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Klushin et al.

[11] **3,892,280**

[45] **July 1, 1975**

[54] **PORTABLE PNEUMATIC IMPACT TOOL**

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[52] **U.S. Cl.** **173/162;** 173/139

[51] **Int. Cl.** **B25d 9/00**

[58] **Field of Search** .... 173/139, 162; 404/133; 91/216 R, 216 A, 217, 216 B, 177; 81/52.35

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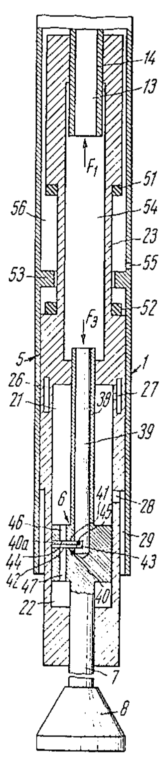
[57] **ABSTRACT**

A tool comprises a casing accommodating a housing for axial movement therein. There is provided a main piston mounted in the casing for axially moving therewith. The main piston is received in a space in the housing which is in constant communication with a compressed air source. The compressed air pressure in said space results in the development of a force applied to the casing so as to urge it away from the housing. There is also provided a hammer piston moving in the housing. The distinguishing feature of the tool consists in the fact that there is provided, on the hammer piston, an additional piston received in said space. During the operation of the tool the housing and the hammer piston perform, under the action of compressed air, reciprocations in the antiphase relation therebetween so that the changes in the volume of said space caused by the reciprocations of the housing are compensated for by the reciprocations of the additional piston, whereby the pressure fluctuations of the compressed air in the space are reduced, thereby lowering vibration at the casing and handle. The tool may be alternatively made with the main piston mounted in the casing to move together with the housing.

8 Claims, 10 Drawing Figures



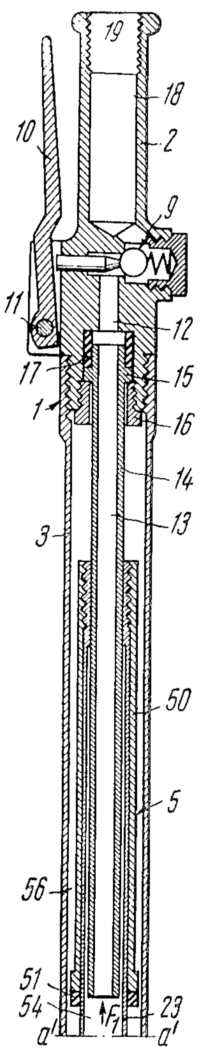


FIG.1

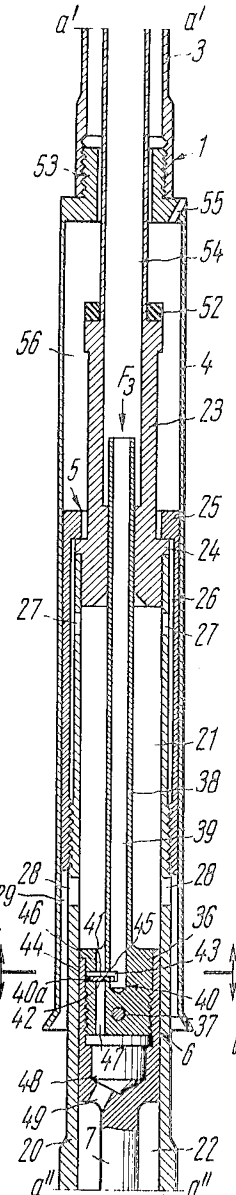


FIG.1'

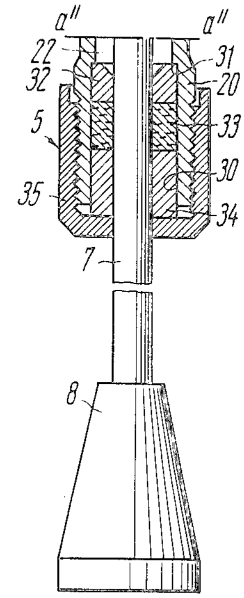


FIG.1''

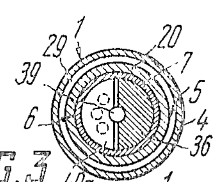


FIG.3

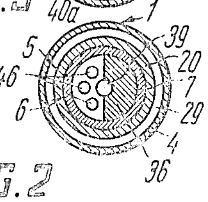
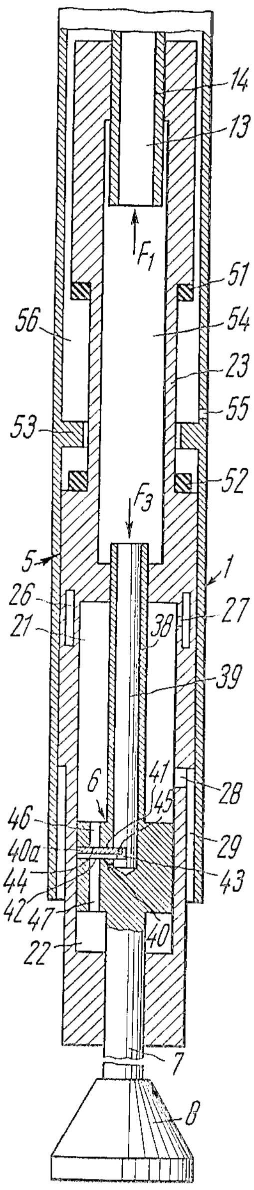


