Sept. 16, 1930. E. H. W. WEIBULL 1,776,057

ARRANGEMENT FOR TRANSFORMING A ROTATING MOVEMENT INTO A STRIKING OR HAMMERING MOVEMENT

Filed Nov. 28, 1927

Fig 1

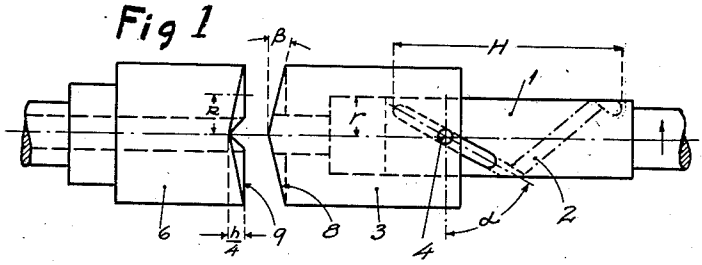


Fig. 3

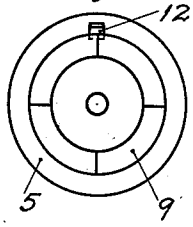


Fig. 2

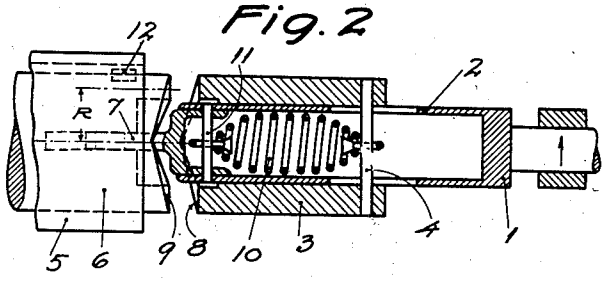


Fig. 4

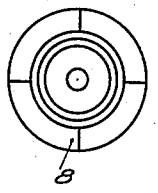


Fig. 5

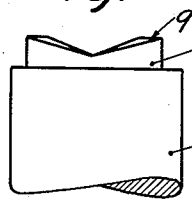


Fig. 7

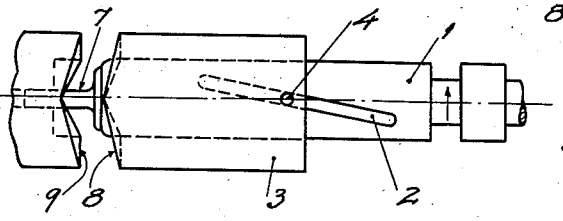


Fig. 6

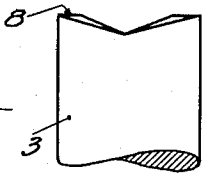


Fig. 8

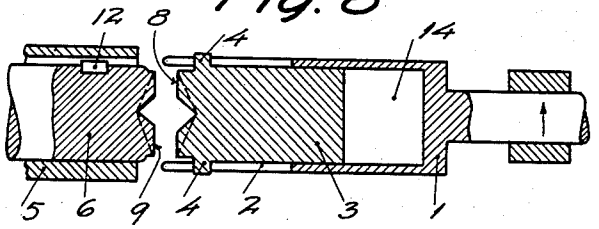
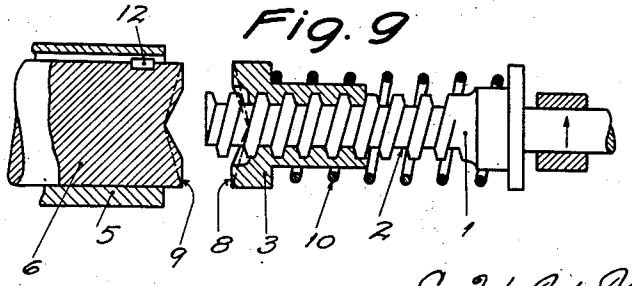


Fig. 9



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UNITED STATES PATENT OFFICE

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ARRANGEMENT FOR TRANSFORMING A ROTATING MOVEMENT INTO A STRIKING OR HAMMERING MOVEMENT

Application filed November 28, 1927, Serial No. 236,352, and in Sweden December 21, 1926.

