March 19, 1940. H. SVENSON 2,194,410

VIBRATING DEVICE

Filed Jan. 14, 1937 2 Sheets-Sheet 1

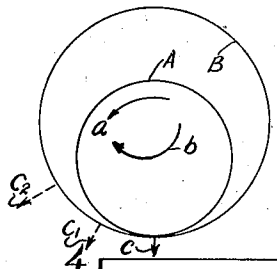


Fig. 1

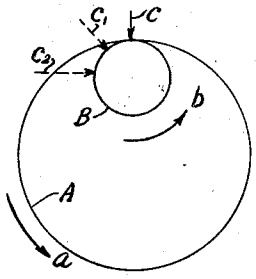


Fig. 2

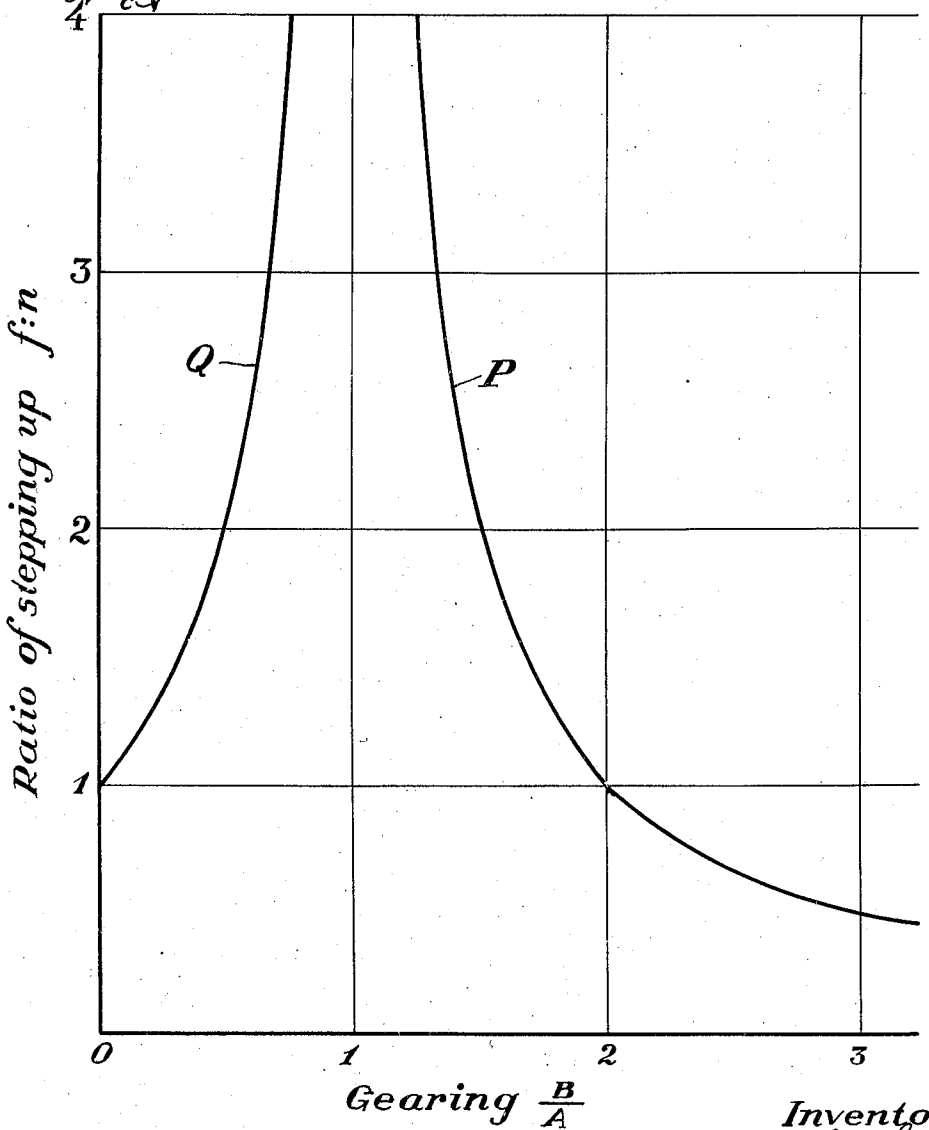


Fig. 3

Inventor:
Sibling Svenson
By Cameron, Kerkam & Sutton
Attorneys

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Fig. 4.

