United States Patent [19]

Varnello et al.

[11] **3,726,508**

[45] **Apr. 10, 1973**

[54] **PNEUMATIC VIBRATOR**

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[21] Appl. No.: **172,421**

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Feb. 23, 1971	USSR	1618404
Feb. 23, 1971	USSR	1618403
Feb. 23, 1971	USSR	1618402

[52] **U.S. Cl.** .... **259/1 R,** 425/456

[51] **Int. Cl.** **B01f 11/00**

[58] **Field of Search** .... 259/1 R, DIG. 43, 259/DIG. 42; 425/456

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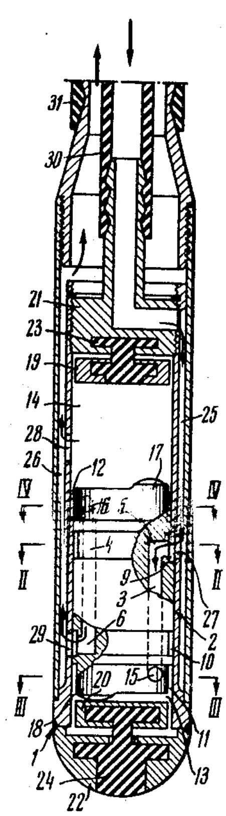
Primary Examiner—Robert W. Jenkins
Attorney—Holman & Stern

[57] **ABSTRACT**

A pneumatic vibrator including a housing inside of which there is mounted a reciprocating impact member having eccentric projections on the opposite end faces thereof, with these projections in operation of the vibrator, being adapted to strike the members mounted adjacent to the end, or terminal walls of the housing, in which way the housing is imparted additional transverse vibrations.

