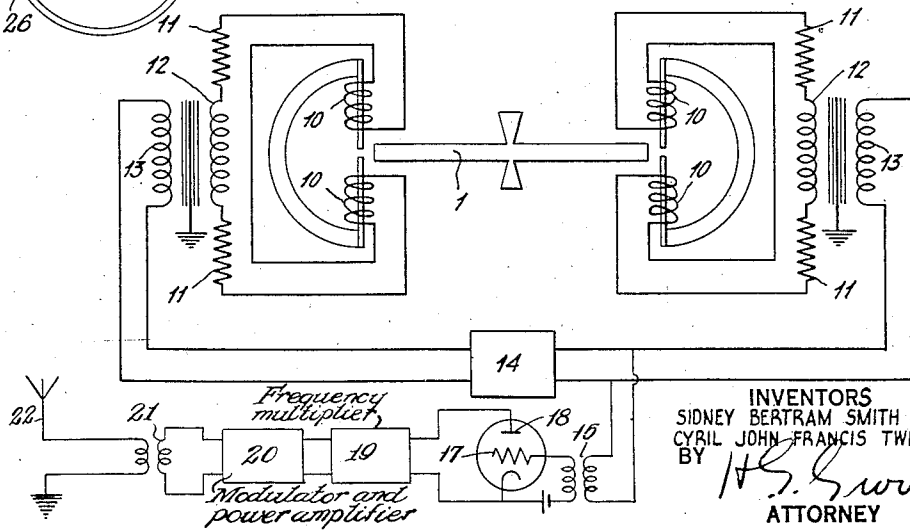


Fig. 6

Fig. 5



INVENTORS
SIDNEY BERTRAM SMITH
CYRIL JOHN FRANCIS TWEED
BY *H. S. Swer*
ATTORNEY

UNITED STATES PATENT OFFICE

2,008,263

FREQUENCY CONTROL MEANS

Sidney Bertram Smith, Chelmsford, and Cyril
John Francis Tweed, Wimbledon Park, London,
England, assignors to Radio Corporation of
America, a corporation of Delaware

Application November 1, 1932, Serial No. 640,648
In Great Britain November 11, 1931

8 Claims. (Cl. 171—327)

This invention relates to improvements in constant frequency periodic devices for use in connection with electrical high frequency oscillators, radio transmitters, and the like.

It is commonly required, for example, in connection with a wireless transmitting station, to provide a substantially constant frequency "master" periodic device to control the frequency of oscillations generated, for example, to maintain a wireless transmitter accurately at a predetermined allotted wave length, and various resonant oscillatory devices have been employed for this and similar purposes.

Inter alia, piezo-electric crystals, magneto-strictive oscillators and tuning forks have been proposed as master constant frequency devices for frequency control and, although these devices are generally satisfactory, each presents practical disadvantages on the score of convenience or cheapness.

Purely mechanical periodic devices, i. e. devices of the tuning fork or vibratory rod type, are very satisfactory from the practical point of view, but devices of this kind as hitherto constructed have presented the disadvantage that it is difficult, if not impossible, to design them to vibrate at frequencies much higher than about 1000 cycles per second, and to work satisfactorily as maintained vibrators at frequencies much above this value. Of course, for the majority of purposes of the type in question a frequency of 1000 cycles per second is too low and it has therefore been generally rendered necessary in the past to employ such purely mechanical vibratory devices in association with frequency multipliers whereby the frequency actually obtained by the periodic device is greatly multiplied; for example, where a frequency of 10^7 cycles per second is required (a by no means unusual requirement) a very considerable degree of frequency multiplication must be employed to derive this frequency from a mechanical vibratory device vibrating at 1000 cycles per second. The provision of frequency multiplying arrangements capable of performing satisfactorily so high a degree of multiplication involves considerable expense and moreover such frequency multipliers are difficult to design owing to the tendency for the final multiplied frequency to contain modulation components of the original frequency and/or intermediate frequencies derived in the process of multiplication. Considerable practical advantage would be obtained if the initial frequency could be raised by a substantial amount, and the present invention has for its object to provide a purely me-

chanical vibratory device suitable for use as a master frequency control device whereby frequencies of the order of 20,000 cycles per second can be directly obtained. It is to be understood that the term "purely mechanical vibratory device" in the present specification is employed in contradistinction to devices of the piezo-electric or magneto-strictive type; i. e. a purely mechanical vibratory device is a device which, although it may be electrically or magnetically maintained in vibration, is considered purely as a vibrator, a mechanical device in the sense in which a tuning fork is a mechanical device.