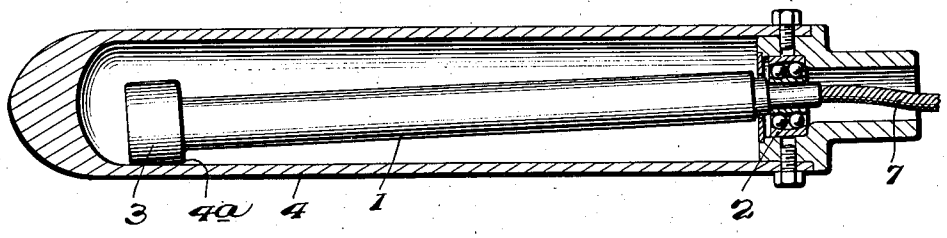


Fig. 5.



Fig. 6.

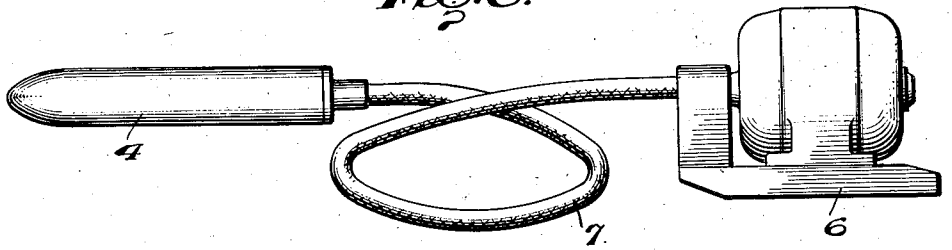
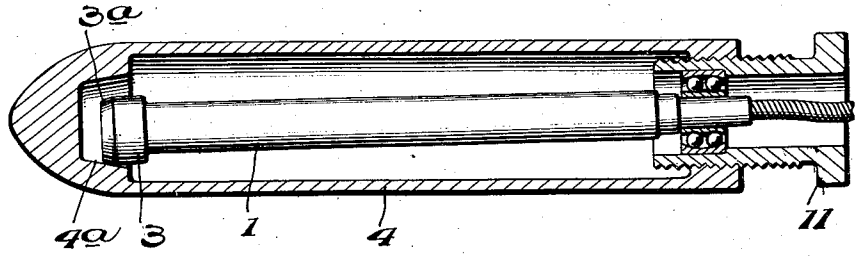


Fig. 7.



Inventor

Hilding Svenson.

By Cameron, Kerkam & Sutton.

Attorneys

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UNITED STATES PATENT OFFICE

2,194,410

VIBRATING DEVICE

Hilding Svenson, Hagalund, Sweden, assignor to Aktiebolaget Vibro-Betong, Stockholm, Sweden, a company

Application January 14, 1937, Serial No. 120,610
In Sweden October 1, 1936

11 Claims. (Cl. 259—1)

This invention relates to vibrating devices in which a rotary motion is transformed into vibratory movements, particularly such movements having a frequency higher than that of the rotary motion. The rotary motion of said vibrating devices may be effected by any suitable means, e. g. a motor, a motor-driven rotary shaft or the like, and the mechanical force thus set up and transformed into vibratory movements may be used for the vibration of solids, liquids or gases, either by means of a direct action of the vibrating device upon these or by the intermediary of suitable arrangements such as membranes, screens, molds, chutes, jigging tables, etc., to which the vibrating device is connected. In particular are these vibrating devices suitable as internal high frequency vibrators for placing concrete.

The advantages and several objects of the invention are more fully described in the following specification and accompanying drawings in which:

Figs. 1–3 are diagrams showing the mechanical principles involved in the invention. Fig. 4 is an axial sectional view, with certain parts shown in full, of one form of vibrating device according to the invention in which the rotary member is arranged to roll on the inside surface of the vibrating member, and Fig. 5 a similar view of another embodiment in which the rotary member engages with the vibrating member by means of a projecting part on the latter, the details of construction and mode of action being more fully described in the following. Fig. 6 is an external view of a device like either of those shown in Figs. 4 and 5, including a motor drive therefor. Fig. 7 is a sectional view, similar to Figs. 4 and 5, of still another form of the invention.

