May 18, 1937. E. H. LUDEMAN, JR 2,080,727

VIBRATION GENERATING APPARATUS

Filed Sept. 15, 1934

Fig. 1.

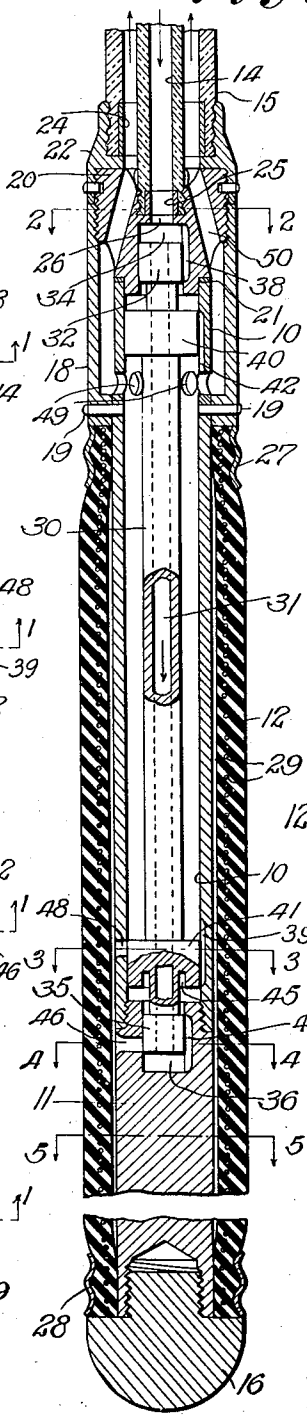


Fig. 2.

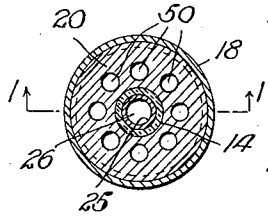


Fig. 3.

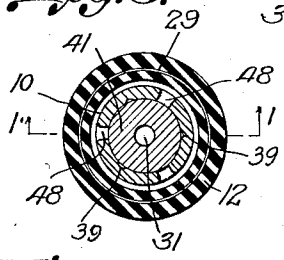


Fig. 4.

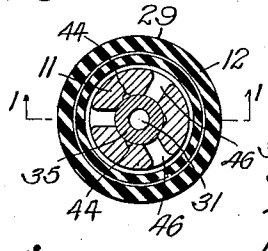


Fig. 5.

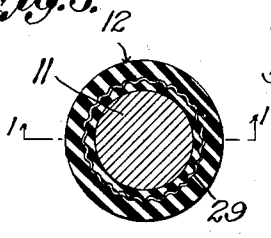
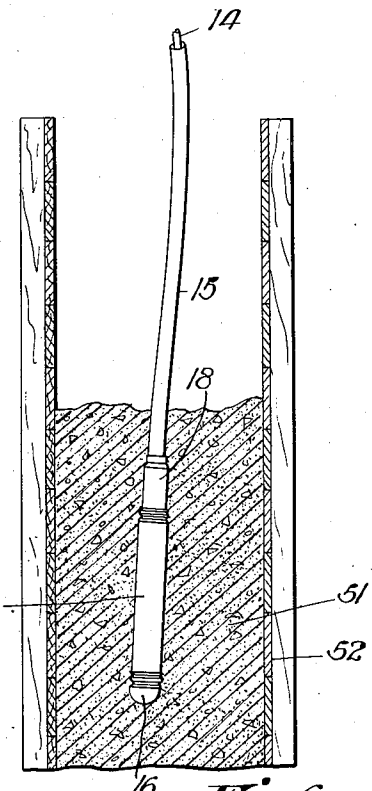


Fig. 6.



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VIBRATION GENERATING APPARATUS

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14 Claims. (Cl. 25—1)

This invention relates to apparatus for internally vibrating plastic or granular materials, for example, concrete.

The primary object of the invention is the provision of a device which may be wholly or partially submerged in the material to be vibrated and which will set up vibrations in the material by reason of high-frequency volumetric changes.

