May 13, 1952 G. C. ELDRIDGE, JR 2,596,226

DEVICE FOR PRODUCING MOTION

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FIG. 1.

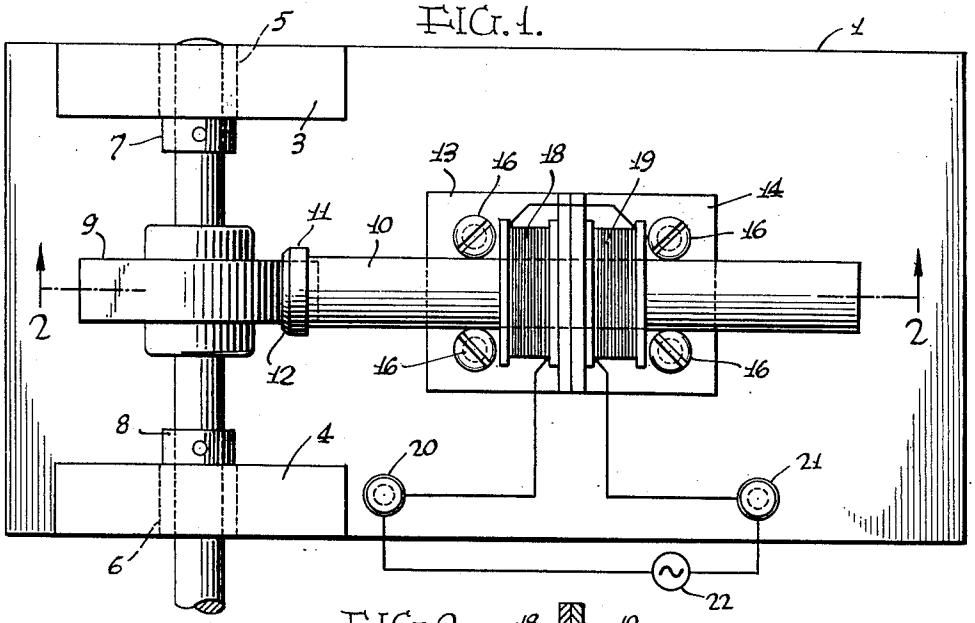
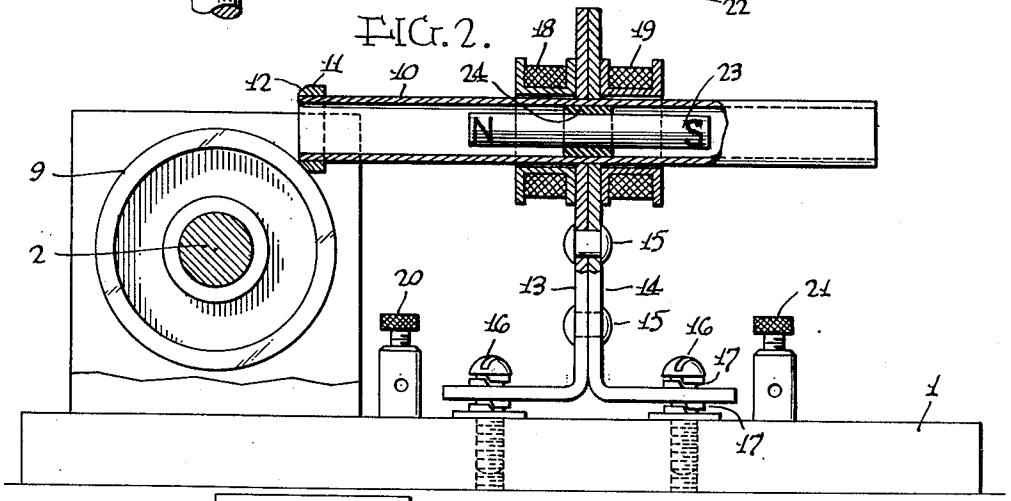



FIG. 2.



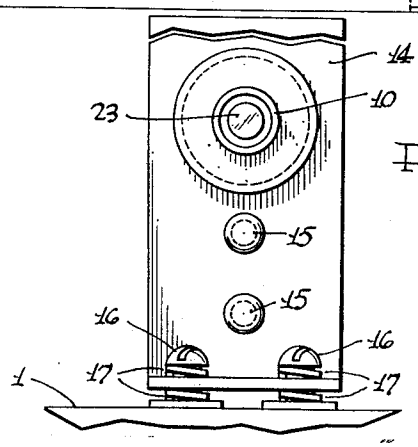




FIG. 3.