FIG.2


14
13
F1
51
56
54
23
55
53
52
F3
5
1
26
27
21
38
39
6
41
28
46
45
40a
29
44
43
42
47
40
22
7
8
FIG. 4

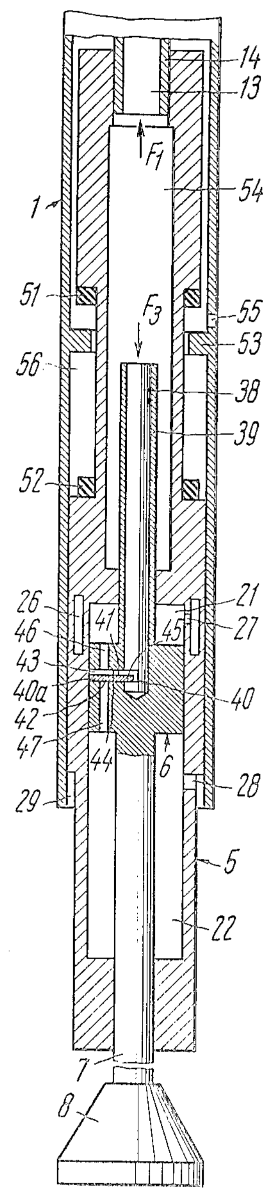

14
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FIG. 5

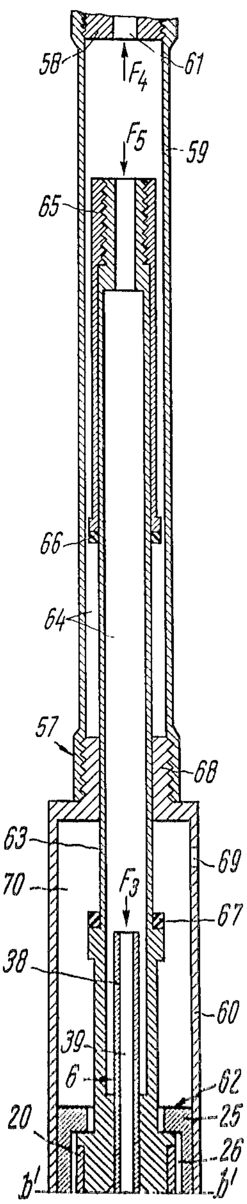

FIG. 7

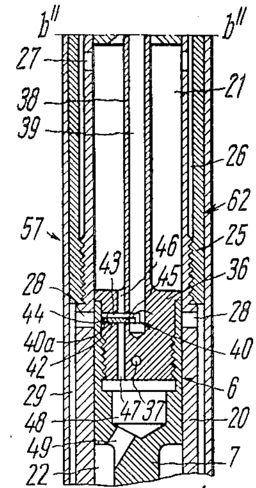

FIG. 7'

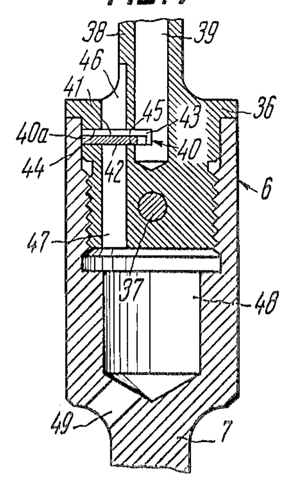

FIG. 6

PORTABLE PNEUMATIC IMPACT TOOL

The present invention relates to pneumatic impact tools, and more particularly to portable pneumatic tools to be used in the machine building, and especially in the foundry for compacting moulding sand, as well in the construction and for municipal works for compacting soil, sand and the like.

Known in the art is a pneumatic impact tool comprising a casing accommodating a housing axially movable relative thereto, a piston mounted in the casing and axially movable together with either casing or housing, a space inside the housing or casing in constant communication with a compressed air source, said piston being received in said space, the air pressure in said space resulting in the development of a force applied to the casing so as to urge it away from the housing, a hammer piston mounted in the housing and axially movable relative thereto, working chambers defined by the housing and the hammer piston, an air-distribution device providing the supply of compressed air into the working chambers so as to impart reciprocations to the housing and hammer piston, whereby the hammer piston imparts useful blows.

The use of the casing in which the housing can move freely enables some reduction of the casing vibration transmitted to the operator hands.

However, as a result of the relative antiphase movement between the hammer piston and the housing, the latter performs longitudinal oscillations relative to the casing, whereby the volume of the space communicated with a compressed air source is subjected to cyclical fluctuations. As a result, the air pressure in the space is also subjected to cyclical fluctuations, whereby the force applied to the casing varies so that there is still rather high vibration level on the casing and handle. Vibration is transmitted, through the handle, to the hands of the operator thus endangering his health conditions. After a continuous operation with such tool the operator is prone to the professional disease. In order to reduce pressure fluctuations in the space communicated with a compressed air source, rather large volume of this space is required which is undesirable since in that case the size and weight of the tool are increased. Furthermore, such prior art tool has considerable size and weight due to comparatively thick housing walls which should accommodate passages for feeding compressed air from the air-distribution device into the working chambers.

Other attempts have been made to lower vibration at the handles of a portable pneumatic impact tool. Thus, known in the art is a pneumatic impact tool, namely a tamper, comprising a handle with means providing the supply of compressed air. Mounted coaxially with the handle are a housing with a working member and a reaction member which are movable relative to the handle. There are provided means for feeding compressed air into the space between the housing and the reaction member, and a spring mounted therebetween so as to impart reciprocations to these members, whereby the working member imparts blows at the material being compacted. In this tool, compressed air and the spring do not generate any forces directed to displace the handle so that no vibration arises on the handle. However, during the operation, the handle weight is applied to the operator since he should hold the handle suspended which results in a rapid fatigue of the operator.