It has been previously known to produce vibrations by mechanical means, particularly for the purpose of vibrating plastic masses such as concrete mixes and the like, by means of revolving shafts supported at both ends by bearings and provided with weights having their center of gravity eccentrically arranged in relation to the central axis of the shaft, and rigidly connected to the same. When the shaft is revolving at high speed, the eccentric weights will set up vibrations in the system, but it is easily seen that the frequency of these will be limited to the frequency of the revolving shaft, the number of cycles of the vibration being equal to the number of revolutions of the shaft. Particularly in regard to the vibration of concrete, it is highly desirous to use vibrations of a very high frequency. The only suitable known way, so far, to obtain a high frequency by mechanical means has thus been to impart a great speed to the revolving shaft by means of a motor, acting either directly on the shaft or by the intermediary of a gearing device between the motor and shaft. The first mentioned arrangement allows of a more robust and dependable construction, but the maximum speed obtainable will be that of the driving motor. In the case of electric motors, this is usually limited to the frequency of the electric current, since only alternating current motors can be used with any advantage for these purposes. The use of gears, on the other hand, increases the cost of the device and makes it more delicate, particularly in cases where flexible shafts are used between motor-driven gears and the vibrating member, on account of the considerable reduction of the durability of the shaft at extremely high speeds, such as are desirable in many cases.

The present invention eliminates these and several other drawbacks, at the same time making it possible to obtain practically any desired frequency, even when using a driving motor or shaft with a reasonably low speed, while simultaneously simplifying the construction of the vibrator. This is accomplished by applying the principles of planetary movement to a device, comprising a rotary member, having the same speed as its driving motor or shaft. This rotary member is provided with an inner or outer circular surface which is brought into contact with a corresponding circular surface on the so-called vibrating member, so that these two surfaces will perform a rolling motion in respect to each other while in contact. In this way the rotary movement of the rotary member may, at certain given relations between the diameters of the two circular surfaces, become transformed into a number of impulses on the vibrating member, so that the latter will vibrate with a higher frequency than the number of cycles of the rotary member.

The underlying principle of the invention is easily understood from Figs. 1–5 which demonstrate special cases of one and the same basic principle. Fig. 1 is a diagram showing the mechanical principle involved in an arrangement according to the invention such as that shown in Fig. 4. Circle A corresponds to rotary member 3 in Fig. 4, and circle B to cylindrical casing 4 in the same figure. When rotary member 3 and shaft 1 (Fig. 4) are given a spinning motion by means of flexible shaft 7, surface 3 coming in contact with surface 4a (circle A and circle B in Fig. 1), their relative movements will become

of the order shown in Fig. 1. The structural details of the arrangement and its mode of action will be more closely described in the following in connection with an explanation of Figs. 4–24. At present it suffices to consider Figs. 1–3 as representing the purely mechanical principles involved in Figs. 4 and 5.

Circle A, Fig. 1 (corresponding to rotor 3 in Fig. 4), which is assumed to have a spinning motion as shown by arrow *a*, will roll against circle B (inner surface 4*a* in Fig. 4) and describe a circling motion as shown by arrow *b*. The rotary force imparted to circle A will have a component *c* radially through the point of contact between circle A and B. This component thus represents a force, which strives to move circle B in the direction of arrow *c*, due to the pressure exerted by the inertia of circle A which, by rolling on the inside of B, is continuously forced to deviate from the straight line ("centrifugal force"). While thus rotating about its center of gravity, as shown by arrow *a*, and performing the circular (planetary) movement in relation to circle B, as shown by arrow *b*, circle A will exert pressure *c* radially on circle B, and this pressure will continue to act radially on circle B while moving along the periphery of the same with circle A, thus assuming positions c_1, c_2, etc. It is thus apparent that the speed with which the force *c* travels along circle B will depend on the speed with which circle A travels along circle B (the movement indicated by arrow *b*). This latter speed is determined by two factors, namely the ratio of the diameters of circles A and B, and the peripheral velocity (the revolving speed as indicated by arrow *a*) of the former. Calling the number of revolutions of circle A about its center (the movement indicated by arrow *a*) *n*, and the number of revolutions of the center of circle A around the center of circle B, *f*, it is seen that *f* represents the frequency set up by the "centrifugal force" *c* of circle A. The relation between the diameters of circles A and B, these diameters being for simplicity called A and B, and movements of circle A (*n*, *f*), is as follows:

$$\frac{A \cdot n}{B-A}=f$$

or

$$\frac{n}{\frac{B}{A}-1}=f$$

It is easily seen that, when the diameter of circle A is less than ½ the diameter of circle B, i. e. ratio $B:A>2$, circle A will have to perform more than one revolution about its own center (the movement indicated by arrow *a*) before having travelled one full revolution along circle B (the movement indicated by arrow *b*), *f* thereby assuming values $<n$. In other words, in such cases force *c* will move along the periphery of circle B (while acting radially thereon) with less speed than circle A revolves about its own center. Thus, if circle A (rotor 3 in Fig. 4) receives a speed of, say, 3000 revolutions per minute, this will be transformed into a force having a component acting radially on circle B so as to vibrate the latter, but this force will in those cases travel along the periphery of circle B with less speed. In other words, the frequency of the vibrations of circle B (casing 4 in Fig. 4) will be less than 3000 per minute. Similarly, when making the ratio of the diameters of circles B and A as 2:1 the special case is obtained, in which the circle A will perform one revolution about its center while making one revolution about center of circle B, since $f=n$ for $B=2A$. In this case the frequency of vibrations will thus become equal to the number of revolutions of circle A about its own center (the revolutions of driving shaft 1 in Fig. 4). In making the ratio of the diameters of circles B and A<2, a stepping up of the frequency is obtained, as will be easily understood from the foregoing *f* assuming values $>n$. The limit, $B:A=1$, which would theoretically mean infinite frequency of force *c*, is for obvious reasons impossible to attain; but a stepping up of the rotary movement to a vibrating frequency in the ratio 1:5 or 1:10, or even higher, is easily accomplished in this way without any difficulties of a mechanical nature. This means that, while using a motor or a shaft rotating at the reasonable speed of, say, 3000 R. P. M. or driving the rotor, the vibrating frequency obtained may be of the magnitude 15,000 to 30,000 R. P. M. or even more.

The above discussed relation between the ratio of the diameters of circles B and A, and the transforming of speed *n* into frequency *f*, the magnitude of which is thus

$$\frac{f}{n}$$

is shown by curve P in the accompanying diagram Fig. 3. As seen, the ratio $f:n$ will be less than 1 (i. e. a stepping down of the initial movement *n* will take place) for ratios of diameters $B:A$ larger than 2, in accordance with what has been demonstrated above. For $B:A=2$ the ratio $f:n$ will become equal to 1, and for all values of $B:A<2$ a stepping up of the frequency will take place, as seen by curve P. As A nears B in size, the rate of stepping up is also increasing, curve P being in fact an equilateral hyperbola, which is asymptotic to the coordinate axes.

Having now explained the general principle as applied in the case shown in Figs. 1 and 4 where the ratio $B:A$ is moving from ∞ to 1, another special case of the same principle will be discussed in connection with Figs. 2 and 5 wherein the ratio $B:A$ is less than 1. This means that the circle A rolls on the outer surface of circle B instead of as before on the inner surface of the latter, while still performing the spinning motion about its own center as indicated by arrow *a*. In this case rotary circle A thus engages with its inner instead of its outer peripheral surface with the vibratory member, which in Fig. 5 is shown as having a cylindrical projection 4*a*, corresponding to circle B in Fig. 2. Circle A will thus also in this case perform a planetary movement along the periphery of circle B. The mathematical conditions in regard to the relation between the frequency of force *c* and the spinning of circle A are in this case

