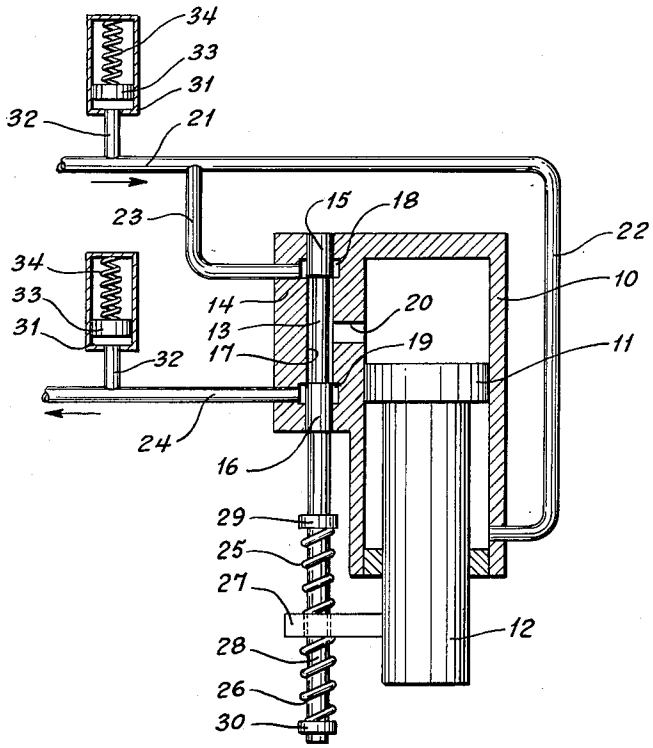
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VIBRATOR

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VIBRATOR

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The inventor has already suggested a vibrator comprising a piston reciprocating in a cylinder and having a piston rod, and a valve body reciprocating in a valve casing for supplying hydraulic liquid from a hydraulic pressure source to the cylinder. The end of the piston connected to the piston rod is permanently subjected to the hydraulic pressure from this source, and the opposite end of the piston is arranged to be connected to the hydraulic source or to an outlet, respectively, according to the position of the valve body. This hydraulic vibrator may be set to work at high frequency, for instance 4000–6000 strokes/min., and with high efficiency and, at the same time the apparatus has small dimensions. The vibrator may with great advantage be utilized for rock drills, for example.

Practically during the whole cycle of operation the piston moves at a varying speed in its cylinder and is at standstill in the reversing positions. From the hydraulic pressure source, however, there is supplied a mainly constant amount of hydraulic liquid per unit of time. Hence, according to the present invention it has proved to be advantageous to provide a hydraulic liquid accumulator in the supply conduit or pipe line from the hydraulic source to the cylinder of the piston and/or in a return pipe from the cylinder to the hydraulic source. This accumulator in the supply conduit for the hydraulic liquid receives excess of the hydraulic liquid in or approximately in the reversing position of the piston between the working stroke of the piston and its return stroke as well as during the latter return stroke. In both cases the quantity of the accumulated hydraulic liquid is discharged to the piston cylinder during the working stroke of the piston so as to impart maximum velocity to the piston. The reason for the fact that accumulation may take place during the return stroke is that the area of the piston exposed to the hydraulic pressure then is relatively small so that a high average pressure is required.

The hydraulic liquid accumulator in the return pipe to the hydraulic source has the purpose of equalizing the pulsations in the return or discharge pipe.

Both accumulators fulfill an important function for preventing a too fluctuating velocity of the oil in the supply and return pipes, respectively, which often consist of flexible hoses. Such fluctuations of the velocity could result in a detrimental loss of energy and could cause unnecessary stresses in the hoses which also could get into so violent vibrations as to be weared and teared by engagement with external objects.

The accumulator may for instance consist of a liquid-container having a spring-loaded piston and containing a volume of 5 $cm.^3$ for instance but the invention is not, of course, restricted to this figure.

Both accumulators or one of them may, if desired, be mounted outside the vibrator unit proper close to the hydraulic liquid pump, but in this case pulsations could arise in the conduit between the accumulator and the vibrator. The accumulator must not be dimensioned so as to accumulate as much a liquid as the quantity required for the working stroke of the main piston. Should the vibrator suddenly be heavily loaded the requisite increase in the liquid pressure cannot be effected rapidly but the accumulator will receive a too great amount of liquid whereby the amount of oil required for the operation of the vibrator will not be supplied to the vibrator and the consequence will be that the vibrator stops.