Inventor:
George C. Eldridge Jr.,
by his Attorneys
Howson & Howson

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## DEVICE FOR PRODUCING MOTION

George C. Eldridge, Jr., Wenonah, N. J.

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7 Claims. (Cl. 172—126)

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This invention relates to devices for producing motion, e. g. rotary motion, and more particularly to such devices which operate by translation of vibratory motion into the desired motion.

Heretofore, various devices of this general character have been proposed which have operated on the ratchet principle, employing a movable vibratory driving member acting either to push or pull a driven member. In such devices, it has been necessary to provide for non-slipping engagement between two members, either by providing teeth or serrations on the driven member or by providing for good frictional engagement between the members. Usually the driving member is part of an electromagnetic vibrator comprising an electromagnet and a movable armature. Such devices are limited in application and are not operable at frequencies much higher than the common frequency of sixty cycles per second employed on A. C. supply lines.

The principal object of the present invention is to provide a device which is superior to prior devices of the character above mentioned, particularly in that it is operable at high frequencies and, therefore, has much wider application than such prior devices.

By this invention, there is provided a device which operates on an entirely different principle than do the aforementioned prior devices. In accordance with the invention, the desired motion is produced by means of rapidly recurring impact between two hard, elastic and preferably smooth surfaces on the driving and driven members respectively. Thus, the operation of the device involves a continuing series of collisions between said surfaces occurring at a sufficiently rapid rate to produce the desired motion of the driven member.

A further feature of the preferred form of the invention is the utilization of magnetostriction to produce rapidly recurring impact between the above-mentioned surfaces. In this way, it is possible to deliver impacts at much greater frequencies than may be used in prior devices such as above mentioned. However, the invention contemplates the use of any means for producing rapidly recurring impact between the surfaces of the driving and driven members even at lower frequencies.

The invention may be fully understood by reference to the accompanying drawing, wherein:

Fig. 1 is a plan view of a device constructed according to the invention;

Fig. 2 is in part an elevational view and in part

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a sectional view taken along line 2—2 of Fig. 1; and

Fig. 3 is an elevational view taken from the right-hand side of the device as illustrated in Figs. 1 and 2.

Referring more particularly to the drawing, there is shown a base 1 on which the elements or parts are mounted. A shaft 2 to be driven is rotatably supported by standards 3 and 4 in bearings 5 and 6, collars 7 and 8 preventing longitudinal movement of the shaft. The shaft may perform any desired function. While it may be driven directly, in the illustrated embodiment it is driven through a wheel 9 mounted thereon, which has a hard elastic, and preferably smooth, peripheral surface. By way of example, this wheel may be formed of hard steel, preferably with its peripheral surface machined to a smooth finish.

Mounted in cooperative association with the wheel 9 is a driving member 10 which is composed of magnetostrictive material. Preferably, the driving member comprises a nickel tube and a small hard steel collar 11 rigidly attached to the end of the tube adjacent the wheel 9 and beveled, as at 12, at a predetermined angle, preferably an angle of 45°. Thus, the collar provides a hard smooth surface which is arranged to engage the hard smooth surface of the wheel 2. As may be seen in Fig. 2, the driving motor 10 is disposed in offset relation to the axis of the wheel so that said member may drive the wheel by impact, as hereinafter described.

The magnetostrictive tube 10 is centrally supported on a support which may comprise a pair of angle brackets 13 and 14 disposed in back-to-back relation and riveted together as at 15. The tube 10 extends through aligned openings in the supporting brackets, and may be held simply by means of a force fit. The rigid supporting structure formed by the two brackets is secured to the base 1 by means of screws 16. Spring washers 17 are provided as shown to permit slight adjustment of the support so as to slightly adjust the tube 10 to vary the impacting force on the wheel 2.

The magnetostrictive tube 10 is magnetically stimulated by means of a pair of coils 18 and 19 which are loosely disposed on the tube 10 in surrounding relation thereto. These coils are connected in series aiding relation between terminals 20 and 21 to which an energizing source 22 of alternating voltage may be connected as shown in Fig. 1. This source may be a variable frequency oscillator or other electrical generator

operable at the desired frequency or frequencies. Preferably, a permanent magnet 23, which may be of cylindrical form, is disposed within the tube 10 and within the stimulating coils, and may be held inside the tube 10 by means of a fiber collar or sleeve 24.

