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Pommeret

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[54] **METHOD AND APPARATUS FOR PRODUCING VIBRATIONS OR IMPULSES**

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[51] **Int. Cl.**..**H02k 33/08**

[58] **Field of Search**..................318/114, 122, 124, 125, 129; 310/19, 23, 30, 28

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[57] **ABSTRACT**

This device for producing vibrations, oscillations or impulses to be converted if necessary into unidirectional impulses or into linear movements comprises a reversible magnetic yoke and core assembly for either driving piles, sheet piles or the like, or generating alternating current, or for measuring vibration and the like.

6 Claims, 3 Drawing Figures

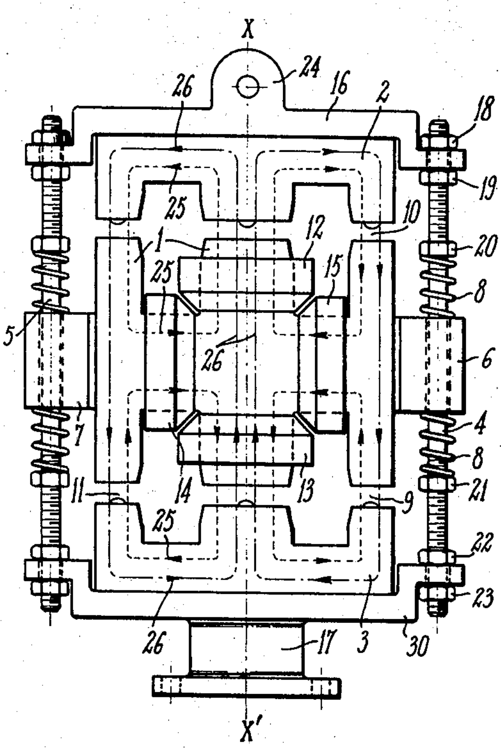

Fig. 1

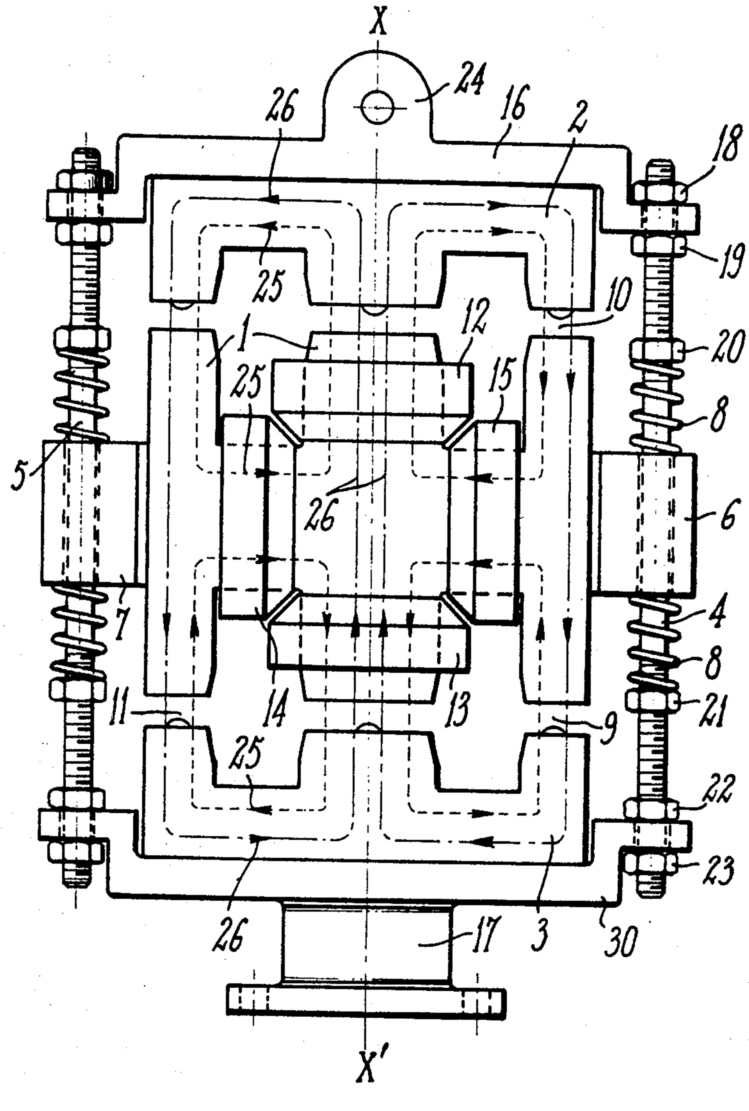

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Fig. 3

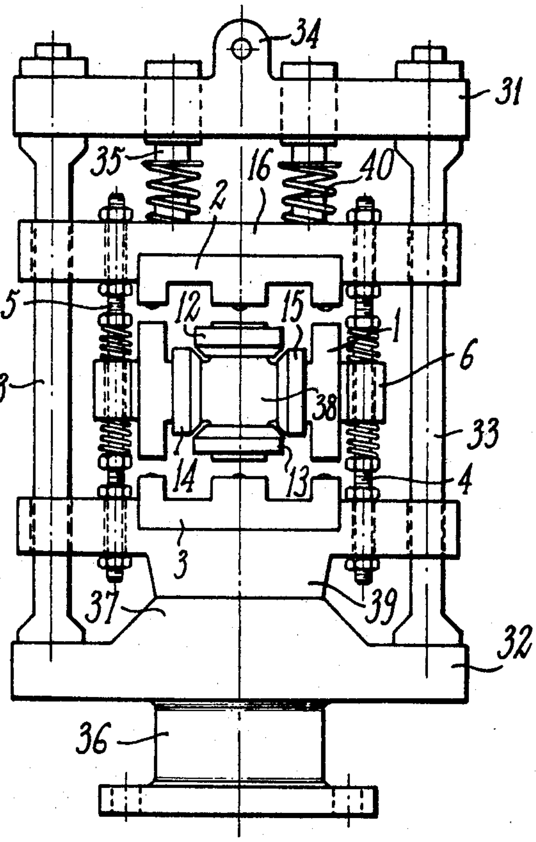
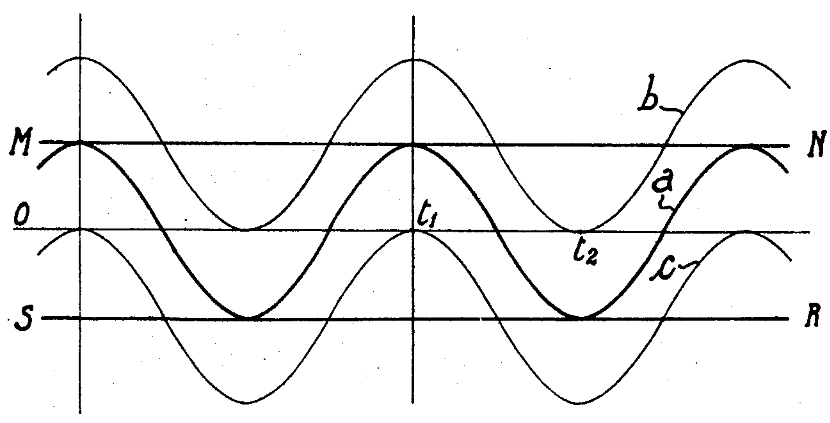


Fig. 2



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METHOD AND APPARATUS FOR PRODUCING VIBRATIONS OR IMPULSES

FIELD OF THE INVENTION

The present invention relates to methods of and means for producing vibrations or impulses adapted to be converted if necessary into unidirectional impulses or into a linear movement. The improved device constituting the practical embodiment of this invention is reversible and may therefore also be used for generating alternating current or in the construction of vibration meazuring apparatus, these applications being given by way of illustration, not of limitation.

DESCRIPTION OF THE PRIOR ART

It is already known to generate vibrations or impulses by means of devices comprising a magnetic yoke and a core also of magnetic material disposed within said yoke and forming therewith a pair of magnetic gaps, the magnetic flux flowing through the magnetic circuit constituted by said yoke and core and also through said gaps consisting of the superposition of a continuous flux and an alternating flux, the resultant flux producing the movements of said yoke and core in relation to each other.

However, these devices are attended by a number of inconveniences. More particularly, the alternating flux produced by the windings energized with alternating current causes the induction, in the windings energized with direct current, of other currents likely to exert a detrimental influence on the DC generators. On the other hand, the power output of these known devices is rather limited.