The invention will now be described in greater detail with reference to an embodiment shown diagrammatically in longitudinal section on the accompanying drawing.

In the drawing, **10** is a cylinder in which a piston **11** is adapted to move axially. The piston is mounted on a piston rod **12** or the like which passes sealingly through one end wall of the cylinder and which has a cross-sectional area preferably approximately half that of the piston **11**. A valve spindle **13** is axially movable in a valve casing **14** which is fitted to or is integral with the cylinder **10**. The directions of movement of the piston and the valve spindle are preferably parallel. The valve spindle is fitted with two cams or slide valve heads **15, 16**, which fit in a recess **17** in the valve casing and which according to their position relative to said casing open or close the communication between a recess **18** or **19**, respectively, and a passage **20** leading to the cylinder above the piston **11**. A pipe **21** from a source of hydraulic liquid (a pump) is in permanently open communication with the chamber under the piston **11** through a branch pipe **22** and with the recess **18** through another branch passage **23**. A discharge pipe **24** or a return pipe to the pump leads from the recess **19**.

The movements of the piston **11** are transmitted to the spindle **13** via either of two springs **25, 26** which are tensioned against each other. In the diagrammatic figure the piston rod **12** has a follower **27** which with a clearance or play is fitted on the portion **28** of the valve spindle projecting outside the valve casing. The springs engage at one end the follower **27** and at the other end the abutments **29, 30**, respectively, on the valve spindle; they are preferably pretensioned. A movement of the piston **11** in either direction first compresses the corresponding spring and then moves the valve spindle.

The aforesaid accumulator communicating with the supply conduit **21** through a conduit **32** is indicated at **31** and is loaded by a spring **34**. Preferably, a similar accumulator is inserted in the return pipe **24**.

The vibrator operates in the following way:

On the bottom side of the piston **11** there is always acting a force which is equal to the specific pressure of the hydraulic liquid multiplied by the annular piston area outside the piston rod **12**, said area as mentioned above, being about half the area of the top side of the piston. Thus, if the valve spindle **13** is in such a position that the valve head **16** affords an open communication between the upper cylinder chamber and the outlet **24** while the hydraulic liquid supply through the conduit **23** is blocked by the valve head **15**, the piston will be subjected to an upward force equal to half the piston area multiplied by the specific hydraulic pressure. If on the other hand the valve spindle **13** is in an upper position in which the outlet **24** is closed while hydraulic liquid is supplied to the upper piston chamber through the recess **18**, the top side of the piston will be subjected to a force which is equal to the whole piston area multiplied by the specific hydraulic pressure. In this case, however, there will act, at the same time, on the bottom side of the piston an upward pressure which is half as great, since said bottom side is permanently actuated by the pressure from the hydraulic source. The resultant downward force will therefore be the same as the upward force in the first mentioned position of the valve spindle.

Thus, in order that the piston **11** shall be in equilibrium the pressure on the free piston side shall be half of the pressure on the piston rod side. This result may be ob-

tained in the neutral position of the valve spindle 13 as shown in the figure, in which the supply of hydraulic liquid through the conduit 23 and the discharge of liquid through the conduit 24 are both blocked so that the specific hydraulic pressure in the upper part of the cylinder is half that of the specific hydraulic pressure in the lower part of the cylinder. The moving elements of the vibrator have the tendency, if they are not disturbed by external forces, to move to this neutral position and even after being actuated by an external force they tend to return to said neutral position. They are, however, prevented from remaining in the neutral position because of the resilient coupling between the piston 11 and the valve spindle 13. If the piston has been forced upwards under the action of an external force, as in the figure, the spring 25 is compressed so that the valve spindle 13 is pushed up. Hence, the supply of hydraulic liquid through the conduit 23 is opened while the outlet 24 is closed. The pressure on the top side of the piston 11 is greater and the piston is urged down. As a result the spring 26 is compressed again and in turn draws the valve spindle 13 downwards. The hydraulic liquid supply to the upper cylinder chamber is interrupted and instead communication with the outlet 24 is opened. The upwards forces on the piston 11 are prevailing so that the piston moves upwards. The whole operation results in a rapid reciprocating movement of the piston 11 and consequently also of the valve spindle 13. The neutral position will always be surpassed and the frequency of the movements of the two elements will be very high.