It will be apparent that a single coil could be used, the only reason for using two coils being to provide a symmetrical arrangement with respect to the support. Actually the two series aiding coils effectively constitute a single coil.

In operation, the alternating voltage applied to the coils 18 and 19 produces a corresponding alternating magnetic field whose stimulative effect on the magnetostrictive tube 10 causes the latter to increase and decrease in length at the frequency of the applied voltage. While this variation in length of the tube 10 is quite small, it is effective to deliver repeated impacting force to the wheel 2 at a rate corresponding to the applied frequency. It is well known that magnetostrictive action may take place at a high rate or frequency, and advantage is here taken of this inherent capability of such action to deliver impacts to a driven member at a rapid rate of recurrence. The permanent magnet 23 provides a magnetic field of desired strength and enhances the efficiency of the device. This biasing magnetic field is essential for vibration of maximum amplitude at the fundamental frequency of the applied voltage. By placing the permanent magnet inside the vibrating member, it is possible to use a relatively small and weak magnet and to conserve space. Maximum amplitude of vibration of the tube 10 occurs when the frequency of the applied voltage corresponds to the natural frequency of the tube. Therefore, the amplitude of vibration may be varied by varying the applied frequency.

As may be seen in Fig. 2, the tube 10 is preferably disposed so that its axis is substantially perpendicular to a vertical plane containing the axis of the wheel 2. Further, the tube is preferably arranged so that its axis forms an angle of 45° with a line extending from the axis of the wheel through the point of contact. It has been found that this arrangement gives best results, apparently because it gives the highest tangential component of the applied force without causing slippage.

It is important to note that the contacting surfaces are highly elastic and have a high coefficient of restitution. Therefore, there is maximum energy transfer and maximum velocity transfer to the driven wheel. This may be shown by application of the law of conservation of momentum.

For a given applied frequency, the speed of the driven wheel will depend upon the diameter thereof. Thus, a smaller wheel having smaller circumference will have a greater angular displacement per unit time. For a given oscillating tube and wheel, the speed of the wheel may be controlled by varying the amplitude of the vibrating member. With a magnetostrictive vibrator, this can be accomplished by varying the magnitude or frequency of the applied voltage or by varying the strength of the established magnetic field.

A device of the character provided by the present invention may be operated at any frequency over a wide range including both sonic and supersonic frequencies. Physical embodiments of this invention have actually been operated at different frequencies ranging from 5,000 to 200,000 cycles per second.

A device of the character provided by the invention may be applied to a wide variety of uses. For example, it may be applied to remote control of two or more toy electric trains operating on the same track. The device can be used directly to drive such a train or it may be used to operate speed-controlling means such as a rheostat or potentiometer. A plurality of these devices may be located on different trains and selectively operated by applying voltages of different frequencies over the track.

By way of specific example, a device having the following structural characteristics was used to drive a toy railway car. The device consisted of a nickel tube ¼" in diameter and 3¾" long. The two ends of the tube were cut at an angle of 45° in such a way that the cut surfaces were parallel. When cut in this manner each longitudinal element of the tube is of the same length. The end of the nickel tube was placed directly against one of the ⅛" steel axles of the car. Thus in this case the wheel of the illustrated embodiment was omitted, as was also the steel collar on the end of the driving tube. A permanent magnet inside the nickel tube furnished the desired magnetic field. Two driving coils, containing 60 turns each, were connected in series aiding and were in series with a 0.25 mfd. condenser. The purpose of the condenser was to provide electrical resonance at the natural frequency of the particular nickel tube which was approximately 26,000 cycles per second. The high frequency power was furnished by a Colpitts oscillator and a 10 watt class B push pull amplifier having an output transformer with a secondary impedance of 8 ohms.

It will be apparent that the invention lends itself to remote control generally, particularly selective control through the medium of different frequencies. In this connection, frequency discriminating means, such as filters may obviously be employed wherever desired.

While a particular embodiment of the invention has been illustrated and described, it will be understood that the invention is not limited thereto but is capable of various forms of physical expression. Thus instead of using a hollow or tubular driving member, a solid member such as a rod of any desired cross-sectional shape may be used. In such case, a permanent magnet may be disposed adjacent the driving member.