In another embodiment of such prior art tool this disadvantage is eliminated by applying a thrust force between the handle and the housing. The handle has a chamber communicating with a compressed air source. This chamber receives a sliding piston connected to the housing so that under the compressed air pressure there are developed, in the chamber, a force applied to the handle and a force applied to the piston, whereby the housing and the handle tend to move apart.

However, during the operation of this tool the housing, which is at the same time the hammer member, performs reciprocations, and the piston also performs oscillations in said chamber axially relative to its intermediate position. The oscillations of the piston cause fluctuations in the volume of said chamber, and hence compressed air pressure fluctuations therein, thereby resulting in unhealthy vibration at the handle.

In addition, in such a tool the amount of displacement of the housing with the working member is comparatively small because it is difficult to make a lightweight housing. This hampers the employment of such tools in compacting thick layers of materials. The amount of said displacement could be increased by using a heavier reaction member which is also undesirable.

The labor conditions could be improved by stabilizing the magnitude of the forces applied to the handle so as to lower unhealthy vibration, with the provision being made to eliminate the transmission of the handle weight to the hands of the operator.

The attempts have been made in this direction by the provision of a portable pneumatic impact tool comprising a handle and a housing accommodated therein and capable of performing a limited axial movement relative thereto, a hammer piston being axially movable in the housing together with means for imparting reciprocations thereto, whereby the hammer piston accomplishes a useful work by imparting blows. Spaces in constant communication with a compressed air source are formed in the housing. Pistons are fixed to the handle and received in said space. The housing vibrates relative to the handle during the operation, and the piston enters and leaves said space. In order to maintain a constant pressure in the space, that is to lower vibration at the handle, there are provided means for feeding compressed air thereinto at the moment, where the volume of said space increases and the pressure therein decreases, as well as means for discharging the compressed air from the space into atmosphere, where the volume of the space decreases and the pressure therein increases. Such tool has, however, an elevated compressed air consumption due to the air exhaust from said space into atmosphere. The exhaust of compressed air into atmosphere results in aerodynamic noise which is also undesirable. In winter, means used for discharging an excess air into atmosphere are iced thus resulting in troubles and even failures in the operation of the means providing the application of a constant force to the handle, whereby vibration is increased. In addition, this tool is complicated.

It is an object of the invention to provide a portable pneumatic impact tool having lower vibration at the tool handle.

Another object of the invention is to provide a pneumatic tool having smaller size and weight with the same capacity.

Still another object of the invention is to provide a pneumatic tool having reduced air consumption.

These and other objects are accomplished by the provision of a pneumatic impact tool comprising a casing having therein a housing axially movable relative thereto, a main piston mounted in the casing and axially movable together with either casing or housing, a space defined inside the casing or housing in constant communication with a compressed air source, said piston being received in said space, the compressed air pressure in said space resulting in the development of a force applied to the casing so as to urge it away from the housing, a hammer piston axially movable in the housing, working chambers defined by the housing and the hammer piston, an air-distribution device providing the supply of compressed air into the working chambers so as to impart reciprocations to the housing and hammer piston, whereby the hammer piston imparts useful blows, wherein, according to the invention, there is provided an additional piston received in said space and drive means for imparting reciprocations to the additional piston substantially in the antiphase relation to the reciprocations of the housing, the variation of the volume of said space caused by said reciprocations of the housing being substantially compensated for by said reciprocations of the additional piston, whereby pressure fluctuations of the compressed air in said space are reduced and the magnitude of the force applied to the casing is thereby maintained constant so as to lower its vibration.

It is advantageous that the additional piston constitute a part of the hammer piston.

This embodiment of the piston simplifies the provision of the drive of the additional piston since the hammer piston reciprocates substantially in the antiphase relation to the reciprocations of the housing.

The additional piston is preferably provided with a passage having one end communicated with a compressed air source and the other end communicated with the air-distribution device.

This permits to increase the volume of said space, whereby pressure fluctuations of the compressed air therein are reduced, and hence vibration at the casing (handle) is lowered. In addition, this enables the reduction of the weight and size of the tool.

The air-distribution device is preferably arranged in the hammer piston, whereby the weight and size of the tool are also reduced.

The invention provides a pneumatic impact tool having lower vibration at the tool handle and smaller weight and size with the same capacity, while unproductive air consumption is eliminated.

The invention will now be described in greater details with reference to specific embodiments thereof illustrated in the accompanying drawings, in which:

FIG. 1 shows a longitudinal section of a portable pneumatic impact tool according to the invention illustrated to the section $a'—a'$;

FIG. 1' is the continuation of FIG. 1 from the section $a'—a'$ to the section $a''—a''$ and down;

FIG. 1'' shows a section from section $a''—a''$ to the bottom of the tool;

FIG. 2 is a partial section taken along the line II—II in FIG. 1';

FIG. 3 is a partial section taken along the line III-III in FIG. 1';

FIG. 4 schematically shows a portable pneumatic impact tool according to the invention, partially in section, illustrating the lowermost position of the hammer piston during the operation;

FIG. 5 is Ditto, with the uppermost position of the hammer piston during the operation;

FIG. 6 shows the hammer piston in the position adjacent to the air-distribution device;

FIG. 7 shows a longitudinal section of another embodiment of the portable pneumatic impact tool according to the invention illustrated to the section $b'—b'$, with the main piston connected to the housing;

FIG. 7' is the continuation of FIG. 7 from the section $b'—b'$ and down.

