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ELECTRIC HAMMER

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Fig. 1

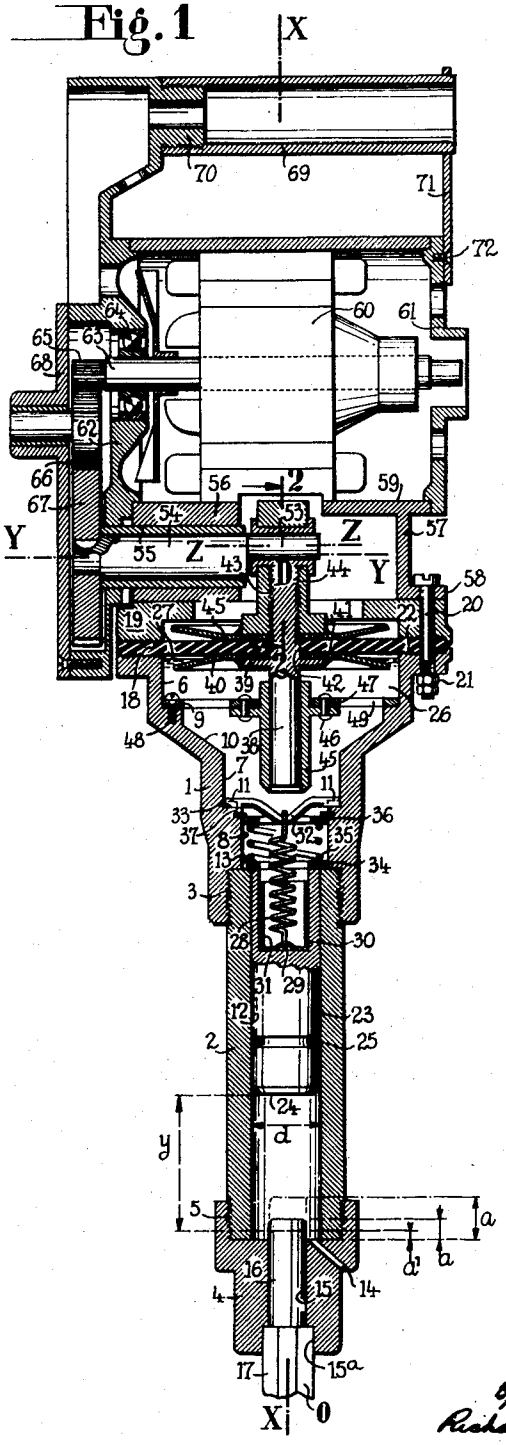
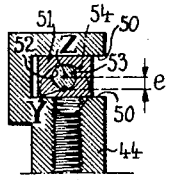


Fig. 2



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ELECTRIC HAMMER

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6 Claims. (Cl. 125—33)

The present invention relates to electric hammers.

The limited commercialization of electric hammers is due in large part to their low power-to-weight ratio. It is known that this power corresponds to

$$\frac{1}{2}mv^2\frac{n}{M}$$

where m is the striking mass, v its velocity, n the frequency of the successive blows and M the total mass of the hammer.

In hammers of known type, the power-to-weight ratio is low for several reasons. The electric motor incorporated in the hammer weighs alone several kilograms so that M is large and, furthermore, the stroke or travel of the striking mass is usually small (except in the case of ball hammers) and in consequence the velocity v is also small.

If it is attempted to obtain a suitable power-to-weight ratio by increasing the frequency n of the blows, it is obvious that the power per blow remains small and insufficient inertia force is available for striking a hard material. The number of blows could be multiplied, but the desired result is still not obtained, because the power of each blow remains less than a minimum value for effective action.

Only pneumatic hammers fully satisfy the requirements of heavy duty but these hammers have a high compressed air consumption, require a compressor at the place of work and are therefore uneconomical and impractical.

Theobject of the invention is to provide an electric hammer which is simple in construction, reliable in operation and has a considerable power-to-weight ratio. This hammer comprises, interposed between the driving member and the piston forming the striking mass, a hydraulic motion converter which is so arranged that a reduced travel of the driving member results in the piston effecting a longer travel which is slightly in excess of the effective operational travel, damping means being combined with this hydraulic converter to absorb the difference between the travel the driving member is capable of imparting to the piston and the effective travel of the latter and to damp the reactions due to the impact of the piston on the tool.