The device according to the present invention is capable of avoiding these inconveniences.

SUMMARY OF THE INVENTION

This device is characterized essentially in that it comprises a yoke divided into two sections disposed on either side of the core, means for interconnecting said sections, means for guiding said core during its movements and means permitting the adjustment of the gaps between said yoke sections and said core.

The device according to this invention is capable of producing vibrations or impulses the amplitude and frequency of which may be modified by varying, simultaneously or not, the alternating voltage, the direct voltage and the frequency of the alternating voltage.

As a rule, it was customary in practical applications of conventional devices of this character for the production of alternating vibrations or impulses, to secure the external member to the member to be actuated, to the core and more generally to the member of this device to which an alternating motion of considerably amplitude is impressed by the electromagnetic forces implemented.

According to a particularly advantageous feature characterizing the device of this invention and in contrast to this prior art characteristic the external member which is to be set in motion is rigidly connected to the member of this device which receives initially the lowest alternating impulses.

The following disclosure refers more particularly to the commonest case wherein this member of the device is the yoke.

Thus, an advantage is obtained in that this device avoids any excessive work when starting the operation of this external member, as a consequence of alternating movements of abnormally great amplitudes as would be observed if said external member were rigid with the core in lieu of the yoke. The yoke movement multiplied by the total mass to be set in motion (namely the yoke and the external member rigidly connected thereto) is equal to the core movement multiplied by the mass of this core alone.

If a member of relatively great mass or a member braked during its movement is to be driven, such as a pile or sheet pile already more or less sunk into the ground, it might prove extremely difficult if not impossible to start the desired

reciprocating motion, unless a considerable power output, not in proportion with the desired result, is available. Under these conditions it is necessary, of course in the specific case of this pile or sheet pile, that the lower limit of the amplitudes of the yoke to which said pile is connected to be that of its elastic reduction or increase in length as a consequence of the force thus applied thereto.

Notwithstanding these initially low amplitude values it is possible, with the variable-frequency means advocated by the present invention, to obtain very rapidly an extremely high driving rate, in the specific case contemplated herein of a pile or sheet pile to be driven into the ground, when resonance frequencies are attained.

With due consideration for the lower amplitude limit, for the reason set forth hereinabove, it is obvious that the shorter the initial stroke of the yoke, the lesser the power necessary for eventually attaining the desired resonance frequency.

It may be pointed out that since the optimum requirement to be met for a proper normal operation of the apparatus rigidly connected to the external member is that corresponding to a frequency approaching the resonance frequency of the system comprising the apparatus itself (i.e. the vibrator) connected to the external member to be driven, this result will be obtained by firstly applying to this external member an excitation close to said resonance frequency by simply varying the energizing frequency.

Then, to accentuate this resonance, i.e. the force imparted to said external member (which is attended by an increment in the vibration amplitude of said member) the inherent frequency of the apparatus must be adapted to the resonance frequency of the system.

This result may be obtained by either changing the core mass (which is hardly feasible) or modifying the stiffness of the core suspension means, such as springs, with a suitable damping coefficient.

The above-described effort for attaining the resonance frequency was developed under reduced power conditions; therefore, the energy necessary for driving the pile is delivered to the system by increasing to the desired value the alternating power output, for example, only during the relatively very short time necessary for the pile driving action, by limiting this power output in order to avoid ruptures.

Of course, similar reasoning and results are applicable to the actuation of any other external member outside the pile or sheet pile mentioned in the foregoing.

A typical and advantageous application of the device of this invention is nevertheless the driving or pulling out of piles, sheet piles, timberings or the like. The means to be implemented for performing such works must meet requirements that are increasingly difficult to meet. More particularly, the power output or rating of the devices now proposed for these works is increasingly higher, but their handiness, reliability and noise level in operation become prohibitive if not extremely noxious. The bearings, journals, power fluid supply lines or hoses, etc. normally equipping these apparatuses for mechanically driving piles or the like cannot withstand or exceed predetermined stress values or dimensions. On the other hand these apparatuses are hardly capable of developing frequencies substantially in excess of 50 Hz, even under relatively low power ratings.