In the description of the embodiments of the invention illustrated in the accompanying drawings specific narrow terms are used for the sake of clarity. It should, however, be noted that each term covers all equivalent elements having similar functions and applicable in solving similar problems.

A portable pneumatic impact tool shown in FIGS. **1**, 1', 1'', **2**, **3** and **6** is a tamper and comprises a casing **1** which consists of a handle **2**, a tube **3** screwed thereto and a tube **4** which is, in turn, screwed on the tube **3.** The casing **1** accommodates a hollow housing **5,** which is axially movable within certain limits relative thereto, and a hammer piston **6** which is also axially movable within certain limits in the housing **5** and has a rod **7** to which there is attached a working tool (shoe) **8.**

The handle **2** is provided with a triggering device **9** of a known design which is actuated by pressing down a lever **10** pivotably fixed to the handle **2** by means of a pivot **11.** In addition, the handle **2** is provided with a passage **12** communicated with a through passage **13** of a main piston **14.** The piston **14** has a shoulder **15.** A nut **16** is screwed into the lower end of the handle **2,** and the shoulder **15** of the piston **14** bears against the nut thereby preventing the piston from falling out of the handle. A sealing bush **17** made of rubber or other sealing material is mounted between the piston **14** and the handle **2,** and in order to ensure satisfactory sealing, the bush **17** is urged by the nut **16** through the shoulder **15** of the piston **14.** A radial space is provided between the nut **16** and the piston **14,** as well as between the piston **14** and the handle **2** so that the piston **14** may be radially displaced by a certain amount. The handle **2** has a passage **18** and an internal thread **19** at the upper end thereof for connection of the tool to a compressed air source (not shown) by known means. The passage **18** can communicate with the passage **12** through the air-distribution device **9.** Chambers **21** and **22** are defined between the housing **5** and the hammer piston **6.** A barrel **20** constitutes the main part of the housing **5.** The upper end of the barrel **20** receives a tube **23** which has a shoulder **24** bearing against the barrel **20** and is secured to the barrel by means of a sleeve **25** urging the shoulder against the barrel. The sleeve **25,** in its turn, is secured to the barrel **20** by means of a threaded connection. In order to eliminate air leakage through this thread, it is sealed with a special adhesive compound, paint or the like (not shown). Where the thread is of a sufficient length, the sealing is ensured by the threaded connection itself, and the above-mentioned sealing materials may be dispensed with. The sleeve **25** functions also as guide for the casing **1.** A chamber **26** is defined between the sleeve **25** and the barrel **20** which communicates with the chamber 21 through openings 27 made in the upper part of the barrel 20. In order to provide the discharge of exhaust air from the chambers 21 and 22, exhaust ports 28 are made in the barrel 20. An aperture 29 communicated with the exhaust ports 28 and with atmosphere is provided between the barrel 20 and the tube 4 of the casing 1 so as to direct the exhaust air downwards to disperse it in the atmosphere. The lower part of the barrel 20 is internally provided with a counterbore 30 defining an annular face 31 of the barrel. A guide bush 32 having a central opening for loosely mounting the rod 7 bears against this face. A seal 33 is located beneath the guide bush 32 to prevent air from leaking into atmosphere from the space 22 through the gaps between the guide bush 32 and the rod 7, as well as between the guide bush 32 and the barrel 20. The seal 33 is made of felt or the like material and is urged against the guide bush 32 by means of a sleeve 34, which is, in turn, urged by a nut 35 screwed on the barrel 20 and having a central bore for loosely mounting the rod 7. To compensate for the wear of the seal 32, the nut 35 can be screwed further on the barrel 20 to compress the seal 33, thereby prolonging its service life.

The hammer piston 6 is made composite. It includes the rod 7 and a shank 36 screwed therein. These elements are locked against unscrewing by means of a pin 37. An additional piston 38 is mounted in the hammer piston 6 which is made integral with the shank 36 so that the hammer piston 6 is concurrently used as drive means of the additional piston 38. It is known that during the operation of the tool the hammer piston moves substantially in the antiphase relation to the reciprocations of the housing 5, and therefore this embodiment of the hammer piston 6 permits to simplify the drive of the additional piston 38. In order to impart reciprocations to the additional piston 38 in the antiphase relation to the reciprocations of the housing 5, other drive means may be used which can ensure the achievement of the same result.

The additional piston 38 is provided with a passage 39 open at the upper end. The lower end of the passage 39 communicates with an air-distribution device 40 of a conventional type having a valve member 40*a* with the upper face 41 and the lower face 42, and a seat 43 with the upper face 44 and the lower face 45 which are adapted to cooperate with the faces 41 and 42 of the valve member 40*a*, respectively. The hammer piston 6 has passages 46 and 47 terminating at the respective faces 44 and 45 of the valve seat 43. The passages 46 communicate with the chamber 21, and the passages 47 communicate with the chamber 22 through passages 48 and 49 made in the rod 7 of the hammer piston 6. A permanent gap is provided between the faces 44 and 45 of the valve seat 43 and the respective faces 41 and 42 of the valve member 40*a*, since the thickness of the valve member 40*a* is smaller than the width of the valve seat 43. Therefore, the valve member 40*a* can perform a limited movement in the valve seat 43. The chambers 21 and 22 can communicate with the passage 39 through the passages 46, 47 and the gap in the valve seat 43, the passage 39 being connected to the chamber 21 when the valve member 40*a* is in the lowermost position, and with the chamber 22 when the valve member is in the uppermost position.