18 Claims, 21 Drawing Figures



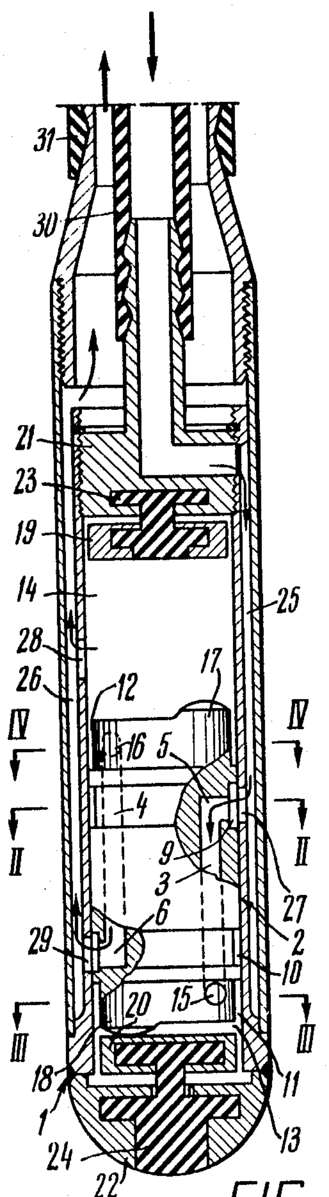


FIG. 1

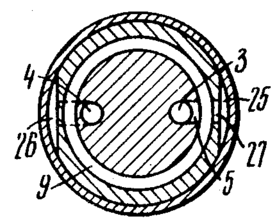


FIG. 2

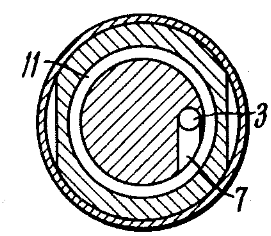


FIG. 3

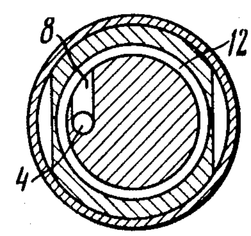


FIG. 4

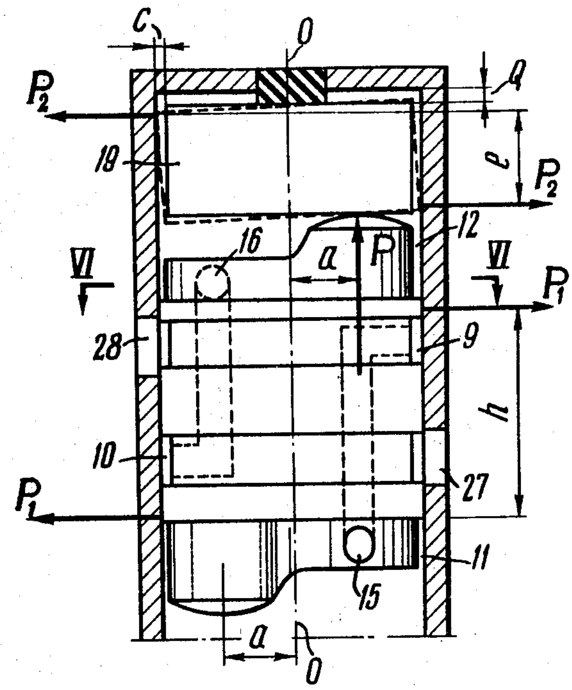


FIG.5

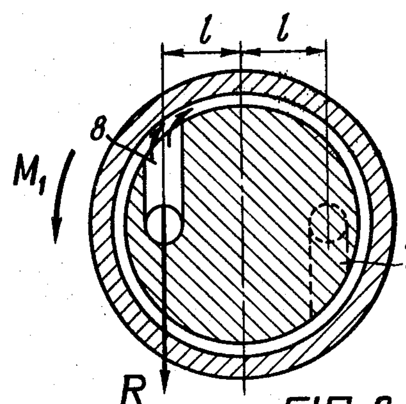


FIG.6

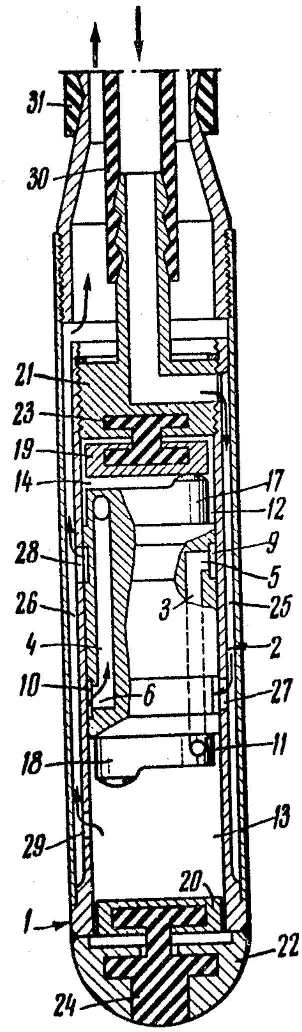


FIG. 7

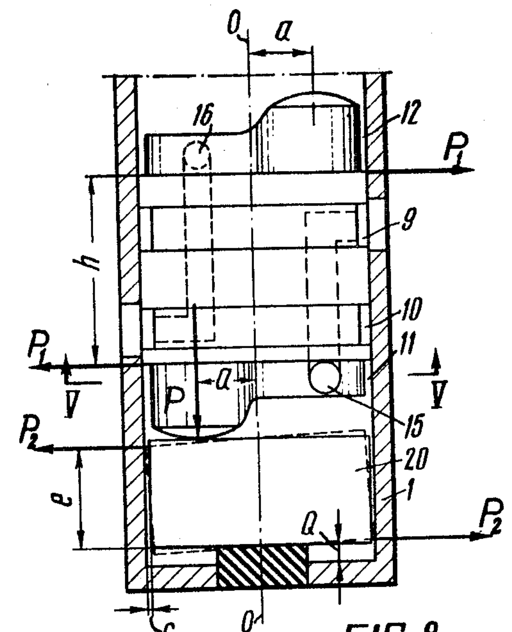


FIG. 8

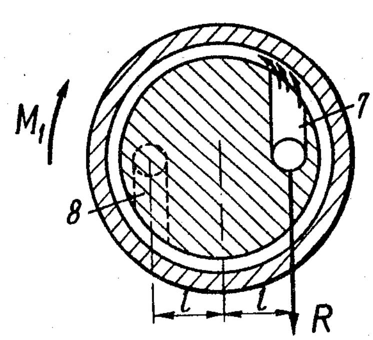


FIG. 9

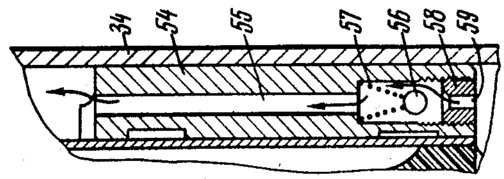


FIG. 15

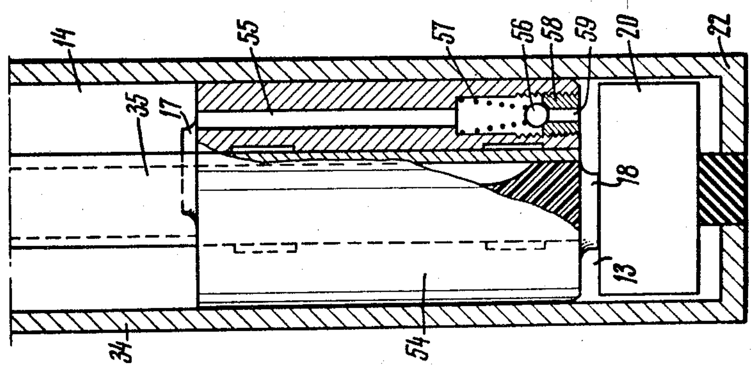


FIG. 14

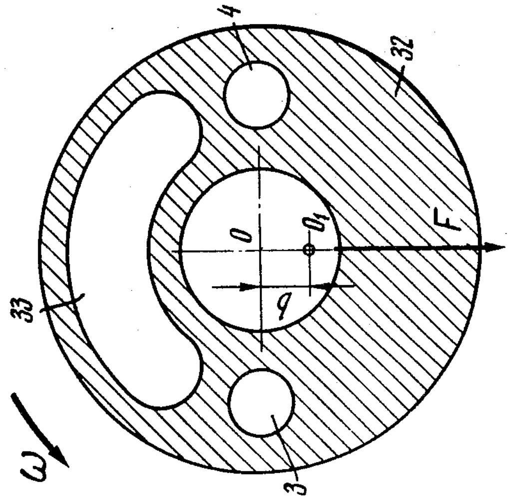


FIG. 10

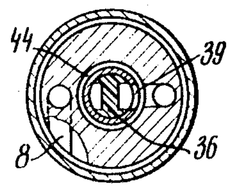


FIG.12

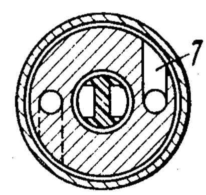


FIG.13

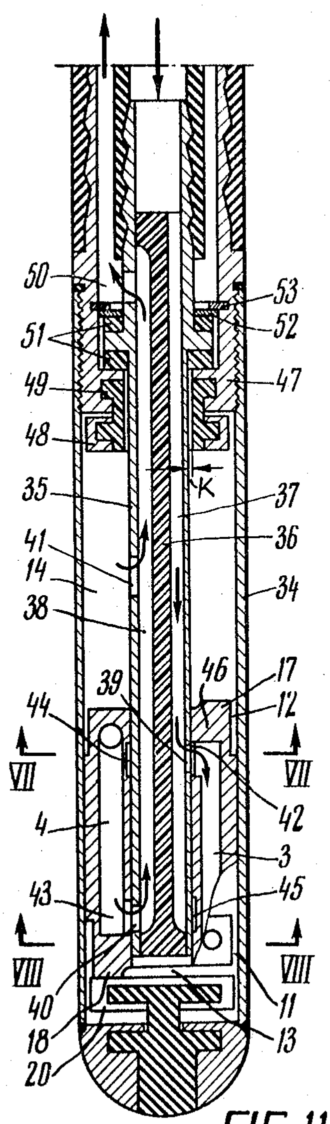


FIG.11

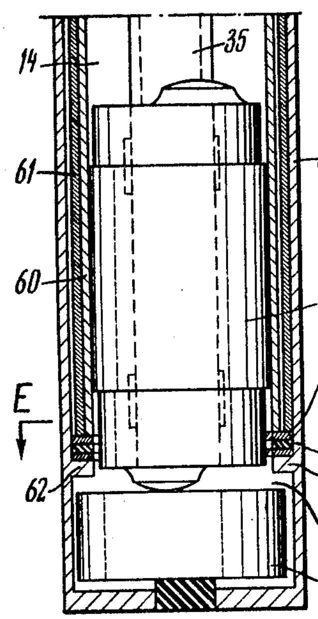


FIG. 16

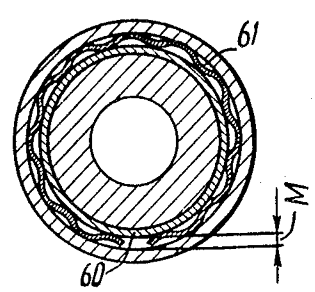


FIG. 17

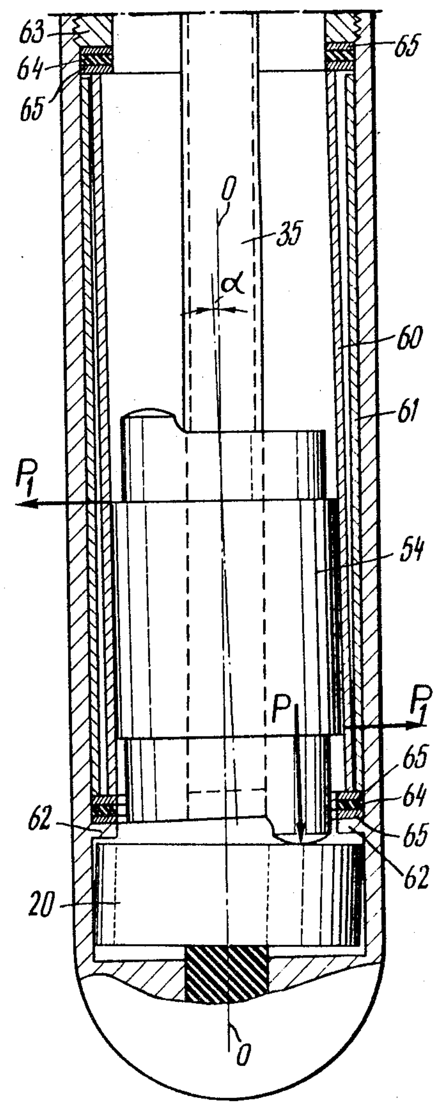


FIG. 18

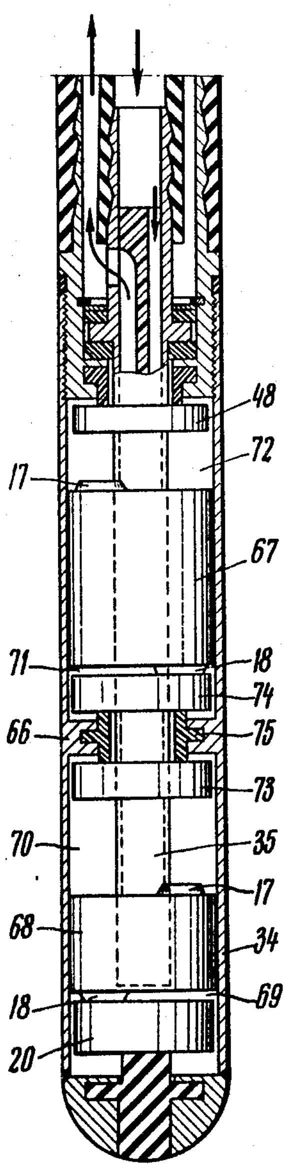


FIG. 19

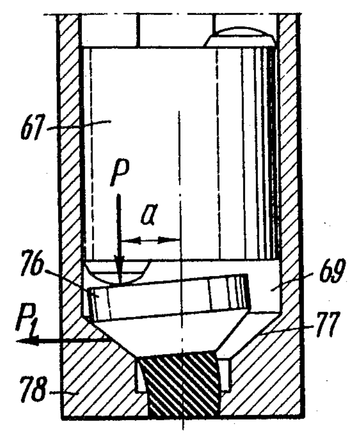


FIG. 20

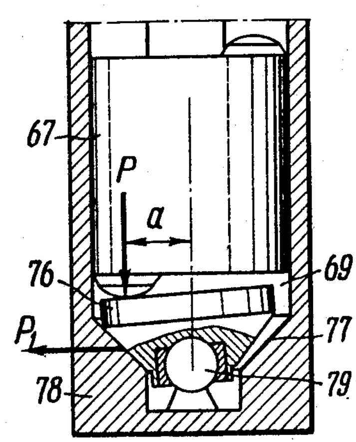


FIG. 21

PNEUMATIC VIBRATOR

BACKGROUND OF THE INVENTION

The present invention relates to construction machinery, and, more particularly, to submersible pneumatic vibrators for compacting concrete mixes.

PRIOR ART

Known in the art is a pneumatic vibrator, which comprises a housing in the form of a closed cylinder having an impact member mounted for reciprocations therein under the action of compressed air and another member for imparting additional transverse vibrations to the housing, in the form of a cylinder with an eccentric projection facing the impact member and adapted to be engaged by the latter, with the bearing surface of this another member being spherical. The last-mentioned member is freely mounted on the bottom, or terminal wall of the