A further object is the provision of such a device which, while undergoing volumetric changes for the purpose of vibrating a mass in which it is submerged, will also be mechanically vibrated by the impact of its internal moving parts, which vibrations will also be communicated to the mass.

A still further object is the provision of a vibrator which may be operated by fluid pressure, such as compressed air, readily obtainable in conjunction with construction work, which will be economical to operate, inexpensive to manufacture, and easily kept in working order at minimum expense.

Other objects and advantages of the invention will be apparent during the course of the following description of the present preferred embodiment of the invention.

The invention is especially adapted for use with concrete mixtures. When undergoing such vibration, the flowability of the material is greatly increased, thereby facilitating its handling and the filling of molds or forms therewith. Furthermore, cavities or pockets within the mass of the material, or between the surfaces of the mass and the forms, or between the material and the interior reenforcement, are filled in and eliminated, resulting in the thorough compaction of the mass, the complete filling of the form, and thorough bonding with the reenforcement.

In the drawing: Fig. 1 is a longitudinal section of the vibrator taken on line 1—1 of Figs. 2, 3, 4, and 5. Figs. 2, 3, 4, and 5 are cross-sectional views on lines 2—2, 3—3, 4—4 and 5—5 respectively of Fig. 1. Fig. 6 is a vertical section through a mass of plastic concrete contained in a wooden form showing the vibrator in a working position.

Similar numerals refer to similar parts throughout the several views.

Referring to the drawing, the embodiment shown, which is designed to be operated by compressed air, is constructed generally as follows: a body comprising a metal cylinder 10 with an extension piece 11, and other associated parts forms the framework of the device. On the outside of the cylinder and extension piece a heavy cylindrical elastic casing 12 of rubber or other suitable material is secured, its ends bound airtight. Ports in the wall of the cylinder 10 and the extension piece 11 communicate with the interior of the elastic casing 12 to permit the entrance to and exhaust from the casing of the compressed air or other fluid. Inside the metal cylinder 10 is high speed automatic valve mechanism which controls the fluid, alternately opening and closing the inlet and exhaust ports. The resulting alternate admission and exhaustion of compressed air to and from the inside of the elastic casing 12 causes it alternately to expand and to contract, which action, being at high frequency, sets up vibrations in the material surrounding the casing. Moreover, the moving part of the valve mechanism alternately strikes opposite ends of the passage in which it moves, its impacts setting up other vibrations in the device which are communicated to the surrounding material.

The compressed air is supplied to the vibrator from a suitable source through the inner flexible hose 14, equipped with a control cock (not shown) at a suitable distance from the vibrator. The exhaust air is conducted away from the vibrator by the outer flexible hose 15, which permits its submersion to any desired depth. The hose also serves as a hand-line by which the operator lowers or casts the vibrator into successive portions of the concrete mass, controls its location and position therein, and withdraws it therefrom.

In detail the construction of the vibrator is as follows: Into the lower end of the metal cylinder 10 is screwed the solid extension piece 11 into which, in turn, is screwed a wearing plug 16, made removable for easy replacement. To the upper end of the cylinder 10 the exhaust hood 18 is secured by means of the pins 19. The top of this hood is threaded to receive the cylinder head 20 which fits into the top of cylinder 10, a tight joint being obtained by the gasket 21. On top of the cylinder head is screwed the hose coupling 22 into which the outer hose 15 is clamped by the expanded metal ring 24. The inner hose 14 is clamped in the top of the cylinder head 20 by the expanded metal ring 25 and the fluid under pressure enters the cylinder head through the hole 26.