A central bore having portions of different diameter is provided in the tube 23. The portion of the bore having a larger diameter is made in the upper part of the tube 23, and the portion of a smaller diameter — in the lower part thereof. The piston 14 is received for reciprocations in the upper part of the bore of the tube 23, the piston 14 being slidably sealed in said tube 23. The additional piston 38 is received for reciprocations in the bore in the lower part of the tube 23, the additional piston being slidably sealed in the tube 23.

A nut member 50 is screwed on the upper part of the tube 23, and a rubber ring 51 is secured to the nut member (e.g., with an adhesive compound). A rubber ring 52 is secured to the lower part of the tube 23. The rings 51 and 52 are used as resilient stops limiting the displacement of the housing 5 in the casing 1. The sleeve 25, nut 32, guide bush 32, sleeve 34, seal 33, tube 23, nut member 50 and the rings 51 and 52 move together with the barrel 20 and form the housing 5 in combination therewith. The casing 1 may bear against the rings 51 and 52 by means of its shoulder 53 arranged to provide a space relative to the tube 23.

The portions of the bore of the tube 23 form therebetween a space 54 communicated with a compressed air source through the passage 13 of the piston 14, the passage 12 of the handle 2, the triggering device 9 and the passage 18. The above-described means used for the slidable sealing of the pistons 14 and 38 prevents air from leaking from the space 54.

An opening 55 is made in the tube 4 of the casing 1 to communicate the space 56 inside the casing with atmosphere thereby maintaining atmospheric pressure in the space 56.

All component parts of the tool interconnected by means of thread are locked by known means.

For better illustration of the operation of the tool, the latter is schematically shown in FIGS. 4 and 5. In FIGS. 4 and 5 the reference numerals indicating similar parts of the tool are identical to those used in FIGS. 1, 1′, 1″, 2, 3 and 6 showing the same tool which is illustrated in the FIGS. 4 and 5 in somewhat simplified manner. Thus, instead of showing the barrel and the elements secured thereto, there is illustrated the housing as an integral piece, the passages 48 and 49 in the hammer piston 6 are not shown, while the passages 47 are communicated directly with the chamber 22, and so on. These simplifications are not critical for the explanation which will be given hereinbelow.

FIGS. 7 and 7′ show another embodiment of the tool comprising a casing 57 consisting of a handle 58, a tube 59 screwed thereon and a tube 60 screwed in the tube 59. The handle 58 is constructed similarly with the handle 2 shown in FIG. 1. A passage 61 made in the handle 58 communicates with a compressed air source through a triggering device of a conventional type (not shown). A housing 62 similar to the housing 5 shown in FIGS. 1, 1′, 1″ is accommodated in the casing 57 axially movable relative thereto within certain limits, and a main piston 63 is secured to the barrel 20 of the housing 62 by means of the sleeve 25 screwed on the barrel 20.

The piston 63 is made hollow and defines, together with the casing 57, a space 64 communicated with a compressed air source through the passage 61 and the triggering device (not shown). A nut 65 is screwed on the upper part of the piston 63, and a rubber ring 66 is secured to the nut 65. A rubber ring 67 is secured to the lower part of the piston 63. The casing 57 has a reduced portion 68 having a bore receiving the slidably and sealingly mounted piston 63. In addition, the reduced portion 68 limits the movement of the housing 62 relative to the casing 57 by means of the rings 66 and 67.

An opening 69 is made in the tube 60 and is communicated with atmosphere and with a space 70 inside the tube 60, whereby atmospheric pressure is maintained in the space 70. Therefore, the function of the opening 69 is similar to that of the opening 55 in FIGS. 1', 4 and 5.

The hammer piston 6 is mounted for a limited axial movement in the housing 62, the construction of the hammer piston being identical with that described above. The additional piston 38 with the passage 39 therein constitutes a part of the hammer piston. The additional piston 38 is received through the central bore in the lower part of the piston 63 for reciprocation in the space 64.

The component parts of the tool shown in FIGS. 7 and 7' are mainly indicated using the same reference numerals as for the components parts of the tool shown in FIGS. 1, 1', 1'', 2, 3, 4, 5 and 6 performing similar functions.

The pneumatic tool shown in FIGS. 1, 1', 1'', 2, 3, 4, 5 and 6 functions as follows.

The initial position is shown in FIGS. 1, 1' and 1'', and in this position of the tool the hammer piston 6 is in such a position, that the chamber 21 communicates with atmosphere through the exhaust ports 28 and the aperture 29. This position corresponds to the instant of the delivery of a blow by the hammer piston 6 at the material being compacted (not shown), and the valve member 40*a* is in its lowermost position so that its lower face 42 is in contact with the lower face 45 of the valve seat 43 to close the passages 47 of the hammer piston 6. Between the upper face 41 of the valve member 40*a* and the upper face 44 of the valve seat 43 there is a gap communicating the passages 46 of the hammer piston 6 with the passage 39 of the additional piston 38. The housing 5 is in the position at which the portion 53 of the casing 1 is located between the rings 51 and 52 and somewhat closer to the ring 52. The lever 10 of the handle 2 is free so that the triggering device 9 is closed.

