

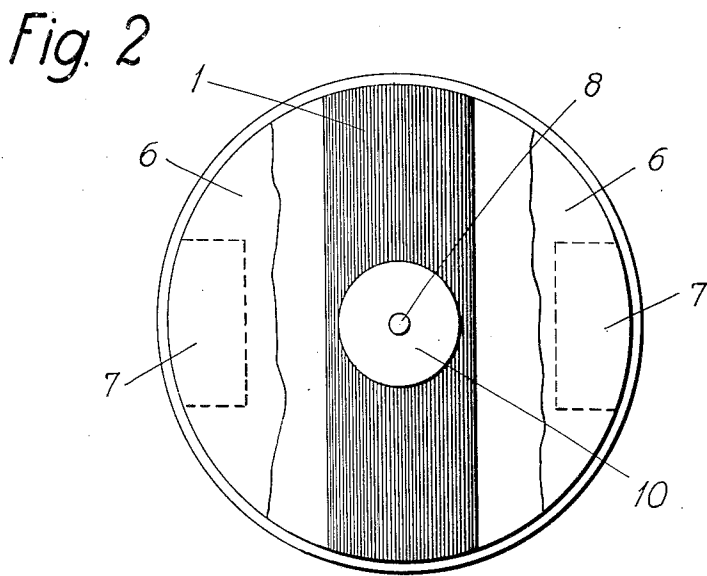
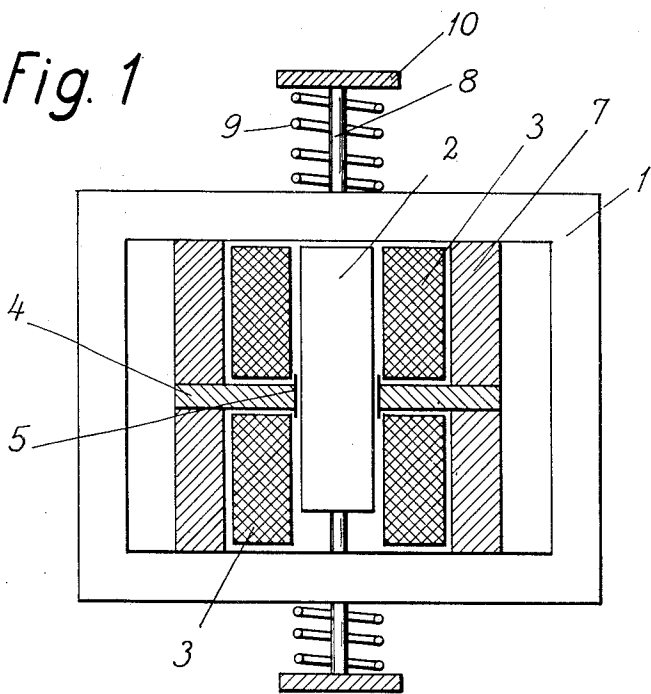
Oct. 30, 1956