$$\frac{A \cdot n}{A-B}=f$$

or

$$\frac{n}{1-\frac{B}{A}}=f$$

and the relation between $f:n$ and $B:A$ is seen from curve Q (Fig. 3). Thus continuing along the X-axis from higher to lower values of $B:A$, the frequency which reached infinity for

$$\frac{B}{A}=1$$

will fall along curve Q as A increases over B. The limit is $f:n=1$ when

$$\frac{B}{A}$$

approaches zero. It is thus evident that the arrangement as shown in Fig. 5 will always produce a stepping up of the speed n to frequency f in the ratio $f:n$ along curve Q. As the diameters of the circular outer surface of projection 4a on vibrating member 4 and the circular inner surface 3a of rotary member 3 (Fig. 5) tend to approach each other in size, the rate of stepping up will increase in the same manner as for curve P, curves Q and P being hyperbolas symmetrical to each other and to the ordinate through $B:A=1$.

Having thus described various special cases derived from one and the same basic principle, the practical realization of these various cases will be more particularly described with reference to Figs. 4–7, it being understood that the various arrangements may be considerably altered in a purely mechanical way without departing from the underlying basic principle, and without limiting the invention to the special cases shown and described.

According to the arrangement of Fig. 4, the vibrating device consists of an outer casing 4, suitably in the form of a tube or the like, having a circular inner surface 4a. A shaft 1 is rotatably supported by bearing 2 in one end of the casing 4, the bearing being of a construction to allow of a free circular movement of the other end of the shaft within the limits set by the diameter of surface 4a and the size of weight 3 on the shaft, as will be understood by the following. The other end of the shaft supports a cylindrically shaped weight 3, for instance in the form of a more or less spherical pulley or the like. The shaft 1 is made to revolve about its axis by means of a flexible shaft 7 or the like, connected to any suitable driving means, such as an electric motor or similar device (not shown). Shaft 1 is suitably made hollow, in order to reduce the weight of the apparatus and to concentrate the momentum to the rotating weight 3 on shaft 1. When starting up the driving means, thus causing shaft 1 to spin about its axis, the rotary weight 3 (the so-called rotary member), upon being only slightly brought out of center, will begin to circle as a conical pendulum supported in jointed or automatically adjustable bearing 2 as fulcrum until it strikes the side of casing 4. When coming into contact therewith, it will at first slide on the inner circular surface 4a of casing 4 (the so-called vibrating member) until, upon gaining momentum, its centrifugal force will become of such magnitude as to keep weight 3 in contact with surface 4a at all positions. As soon as this takes place weight 3 will begin to roll on surface 4a, as described above with reference to Fig. 1. It is thus seen, that weight 3 will serve as its own frictional clutch and only be gradually thrown into action as it gains speed and momentum, which is of great importance for the prevention of undue strain on mechanical or electrical driving parts when starting the vibrating device. Dependent upon the revolving speed of shaft 1 and the ratio between the diameters of weight 3 and the inner circular surface 4a of vibrating member 4, the whole device will vibrate with frequencies the magnitude of which is determined by curve P, Fig. 3.

The arrangement shown in Fig. 5 is a slightly modified construction. Weight 3 is in this case provided with a recess having a circularly shaped surface 3a, and the vibrating member is correspondingly provided with a projection 4a having an outer surface of revolution. Weight 3 will thus be able to roll with surface 3a on surface 4a in accordance with the principle shown and described with reference to Fig. 2. The mode of action is the same as that of the device shown in Fig. 4, the conditions for a transformation of the spinning of shaft 1 into vibrations of the device being already set forth and explained in connection with curve Q, Fig. 3.

Fig. 6 is a general view of a vibrating device like those shown in Figs. 4 and 5. Shaft 1 is in these cases driven by motor 6 and flexible shaft 7. The devices shown in Figs. 4–6 are particularly well suited for the placing of concrete, the outer casing 4 being tube-shaped so as to be directly inserted in the concrete for vibrating the same.