When the operator presses down the lever 10, the triggering device 9 is actuated, and the compressed air is fed through the passage 12 of the handle 2 and the passage 13 of the piston 14 into the space 54 of the tube 23. During the operation, the space 54 is under the pressure of compressed air which is about equal to the pressure in the air line. Thus, a substantially constant upwardly directed force F_1 is applied to the casing 1 whose magnitude is equal to the product of the total area of the cross-section of the piston 14 (including the clear area of the passage 13) by the air pressure in the space 54. In order to improve the labor conditions, the magnitude of this force F_1 is preferably selected to be greater than the weight of the casing 1. A substantially constant force F_2 (not shown) is applied downwards in the space 54 to the tube 23, and hence to the housing 5 as a whole, the magnitude of this force being equal to the product of the air pressure in the space 54 by the area of a ring surface which given by the difference between the cross-sectional area of the piston 14 and the total cross-sectional area of the additional piston 38 (including the clear area of the passage 39). The magnitude of this force is selected depending on the parameters of the tool. Approximately constant force F_3 equal to the product of the air pressure in the space 54 by the cross-sectional area of the additional piston 38 is applied to the hammer piston 6 downwards.

The compressed air from the space 54 enters the lower end of the passage 39. Then the compressed air enters the chamber 21 through the gap between the upper face 41 of the valve member 40*a* and the upper face 44 of the valve seat 43 and the passages 46 of the hammer piston 6. The air is exhausted into atmosphere from the chamber 21 through the ports 28 and the aperture 29. The clear cross-section of the gap between the upper face 41 of the valve member 40*a* and the upper face 44 of the valve seat 43 is the smallest one along the entire air duct of the tool, and for that reason the air velocity at that point is at its maximum, while the static head is at its minimum.

At the same time, the compressed air leaks through microscopic gaps which are always available between the lower face 42 of the valve member 40*a* and the lower face 45 of the valve seat 43. The pressure acting upon the face 42 of the valve member 40*a* is substantially equal to the air line pressure, and this pressure is, of course, greater than the pressure applied to the face 41 thereof, whereby the valve member 40*a* will be substantially instantaneously shifted upwards to take the position shown in FIG. 4. In this position the face 41 of the valve member 40*a* is in contact with the face 44 of the valve seat 43 to shut-off the passages 46 of the hammer piston. Compressed air flow into the chamber 21 is interrupted, and the air begins to flow into the chamber 22 through the gap formed between the lower face 42 of the valve member 40*a* and the lower face 45 of the valve seat 43, and the passages 47, 48, 49 in FIGS. 1' and 6 or through passages 47 in FIGS. 4 and 5.

The pressure in the chamber 22 starts increasing and acts upon the hammer piston 6 and the guide bush 32, and thereby upon the housing 5 as a whole. When the air pressure force applied to the hammer piston 6 from the side of the chamber 22 will overcome the force F_3 and the weight of the hammer piston 6, the hammer piston will begin to move upwards. The housing 5, under the action of the pressure force in the chamber 22, as well as under the action of the force F_2 and its own weight, will begin to move downwards.

During the combined movement of the housing 5 and the hammer piston 6, the latter will shut-off the exhaust ports 28, and the compression of the air entrapped by the hammer piston 6 will begin to occur in the chamber 21. During further movement of the housing 5 and the hammer piston 6 the exhaust ports 28 are opened, and the chamber 22 is communicated with atmosphere through these exhaust ports and the aperture 29. The exhaust of the air from the chamber 22 into atmosphere begins, and the air pressure therein will start decreasing so as to become equal to the atmospheric one. The pressure in the gap between the lower face 42 of the valve member 40*a* and the lower face 45 of the valve seat 43 also decreases. The hammer piston 6 and the housing 5 continue to move towards each other so that the pressure in the chamber 21 will grow higher. At a certain point the pressure applied to the upper face 41 of the valve member 40*a* will overcome the pressure applied to its lower face 42, and the valve member 40a will be shifted into the lowermost position so that the compressed air will enter the chamber 21 from the passage 39 through the gap between the upper face 41 of the valve member 40*a* and the upper face 44 of the valve seat 43 and through the passages 46. The chamber 21 communicates with the chamber 26 through the openings 27. The chamber 26 constitures something like the additional volume of the chamber 21 thus contributing to more gradual pressure growth. This causes an increase in the stroke of the hammer piston 6 relative to the housing 5 which is favourable for the energy performance of the tool. The movement of the housing 5 is slowed down under the action of the pressure force of the air compressed in the chamber 21 and entering said chamber 21 from the passages 46, and a certain space will remain between the ring 51 moving together with the housing 5 and the portion 53 of the casing 1. Under the action of the pressure force in the chamber 21, under the own weight of the hammer piston 6 and under the action of the force F_3, the hammer piston 6 will be slowed down approximately at the same point, when its enalrged portion has not yet reached the tube 23.

During all that time, the additional piston 38, which constitutes a part of the hammer piston 6 and moves upwards together therewith, telescopes into the space 54, the volume of the space 54 decreasing by the amount equal to the product of the total cross-sectional area of the additional piston 38 by the stroke of the hammer piston 6 relative to the housing 5. However, since the housing 5, during that time, was moving in the direction opposite to the direction of movement of the hammer piston 6, that is downwards so that the housing 5 telescoped from the casing 1, the volume of the space 54 has been increased by the amount equal to the product of the total cross-sectional area of the piston 14 secured to the handle 2 by the stroke of the housing 5 relative to the casing 1. A change in the volume of the space 54 is equal to the difference between the increments of its volume due to the telescoping of the additional piston 38 into the space and the telescoping of the housing 5 from the casing 1 to whose handle 2 there is attached the piston 14. With an appropriate selection of the total cross-sectional areas of the pistons 14 and 38 and the strokes of the hammer piston 6 relative to the housing 5 and of the housing 5 relative to the casing 1, the change in the volume of the space 54 may be substantially reduced to zero. It is obvious that in that case the air pressure in the space 54 remains practically unchanged, and therefore, the force F_1 applied to the casing 1 is also constant so that the casing 1 and the handle 2 are not subjected to any excitation, that is they will not vibrate.