housing, with an annular clearance being left between the member and the cylindrical wall of the housing. The vibrator also includes an air distributor which is either a valve or a slide valve cooperating with a system of passages and openings in the wall of the housing for alternate supply of compressed air into the working spaces and outlet of the used-up air into the atmosphere.

The air distributing means may have no valve means. In this case, the part of the valve means is played by the impact member itself, there being provided axial and radial passages in the body of the impact member and annular grooves in the surface thereof. The passages and the grooves alternatingly connect the working spaces within the housing with the above-mentioned passages and openings in the wall of the housing.

In the operation of vibrators of this type, there are effected not only longitudinal vibrations, but also additional transverse vibrations of the housing.

However, this known type of vibrators features a relatively low frequency of the additional transverse vibrations and does not provide for the circular character of these vibrations. Moreover, the transverse vibrations of this vibrator are of a small amplitude and of a simple shape, and the very low frequency component of these vibrations is practically absent.

The above disadvantages of the known type of vibrators lower the effectiveness of compacting of concrete mixes. Besides, the above specified known vibrator has a relatively great weight on account of the location of the conduits and passages in the housing wall thereof, as well as insufficient durability.

It is an object of the present invention to provide a pneumatic vibrator which ensures a higher frequency of the additional transverse vibrations of the housing with a sufficient amplitude and a circular character of these vibrations.