Fig. 7 shows a vibrating device of the same general construction as that shown in Fig. 4 but which is especially adapted to demonstrate the general principle of adjustable frequency of vibrations. The co-acting surfaces 3a and 4a of rotating member 3 and vibrating member 4 are in this case made conical. By means of a bushing 11 or other suitable arrangement, the member 3 may be made to contact with various zones of the conical surface 4a, which zones represent different diameters of path on which member 3 will roll. Since, as was demonstrated in connection with Figs. 1 and 3, the ratio between the diameters of surfaces 3a and 4a is a factor which, other conditions being equal, determines the frequency of vibration of the vibrating member, it is easily seen that this arrangement will allow of an adjustment of the frequency. This arrangement may be used in connection with any of the other devices shown, as ought to be clear from the foregoing. Instead of being conical the surfaces may be given any suitable form to produce the desired variation of ratio of diameters.

The constructions shown and explained above in connection with Figs. 4–7 are, as seen, only special cases of one and the same fundamental principle, and it is evident that the practical embodiment of said principle may be accomplished in a number of ways without deviating therefrom, it being particularly understood that the invention is in no way limited to the particular forms shown in the drawings. Reference is therefore to be had to the appended claims for a definition of the scope of the invention.

What is claimed is:

1. In a vibrating device, a vibratory member, a rotatable shaft having a weighted member adjacent one end thereof, a bearing for the other end of said shaft carried by said vibratory member, said weighted member having a surface of revolution contacting with a surface of revolution fixed relatively to said vibratory member, said bearing and shaft being so constructed and arranged that said weighted member forms the outer end of a conical pendulum rotatable about the axis of said shaft and movable circularly relative to the vibratory member, and means for adjusting the position of said bearing relative to said vibratory member in the axial direction of said shaft.

2. In a vibrating device, a rotatable shaft, a weighted member fixed to said shaft in concentric relation thereto and having a surface of revolution, means for rotating said shaft and weighted member, a vibratory member having a surface of

revolution contacting with the surface of said weighted member, said members being arranged one inside the other and performing a rolling planetary motion with respect to each other, the vibratory member receiving its moving impulses from the weighted member by the centrifugal action of the vibrating system, and means for varying the ratio between the diameters of the contacting surfaces of said weighted and vibratory members, whereby the frequency of the vibrations produced in said vibratory member may be adjusted.

3. In a vibrating device, a rotatable shaft, a weighted member fixed to said shaft in concentric relation thereto and having a surface of revolution, means for rotating said shaft and weighted member, a vibratory member having a surface of revolution contacting with the surface of said weighted member, said members being arranged one inside the other and performing a rolling planetary motion with respect to each other, the vibratory member receiving its moving impulses from the weighted member by the centrifugal action of the vibrating system, the surface of revolution of at least one of said weighted and vibratory members being of different diameters at different points axially thereof, and means for adjusting said members relatively to one another in an axial direction to vary the ratio between the diameters of their contacting surfaces, whereby the frequency of the vibrations produced in said vibratory member may be adjusted.

4. In a vibrating device, a vibratory member, a shaft rotatably suspended at one end for a conically pendulous movement, said shaft supporting adjacent its other end a concentrically arranged body having a surface of revolution and revolving with said shaft, and an annular member carried by said vibratory member having a surface of revolution contacting with the surface of revolution of the revolving body supported by said shaft, said surfaces of revolution being adjustable relatively to each other in an axial direction and having such shapes that the ratio between their diameters at the points of contact varies with said adjustment.

5. In a vibrating device, a vibratory casing, a shaft rotatably supported at one end by and revolving about its axis within said casing, said shaft supporting a concentrically arranged annular member having its inside provided with a surface of revolution, and a member carried by said casing projecting inside said annular member and having a surface of revolution contacting with the surface of revolution of the annular member, said annular member being rotatable with said shaft and performing a planetary movement while rolling on the surface of said projecting member, said casing receiving a vibrating motion due to the rolling contact between said projecting member and said rotatable annular member.