After the housing 5 has been slowed down, it starts moving upwards under the action of the pressure force in the chamber 21 overcoming the force F_2 and the own weight of the housing 5. After the hammer piston has been slowed down, it starts moving downwards under the action of the pressure force in the chamber 21, its own weight and the force F_3.

During the downward movement of the hammer piston 6 and during the upward movement of the housing 5 the exhaust ports 28 are closed, and the compression of the air entrapped in the chamber 22 begins so that the pressure in this chamber increases. During further upward movement of the housing 5 and the downward movement of the hammer piston 6 the exhaust ports 28 are opened, and the exhaust air will leave the chamber 21 into atmosphere through these ports and through the aperture 29 so that the pressure in the chamber 21 abruptly drops. The pressure will be also decreased in the passages 46 and in the gap between the upper face 41 of the valve member 40*a* and the upper face 44 of the valve seat 43. When the air pressure applied to the lower face 42 of the valve member 40a will overcome the pressure acting upon its upper face 42, the valve member is shifted to the uppermost position so as to shut-off the passages 46 with its face 41, and the compressed air flow into the chamber 21 will be interrupted. The compressed air will begin to flow through the gap between the lower face 42 of the valve member 40*a* and the lower face 45 of the valve seat 43 and through the now open passages 47 into the chamber 22.

The hammer piston 6 will deliver, with the working tool (shoe) 8, a blow at the material being compacted (not shown) overcoming the pressure force in the chamber 22. The relative position of the component parts of the tool at the instant of the delivery of a blow is schematically shown in FIG. 5. After the delivery of a blow, the hammer piston 6 will start moving upwards under the action of the pressure of compressed air in the chamber 22, and partially due to the rebound from the material being compacted, overcoming its own weight and the force F_3 which is permanently applied to the hammer piston 6 in the downward direction. The housing 5, under the action of the pressure of the compressed air in the chamber 22, as well as under its own weight and the force F_2 applied thereto upwards from the space 54, will be also stopped approximately at the instant of blow and will start moving downwards under the action of the above-mentioned forces. At the instant of the immobilization of the housing 5 a space still remains between the portion 53 of the casing 1 with the handle and the housing ring 52. Then the cycle of operation is repeated.

During the period of the upward movement of the housing 5 and the downward movement of the piston 6, due to the telescoping of the additional piston 38 from the space 54, the volume of this space increases by the amount equal to the product of the total cross-sectional area of the additional piston 38 by the stroke of the hammer piston 6 relative to the housing 5. At the same time, due to the telescoping of the housing 5 into the casing 1, the volume of the space 54 decreases by the amount equal to the product of the total cross-sectional area of the piston 14 by the stroke of the housing 5 relative to the casing 1. This decrease in the volume of the space 54 is compensated for by the increase in its volume due to the telescoping of the additional piston 38 therefrom, whereby the volume of the space 54 remains practically unchanged which, as it was mentioned above, contributes to the lowering of vibration at the casing 1 and handle 2.

During the operation of the tool the volume of the space 56 is cyclically varied, but since this space communicates through the opening 55 with atmosphere, a constant pressure is maintained therein which is equal to the atmospheric one, and variations of this volume do not result in any increase in vibration of the casing 1 and the handle 2.

Under steady operating conditions, the housing 5, while reciprocating, oscillates about a certain point so that it does not reach the portion 53 of the casing 53 with its rings 51 and 52. Random hitting of one of the rings 51, 52 against the portion 53 with the resulting vibration at the casing 1 and the handle 2 may be readily eliminated by moving the entire casing 1 up or down.

Therefore, during the operation of the impact tool according to the invention, due to the movement of the piston 14 and additional piston 38 in the space 54, the volume of this space 54 remains substantially unchanged. The constant volume of the space 54 contributes to the maintenance of a constant air pressure therein so as to ensure a constant force applied during all the time to the casing 1 and handle 2. The absence of the force fluctuation results in the absence of vibration at the casing 1 and the handle 2 held by the operator.

The operation of the portable pneumatic tool, namely of the tamper shown in FIGS. 7 and 7' is practically similar to the operation of the tool shown in FIGS. 1, 1', 1'', 2, 3, 4, 5 and 6.

After the triggering device (not shown) is actuated, compressed air enters the space 64 through the passage 61. During the operation the space 64 is permanently under the pressure of compressed air. Therefore, substantially constant force F_4 is applied upwards to the casing 57, the magnitude of this force being equal to the product of the total cross-sectional area of the piston 63 at any section intermediate the portion 68 and the ring 66 or 67 (including the cross-sectional area of the space 64 at that point which is enclosed by the piston 63) by the air pressure in the space 64.

A substantially constant force F_5, which is equal to the force F_4 and is directed downwards, is applied to the piston 63, and thereby to the housing 62 as a whole.

A substantially constant force F_3 is applied downwards to the hammer piston 6, which is equal to the product of the cross-sectional area of the additional piston 38 by the air pressure in the space 64.

The compressed air is fed from the space 64 through the passage 39 to the air-distribution device 40 and is fed thereby alternately into the chambers 21 and 22 as it was described with reference to FIGS. 1, 1', 1'', 2, 3, 4, 5 and 6, whereby the hammer piston 6 and the housing 62 perform reciprocations, the hammer piston 6 moving substantially in the antiphase relation to the reciprocations of the housing 62 and delivering useful blows at the material being compacted (not shown).