According to this invention a mechanical vibratory device suitable for use as a constant frequency master control device consists of a vibratory rod supported as nearly as possible solely at a nodal point or points in such manner that substantially no transference of energy takes place between the vibratory rod and the supporting means. It will, of course, be appreciated that it is theoretically impossible to support a vibratory member exactly and exclusively at a nodal point since the supporting means must have some area and a nodal point theoretically has, of course, no area.

The present invention, however, envisages supporting the vibratory rod by supporting means of the knife edge type arranged as accurately as possible at a nodal point in the length of the vibratory rod.

It has been found that transference of energy between the vibrator and its supporting means has been one of the principal causes hitherto militating against satisfactory operation of mechanical vibratory devices at the higher frequencies, the supporting means adversely affecting the constancy of the frequency of vibration.

The invention is illustrated in the accompanying drawing which shows one arrangement in accordance therewith. In the drawing Figure 1 is a sectional elevation and Figure 2 a plan view of a mechanical vibratory device in accordance with this invention, Figure 3 being an end view of the device shown in Figure 1, and Figure 4 a section taken on the line A—B of Figure 1. Figure 5 is a diagrammatic representation of the vibrator arrangement shown in Figures 1 to 4, Figure 5 showing the said arrangement in association with its cooperating electrical circuits. Figure 6 is a detail of a telephone receiver ear piece which may be used as one of the elements in the system.

Referring to the drawing, a vibratory device consists of a rod 1 of circular section $\frac{1}{8}$ th of an

inch in diameter and $4\frac{1}{8}$ th of an inch long. It is to be understood that the dimensions given in the present example are only by way of guidance and exemplification, the said dimensions relating to an embodiment capable of producing directly a frequency of about 20 kilocycles. This rod, which is made of magnetic material or is fitted with end pieces of magnetic material is arranged to vibrate as a free ended vibrator, i. e., it is supported at its middle point so that each half of the rod is free to move, the middle point being a node and the ends of the rod being antinodes each remote from the node by a distance of a quarter of the working wave length of mechanical vibration. The central supporting means is of the knife edge type and consists of an annulus 2 whose inner curved surface is as nearly as possible a line; i. e., the section of the annulus is of knife edge shape. The width of the annulus at its outer curved surface may conveniently be a quarter of an inch, the said annulus being thickened up symmetrically and smoothly as shown from its inner, knife-like, edge to a cylindrical edge. This annular supporting member is itself supported by a second or outer circular knife edge 3, the said knife edge engaging with the flat outer curved surface of the first supporting annulus along the center line thereof. The outer supporting means are carried upon a rigid heavy base member 4, for example, by means of a construction as shown. In this support the outer circular knife edge supporting means is split, the upper half constituting the upper member of the construction and the lower half constituting the lower member, the two members being clamped together by bolts 5 as shown. The rod 1 is included in two independent magnetic circuits, each end of the rod or the magnetic piece fitted thereto completing one magnetic circuit through air gaps. Each of these magnetic circuits includes, besides the appropriate end of the rod, the magnetic circuit of a device 6 constructed generally similarly to the well-known reed driven telephone ear pieces, the appropriate end of the rod being arranged (in place of the ear piece diaphragm) adjacent the gap in the magnetic circuit (see Figure 3). Figure 6 shows an ear piece of a well known telephone receiver which may comprise the device 6. In Figure 6 there is shown a horseshoe permanent magnet 25 having laminated pole pieces 26 attached to these poles. Coils 27 are placed on the pole pieces and the arrangement is such that the end of the bar 1 of the figures is brought over the pole tips 28. The telephone fitting in its case 24 is affixed to the blocks as described. More in detail, the device 6 may include a core and a pair of windings therein which set up a field in which the end of said rod is positioned for vibration as shown more in detail in Figure 5. These adapted telephone ear pieces 6, which are provided with adjustment means, indicated at 7, to adjust the width of the air gap are carried upon the base member by block like constructions indicated at 8 in Figures 1, 2 and 3. Each adapted telephone ear piece is clamped between clamping members, the lower halves of the clamping members being bolted to the base member by bolts 9. Very little alteration of an ordinary reed-driven ear piece is necessary to adapt it for the purpose of the present invention, this alteration consisting principally in the removal of the diaphragm (which is in effect replaced by the appropriate end of the rod) and the modification of the pole pieces and magnetic circuit generally to suit the high frequencies which

are to be handled. The free length of the base member between the clamp device by which the adapted ear pieces are carried is made to be exactly the same as the length of the rod and the various parts are accurately manufactured and assembled so that as nearly as possible perfect symmetry is obtained about a line perpendicular to the base member and passing through the nodal point.