When a new stroke begins the piston 11 will thus move at an accelerating speed and will drive the valve spindle 13 in the same direction but it should be noted that due to the inertia of the valve spindle and the spring coupling with the piston, the valve spindle will lag behind and the spring will be compressed in accordance to the acceleration force of the motion of the valve spindle. When the valve spindle subsequently has passed the neutral position and arrives to the position in which the hydraulic pressure on the piston is reversed the working piston will be stopped and reversed but the valve spindle will continue further until the spring system has reached the neutral position and has been tensioned sufficiently in the other direction to be able to slow down the valve spindle to stop it and then to start its movement in the other direction.

During the upward return stroke of piston 11 and while the piston is at standstill in the upper reverse position the accumulator 31—34 inserted in the conduit 21 will receive hydraulic liquid due to the fact that the piston 33 moves upwards against the action of spring 34. The accumulated quantity is discharged to the cylinder of piston 11 during the downward working stroke of this piston.

The accumulator in the return conduit 24 will function in a similar manner.

The frequency and amplitude of the vibrator and its piston, respectively, can be adjusted by altering the dimensions of the springs 25 and 26. A control can also be provided within limits by varying the hydraulic pressure and the quantity of the hydraulic liquid. The hydraulic pressure can for instance be 50 to 100 kg./cm.^{2}. In one embodiment with 5,000 to 6,000 strokes a minute, the pressure was 70 kg./cm.^{2}; the liquid consumption 120 litres/min; the stroke energy 6.4 kgm./stroke; the stroke length 8 mm. and the piston speed 6.5 metres/sec. The invention is, however, in no way limted to these figures.

The hydraulic liquid may, for example, be oil or water. In rock drilling flushing water is supplied to the drilling holes. The driving liquid required for the vibrator approximately corresponds to the amount of flushing water needed. It is therefore possible when drilling at great depths, such as some 100 metres, to drive the vibrator with water from the ground level, thus without any supply of external energy since the energy due to the level of water is sufficient for driving the vibrator. The piston rod 12 can be connected directly with the drill so that they both vibrate together, or the piston rod 12 and its associated elements can transmit their vibratory movement to the drill shank.

The invention can be applied in many other fields such as in excavating and loading machines; the vibrator then being coupled to the excavating elements to facilitate their digging into the material to be loaded. Further examples of applications in which the vibrator can be used with advantage are: releasing material in funnels and bins by shaking, conveying material in feed channels and dewatering of various various materials (for example, thickening pulp).

If the machine is used as a beating (hammering) machine the coupling between the piston rod and the tool is adjusted so that the impact occurs before the piston motion meets the counter pressure from the liquid. This brakes the working piston so that the valve spindle catches up and reverses the direction of motion.

If a pressure reduction valve or similar device is used so that the hydraulic pressure on the piston rod side of the piston for instance is lower than the hydraulic pressure in the conduit 23, the hydraulic forces acting on the two sides of the piston can nevertheless be made equal or approximately equal by a corresponding choice of the ratio between the outer diameters of the piston and piston rod.

What I claim is:

1. A vibrator device comprising in combination a working cylinder, a piston reciprocating in said cylinder, and a power transmitting piston rod fixed on one side of said piston, a pressure fluid conduit for supplying fluid under pressure from a pressure fluid source to said cylinder, reciprocating valve means in operative relationship with respect to said cylinder for connecting said cylinder on the side of said piston opposite to said piston rod alternately with said pressure fluid conduit and with an outlet pressure lower than the pressure of said pressure fluid source, said pressure fluid conduit having one branch connected with said valve means and another branch directly connected with the piston rod side of the cylinder, whereby movement of said piston in a first working direction and a reverse working direction, respectively, is provided, and a hydraulic accumulator in said pressure fluid conduit in advance of the branch point of said two branches for accumulating at least part of the liquid quantity, as against average delivery of the pressure fluid, by which the consumption of the vibrator varies within a cycle, the effective surface on said one side of said piston being decreased by the presence of said piston rod so as to maintain in said conduit a pressure differential allowing accumulation of liquid by said accumulator also during the reversing movement as well as to feed, during the working movement, of pressure fluid from the piston rod side of the cylinder to the opposite side thereof through said conduit branches and said branch point, contributing to the equalization effect of the accumulator.

2. A vibrator according to claim 1 in which said hydraulic accumulator comprises a cylinder in connection with said conduit and a piston mounted to reciprocate in said cylinder and being subjected on one side to the pressure fluid pressure and on the other side to a constant force.

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