As a result of the above-described movement of the housing 62, the piston 63 moving together therewith will alternately telescope into and from the space 64 to respectively reduce and increase the volume of said space. At the same time, the additional piston 38, which constitutes a part of the hammer piston 6 and moves in the antiphase relation to the reciprocations of the housing 62, and hence of the piston 63, alternately telescopes from and into the space 64 to respectively increase and reduce the volume of said space. The cross-sectional area of the piston 63, the stroke of the housing 62 relative to the casing 57 and the cross-sectional area of the additional piston 38 and the stroke of the hammer piston 6 relative to the housing 62 are selected in such a manner that the decrease in the volume of the space 64 due to the telescoping of the piston 63 thereinto is substantially compensated for by the increase in the volume of the space 64 due to the telescoping therefrom of the additional piston 38, while the increase in the volume of the space 64 due to the telescoping of the piston 63 therefrom is substantially compensated for by the decrease in the volume of the space 64 due to the telescoping of the additional piston 38 thereinto, whereby the volume of the space 64 remains substantially unchanged.

Due to the constant volume of the space 64, the air pressure therein is constant, and therefore, the force F_4 applied to the casing also remains unchanged, so that the casing and the handle 58 are not subjected to any excitation, that is they do not vibrate.

Under steady operating conditions the housing 62, while receprocating, performs oscillations about a certain point so that its rings 66 and 67 do not reach the portion 68. Random hitting of one of the rings 66, 67 against the portion 68 and the resulting vibration of the casing 57 and the handle 58 are readily eliminated by moving the entire casing 57 up or down.

It should be noted that the embodiment of the invention illustrated in the accompanying drawings and described hereinabove represent an illustrative example only and various modifications may be made as regards the shape, dimensions and arrangement of certain elements. Thus, the components parts illustrated in the drawings and described above may be replaced by their equivalents, the position of some elements may be changed, and certain elements of the invention may be used independently without departure from the spirit and scope of the invention as defined in the appended claims.

An experimental pneumatic tamper constructed in accordance with the invention has been tested by compacting various materials, such as moulding sand, sand, loose soil and the like under divers conditions in comparison with known tampers. The tests have shown that the vibration level at the casing and handle of the tamper according to the invention was substantially lower as compared with the known tampers with a smaller weight of the tamper and other parameters being the same.

What is claimed is:

1. A portable pneumatic impact tool comprising: a casing; a housing in said casing axially movable relative thereto and having a space in constant communication with a compressed air source; a main piston mounted in said casing and received in the space of said housing for axial movement together with said casing relative to said housing, the compressed air pressure in the space of said housing resulting in the development of a force applied to said casing so as to urge it away from said housing; a hammer piston mounted for axial movement in said housing for imparting useful blows; said housing and said hammer piston defining working chambers which are alternately communicated with a compressed air source and atmosphere; means for alternately feeding compressed air into said working chambers for thereby imparting reciprocations to said housing and said hammer piston, whereby said hammer piston imparts useful blows; an additional piston; drive means for imparting reciprocations to said additional piston substantially in the antiphase relation to the reciprocations of said housing; said additional piston being received in the space of said housing during the reciprocations so that variations in the volume of the space of said housing caused by the reciprocation of said housing are substantially compensated for by the reciprocations of said additional piston, whereby the volume of the space of said housing remains substantially unchanged, and hence the pressure fluctuations of the compressed air in the space of said housing are reduced, whereby the force applied to said casing is maintained constant and vibration of said casing is lowered.

2. A pneumatic tool according to claim 1, wherein said additional piston constitutes a part of said hammer piston.

3. A pneumatic tool according to claim 1, wherein said means for alternately feeding compressed air into said working chambers comprises a valve-type air-distribution device accommodated in said hammer piston and communicated with a compressed air source.

4. A pneumatic tool according to claim 3, wherein said additional piston is provided with a passage having one end in permanent communication with a compressed air source and the other end in permanent communication with said air-distribution device.

5. A pneumatic impact tool comprising: a casing having a space in constant communication with a compressed air source; a housing axially movable in said casing; a main piston mounted in said casing and received in the space of said casing for axial movement together with said housing relative to said casing, the compressed air pressure in the space of said casing resulting in the development of a force applied to said casing so as to urge it away from said housing; a hammer piston mounted for axial movement in said housing for imparting useful blows; said housing and said hammer piston defining working chambers which are alternately communicated with a compressed air source and atmosphere; means for alternately feeding compressed air into said working chambers for thereby imparting reciprocations to said housing and said hammer piston, whereby said hammer piston imparts useful blows; an additional piston; drive means for imparting reciprocations to said additional piston substantially in the anti-phase relation to the reciprocations of said housing; said additional piston being received in the space of said casing during the reciprocations so that variations in the volume of the space of said casing caused by the reciprocations of said housing are substantially compensated for by the reciprocations of said additional piston, whereby the volume of the space of said casing remains substantially unchanged, and hence the pressure fluctuations of the compressed air in the space of said casing are reduced, whereby the force applied to said casing is maintained constant and vibration of said casing is lowered.

6. A pneumatic tool according to claim 5, wherein said additional piston constitutes a part of said hammer piston.

7. A pneumatic tool according to claim 5, wherein said means for alternately feeding compressed air into said working chambers comprises a valve-type air-distribution device accommodated in said hammer piston and is communicated with a compressed air source.

8. A pneumatic tool according to claim 7, wherein said additional piston is provided with a passage having one end communicated with the space which is permanently communicated with a compressed air source, and the other end communicated with said air-distribution device.

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