The maintaining or driving circuit employed is similar to that ordinarily employed for tuning fork maintenance. As shown in Figure 5 the two coils 10 of each ear piece 6 of Figure 1 are connected to one another through a loop circuit consisting of a pair of similar resistances 11 and the primary winding 12 of a transformer in series, i. e., one end of one coil is connected through one of the resistances, the transformer primary, and the other resistance in series, to one end of the other coil, the second end of the second coil being directly connected to the second end of the first. Similar circuits are employed for both adapted ear pieces 6 and the two secondaries 13 of the two transformers are connected to the terminals of a variable gain amplifier 14 as shown. The rod 1 is mounted at a nodal point on knife-edge supports as shown in Figure 1 and indicated diagrammatically by the wedge-shaped locks on the rod 1 of Figure 5. The field produced by the winding 10 acts on the rod 1, which is of magnetic material or carries a piece of magnetic material, to produce mechanical vibrations of the same at a frequency determined by the length, size, etc., of the rod 1. These mechanical vibrations of the rod 1 in turn produce changes in the air gap and in the impedance of the transformer circuit. The electrical variations produced are amplified and applied to the field to reinforce the vibrations. Sustained oscillations of constant frequency and amplitude are produced which may be utilized in any known manner. In the particular construction described the air gaps between the adapted ear pieces and the free ends of the rod may conveniently be from 10 to 15 mils.

Any suitable utilization circuit such as a transformer similar to 12 and 13 may be connected to the output of amplifier 14 in parallel relationship to the coil 13. This utilization circuit may then, if desired, be connected in the control circuit of an amplifier or frequency multiplier. Figure 5 merely shows by way of exemplification such a suitable circuit. The output of the variable gain amplifier 14 is connected to a transformer 15, the secondary of which is connected in the grid circuit 17 of a three electrode valve of which the anode 18 is connected to a frequency multiplier 19. This is connected through a modulator and power amplifier 20 to an aerial 22 through a coupling coil 21.

It has been found that the arrangement above described is capable of directly producing a frequency of about 20 kilocycles per second and it will be noted that despite the care which must be exercised in manufacture, the apparatus is relatively inexpensive to produce, the rod being turned from the solid and being much cheaper to produce than would an ordinary tuning fork which requires very careful machining and balancing. It will further be noted that by reason of the method employed for supporting the rod, there will not occur any serious losses despite slight lack of symmetry while the magnetic driving arrangements are very simple and well adapted to maintain comparatively high fre-

quency oscillations in a stable and constant manner.

It is obviously possible to drive the rod in other than electromagnetically.

5 Having thus described our invention and the operation thereof, what we claim is:

10 1. A constant frequency periodic device comprising supporting means for a cylindrical vibratory rod, said supporting means including an annular knife edge device having a circular knife edge engaging the rod and a second knife edge device supporting such first mentioned knife edge device and engaging the outer periphery thereof.

15 2. An arrangement as claimed in claim 1 and in which the second knife edge device is formed in two parts with means to clamp the parts together, the first knife edge device being clamped between the two parts of the second knife edge device.

20 3. An arrangement as recited in claim 1 in which the free ends of the vibratory rod cooperate with driving means therefor which are carried from a relatively heavy base plate from which the supporting means for the rod are also carried.

25 4. Means for producing oscillations of a constant frequency comprising, a mechanical vibratory device consisting of a vibratory rod supported by an annular knife-edged device at a point intermediate its ends which are free for vibration, the ends of said rod being of magnetic material, said annular knife edge device engaging said rod around the outer surface thereof, each end being located in the field of a magnetic circuit, and each of said circuits including field producing windings coupled together by way of an amplifier.

5. A constant frequency periodic device comprising a base member, a support thereon including a pair of annular knife-edged devices, one within the other, a cylindrical vibratory rod mounted intermediate its ends within said inner knife-edged device, an additional support mounted on said base member at each end of said vibratory rod, and an electro-mechanical means carried by each of said last named supports adjacent the ends of said rod.

6. A device as recited in claim 5 in which said electro-mechanical means are coupled together by way of an oscillatory energy amplifier.

7. A device as recited in claim 5 in which each of said electro-mechanical devices comprises a core member, energizing windings mounted thereon, and in which said windings are connected to the winding of a transformer and in which said transformers are coupled together through the intermediary of another winding of each of said transformers and by way of an amplifier.

8. An arrangement for producing oscillations of a constant frequency comprising a vibratory rod having a length equal to one-half the working wave length of mechanical vibration, a support for said rod at its middle point comprising a knife-like edge, said middle point being a node of vibration, and an electrical field circuit comprising a coil located at one end of said rod, said coil being coupled to the other end of said rod, the mechanical vibrations of said rod being arranged to produce changes in the impedance of said field circuit, whereby said coil is responsive to the vibrations of the rod for driving same to sustain vibratory motion.

SIDNEY BERTRAM SMITH.
CYRIL JOHN FRANCIS TWEED.