T. P. KRISTIANSEN
ELECTROMAGNETIC VIBRATOR

2,769,103

Filed March 13, 1953

2 Sheets-Sheet 1



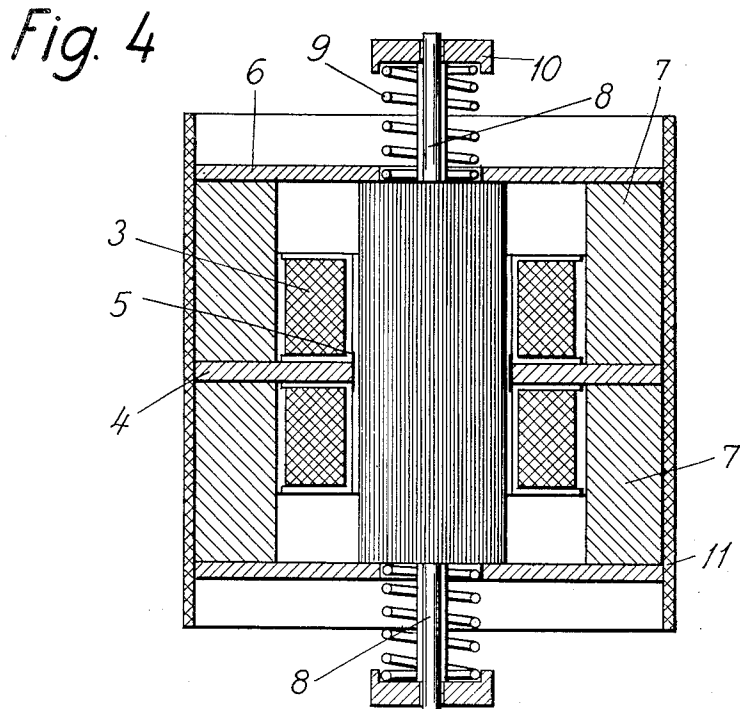
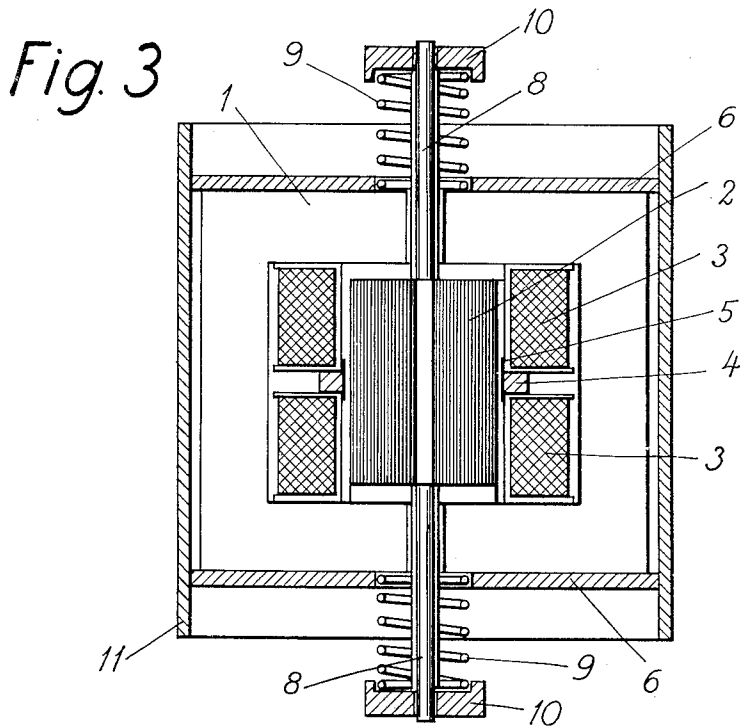
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1

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ELECTROMAGNETIC VIBRATOR

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Application March 13, 1953, Serial No. 342,134

Claims priority, application Denmark March 15, 1952

3 Claims. (Cl. 310—30)

The present invention relates to an electric vibrator consisting of an annular yoke of magnetizable material with two end pieces and intermediary side pieces and with two or more projecting pole legs which are provided with pole shoes and extend from the centre of the side pieces towards the interior of the ring, and having an oscillating member which is movably mounted in its longitudinal direction between the end pieces of the yoke and which at its central section is separated from the pole shoes by air gaps, the said vibrator having furthermore two or more permanent magnets disposed between the end pieces of the yoke and the projecting pole legs, in addition to which means are provided to magnetize the oscillating member with alternating polarity.

There are known vibrators of the aforesaid kind, but they are distinguished from the vibrator according to the present invention thereby that the magnetic system has poles of opposite nature in the two end surfaces, whereas the vibrator according to the invention is characterised thereby that the magnets have poles of like nature at the end pieces of the yoke, so that the oscillating member consists of a cylindrical armature through which a magnetic flux passes from the pole shoes to the cylindrical surface of the armature and further out through the end surfaces of the armature and through air gaps to the end pieces of the yoke. Furthermore, coils are provided coaxially with the armature between the projecting pole legs and the end pieces of the yoke.

The result obtained hereby is that the alternating field does not weaken the permanent field, but, on the contrary, intensifies this field, which is of vital importance to the durability of the permanent magnets.

In contrast to the known vibrators an essential feature of the vibrator according to the invention is, furthermore, that the yoke constitutes a magnetic connection between the like poles of the magnets, and that the magnets disposed between the one end piece of the yoke and the projecting pole legs intensify the field of the magnets disposed between the other end pieces of the yoke and the projecting pole legs, so that the resulting permanent magnetic field is strongest at that end of the armature where the air gap between armature and yoke is narrowest.

As a result of this the permanent field is largest when the alternating field is largest, which also prevents a demagnetization of the permanent magnets; as a further result the force that carries the armature into its extreme position attains its maximum in that position, which is of importance for the transmission of this force to the load connected with the vibrator.