Moreover the invention is not limited to the production of rotary motion. Thus it is applicable to the production of rectilinear motion. For example, it has been utilized to drive a smooth steel plate resting on a smooth surface by applying the end of a vibrating nickel tube to the steel plate at an angle of 45°.

As used herein and in the appended claims, the words "hard elastic" mean that the member referred to is sufficiently hard or rigid to be useful for the intended purpose and that it has sufficient elasticity to give suitable transfer of energy and velocity from the driving member to the driven member.

I claim:

1. A device for producing unidirectional motion, comprising a member arranged to be driven and having a hard elastic surface, a magnetostrictive driving member closely adjacent to said first member to drive said first member undirectionally by repeated impact, said driving member having a hard elastic surface arranged coopera-

tively with the surface of said first member to impact the same, means adjustably supporting said driving member to enable variation of its impacting force on said first member, and electrical means closely adjacent to said driving member for effecting high frequency magnetic stimulation of said driving member to cause rapidly recurring impact between said surfaces, thereby to drive said first member.

2. A device for producing unidirectional motion, comprising a member arranged to be driven and having a hard elastic surface, a magnetostrictive driving member closely adjacent to said first member to drive said first member unidirectionally by repeated impact, said driving member having a hard elastic surface arranged cooperatively with the surface of said first member to impact the same, a permanent magnet closely adjacent to said driving member to provide a biasing magnetic field therefor, and electrical means closely adjacent to said driving member for effecting high frequency magnetic stimulation of said driving member to cause rapidly recurring impact between said surfaces, thereby to drive said first member.

3. A device for producing rotary motion, comprising a rotatably mounted wheel having a hard elastic surface, a magnetostrictive driving member closely adjacent to said wheel in offset relation to the wheel axis to drive the wheel by repeated impact, said driving member having a hard elastic surface in impacting relation with the surface of said wheel, means adjustably supporting said driving member to enable variation of its impacting force on said wheel, and electrical means closely adjacent to said driving member for effecting high frequency magnetic stimulation of said driving member to cause rapidly recurring impact between said surfaces, thereby to drive said wheel.

4. A device for producing rotary motion, comprising a rotatably mounted wheel having a hard elastic surface, a magnetostrictive driving member closely adjacent to said wheel in offset relation to the wheel axis to drive the wheel by repeated impact, said driving member having a hard elastic surface in impacting relation with the surface of said wheel, a permanent magnet closely adjacent to said driving member to provide a biasing magnetic field therefor, and electrical means closely adjacent to said driving member for effecting high frequency magnetic stimulation of said driving member to cause rapidly recurring impact between said surfaces, thereby to drive said wheel.

5. A device for producing rotary motion, comprising a rotatably mounted wheel having a hard elastic surface, a straight driving member composed of magnetostrictive material and having a hard elastic end surface, means supporting said driving member closely adjacent to said wheel in offset relation to the wheel axis with the said end surface in impacting relation with the surface of said wheel, a coil surrounding said driving member, and means for supplying alternating current to said coil at supersonic frequency, whereby to effect magnetic stimulation of said driving member at supersonic frequency and thus drive said wheel by rapidly recurring impact between said surfaces.



6. A device for producing rotary motion, comprising a rotatably mounted wheel having a hard elastic surface, a straight tubular driving member composed of magnetostrictive material and having a hard elastic end surface, means supporting said driving member closely adjacent to said wheel in offset relation to the wheel axis with the said end surface in impacting relation with the surface of said wheel, a straight permanent magnet within said driving member, and a coil surrounding said driving member and said magnet and adapted to be connected to a high frequency alternating voltage source, whereby to effect high frequency magnetic stimulation of said driving member and thus drive said wheel by rapidly recurring impact between said surfaces.

7. A device for producing rotary motion, comprising a rotatably mounted wheel having a hard elastic surface, a straight tubular driving member composed of magnetostrictive material and having a hard elastic end surface, means supporting said driving member closely adjacent to said wheel in offset relation to the wheel axis with the said end surface in impacting relation with the surface of said wheel, a coil surrounding said driving member and adapted to be connected to a high frequency alternating voltage source, whereby to effect high frequency magnetic stimulation of said driving member and thus drive said wheel by rapidly recurring impact between said surfaces, and means for adjusting said driving member at will to vary the force of impact thereof on said wheel.

GEORGE C. ELDRIDGE, JR.

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