Owing to the fact that the hydraulic motion converter increases the travel, a relatively short travel (of about a centimetre) consistent with a cam, eccentric journal or like drive from the driving member, is converted into a large travel (of about 10 cm. or more) and therefore a high velocity of the piston.

Further, owing to the excess travel of the piston, the impact occurs before the piston has reached the end of its travel and advantage is therefore gained from the fact that this piston has at that moment a high velocity. Furthermore, adjustment of the strokes or travels is no longer critical, particularly in respect of the distance from the tool to the extreme upper position of the piston.

Obviously, as the blow on the tool is stronger the reaction is greater, but, owing to the damper, this reaction is absorbed and the user experiences no disagreeable effect.

In one embodiment of the invention, the body of the hammer comprises a cylinder into one end of which extends the shank of the tool and in which said piston slides, the other end of this cylinder being in communication with a chamber which has a larger cross-sectional area and is closed by the driving member which is connected to an electromechanical drive device which imparts to the driving member a reciprocating movement having a pre-determined small amplitude, the fluid-tight space formed in said body between the piston and the driving member being substantially full of a liquid and the ratio between the cross-sectional areas of the cylinder and the chamber being such that the amplitude of the movements of the driving member corresponds to said slightly excessive travel of the piston.

In a preferred embodiment, the driving member is formed by a flexible diaphragm fixed at its periphery to the hammer body, so that this diaphragm also performs the function of a closing member for the corresponding chamber, the central portion of this diaphragm being connected to the electromechanical drive device.

The means which compensates for the difference between the travel of the piston and that of the driving member and resiliently absorbs the reaction due to the impact of the piston on the tool, may consist in a small volume of air trapped in the liquid in the chamber formed between the piston and the diaphragm and/or in the diaphragm owing to an elastically-yieldable deformation of its free part and/or in a dashpot or other device disposed outside, but communicating with, the chamber.

Further features and advantages of the invention will be apparent from the ensuing description with reference to the accompanying drawing to which the invention is in no way limited.

In the drawing:

Fig. 1 is a vertical longitudinal sectional view of an electric hydro-pneumatic hammer embodying the invention, the moving part thereof being shown in its extreme upper position, and

Fig. 2 is a partial sectional view taken along line 2—2 of Fig. 1.

The body of the hammer comprises the combination of a housing **1**, a tube **2** screw-threadedly engaged at **3** in the latter, and an end member **4** screw-threadedly engaged at **5** on the lower end of the tube **2**. The body has a cylindro-conical shape, the conical portion thereof being formed between two cylindrical portions so that this body comprises three cylindrical bores having decreasing diameters **6**, **7** and **8**, the bores **6** and **7** being interconnected by a shoulder **9** and an adjacent conical portion **10**, and the bores **7** and **8** being interconnected by a shoulder **11**.

The tube **2** comprises a cylindrical bore **12** whose diameter d is less than that of the bore **8** so as to provide between these bores a further shoulder **13**, formed in the presently-described embodiment by the end of the tube **2**. The diameter d is therefore less than the diameter D of the bore **6** and the ratio

$$\frac{D}{d}$$

which is equal to m, could easily be ten or even more.

The end member **4**, which is provided with an air vent **14**, has an axial aperture comprising a cylindrical portion **15** and an adjacent prismatic portion **15a**. Engaged in the aperture **15**, **15a**, are corresponding cylindrical and prismatic portions **16** and **17** of the shank of a tool O. The cylindrical portion **16** extends a distance a into the bore **12**. The distance a varies according to the tool and

the wear of the latter and may be, for example, between a minimum value a^1 and a maximum value a^2.

The bore 6 is closed by a flexible diaphragm 18 of natural rubber or the like, and its periphery is clamped between the part 1 of the body and a ring 19 secured to the part 1 and tightened down by bolts 20 and nuts 21.

Preferably, to obtain a good fluid-tight connection, the facing surfaces of the body 1 and the ring 19 are provided with concentric grooves 22 which ensure an excellent fixing of the diaphragm 18 and increase the contact in the radial direction, owing to the zig-zag shapes of these grooves.