In the known vibrators of this kind the oscillating system is guided in axially movable ball bearings, whereas an essential feature of the vibrator according to the invention is that the armature is suspended between resilient members, the tensional force of which, when the armature touches one of the end pieces of the yoke, substantially equalises the attraction exerted by the field of the permanent magnets.

2

As a result of this, the force originating from the alternating field attains its maximum in the said extreme position.

In order to obtain a maximum efficiency of the vibrator according to the invention, provision has been made to obtain that the resilient members are tuned in such a way that in combination with the mass of the oscillating system and with, for example, an outside effect produced by the load to which the vibrator is subjected, they give the oscillating system a natural period equal to the number of cycles of an alternating current, which is fed to the coils, or a multiple of the said number.

The special conditions of the magnetizing and demagnetizing fields will now be more fully described with reference to the drawings, in which:

Figure 1 shows diagrammatically a vibrator according to one embodiment of the invention,

Figure 2 shows a convenient embodiment of a vibrator in accordance with the invention, viewed from above,

Figure 3 is a section of same on a plane parallel to the plane of the yoke,

Figure 4 is the same, on a central section at right angles to the section shown in Figure 3.

Figure 1 shows diagrammatically a vibrator of the said kind, consisting of a yoke 1 of laminated, magnetic soft iron and provided with an armature 2 of the same material. The armature 2 is surrounded by two coils 3 fed with alternating current. The coils are separated from each other by projecting pole legs 4 with pole shoes 5.

Between the projecting pole legs 4 and the upper and the lower end pieces of the yoke 1 there are disposed permanent magnets 7 in such manner that the pole shoes 5 receive a definite polarity, whereas the end pieces of the yoke 1 receive a different polarity. If the pole shoes 5 is a north pole, each side of the vibrator will have two magnetic circuits in which the flux passes from the pole shoe on to the cylindrical surface of the armature and through the end surfaces of the armature out into the upper and the lower end pieces of the yoke, hence to return through magnets 7 and the pole leg 4 to the pole shoe 5.

The armature 2 is provided with air gaps at either end and mounted on a shaft 8 so as to be capable of freely oscillating in the direction of the shaft. When the coils 3 are fed with alternating current, the armature will make time oscillations with the alternating current. However, the magnets are not subjected to demagnetizing forces of similar magnitude as those in the known designs, and this will now be described in detail.

Assuming that the field of the coils 3 is oriented during a half cycle in such manner as to intensify the magnetization of the upper magnets, this means that the armature is simultaneously pulled up into its upper position. Consequently, the field produced by the upper coil has a closed flux passage to pass, and so it will be comparatively powerful. The fact is that the lines of force will pass through the upper part of the armature and through the upper end piece of the yoke, hence from to be divided, one portion of the lines of force passing down through the upper magnets, and another portion passing through the vertical sides of the yoke. From the vertical sides of the yoke the lines of force pass on to the lower end of the lower magnets, and a part of the lines of force hence pass up through the lower magnets to join the lines of force passing through the upper magnets. Through the pole legs 4 and the pole shoes 5 the lines of force return to the armature. Such portion of the flux as does not pass through the magnets is passed on through the lower end piece of the yoke and up through a comparatively large air gap between the lower end piece of the yoke and the armature.

It will be evident from the foregoing that the lines of

force from the upper circuit, if, for example, the upper end of the armature is a north pole, will pass through the magnets from the upper and the lower end pieces of the yoke inwards toward the pole leg, so that the permanent magnets, which in this case have a south pole at the upper and the lower end pieces of the yoke and a north pole at the pole leg, will have their magnetization increased.

Conditions are the same in the circuit produced by the lower coil except that the fields produced here tend to weaken the permanent magnets. However, these fields are insignificant, since the circuit here in the case of all the lines of force comprises the big air gap between the lower end of the armature and the lower end piece of the yoke. Consequently, the fields which tend to intensify the permanent magnets will overcome the fields which tend to weaken the permanent magnets. When the flow of the alternating current is reversed, the armature will be in its central position on its way towards its lower extreme position, so that conditions will be identical for the upper magnets as described above for the lower magnets when the yoke is in its top position.