SUMMARY OF THE INVENTION

The above and other objects are accomplished in a pneumatic vibrator comprising a housing defined by a cylinder with the closed ends, an impact member mounted for reciprocations therein, said impact member having passages and annular grooves in the body and in the peripheral surface thereof respectively for the passage of compressed air; a member for imparting additional transverse vibrations to said housing, mounted adjacent to the end wall of the housing with a radial clearance from the wall of said housing and cooperating with said housing and with a striking means adapted to deliver impacts upon the surface of said member, remote from the center thereof; and an air distributing means. In accordance with the present invention, said vibrator comprises two impact-receiving members mounted in said housing with radial and axial clearances, adjacent to said end walls of said housing and connected therewith, said impact-receiving members being adapted to impart additional transverse vibrations to said housing, and said striking means being defined by eccentric projections on the respective opposite end faces of said impact member, adapted to engage said impact-receiving members at the impacts of said impact member.

The substitution of the idle return stroke by the working stroke, resulting from the incorporation of the present invention, increase the frequency of the additional transverse vibrations of the housing of the vibrator.

It is expedient, in order to obtain circular additional transverse vibrations, for said impact member to have tangential passages in the body thereof, for effecting rotation of said impact member under the action of the pressure of the compressed air issuing from said tangential passages, and for said tangential passages to have the inlets and outlets thereof located within said annular grooves of said impact member.

It is further expedient for said impact-receiving members for imparting additional transverse vibrations to said housing to be constituted by discs coaxial with the respective end walls of said housing, with said discs being resiliently connected with said end walls.

In this way, the mounting of said impact-receiving members is simplified, and, what is more, there is no need to impose very strict requirements as concerns the accuracy of the size of these members and the balancing thereof, in order to ensure a uniform radial annular clearance between these members and the cylindrical wall of the housing.

It is also expedient, in order to increase the amplitude of the additional transverse vibrations of the housing of the vibrator and to reduce the weight of the vibrator, to mount said impact member reciprocably about a hollow shaft having built therein a profiled longitudinal partition defining with said hollow shaft conduits for the supply and exhaust of compressed air.

It is further expedient, in order to create in said vibrator a variable agitating force, to attain a low frequency of the additional transverse vibrations, and to increase the amplitude of these vibrations, that the gravity center of said impact member is displaced relative to the axis of the rotation thereof.

It is also expedient, in order to increase the amplitude of the additional traverse vibrations, to mount a one-way valve means in the body of said impact member, adapted to open upon the pressure in the working space rising above the rated supply pressure value.

It is further expedient, in order to step up the reliability of the performance of the vibrator and its durability, that a protective cylinder is mounted interiorly of with said housing, said cylinder reciprocably receiving said impact member therein, and resilient means being interposed intermediate of said cylinder and said housing.

It is also expedient for said impact-receiving members for imparting additional transverse vibrations to said housing, as well as for said end walls to have conically tapering peripheral surfaces along which said members and said end walls will engage one another at the impacts of the impact member. With these members and the end walls having these tapering surface, the longitudinal components of the impacts are partially used for imparting additional transverse vibrations to said housing.

These impact-receiving members may be connected with said end walls by spherical bearing means.

This manner of the connection between the impact-receiving members and the respective end walls can be considered as one of the possible embodiments of the present invention.

It may also be found expedient to divide the internal space of the housing of said vibrator by at least one transverse partition into chambers, to mount reciprocably one impact receiving member in each chamber with, said transverse partition serving in this case as an intermediate end wall of said housing, on which, similar to the aforesaid upper and lower end walls, is mounted discs cooperating with said impact members, for imparting additional transverse vibrations to said housing.

In this way, the shape of the additional transverse vibrations of the housing becomes even more complex, and the quantity of the different frequencies of these vibrations is increased; moreover, this ensures variable parameters of the vibration, and thus the effectiveness of the employement of the vibrator is stepped up.

It is further expedient that the abovementioned additional features of a pneumatic vibrator, constructed in accordance with the present invention, be also applied to the vibrator having the housing thereof divided by at least one partition into two chambers, with each chamber having an impact member mounted reciprocably therein.

The present invention will be further described in connection with preferred embodiments thereof, reference being had to the accompanying set of drawings, wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows schematically mainly in cross section a pneumatic vibrator embodying the invention, with the compressed air conducts disposed on the housing and the impact member being in its lowermost position;

FIG. 2 is a view taken along line II—II of FIG. 1;

FIG. 3 is a view taken along line III—III of FIG. 1;

FIG. 4 is a view taken along line IV—IV of FIG. 1;

FIG. 5 shows schematically the upper portion of the vibrator, illustrating the manner in which the housing of the vibrator is imparted additional transverse vibrations;

FIG. 6 is a view taken along line VI—VI of FIG. 5;

FIG. 7 shows schematically mainly in cross section a pneumatic vibrator embodying the present invention, with the compressed air conduit disposed in the housing and the impact member in the topmost position;

FIG. 8 shows schematically the lower portion of the vibrator, illustrating the manner in which the housing of the vibrator is imparted additional transverse vibrations;

FIG. 9 is a view taken along line V—V of FIG. 8, illustrating the manner in which rotation of the impact member about its axis is effected;

FIG. 10 is a cross-sectional view of the impact member with the radially displaced gravity center;

FIG. 11 shows schematically a longitudinally sectional view of pneumatic vibrator embodying the invention, incorporating a hollow shaft having built therein a profiled longitudinal partition;

FIG. 12 is a view taken along line VII—VII of FIG. 11;

FIG. 13 is a view taken along line VIII—VIII of FIG. 11;

FIG. 14 shows the lower part of the vibrator having the impact member incorporating a one-way valve;

FIG. 15 shows the open position of the one-way valve a partly broken-away view of FIG. 14;

FIG. 16 shows the lower portion of the vibrator incorporating a protective cylinder and a resilient interposing member;

FIG. 17 is a view taken along line E—E of FIG. 16;

FIG. 18 shows the lower portion of the vibrator incorporating the protective cylinder;

FIG. 19 shows a pneumatic vibrator embodying the invention, having two impact members mounted in the housing thereof;

FIG. 20 shows the lower portion of the vibrator wherein the discs cooperate with the bottom walls of the housing; and

FIG. 21 shows the lower portion of the vibrator wherein the discs are connected with the bottom walls through spherical bearing means.