The diphhragm 18 constitutes the driving member which closes one end of the fluid-tight space formed by the aforementioned bores, the other end being closed by a piston 23 which has a lower striking face 24 and is movable in the bore 12. This piston moves in the bore in a fluid-tight manner owing to the provision of one or more sealing rings 25.

The fluid-tight chamber thus formed is almost completely filled with oil or other liquid 26, that is, an incompressible fluid. This chamber contains a small amount of air represented by the small space 27 between the diaphragm 18 and the surface of the liquid in Fig. 1, in which figure the hammer is at rest. In the course of hammer operation, the air 27 is dispersed in the liquid 26.

Owing to the ratio m between the dimensions of the bores 6 and 12, it will be immediately apparent that any downward movement of the diaphragm 18 results in a displacement of the piston 23 which is m times greater, since the volume of the liquid 26 in the chamber between the diaphragm and the piston is incompressible, no account being taken of the possible compression of the air 27 whose function will be described hereinafter.

At rest, the piston 23 is maintained in the illustrated position by a helical extension spring 28 which is hooked at 29 to a member 30, welded or otherwise secured in a recess 31 formed in the piston 23, whereas the upper end of the spring is hooked on a transverse rod 32 bearing against the shoulder 11. This rod 32 has preferably a bent middle portion and is held in position by the engagement of its ends in two radial recesses 33 formed in the shoulder 11.

In this uppermost position of the piston, the latter abuts, through the medium of a washer 34, a spring 35 which acts as a damper and bears at its upper end against a ring 36 held by a resilient split ring 37 engaged in an annular recess in the bore 8.

The central portion of the diaphragm 18 is connected to an electro-mechanical drive device D which imparts to the diaphragm an oscillation of amplitude x, so that the corresponding travel $y=mx$ of the piston 23 is equal to the distance between the lower face of the piston, when the latter is in its uppermost position, and the inner end face of the shank 16 of the tool O, the latter extending into the bore 12 the minimum distance a^1. Thus for all distances a ranging between a^1 and a^2, this travel or stroke y is slightly greater than the effective operational travel.

It will be observed that a rod 38 extends into the chamber containing the liquid and is guided therein on the longitudinal axis XX of the hammer by a tubular guide 45 secured by rivets 46, or other means, to a plate 47 itself attached by screws 48 to the shoulder 9 of the part 1 of the hammer body. The plate 47 is provided with openings permitting the free passage of the liquid 26.

A head 44 which is connected to the rod 38 and therefore moves with the diaphragm 18, has the shape of a hook, as shown in Fig. 2. Slidable in the recess having parallel and transverse faces 50 in this head 44 is a slide 51. The latter is provided with a cylindrical aperture 52 in which is journalled a journal 53 formed at the end of a shaft 54 which has an axis YY perpendicular to the axis XX, the journal 53 having an axis ZZ which is offset a distance e from the axis YY so that, for each complete rotation of the shaft 54, the journal 53 reciprocates the head 44 and the rod 38 in the vertical direction, this reciprocation being imparted to the diaphragm 18 and in consequence to the piston 23.

The driving shaft 34 is driven by an electric motor and the latter can be combined with the hammer, as shown in the figures, or could drive this shaft at a distance by way of a flexible shaft, which reduces the total weight or mass M of the hammer to the extent of the weight of this driving motor.

The illustrated embodiment, however, has the advantage of combining the motor and hammer in a single unit.

The shaft 54 is journalled in an anti-friction bushing 55 which is mounted in a boss 56 formed on a support 57 secured by lugs 58 and the bolts 20 to the part 1 of the hammer body. This support 57 comprises a transverse bore 59 in which is mounted an electric motor 60. This bore is closed at one end by a cover 61 and at the other end by a plate 62 in which the output shaft 63 of the motor is journalled through the medium, of a ball bearing 60. The end of the shaft 63 carries a gear 65 and the latter is operatively connected by an idler gear 66 to a gear 67 keyed to the shaft 54. The speed reducing gear train 65—66—67 is covered by a cover 68.

If the motor 60 is a universal motor, which rotates at high speed, for example at 18,000 R. P. M., the gear ratio is about 6 to 12 so that the frequency n of the blows on the tool is about 1,500 to 3,000 blows per minute. It will be observed that an asynchronous motor having a direct drive could be used.