In addition to the possibility of affording a considerably reduction in the power outputs involved and producing oscillations of variable frequency and amplitude, the device according to this invention is advantageous in that it is capable of operating without resorting to heavy rotary parts, bearings, pinions, etc. i.e. fragile components to which strict load and stress limitations are imposed.

BRIEF DESCRIPTION OF THE DRAWINGS

Other features and of this invention will appear as the following description proceeds with reference to the attached drawings illustrating diagrammatically by way of example typical forms of embodiment of the invention. In the drawings:

FIG. 1 is a front elevational view of a device according to this invention;

FIG. 2 is a diagram showing curves depicting the magnetic fluxes passing through the gaps; and

FIG. 3 is another elevational view showing a combined apparatus according to this invention for generating unidirectional impacts, this apparatus being actuated or energized by a device of the type shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The oscillation generator illustrated in FIG. 1 is shown in a vertical position and comprises a core 1 of magnetic laminations, having substantially the shape of a double H and adapted to perform a reciprocating motion of predetermined amplitude between two yokes 2 and 3 also of magnetic laminations which are mechanically interconnected through rods 4 and 5 acting at the same time as guide members to said core 1 through the medium of slides 6 and 7. Coil compression springs 8 retained and prestressed by nuts 20, 21 engaging threaded portions of rods 4 and 5 are provided for holding the core in an intermediate position, in the inoperative condition of the assembly, between the yokes 2 and 3, whereby substantially equal magnetic gaps 9 and 10 are obtained before starting the apparatus, irrespective of its position. These gaps are adjustable of course for example by means of the nuts 18, 19 and 22, 23 engaging the upper and lower ends of rods 4, 5. Stop means 11 are also provided for preventing the core 1 from striking the yokes 2 and 3 in case of misadjustment of the apparatus. The laminations of yoke 2 are strongly clamped by a strap 16 comprising at its ends a pair of lugs formed with holes engaged by the rods 4 and 5 acting as stiffening members and distance-pieces, with the assistance of said nuts 18 and 19. This strap 16 carries in its central portion a suspension ring or hook 24.

The other strap 30 of yoke 3 is secured by means of nuts 23, 24 and has the same characteritics as the firs strap 16, except that it comprises a flanged gripping member 17 adapted to be secured to the element or member to be vibrated. However, this element or member may also be secured directly to the core.

The vertical central portion or web of core 1 carries at its upper and lower ends a pair of coils 12, 13 consisting of windings of insulated copper wire adapted to be supplied with alternating current, and each portion of the intermediate horizontal portion or web of said core comprises a coil 14, 15, adapted to be energized with direct current.

The coils 12 and 13 are so connected that they develop magnetic fluxes having the same direction. In contrast thereto, the fluxes produced by the DC coils are opposed to each other. Under these conditions, the lines of force have the following path :

In the case of direct-current fluxes, the lines of force are designated by dotted lines and their directions are also shown in FIG. 1 by arrowheads 25. Since the fluxes of coils 14 and 15 are in mutual opposition they are separated in the median plane of the vertical central portion of core 1 and each directed towards the ends of this portion. The resulting fluxes form a path through the yoke and the vertical lateral arms of the core, the loops being completed within the coils.

In the case of alternating fluxes at a given moment of an AC cycle (for example at the peak thereof) the path is shown in dash and dot lines and arrow heads 26. The path of these fluxes runs throughout the central vertical portion of core 1 and the loops are closed through the yokes and the lateral arms of the core within said central portion.

The alternating and direct fluxes are thus constituted as follows: when a peak alternating flux, assumed to have the same strength as the direct flux, occurs, the flux in gap 9 is zero since the two fluxes having opposite directions are substracted from, and cancel, each other. Thus, the core will be attracted by the yoke 2. This action is reversed when the direction of the AC is reversed. The assembly thus energized on the one hand by a continuous flux and on the other hand by an alternating flux will start oscillating along its central axis XX' at a frequency strictly synchronous with that of the mains supply.