DETAILED DESCRIPTION OF THE INVENTION

Referring now in particular to the appended drawings, the pneumatic vibrator illustrated in FIGS. 1 to 7 includes a cylindrical closed housing 1 (FIGS. 1 and 7) within which there is mounted for reciprocation and rotation an impact member 2. The body of the impact member 2 has made therein axial passages 3 and 4, radial passages 5 and 6, tangential passages 7 and 8 (FIGS. 3 and 4) and annular grooves 9, 10, 11 and 12, with the aforementioned passages and grooves serving to supply compressed air into working spaces 13 and 14 of the vibrator and to direct the used-up air therefrom into ambient atmosphere. Outlets 15 and 16 of the tangential passages 8 and 7, respectively, are disposed within the annular grooves 11 and 12. The respective opposite end faces of the impact member 2 are provided with off-center projections 17 and 18, with their eccentricity relative to the axis of the impact member being equal to a (FIGS. 5 8), the projections serving to strike respective discs 19 and 20 (FIGS. 1 and 7), mounted within the housing 1 of the vibrator, at reciprocations of the impact member 2 and thus to impart additional transverse vibrations to the wall of the housing 1. The discs 19 and 20 are mounted on the respective end walls 21 and 22 of the housing 1 with the help of resilient suspension members 23 and 24 which may be, for example, of rubber.

Provided in the cylindrical wall of the housing 1 are an air supply passage 25 and an air outlet passage 26 communicating with the interior of the housing 1 through respective openings 27 28, and 29. These openings function to establish communication of the passages 25 and 26 in the housing 1 through the passages 3, 4, 5, 6, 7 and 8 and annular grooves 9, 10, 11 and 12 in the body of the impact member 2 with the working spaces 13 and 14.

The impact member 2 acts itself as the air distributing means affecting the supply of compressed air alternatingly into the working spaces 13 and 14 inside the housing 1.

There are left radial clearances c and axial clearances Q between the discs 19 and 20 and the respective adjacent walls of the housing 1.

The compressed air is supplied into and the used-up air is exhausted from the vibrator through respective hoses 30 and 31 of rubber or any other suitable material.

The vibrator illustrated in FIGS. 1 to 8 operates, as follows.

Compressed air from a supply source (not shown) flows through the air supply hose 30 into the air supply passage 25, from which it flows through the opening 27, the annular groove 9, the radial passage 5, the axial passage 3, the tangential passage 7, and the annular groove 11 into the working space 13 within the housing 1 (the direction of the air flow is indicated by arrow lines in the drawings). By reason of the pressure of the air acting upon the face end of the impact member 2 in the working space 13, the impact member is driven longitudinally toward the disc 19 (the upper disc in the appended drawings). Simultaneously with its longitudinal translation, the impact member 2 is bodily rotated by the action of the reactive torque M_1 (the direction of this torque is shown with the respective arrow line in FIG. 6).

The torque M_1 can be found from the following equation:

$$M_1 = R \cdot l \qquad (1)$$

where R is the reactive force of the stream of compressed air issuing from the tangential passage 7 and acting upon the bottom end of this passage,

l is the arm of the application of the reactive force R.

At the end of the above-described working stroke, the impact member 2 strikes by its off-center projection 17 on the respective face end, upon the disc 19 at a point radially remote from the central axis of this disc, with the impact force being equal to P. The disc 19, as described hereinabove, being mounted resiliently with the help of the resilient suspension member 23, has a limited freedom of motion relative to the axis of its symmetry. Consequently, following the impact, the disc 19 is deflected from its normal position and strikes against the cylindrical internal wall of the housing 1.

The torques originated by the impact of the impact member 2 upon the disc 19 and by the impact of the disc 19 upon the wall of the housing 1 are equal to

$$M_2 = P \cdot a = P_1 \cdot h \qquad (2)$$

where P_1 is the force of the pressure of the impact member 2 upon the wall of the housing 1 at the instant of the impact,

and a, h are, respectively, the arms of the application of the forces P and P_2, and

$$M_3 = P_2 \cdot e \qquad (3)$$

where P_2 is the force of the impact of the side wall of the disc 19 upon the internal wall of the housing 1, with this force being the agitating force of the lateral oscillations of the herein disclosed vibrator,

and e is the arm of the application of the force P_2.

As the impact member 2 moves within the housing 1 and strikes upon the disc 19, the housing 1 is imparted longitudinal vibrations, and as the disc 19 strikes against the internal wall of the housing 1, the latter is imparted additional transverse vibrations which are even more useful for the cause of deep compacting of concrete mixes, than the longitudinal vibrations. Here, the longitudinal vibrations help the vibrator to submerge rapidly into the concrete mix to be compacted, but the amplitude of these vibrations should not be excessively great.

The amplitude of the additional transverse vibrations of the housing 1 is directly proportional to the impact force P_2 which, in turn, is directly proportional to the impact force P with which the impact member 2 strikes against the disc 19.

In the herein disclosed vibrator the amplitude of longitudinal vibrations is reduced on account of the resilient suspension members 23 and 24 having been provided intermediate of the end walls 21 and 22 of the housing 1 and the discs 19 and 20, respectively. These resilient suspension members serve not only to reduce the amplitude of the longitudinal vibrations of the housing, but also to return the discs 19 and 20 into their initial normal position after their impacts with the impact member 2.

At the end of the working stroke of the impact member 2 (FIG. 7) toward the disc 19, the working space 13 becomes connected in the fluid communication sense with the exhaust openings 29 and 28 in the wall of the housing 1, with the opening 28 communicating with the space 13 through the annular groove 11, the passages 7, 3 and 5, and the annular groove 9 in the body of the impact member 2. From these two exhaust openings, the used-up air flows through the discharge passage 26 and the discharge hose 31 into ambient atmosphere.

Simultaneously, also at the end of the working stroke of the impact member 2 toward the disc 19, the annular groove 10 of the impact member 2 starts communicating with the opening 27 in the wall of the housing 1 (FIG. 7), whereby compressed air starts flowing from the passage 25 in the wall of the housing 1 through this annular groove 10, the radial passage 6, the axial passage 4, the tangential passage 8 (FIG. 6) and the annular groove 12 into the upper working space 14. Now, the action of the pressure of the compressed air within the space 14 upon the respective face end of the impact member 2 drives the latter for the return stroke toward the disc 20 (FIGS. 7 and 1). At the end of this return working stroke, the off-center projection 18 on the face end of the impact member 2, facing the disc 20, strikes the disc 20 at the point thereof, remote from the longitudinal axis, with the force P.