The elastic casing 12 is clamped at the top to the cylinder 10 by the rolled metal ring 27, with its end abutting the lower rim of the exhaust hood 18, and is similarly clamped by the ring 28 at the bottom to the extension piece 11, its lower

end abutting the upper face of the wearing plug 16. The elastic casing 12 is shown in Figs. 1, 3, and 4 dilated as it would be when subjected to internal air pressure. Fig. 5 represents it as contracted. To limit the extent of its dilation under pressure it is provided with sinuous cords 29 (Fig. 5) which are molded into the rubber or other elastic material. Upon dilation of the casing the sinuous bends are straightened out and the then circular cords serve to limit the extent of the dilation, especially when the vibrator is not immersed or only partially immersed. The casing 12 is made of such a diameter that when assembled on the members which support it it is under appreciable tension around them. Each rapid expansion and subsequent rapid contraction of the casing produces respectively a compression and rarefaction in the surrounding material, which together constitute a complete vibration. In order to produce rarefaction pressures appreciably below atmospheric, while still employing exhaust pressures equal to or greater than atmospheric, it is necessary that the casing be under suitable circumferential tension, even in the contracted position.

The automatic valve mechanism, which is contained inside the metal cylinder 10, comprises a reciprocating piston valve 30 through which extends axially an air passage 31. The ends of the piston valve are identical, the upper end having a valve head 32 which slides in the cylindrical chamber 34 in the cylinder head 20. The lower end has a similar valve head 35 which slides in the cylindrical chamber 36 in the extension piece 11. The chambers 34 and 36 are each provided with three grooves or scorings (see Figs. 1 and 4), those in the cylinder head 20 being designated 38 and those in the extension piece 11 designated 44. These scorings are for the passage of compressed air around the valve heads in a manner which will be described in connection with the explanation of the operation of the valve.

The piston valve 30 also carries the upper piston head 40 and the lower piston head 41, each machined to closely fit the inside of the cylinder 10. In the wall of the cylinder 10 adjacent the piston heads 40 and 41 are grooves or scorings 42 and 39, for the passage of fluid past the respective piston heads for purposes described in explaining the operation. Each of the piston heads 40 and 41 is provided with an annular clearance pocket 45, as shown in the broken section of the piston head 41.

For the admission of compressed air or other fluid to the inside of the elastic casing 12, inlet ports 46 are provided in the extension piece 11, communicating with the chamber 36. With the reciprocation of the piston valve 30 these ports are alternately covered and uncovered by the valve head 35.

For the escape of the fluid from the inside of casing 12 exhaust ports 48 are provided adjacent the piston head 41. With the reciprocation of the piston valve 30 these ports are alternately covered and uncovered by the piston head 41. The exhaust fluid travels upwardly through cylinder 10 around the piston valve 30 and enters the exhaust hood 18 through the exhaust openings 49, from whence it escapes into the outer hose 15 through the holes 50 in cylinder head 20.

In Fig. 6, a vibrator is shown in position to vibrate a mass of concrete 51 held between forms 52.

The operation of the vibrator will now be described, taking up first, the manner of reciprocation of the piston valve 30, which operates on a principle known to the art in connection with pneumatic tools, and second, the manner in which this reciprocation of the piston valve 30 brings about the desired alternate expansion and contraction of the rubber casing 12.

The piston valve is double-acting, inasmuch as its ends are identical, as are the ends of the cylinder 10 and the chambers 34 and 36, in so far as they effect the reciprocation of the piston valve 30. The reciprocation is produced by compressed air admitted and exhausted through air passages of restricted capacity, namely, the inlet scorings 38 and 44 and the exhaust scorings 42 and 39, which passages are opened and closed by the valve heads 32 and 35, and piston heads 40 and 41, respectively.

Compressed air is made available to the upper end of the piston valve 30 directly from the supply hose 14, and flows through the axial passage 31 throughout the length of the piston valve 30, thus supplying compressed air to the lower chamber 36.

With the piston valve 30 starting upward from a position of rest at the bottom of its stroke, the action on the piston heads 40 and 41 is as follows: The lower inlet scorings 44 are open and the lower exhaust scorings 39 are closed by piston head 41, while the upper inlet scorings 38 are closed by valve head 32 and the upper exhaust scorings 42 are open. Thus compressed air, admitted under the lower piston head 41 starts the piston valve 30 on its upward stroke.