The hammer is provided with a handle 69 mounted between a boss 70 forming part of the same material as the plate 62 and a bracket 71 secured by screws 72 or by welding to the cover 61.

The hammer operates in the following manner:

Assuming that the hammer is in the position shown in Fig. 1, as soon as the motor 60 is supplied with current, the current supply circuit being controlled by a switch (not shown) which is advantageously carried by the hammer, for example in the vicinity of the handle 69, the motor 60 drives the shaft 54 through the speed reducing gear train and, for each rotation of this shaft, the eccentric journal 53 causes a reciprocation of the diaphragm 18. When the latter moves downwardly, it exerts a thrust on the piston 23 through the medium of the liquid 26 and without appreciable compression of the air 27, this piston being substantially in equilibrium owing to the actions of its weight and the spring 28 which holds it in its uppermost position, the action of this spring being slightly preponderant.

As the throw e of the journal 53 has been chosen to result in the afore-mentioned travel or stroke y of the piston, that is, a slightly excessive travel, this piston strikes the tool 16 before the diaphragm reaches its lowermost position. This is advantageous since it is always ensured that the piston 23 strikes the shank 16 of the tool irrespective of the distance a, which varies between the extreme values a^1 and a^2 and corresponds to the extent to which the tool penetrates the bore 12. The hammer can therefore be used even with partly worn tools.

At the moment the piston 23 strikes the tool, the impact on the tool is great since the piston has not yet reached its lowermost position. Simultaneously, there is a reaction which would be transmitted by the liquid 26 to the diaphragm, the latter in turn transmitting this reaction to the upper part of the hammer and to the handle 69, if it were not for the fact that this reaction is damped by the air 27 in the chamber 23 which is situated above the liquid at the beginning of the operation and is substantially dispersed in this liquid when the hammer has operated several minutes.

Experiments have shown that this small amount of air 27 in fact damps the whole of the reaction due to the impact of the piston against the tool, so that the work-

man who holds the hammer by the handle **69** experiences practically no unpleasant effect of this reaction.

As soon as the diaphragm **18** passes upwardly through the point which corresponds in its downward movement to the engagement of the piston **24** with the tool, the piston **24** rises due to the combined action of the atmospheric pressure, which is applied to the lower transverse face of the piston through the air vent **14**, and the spring **28** which, having been extended during the downward movement of the piston, tends to resume its normal free length. At the end of the upward travel, the piston **24**, which has a limited inertia force, abuts the washer **34** and its travel is damped and then stopped by the spring **35**, which absorbs this inertia force and, in slightly extending, returns the piston to its upper position shown in Fig. 1.

This corresponds to a complete operational cycle and a further cycle commences.

Although a specific embodiment of the invention has been described, many modifications and changes may be made therein without departing from the scope of the invention as defined in the appended claims.

If desired, the air **27** could be dispensed with or its action could be completed by a large elastic deformation of the diaphragm **18** in its peripheral portion adjacent the wall of the bore **6**, this diaphragm, above all if it is very flexible and rather thick, could at least contribute to the absorption of the reaction due to the impact of the piston against the tool. The same damping effect could also be obtained in connecting the chamber **23** to an auxiliary chamber comprising a damper of any known type, for example a damper having a dashpot.

Having now described my invention what I claim as new and desire to secure by Letters Patent is:

1. Electric hammer comprising, disposed in a housing, a movable driving member having a travel of a given amplitude, a striking mass formed by a slidable piston, hydraulic motion converting means interposed between said driving member and said piston, said means being such that the travel of the driving member causes a longer travel of the piston which slightly exceeds the length of travel said piston must effect to strike against the shank of the tool, damping means combined with said converting means for absorbing the difference between the travel that said driving member is capable of imparting to said piston and the effective travel of the latter and for damping the reactions due to the impact of said piston against said tool, and driving means for driving said driving member.