As the impact member 2 is being driven through this return working stroke toward the disc 20, the motion thereof is again both translatory and rotary. The rotation of the impact member 2 is brought about by the action of the reactive torque M_1 (FIG. 9) which can be found from the equation (1) hereinabove. The disc **20** being mounted within the housing **1** with the radial clearance c and the axial clearance Q from the respective internal walls of the housing **1**, as it has been already mentioned, and being connected to the wall **22** of the housing **1** through the resilient suspension member **24**, the impact of the impact member **2** upon the disc **20** makes the latter deflect from its normal position and strike by its side cylindrical wall the internal cylindrical wall of the housing **1** with the force P_2 (FIG. **8**) creating the torque equal to

$$M_4 = M_3 = P_2 \cdot e \qquad (4)$$

The torque M_4 is responsible for the housing **1** being imparted an additional transverse vibration and a longitudinal vibration.

At the end of the last-described working stroke of the impact member **2** toward the disc **20**, the working space **14** communicates with the exhaust openings **28** and **29**, the opening **29** communicating now with the working space **14** through the annular groove **12**, the passages **8**, **4** and **6**, and the annular groove **10** in the body of the impact member **2**. From the openings **28** and **29**, the used-up air flows through the passage **26** in the wall of the housing **1** into the exhaust hose **31** and then into ambient atmosphere.

Simultaneously, at the end of the working stroke of the impact member **2** toward the disc **20**, the annular groove **9** communicates with the supply opening **27** in the wall of the housing **1**, and the above-described complete cycle of the operation of the vibrator is repeated.

As it can be seen from the above description of the operation of the vibrator, the impact member **2** reciprocates in the housing **1** and also rotates therein. Therefore, the points of the successive impacts of the impact member **2** upon the discs **19** and **20** will be distributed along corresponding circles on the respective face ends of these discs. Consequently, the housing **1** of the vibrator is further imparted additional circular vibrations of a high frequency and with a certain amplitude, which fact also improves the quality of the compacting of concrete mixes, performed by the vibrator.

It is commonly known that, since the particles making up the filler of a concrete mix are usually of different sizes, it is essential that each particle differing from others by its weight and size should be imparted vibrations of the specific frequency and amplitude. Therefore, the more complex are the vibrations of the housing of a vibrator and the greater is the quantity of the frequencies of these vibrations, the more effective is the compacting of concrete mixes with complex fillers performed by this vibrator.

The effectiveness of the compacting of concrete mixes can be further stepped up by a vibrator featuring variable parameters of its vibration (the amplitude, the frequency of vibrations, the agitating force).

To attain a variable amplitude of the transverse vibrations and a low frequency of these vibrations, accompanied by a variable agitating force, the center of the gravity of the impact member should be displaced radially from the axis of the rotation thereof, i.e., from the point O into the point O_1 (FIG. **10**).

The displacement of the gravity center of the impact member through a distance b can be achieved by providing in the body of impact member **32** a hollow cavity **33**.

With the structure of the herein disclosed vibrator thus modified, the operation thereof is also somewhat modified. With the center of gravity of the rotating impact member **32** being displaced radially from the axis of the rotation thereof, there appears an unbalanced mass m which, as it is rotating about the axis O — O with an angular speed w, creates an additional agitating centrifugal force F. The latter is equal to

$$F = m \cdot w^2 \cdot b \qquad (5)$$

where b is the distance from the gravity center of the impact member **32** to the axis of the rotation thereof.

Thus, as the impact member **32** reciprocates between the discs **19** and **20**, the housing **1** is imparted further additional transverse vibrations, besides the transverse vibrations which the housing **1** is imparted by the impacts of the impact member **32** upon the discs **19** and **20** and by the impacts of these discs upon the housing **1**.

The rotation of the impact member **32** about the axis thereof being accompanied by friction between the impact member and the internal wall of the housing **1**, the angular speed of the rotation of this impact member is bound to be comparatively low, and, consequently, the additional agitating force F will drive the housing **1** for low-frequency transverse vibrations.

Furthermore, the total agitating force will be then a variable value equal to the sum total of the agitating forces P_2 and F.

The other features of the operation of the vibrator illustrated in FIG. **10** are similar to those of the modification described hereinabove in connection with FIGS. **1** to **9**.

The amplitude of the transverse vibrations created by the agitating force P_2 can be increased, and the weight of the vibrator reduced by mounting within housing **34** (FIGS. **11**, **12** and **13**) a hollow shaft **35** having built therein a profiled partition **36** defining with the internal wall of the shaft **35** an air supply passage **37** and an air exhaust passage **38** which, in this modification of the herein disclosed vibrator, take the place of the air supply and exhaust passages **25** and **26** in the housing **1** of the previously described modification of the vibrator. The hollow shaft **35** has radial openings **39**, **40** and **41** through the wall thereof, to substitute for the openings **27**, **28**, **29** through the internal wall of the housing **1** of the previous embodiment for the same purpose. The openings **39**, **40** and **41** establish communication between the passages **37** and **38** within the hollow shaft **35** and the working spaces **13** and **14** through the axial passages (**3** and **4**), radial passages (**42** and **43**), tangential passages (**7** and **8**) and annular grooves (**44** and **45**) in the body of impact member **46**. The annular grooves **44** and **45** of this embodiment are for the same purpose as the annular grooves **9** and **10** in the impact member **2** of the previously described embodiment.

The hollow shaft **35** passes through the impact member **46**, disc **48**, resilient suspension member **49** and through upper end wall **47** of the housing **34** of the vibrator. There is provided an annular clearance K between the hollow shaft 35 and the above listed parts through which it passes, with the clearance preventing jamming of the impact member 46, as the latter reciprocates within the housing 34 along the hollow shaft 35, and providing for rocking of the disc 48 relative to the axis of symmetry thereof, resulting from the impacts of the impact member 46 upon this disc.

A socket 50 in the end wall 47 of the housing 34 accommodates an elastic pivot mount 51, with the hollow shaft 35 having the upper extremity thereof elastically mounted by means of this elastic pivot mount 51. The latter serves additionally as a sealing means preventing bleeding of the compressed air from the upper working space 14 into atmosphere through the annular clearance K in operation of the vibrator. The elastic pivot mount 51 is retained in the axial direction by a washer 52 and a lock ring 53.

In this embodiment of the vibrator, the projections 17 and 18 provided on the respective face ends of the impact member 46 are spaced farther from the axis of the impact member than in the previously described modification, which leads to an increased value of the torques M_3 and M_4. Therefore, the housing 34 is imparted transverse vibrations with a greater amplitude.