On reaching mid-stroke position the lower inlet scorings 44 are closed, and the lower exhaust scorings 39 are about to be opened, while the upper exhaust scorings 42 are closed and the upper inlet scorings 38 are about to be opened.

As the valve 30 travels upward the air under the lower piston head 41 escapes only gradually, due to the restricted capacity of the exhaust scorings 39. Also, due to the restricted capacity of the inlet scorings 38 pressure is built up only gradually on the upper piston head 40. As a result of these conditions and of its own momentum, the valve 30 continues on its upward stroke until it rebounds downward upon the upper piston head's striking the cylinder head 20. By this time the pressure on the upper piston head 40 has materially increased, and the pressure on the lower piston head 41 has materially decreased. The valve 30 is thus driven downward with increasing speed.

Upon the valve's reaching mid-stroke position of the downward stroke, in which position it is shown in Fig. 1, the cycle of events just described is repeated except that the role of the ends is reversed and the direction of movement is opposite. Upon reaching mid-stroke position of the upward stroke the complete cycle is repeated. Thus the piston valve 30 continues to reciprocate in the desired manner.

By means of the reciprocation of the piston valve 30 the inlet ports 46 in the extension-piece 11 and the exhaust ports 48 in the cylinder 10 are alternately opened and closed. During the interval in which the valve is above its mid-stroke position the inlet ports 46 are open, and compressed air is admitted between the outside of the metal cylinder 10 and extension-piece 11 and the rubber casing 12, thus dilating the casing, and when the valve 30 passes through mid-stroke position on its downward stroke the inlet ports 46 are closed and the exhaust ports 48 are opened. This permits the casing to expel the air from

between the cylinder 10 and extension-piece 11 and the casing 12, by contracting. The exhaust ports 48 remain open until the piston valve 30 passes mid-stroke position on its upward stroke, at which time they are closed by the piston head 41 and the inlet ports 46 are opened by the valve head 35. Compressed air is thus admitted to dilate the casing 12 as above described, the cycle being repeated.

While in the illustrated embodiment a set of ports for inlet, and a set of ports for exhaust of air have been provided for the operation of the valve, if desired, the functions of both sets of ports may be served by one set of ports alternately connected to the pressure supply and the exhaust conduit by the piston valve in a manner known to the art.

Also, while an apparatus has been shown in which both inlet and exhaust valves are employed for admitting and permitting exhaustion of air from within the extensible casing, if desired, either one of these valves may be omitted and a throttling passage of suitably restricted capacity employed in its stead.

Additional vibration of the material in which the vibrator is immersed will be caused by the reciprocation of the piston valve 30, which, as just described, successively strikes the cylinder head 20 and the extension piece 11. As is obvious, these impacts of the piston valve will cause a vibration of the device along its longitudinal axis. These impactive vibrations thus generated are communicated to the material through extension piece 11 and the wearing plug 16, facilitating the introduction of the vibrator into stiff plastic or granular materials, and assuring the solidification of the material beneath the vibrator as it is withdrawn therefrom. The piston valve 30 is of course so constructed, in ways known to the art, that the impacts will not interfere with its continued functioning.

While the embodiment described has an elastic rubber casing it is within the purview of the invention to use any form of outer member which is capable of undergoing volumetric changes when subjected to varying pressures. For example, a flexible metal tube either elliptical or square in cross-section would, under increased pressure, undergo volumetric expansion. Likewise the outer member might consist of rigid members secured to flexible anchorages so as to move bodily under pressure fluctuations.

While I have shown and described a preferred embodiment of my invention, it is to be understood that the invention is not limited to the particular embodiment disclosed, but includes such modifications and variations as come within the spirit of the invention and within the scope of the appended claims.

What is claimed is:

1. Vibration generating apparatus operating directly from constant fluid pressure comprising a flexible member capable of undergoing volumetric expansion, a support for said member, and an automatic valve for intermittently admitting the fluid under pressure to the interior of said member and permitting it to exhaust therefrom, whereby its volume is caused to fluctuate.