6. In a high frequency vibrator for vibrating plastic masses such as concrete and the like, a portable vibratory member adapted to be manually placed and maintained in contact with the mass to be vibrated and having a fixed internal annular surface of revolution, a rotatable shaft rigid throughout its length, means directly connected with said shaft for rotating the latter, and a bearing carried by said vibratory member, one end of said shaft being rotatably mounted in said bearing and the other end thereof being free to swing in a circle about the axis of said bearing, said bearing and shaft being so constructed and arranged that the free end of the shaft swings outwardly by centrifugal force when the shaft is rotated and forms the outer end of a conical pendulum rotatable about the axis of said shaft and movable in contact with and circularly relatively to the surface of revolution of said vibratory member.

7. In a high frequency vibrator for vibrating plastic masses such as concrete and the like, a portable vibratory member including a tube-like casing adapted to be manually placed and maintained in contact with the mass to be vibrated and having a fixed internal annular surface of revolution, a rotatable shaft rigid throughout its length, means directly connected with said shaft for rotating the latter, and a bearing carried by said vibratory member and arranged substantially concentrically of said surface of revolution, one end of said shaft being rotatably mounted in said bearing and the other end thereof being free to swing in a circle about the axis of said bearing, said bearing and shaft being so constructed and arranged that the free end of the shaft swings outwardly by centrifugal force when the shaft is rotated and forms the outer end of a conical pendulum rotatable about the axis of said shaft and movable in contact with and circularly relatively to the surface of revolution of said vibratory member.

8. In a high frequency vibrator for vibrating plastic masses such as concrete and the like, a portable vibratory member adapted to be manually placed and maintained in contact with the mass to be vibrated and having a fixed internal annular surface of revolution, a rotatable shaft rigid throughout its length, means directly connected with said shaft for rotating the latter, a bearing carried by said vibratory member, one end of said shaft being rotatably mounted in said bearing and the other end thereof being free to swing in a circle about the axis of said bearing, and a weighted member fixed to said shaft adjacent the free end thereof in concentric relation to said shaft, said bearing and shaft being so constructed and arranged that the weighted member swings outwardly by centrifugal force when the shaft is rotated and forms the outer end of a conical pendulum rotatable about the axis of said shaft and movable in contact with and circularly relatively to the surface of revolution of said vibratory member.

9. A high frequency vibrator for vibrating plastic masses such as concrete and the like comprising a portable vibratory member adapted to be manually placed and maintained in contact with the mass to be vibrated, a rotatable shaft rigid throughout its length and having a weighted member fixed thereto adjacent one end thereof, a bearing for the other end of said shaft carried by said vibratory member, and means directly connected with said shaft for rotating the latter at the same speed as said rotating means, said weighted member having a surface of revolution contacting with a surface of revolution fixed relatively to said vibratory member, said bearing and shaft being so constructed and arranged that said weighted member forms the outer end of a conical pendulum rotatable about the axis of said shaft and movable circularly relative to the vibratory member.

10. A high frequency vibrator for vibrating plastic masses such as concrete and the like comprising a portable vibratory member including a tube-like casing adapted to be manually placed and maintained in contact with the mass

to be vibrated, a rotatable shaft housed within said casing and having a weighted member fixed thereto adjacent one end thereof, a flexible bearing for the other end of said shaft carried by the casing of said vibratory member, said shaft being rigid throughout its length, and means directly connected with said shaft for rotating the latter at the same speed as said rotating means, said weighted member having a surface of revolution contacting with a surface of revolution fixed relatively to said vibratory member, said weighted member forming the outer end of a conical pendulum rotatable about the axis of said shaft and movable circularly relative to the vibratory member.

11. A high frequency vibrator for vibrating plastic masses such as concrete and the like comprising a portable vibratory member adapted to be manually placed and maintained in contact with the mass to be vibrated, a rigid shaft rotatably supported at one end by said vibratory member, a weight fixed to said shaft and having a surface of revolution coaxial therewith, means directly connected with said shaft for rotating the latter at the same speed as said rotating means, and an annular member fixed relatively to said vibratory member and having its inside provided with a surface of revolution contacting with the surface of revolution of said weight, whereby the latter is adapted to revolve inside said annular member and to perform a rolling motion along the periphery thereof, the ratio between the diameters of the contacting surfaces of said annular member and weight having a numerical value between 1 and 2, said annular member receiving a vibrating motion due to the rolling contact therewith of said revolving weight.

HILDING SVENSON.