The air supply passage 37 and the air exhaust passage 38 being defined by means of longitudinal partition 36 within the hollow shaft 35, instead of the passages 25 and 26 serving the same purpose, provided in the wall of the housing 1 of the previously described modification, the thickness of the wall of the housing 34 can be substantially reduced, since in this case the thickness is selected to meet the strength and abrasion wear requirements only. Consequently, the heaviest part of the vibrator, its housing, can be substantially lighter, and thus the weight of the vibrator, as a whole, can be reduced, which is essential for a manually operated tool.

In order to reduce the weight of the vibrator still further, the profiled longitudinal partition 36 is preferably made from a material lighter than metal, e.g., by the hollow shaft being mounted in a mold in the course of the manufacture thereof, and the partition 36 being pressure-molded from a plastic material.

The operation of the last-described embodiment is similar to the operation of the vibrator described previously in connection with FIGS. 1 to 10.

To increase still further the amplitude of the transverse vibrations of the housing, resulting from the agitating force P_2, there is made, in accordance with another embodiment of the present invention in the body of impact member 54 (FIGS. 14 and 15), a two-diameter bore 55 receiving therein a one-way valve. The valve includes a ball-shaped valve member 56, a spring 57 and a valve seat 58. The latter has a bore 59 extending therethrough, through which and the bore 55, the lower working space 13 communicates with the upper working space 14 when the valve opens. The pressure exerted by the spring 57 upon the valve member 56 is adjusted for the valve to open when the pressure within the working space rises above the mean rated pressure for the operation of the vibrator. With the valve thus adjusted, there is prevented excessive bleeding of compressed air through the valve.

The one-way valve assembly in the impact member operates, as follows. As the impact member 54 is approaching the disc 20, there is produced intermediate of the impact member 54 and the end wall 22 of the housing 34, an air cushion wherein the air pressure is higher than the rated supply pressure. This air cushion presents a great resistance to the motion of the impact member 54 and, consequently, reduces the kinetic energy stored by the impact member during its movement from the disc 19. However, in this embodiment of the invention, this reduction, i.e., the influence of the air cushion on the impact energy of the impact member 54 is but minimal, since prior to the impact, the pressure in the working space 13 is reduced to the rated supply value by a portion of the compressed air being discharged therefrom via bore 55 (FIG. 15) into the working space 14 which, at this moment, communicates with ambient atmosphere. Consequently, the kinetic energy of the impact member 54 at the instant of the impact thereof upon the disc 20 will be greater than in the case of the impact member not incorporating the above-described one-way valve assembly, and, therefore, the disc 20 will deliver a stronger impact upon the wall of the housing 34. As a result, the amplitude of the transverse vibrations of the housing 34 is increased. In every other respect the operation of the modification illustrated in FIGS. 14 and 15 is similar to that of the embodiments described in connection with FIGS. 1 to 13.

To prevent untimely wear of the wall of the housing 34, resulting from the interaction thereof with the impact member 54, there can be mounted interiorly of the housing 34 a thin-walled protection cylinder 60 (FIGS. 16 to 18), with there being mounted intermediate this cylinder and the internal wall of the housing 34, a resilient member 61. Now, the protection thin-walled cylinder 60 takes the place of the wall of the housing 34 in the interaction of the housing 34 with the impact member 54. The resilient member 61 may be a corrugated leaf spring positioned within the radial annular clearance M left intermediate of the internal wall of the housing 34 and the thin-walled cylinder 60.

As the impact member delivers its successive impacts alternatingly upon the discs 19 and 20, there are created the torques M_2 (see above expression (2)). Under the action of these torques, the impact member 54, on account of its being provided with the off-center projections 17 and 18 on the respective face ends thereof, is biased at the moments of the impacts to turn from the vertical position thereof toward a horizontal one. This bias applied to the impact member 54 is taken up by the internal wall of the housing 34, which is thus subjected to the normal pressure of the impact member with the force P_1 (FIGS. 5, 8 and 18). As this force P_1 is repeatedly applied to the wall of the housing 34, the wall is liable to wear out comparatively rapidly, which might lead to the impact member 54 eventually becoming jammed in the housing 34 in operation of the vibrator.

The provision of the protective cylinder 60 and of the intermediate corrugated spring 61 considerably decreases the wear of the cylindrical wall of the housing 34.

In this embodiment of the invention, the protective cylinder 60 is mounted within the housing 34 intermediate of annular abutments 62 and 63 (FIG. 18), with the abutment 63 being the face end of the bottom wall 47 of the housing 34. Interposed between the respective ends of the cylinder 60 and the abutments 62 and 63 are assemblies comprising each a rubber ring 64 sandwiched between two rigid rings 65. To bring down the friction in the contact areas, the rings 65 contacting the ends of the cylinder 60 are preferably of an antifriction material, e.g., from graphite bronze. The ring assemblies also serve to seal the working spaces 13 and 14, thus preventing leakage of compressed air into the annular clearance *M*, when the cylinder 60 is skewed relative to the axis of the housing 34 in operation.

With the force P_1 acting upon the cylinder 60, the latter is skewed relative to the axis O — O through an angle α, and thus the deformation of its surface cooperating with the impact member 54 is bound to be smaller than in the case of the housing devoid of the protective cylinder.

In every other respect the operation of the presently described embodiment is similar to that of the vibrators described in connection with FIGS. 1 to 15.

In order to make the pattern of the transverse vibrations of a vibrator constructed in accordance with the invention even more complex, there may be provided interiorly of the housing 34 a transverse partition 66 (FIG. 19) dividing the internal space of the housing 34 into two chambers defining together with respective two impact members 67 and 68 received within these chambers, four working spaces 69, 70, 71 and 72.

The transverse partition 66 is in fact an intermediate additional end wall of the housing, having a pair of discs 73 and 74 mounted at the opposite sides thereof with the help of a double-sided tubular resilient suspension member 75. The connection of the discs 73 and 74 with the wall 66 is thus similar to the connection of the discs 49 and 20 (FIG. 11), respectively, with the walls 21 and 22 (see above, FIG. 1), and the only difference is in the modified shape of the resilient suspension member. The impact members 67 and 68 are provided, like the previously described impact member 2, with the off-center projections 17 and 18 on the opposite end faces thereof, adapted to deliver impacts upon the respective ones of the discs 73, 20, 48 and 74. The impact members 67 and 68 are preferably designed to have different frequencies of the impacts upon the respective discs 73, 20 and 48, 74; moreover, they may have different angular speeds of rotation about their respective axes.