2. Vibration generating apparatus operating directly from constant fluid pressure comprising a support, a flexible member around said support airtight at its ends, and automatic valve mechanism for admitting fluid under pressure to the inside of said member and exhausting it therefrom to produce volumetric changes in said flexible member.

3. Vibration generating apparatus operating directly from constant fluid pressure comprising a support having a chamber therein, a sealed elastic member secured to said support, automatic valve mechanism in said chamber adapted to intermittently admit fluid under pressure into said elastic member and to exhaust it therefrom, and means for supplying fluid under pressure to said valve mechanism.

4. Vibration generating apparatus adapted to undergo volumetric fluctuation comprising an airtight flexible member, a hollow cylinder within said member having inlet and exhaust ports for fluid under pressure communicating with the interior of said member, an automatic pneumatic valve in said cylinder adapted to alternately open and close said ports, and means for conducting fluid under pressure to and from said ports.

5. In apparatus for generating vibrations by volumetric fluctuations resulting from fluctuations in fluid pressure in an elastic member, automatic valve mechanism for controlling the flow of fluid comprising a reciprocating piston valve, a cylinder within which said valve slides, a piston head near each end of said valve and fitted to said cylinder, restricted exhaust passages in the wall of said cylinder adjacent to and controlled by said piston heads, a valve head on each end of said valve each fitted to slide in its own chamber, restricted inlet passages in the walls of said chambers through which the flow of fluid into each end of said cylinder is controlled by said valve heads, and inlet and exhaust ports communicating with said elastic member and controlled by the reciprocation of said piston valve.

6. An expansible casing for apparatus adapted to generate vibrations by volumetric fluctuations consisting of a cylindrical body of elastic substance having embedded sinuous members to limit the extent of expansion of the casing.

7. In vibration generating apparatus of the volumetric expansion type, the combination of a rigid supporting member with an elastic expansible member, said elastic member being applied to said supporting member under substantial tension.

8. Vibration generating apparatus comprising a hollow cylinder, an extension piece secured to one end of said cylinder, a cylinder head secured to the other end of said cylinder, an automatic piston valve arranged to reciprocate in said cylinder, a flexible casing arranged exteriorly of said cylinder and extension piece and secured airtight at its ends, means controlled by said valve for admitting fluid under pressure to said casing, means also controlled by said valve for permitting the fluid to exhaust from the casing, and means for causing the piston to reciprocate when fluid pressure is applied thereto.

9. Vibration generating apparatus for plastic or granular materials comprising a flexible member capable of producing volumetric expansions, automatic mechanism associated with said member for producing pressure fluctuations within said member, and means rendering said member rigid to enable its insertion into a mass of plastic or granular material.

10. In apparatus for vibrating plastic or granular materials, the combination of a member volumetrically responsive to rapid fluctuations of internal fluid pressure, means for admitting fluid pressure into said member and exhausting it therefrom, and automatic means directly oper-

able from a unidirectional flow of pressure fluid to interrupt said flow with high frequency.

11. In apparatus for treating plastic or granular materials by vibration of a member volumetrically responsive to fluctuations of internal fluid pressure, the combination with such member of means producing other vibrations by the acceleration of a mass, and means for communicating the last mentioned vibrations to the material to be treated so as to facilitate the insertion of the apparatus into the material.

12. Vibration generating apparatus for plastic or granular materials comprising a flexible member capable of volumetric expansions, mechanism associated with said member for producing said expansions, and means for manipulating said member and said mechanism together for insertion into said materials to vibrate the same.

13. In vibration generating apparatus for plastic or granular material, the combination of an element capable of immersion in said material, said element comprising a volumetrically expansible member and mechanism for producing volumetric expansions of said member, and means for supplying energy to said mechanism.

14. In apparatus for generating vibrations in a mass of plastic or granular material, the combination of a unit comprising a volumetrically expansible member and mechanism for producing volumetric expansions of said member, with means for supplying energy to said mechanism, and means for manipulating said unit, said unit being capable of insertion into said materials to vibrate the same.

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