Actually, this vibration generator operates as a synchronous AC motor performing sinusoidal linear movements. Its operation is therefore similar to that of a rotary synchronous motor. In the case of a synchronous motor the polar wheel and the rotating field are merged into one, under no-load conditions, and assume an angular shift when a load is applied to the shaft. In the case of a generator according to this invention the core movement is shifted by $\pi/2$ in relation to the sine alternating force producing this movement. The work developed by this movement during one cycle is zero. If a load appears, the shift is less than $\pi/2$ and then a positive product of the movement and force appears.

The flux composition in the apparatus is illustrated in the diagram of FIG. 2, plotting in abscissa the time and in ordinates the flux. The line MN designates the continuous flux flowing through the central vertical upper section of the core and the gap 10. The line SR designates the continuous flux opposite to the first one, which propagates through the lower portion of the central vertical section of core 1 and the gap 9.

The thick line sine wave *a* corresponds to the flux produced along the central vertical section by the alternating current and flowing through the gaps 10 and 9.

At a time t_1 corresponding to the maximum alternating flux (curve *b*) the sum of the alternating and continuous fluxes flows through the gap 10, and at a time t_2 the fluxes are substracted and cancelled, since in the case contemplated the direct current and alternating current have the same amplitude. In the gap 9 (curve *c*) the same effects are observed but in the reverse direction and with a shift π in relation to the preceding ones. In fact, the maximum value of the alternating flux is added to the direct current flux at said time t_2 of the cycle, while these fluxes cancel each other at gap 10.

Thus, a pulsating or undulated flux of reverse direction flows through the lower and upper portions of the central vertical section of core 1, this flux varying from 0 to a maximum and then returning to 0.

A specific feature of the vibration generator of this invention lies in the DC coil disposal in relation to the AC flux path. In fact, it is most likely that a certain dispersion of the alternating flux occurs through the central horizontal section of core 1 about which the DC coils are disposed. But since the dispersions produced by coils 12 and 13 are equal and of opposite directions, no induction can take place therein, so that no alternating voltage likely to prove detrimental to the DC generator appears, and it would be possible, according to the relative coupling of the DC coils, to produce short circuits in these coils and therefore damage or destroy them.

Apparatus designed for producing unidirectional impacts generated by the transformation of alternating oscillations are already known; these alternating oscillations are produced as a rule by a mechanical exciter comprising a flywheel having an unbalancing mass or weight. Now the electrical generator according to this invention may constitute an advantageous substitute for the mechanical exciter of these known apparatus.

FIG. 3 illustrates an apparatus of this general type, disposed vertically and equipped with an electrical exciter according to this invention.

This impact generator comprises a rigid frame structure comprising a pair of cross members 31, 32, rigidly interconnected by lateral posts, columns or uprights 33. The upper cross member is provided with a suspension ring or hook 34 and a pair of screw jacks 35 for a purpose to be explained presently. The lower cross member comprises intermediate its ends on the one hand a flanged gripping member 36 adapted to be connected to the object to be driven, and on the other hand an anvil 37 adapted to receive the impacts produced by the exciter 38. This exciter constructed like the device described hereinabove with reference to FIG. 1 is adapted to slide and be guided along the two vertical posts 33 of the frame structure. It comprises at its lower portion a drop-hammer 39 normally urged by springs 40 for engagement with the anvil **37**. These springs **40** are adapted to be more or less prestressed by actuating the screw jacks **35**.

This assembly operates as follows:

When the voltage and frequency values of the current fed to the exciter are such as to develop therein forces capable of overcoming the spring force, the drop-hammer **39** moves away from the anvil **37** and, at the end of the downward stroke resulting from the reversal of the alternating force, strikes this anvil **37** again. The stroke frequency is equal to the frequency of the AC mains supplying the apparatus. To obtain a higher frequency, the compression of springs **40** must of course be increased concomittantly with the increment in the frequency of the current supply.

This apparatus is free of any fragile component element likely to compromise its operation. Its power rating and beat frequency are practically illimited and therefore impacts of the order of several thousands tons can be obtained. In addition to these considerable advantages this apparatus is characterized by a high reliability, a completely noiseless operation of the vibration generator, and notably the possibility of embodying its principle in a very wide range of apparatus for operation on land or under water, with a wide range of power ratings.