2. In an electric hammer, a housing comprising a cylinder, an aperture in the end of said cylinder through which the shank of the tool extends into said cylinder, a piston slidable in said cylinder for striking against said shank, a chamber formed in said housing and having a greater cross-sectional area than that of said cylinder and communicating with said cylinder, a movable driving member closing said chamber, electro-mechanical driving means connected to said driving member for imparting to the latter small alternating movements of a given small amplitude, the space provided between said driving member and said piston being fluid-tight and substantially full of liquid; and the ratio between the cross-sectional areas of said cylinder and said chamber being such that the amplitude of the movements of said driving member corresponds to a travel of said piston which is slightly in excess of the travel said piston must effect to strike against the shank of the tool, and damping means for absorbing the difference between the travel that said driving member is capable of imparting to said piston and the effective travel of the latter and for damping the reactions due to the impact of said piston against said tool.

3. In an electric hammer, a housing comprising a cylinder, an aperture in the end of said cylinder through which the shank of the tool extends into said cylinder,

a piston slidable in said cylinder for striking against said shank, a chamber formed in said housing and having a greater cross-sectional area than that of said cylinder and communicating with said cylinder, a flexible diaphragm fixed at its periphery to the inner wall of said chamber for closing said chamber and constituting a movable driving member, electro-mechanical driving means operatively connected to the centre of said diaphragm for imparting to said diaphragm small alternating movements of a given small amplitude, the space provided between said diaphragm and said piston being fluid-tight and substantially full of a liquid, and the ratio between the cross-sectional areas of said cylinder and said chamber being such that the amplitude of the movements of said diaphragm corresponds to a travel of said piston which is slightly in excess of the travel said piston must effect to strike against the shank of the tool, and damping means for absorbing the difference between the travel that said driving member is capable of imparting to said piston and the effective travel of the latter and for damping the reactions due to the impact of said piston against said tool.

4. In an electric hammer, a housing comprising a cylinder, an aperture in the end of said cylinder through which the shank of the tool extends into said cylinder, a piston slidable in said cylinder for striking against said shank, a chamber formed in said housing and having a greater cross-sectional area than that of said cylinder and communicating with said cylinder, a flexible diaphragm fixed at its periphery to the inner wall of said chamber for closing said chamber and constituting a driving member, an electric motor, positive transmission means connecting said motor to said diaphragm for imparting to said diaphragm alternating movements of a given small amplitude, the space provided between said diaphragm and said piston being fluid-tight and substantially full of a liquid, and the ratio between the cross-sectional areas of said cylinder and said chamber being such that the amplitude of the movements of said diaphragm corresponds to a travel of said piston which is slightly in excess of the travel said piston must effect to strie against the shank of the tool, and a small volume of air enclosed in said chamber with said liquid for absorbing the difference between the travel that said driving member is capable of imparting to said piston and the effective travel of the latter and for damping the reactions due to the impact of said piston against said tool.

5. In an electric hammer, hammer body comprising a cylinder in one end of which cylinder the shank of the tool extends, a piston axially movable in said cylinder, a chamber in said body communicating directly with said cylinder without interposition of any hydraulic pipe, said chamber having a cross-sectional area greater than that of said cylinder, a diaphragm closing said chamber, a liquid in said chamber, a small volume of air enclosed in said chamber with said liquid, a support fixed to said body, an electric motor fixed to said support, positive transmission means operatively connecting said motor to said diaphragm for imparting to said diaphragm alternating movements having a given amplitude, the ratio between the cross-sectional areas of said cylinder and said chamber being such that the amplitude of the movements of said diaphragm corresponds to a travel of said piston which is slightly in excess of the travel said piston must effect to strike against the shank of the tool, said hammer forming a single compact unit.

6. In an electric hammer comprising a housing, said housing comprising a cylinder having a longitudinal axis of symmetry, an aperture in the end of said cylinder through which the shank of the tool extends into said cylinder, a piston slidable in said cylinder along said longitudinal axis for striking against said shank; in said housing, a chamber having a longitudinal axis in alignment with said longitudinal axis of said cylinder, a flexible diaphragm closing said chamber and having its center on

said longitudinal axis; a support fixed to said housing and provided with a transverse bore, an electric motor disposed in said bore, transversely of said longitudinal axis, a plate closing one end of said bore, a cover fixed to said plate, a speed reducing gear disposed between said plate and said cover, a shaft having an eccentric journal and journalled in said housing and operatively connected to said gear train and to said center of said diaphragm to

reciprocate said center along said longitudinal axis, and a handle fixed to said support.

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