Figures 3 and 4 disclose how the vibrator is constructed in a commercial embodiment. The yoke 1 and the magnets 7 are here mounted each in their plane, as shown in Figure 2, the said planes being at right angles to each other so as to give the vibrator a compact construction. End plates 6 are provided around the upper and the lower end pieces of the yoke 1 so that the permanent magnets 7 are mounted between the end plates 6 and the pole legs 4. The shaft 8 is suspended by springs 9 fastened between the yoke 1 and nuts 10 which are screwed on the ends of the shaft 8. As a result of this the tensional force, which is rather great, is distributed on the two springs, which is of advantage, since a single spring would have to be too bulky to cope with such a force. The said springs 9 are tuned in such manner that in combination with the mass of the oscillating system and, the effect produced by the external load to which the vibrator is subjected they give the oscillating system a natural period which is either equal to the number of cycles of the alternating current or a multiple thereof.

Furthermore, the springs 9 may be of such resiliency that, when the armature is in one of its extreme positions they will actually eliminate the attraction exerted by the field of the permanent magnets, whereby the alternating current is afforded a better curvature, since the current will not have to supply any energy to move the armature from its extreme position back to its central position and further owing to the inertia, whereby the influence of the air gap on the attraction is reduced, the armature being, in fact, capable of oscillating "in advance of" the alternating current.

What I claim and desire to secure by Letters Patent is:

1. An electromagnetic vibrator having a ferromagnetic structure including an outer shell and end plates secured to the respective ends of said shell, a rectangular yoke of rectangular cross section inside said shell, said yoke having two opposite end portions and two opposite side portions, at least two pole legs projecting from the inner surface of said shell perpendicularly to the plane of said yoke, said pole legs being provided with pole shoes defining a central aperture in which is positioned an armature mounted for reciprocatory movement to and from said opposite end portions of said yoke, permanent magnets of parallelepipedal shape mounted between said pole legs and said end plates and disposed in a central plane perpendicular to the plane of said yoke, said central plane containing the axis of said armature, said permanent magnets having first end surfaces with poles of like sign abutting said yoke end portions and second end surfaces abutting said pole legs, and coils mounted coaxially around said armature and adapted to be connected to a source of alternating current, whereby a plurality of closed magnetic paths for the permanent flux are provided through

the armature and through said opposite end portions of said yoke, said armature being suspended between resilient members to equalize the attraction in said armature by the permanent flux in the extreme positions of reciprocating movement of said armature, said resilient members being selected to have under the conditions of use a natural oscillating frequency equal to the frequency of the alternating current fed to said coils or a multiple thereof.

2. An electromagnetic vibrator having a ferromagnetic structure including an annular yoke of rectangular radial cross-section formed from laminated magnetic material and having two opposite end portions and two opposite side portions, permanent magnets mounted between said opposite end portions of the yoke, at least two pole legs, said pole legs being provided with pole shoes, said permanent magnets being separated from said opposite side portions of the yoke by a substantially insulating air gap and having first end surfaces with poles of like sign abutting said end portions and having second end surfaces abutting said pole legs, an armature disposed between said pole shoes, said armature being mounted for reciprocatory movement to and from said opposite end portions of the yoke, coils mounted coaxially around said armature and adapted to be connected to a source of alternating current, whereby a plurality of closed magnetic paths for the permanent flux are provided through said pole legs and said armature and through said opposite end portions of the yoke, said armature being suspended between resilient members to equalize the attraction in said armature in its extreme positions exerted by the permanent flux, said resilient members being selected to have under the conditions of use a natural oscillating frequency equal to the frequency of the alternating current fed to said coils or a multiple thereof.

3. An electromagnetic vibrator having a ferromagnetic structure including an outer shell and end plates secured to the respective ends of said shell, an annular yoke of rectangular radial cross-section disposed inside said shell, said yoke being formed from laminated magnetic material and having two opposite end portions and two opposite side portions, at least two pole legs projecting from the inner surface of said shell perpendicularly to the plane of said yoke, said pole legs being provided with pole shoes, an armature disposed between said pole shoes, said armature being mounted for reciprocatory movement to and from said opposite end portions of the yoke, permanent magnets mounted between said end plates and said pole legs and disposed in a central plane in said shell containing the axis of said armature, said permanent magnets having first end surfaces with poles of like sign abutting said end plates and second end surfaces abutting said pole legs, coils mounted coaxially around said armature and adapted to be connected to a source of alternating current, whereby a plurality of closed magnetic paths for the permanent flux are provided through said end plates and said shell and through said pole legs and said armature and through said opposite end parts of the yoke back to said end plates, said armature being suspended between resilient members to equalize the attraction in said armature in the extreme positions exerted by the permanent flux, said resilient members being selected to have under the conditions of use a natural oscillating frequency equal to the frequency of the alternating current fed to said coils or a multiple thereof.

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