The device of this invention is advantageously applicable in many fields, inter alia:

a. In public works and contractors'works, and industries relating thereto, for example in branches such as:

Exploration of subsoils, both inland and, by using watertight apparatus, on sea bottoms;

Drilling, driving and pulling out piles, sheet piles, timbering, etc. whether vertically, obliquely or horizontally; sonic frequencies may notably be used;

Compacting, ramming, tamping surfaces, coatings or the like, or subsoil at certain depths;

b. In handling industries and the like:

Shaking static conveyors and shoots for transporting materials such as grains, corn, coal, agglomerated products and miscellaneous materials, etc. by replacing the eccentric load oscillators usually employed to this end;

c. In the electrical industry:

Construction of AC generators, with the core of the device designed and mounted for performing alternating movement of translation along its axis, for example with the assistance of crankshaft mechanisms, in order to generate alternating currents in windings of the type contemplated in the central portion of the device described hereinabove;

Utilizing this generator as an apparatus for detecting and measuring the amplitude and frequency, even of relatively low value, of vibrating members or objects.

Of course, it will readily appear to those conversant with the art that this invention should not be construed as being strictly limited to the specific forms of embodiment described and illustrated herein, since many modifications may be brought thereto without departing from the basic principles of the invention as set forth in the attached drawings. Thus, these principles may be applied to the construction of an engine for automotive or self-propelled vehicle in which only the impulses produced in one direction are utilized for the drive.

Furthermore, instead of arranging the DC and AC coils on the core as contemplated in the above-described forms of embodiment, these coils may be disposed on the yoke or even distributed to the core and yoke according to any suitable arrangement.

What I claim is:

1. Device for producing vibrations or impulses, of the type comprising a yoke of magnetic material and a core also of magnetic material disposed within said yoke and separated therefrom by magnetic gaps, and windings through which a direct current and an alternating current are caused to flow, respectively, in order to create direct and alternating magnetic fluxes superposed to each other and producing a resultant flux determining movements of translation of said yoke and core in relation to each other, said device comprising a yoke divided into two sections disposed on either side of said core, means for interconnecting said sections, means for guiding said core during its movement, means for rigidly connecting a member to which the vibrations or impulses are to be impressed to one of said sections of said yoke, elastic means of adjustable stiffness between said core and said yoke to adjust the frequency of the movements of said core and of said elastic means to the resonance frequency of the whole system comprising said yoke, said member to be vibrated and the external forces acting on the latter, the alternating current being adjusted to the resonance frequency of said whole system.

2. Device according to claim **1** wherein said elastic means of adjustable stiffness are a plurality of springs of which one is chosen to set in place according to the resonance frequency of said whole system.

3. Device according to claim **1**, wherein the said core has substantially the shape of a double "H" with the central element or web of the core provided, on either side of the median branch, with a winding adapted to be energized with alternating current and wherein each one of the two sections of said central web, on either side of said central branch, is provided with a winding adapted to be energized with direct current, the AC windings producing fluxes having the same direction and the DC windings producing fluxes of opposite directions, whereby the direct and alternating fluxes of same amplitudes are added to each other in the gap between said core and one of the yoke sections and substracted from each other in the other gap between said core and the other yoke section in order to impart to said core a reciprocating motion having the same frequency as the AC utilized, the lower and upper portions of said central branch of the core thus receiving an undulated flux of opposite direction for each of them which varies from zero value to a maximum value and then return to zero value.

4. Device according to claim **3**, wherein the DC windings are so disposed in relation to the alternating flux path that the dispersion of the alternating flux through those portions of the median branch which are surrounded by the DC windings cannot produce any induced current in said windings.

5. Device according to claim **1**, wherein the alternating oscillations produced in said core are converted into unidirectional impact movements by providing adjustable resilient members between that portion of one of the yokes which is opposed to one of said gaps, or between a member rigid with said portion, and a rigid frame structure surrounding the oscillation generator assembly, said frame structure comprising on its face opposed to the portion of the other yoke which is itself opposed to the other gap, an anvil adapted to be struck by said portion of said other yoke or by a member rigid with said last-named portion, guide means being furthermore provided for the alternating movement of said generator within said rigid frame structure.

6. Device according to claim **5**, wherein the said rigid frame structure comprises at its upper portion a gripping member and at its lower portion a member for rigidly coupling same to the element to which the unidirectional impulses produced by the device are to be applied.

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