The different frequencies of the impacts of the impact members 67 and 68 and the different speeds of their rotation can be attained by the members having different masses, different face end areas or different lengths of the strokes; alternatively, this can be effected by supplying different amounts of compressed air into the respective working spaces, or else by ensuring that the respective tangential passages 7 and 8 (FIGS. 3 and 4) have different flow passage areas.

The last-described embodiment is in fact a double vibrator offering low-frequency and high-frequency transverse vibrations due to the respective agitating forces *P* and also high-frequency and low-frequency transverse vibrations brought about by the centrifugal agitating forces *F*.

The operation of the last-described vibrator is similar to the operation of the embodiments described in connection with FIGS. 1 to 18, except that here two impact members operate jointly.

The last-described vibrator has variable vibration parameters, such as the frequency of the impacts, the agitating force, the amplitude of the transverse vibrations, with these parameters varying automatically owing to the inherent structure of the vibrator.

In the case of pneumatic vibrators constructed in accordance with the invention, designed to operate with great impact energies, it may be advisable, in order to prevent intensive wear, for the discs 76 (FIGS. 20 and 21) at the moments of their interaction with the impact member 67 to deliver their impacts upon tapering surfaces 77 of walls 78 and for the discs 76 to be connected with the walls 78 through spherical bearing means 79 (FIGS. 20 and 21).

In other respects the operation of the embodiment described in the foregoing paragraph is similar the operation of the vibrators described hereinabove.

What we claim is:

1. A pneumatic vibrator, comprising: a housing including a closed cylinder; an impact member mounted for reciprocation within said housing, said member having opposite end faces and passages in the body thereof and annular grooves in the peripheral surface thereof for the passage of compressed air; compressed air distributing means, two impact-receiving members for imparting additional transverse vibrations to said housing, said two impact-receiving members being mounted within said housing with radial and axial clearances therefrom, adjacent to the opposite end walls of said housing and connected with said end walls; striking means for delivering impacts upon said impact-receiving members at the points thereof remote from the axes of said impact-receiving members, said striking means being defined by off-center projections on the respective opposite end faces of said impact member, adapted to engage said impact-receiving members at the successive impacts of said impact member.

2. The vibrator according to claim 1, wherein, in order to obtain additional circular transverse vibrations, said impact member has tangential passages in said body thereof, for effecting rotation of said impact member about the axis thereof under the action of compressed air issuing from said tangential passages, and said tangential passages having their respective inlets and outlets disposed within said annular grooves.

3. The vibrator according to claim 2, wherein, in order to increase the amplitude of the additional transverse vibrations, a one-way valve means is mounted in said body of said impact member, adapted to open when the pressure in the working space rises above the rated supply pressure value.

4. The vibrator according to claim 2, wherein, in order to increase the reliability of the performance and the durability, there is mounted within said housing a protective cylinder for reciprocation therein of said impact member, and resilient means interposed intermediate of said protective cylinder and said housing.

5. The vibrator according to claim 2, wherein said impact-receiving members for imparting additional transverse vibrations to said housing are defined by discs mounted coaxially with said end walls of said housing and connected with said respective end walls with resilient connecting means.

6. The vibrator according to claim 1, wherein, in order to increase the amplitude of the additional transverse vibrations and to lower the weight, said impact member is reciprocably mounted on a hollow shaft having built therein a profiled longitudinal partition defining together with said hollow shaft conduits for the supply and exhaust of compressed air.

7. The vibrator according to claim 1, wherein, in order to create a variable agitating force, to attain low-frequency additional transverse vibrations and to increase the amplitude of these vibrations the gravity center of said impact member is displaced radially from the geometric center of said impact member, with the axis of the rotation of said impact member passing through said geometric center.

8. The vibrator according to claim 1, wherein said impact-receiving members for imparting additional transverse vibrations to said housing and said end walls of said housing have conically tapering peripheral surfaces along which said impact-receiving members and said end walls cooperate at the impacts.

9. The vibrator according to claim 1, wherein said impact-receiving members and said respective end walls are connected with spherical bearing means.

10. A pneumatic vibrator, comprising: a housing including a cylinder with closed opposite ends, said cylinder divided into two adjacent internal chambers by at least one transverse partition serving as an end wall for said two adjacent internal chambers, impact members mounted for reciprocation, respectively, in each one of said adjacent internal chambers, each said impact member having opposite end faces and passages in the body thereof and annular grooves in the peripheral surface thereof for the passage of compressed air; an air distributor; discs mounted in each said chamber adjacent to said end walls, with radial and axial clearances, said discs being resiliently connected with said respective end walls, and said discs being adapted to impart additional transverse vibrations to said housing; said impact members having projections located eccentrically on the respective opposite end faces thereof for delivering impacts upon the portions of said discs, remote from the axes of said discs, with said projections engaging said discs at the impacts of said impact members.

11. The vibrator according to claim 10, wherein, in order to obtain additional circular transverse vibrations, said impact members have each tangential passages in the bodies thereof, for effecting rotation of said impact members about their respective axes under the action of compressed air issuing from said tangential passages, with said tangential passages having their respective inlets and outlets disposed within said annular grooves.

12. The vibrator according to claim 11, wherein, in order to increase the amplitude of the additional transverse vibrations, one way valve means are mounted within said impact members, adapted to open upon the pressure inside the working spaces rising about the rated supply pressure value.

13. The vibrator according to claim 11, wherein, in order to increase the reliability of the performance and the durability, there are mounted within said adjacent internal chambers of said housing protective cylinder means reciprocably receiving said impact members therein and resilient means interposed intermediate of said protective cylinder means and said housing.

14. The vibrator according to claim 11, wherein said members adapted to impart additional transverse vibrations to said housing are defined by discs mounted coaxially with said end walls of said housing, resiliently connected with said end walls.

15. The vibrator according to claim 10, wherein, in order to increase the amplitude of the additional transverse vibrations and to lower the weight, said impact members are reciprocably mounted on a hollow shaft having built therein a profiled longitudinal partition defining together with said hollow shaft conduits for the supply and discharge of compressed air.

16. The vibrator according to claim 15, wherein said members adapted to impart additional transverse vibrations to said housing and said end walls of said housing have conically tapering peripheral surfaces along which said impact-receiving members and said end walls cooperate at the impacts.

17. The vibrator according to claim 15, wherein said impact-receiving members and said respective end walls are connected by spherical bearing means.

18. The vibrator according to claim 10, wherein, in order to create variable agitating forces, to attain low-frequency additional vibrations and to increase the amplitude of these vibrations, the respective gravity centers of said impact members are displaced radially from the axis of the rotation thereof.

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