The present invention relates to a mechanism for the conversion of rotary movement into a striking movement and differs from known arrangements of this kind by the fact that the recoil movement of the striking body is effected by its striking against the anvil or the like to which the striking force is transmitted and not, as hitherto, for instance, by the co-operation of a rotating motor driven part itself.

According to a generic form of this invention a striking body sliding axially for instance on the motor driven rotating part or shaft is provided with an oblique striking face which in one end position of the striking body co-operates with an oblique striking face arranged on an anvil or the like, and with an energy storing device associated or co-operating with the striking body, said storing device being supplied with the whole or part of the energy necessary for the next striking movement on the recoil of the rotating striking body from the oblique striking face of the anvil.

Fig. 1 is a diagrammatic elevation of the driving shaft, striking body, anvil and associated parts of an arrangement for transforming rotary movement into a striking or hammering movement in accordance with the invention.

Fig. 2 is an axial section in detail through a practical embodiment of the invention, partly broken away.

Fig. 3 is an end elevation of the anvil.

Fig. 4 is an end view of the striking body.

Fig. 5 is a fragmentary side elevation of the anvil.

Fig. 6 is a side elevation of a part of the striking body.

Fig. 7 is an elevation of the striking body and driving shaft.

Figs. 8 and 9 are axial sections through modifications of the invention.

In Figs. 1–7 1 is the driving shaft provided with a guide groove 2, which may be straight or for instance of the shape shown in Fig. 1. The striking body 3 slides on the driving shaft 1 and in its axial movement along the driving shaft, is forced to follow the guide groove 2 by means of a bolt or shaft 4 taking into said groove. The driving shaft 1 has its face end provided with or connected to a guide journal 7 extending into the anvil 6 and the latter is mounted to slide in a suitable frame part 5 but prevented from turning therein by means of a wedge 12. At the ends directed towards each other, the striking body 3 and the anvil 6 according to this invention are provided with one or more oblique striking faces 8 and 9. For the storing of energy the striking body 3 is connected with the driving shaft by means of a tension spring 10, which has one end attached to the bolt 4 and the other end to a bolt 11 inserted in the end of the driving shaft.

On the shaft 1 being rotated by the electric motor, the striking body 3 will be forced to partake into this rotation by means of the bolt 4 extending into the groove 2. If starting, at this occasion, from that position, the striking body 3 occupies its rear position, in which the energy storing device is charged, following operation will take place.

The striking body will be advanced towards the anvil and at the same time it will be rotated at a very great speed. When, at this time, the oblique faces 8 of the striking body 3 strike against the oblique faces 9 of the anvil 6, a shock or a strike will be transmitted to the anvil, the magnitude of this shock or strike being, at this event, dependent on the axial movement as well as on the rotating one of the striking body. The rotating movement of the striking body will, besides, effect such a cooperation between the oblique faces 8 and 9 located on the striking body and the anvil respectively that the striking body, utilizing a portion of the rotating energy supplied to the striking body

by the electric motor, will be imparted a rapid recoiling movement against the influence of the energy storing device, which is supplied with energy from the striking body. Thus, the recoiling movement of the striking body will be gradually stopped. The striking body will then once more be thrown forwards by the influence of the energy, stored in the energy storing device, and, after this, the same operation will be repeated. Thus, the striking body will receive its recoiling movement by the energy absorbed from the motor at the moment the shock or the strike occurs, whilst the forward movement of the striking body is effected by the energy storing device.

In order in conjunction with the above stated operation to obtain a shockless running of the driving shaft, certain conditions must be complied with, as hereinafter briefly set forth by reference to Fig. 1.

In the form of the invention above referred to the axial bearing in the motor-driven rotating part 1 is constituted by an inclined or spiral groove 2 in said rotating part and by a bolt 4 secured to the striking body 3 and engaging with said groove 2 or vice versa.

The pitch H of the spiral groove 2 in the rotating power actuated part 1 (the driving shaft) may be expressed by the formula

$$H=2\pi r tn\alpha$$

r being the radius of the driving shaft 1 and α the angle of inclination of the groove. Accordingly the inclination h of the oblique striking face 9 of the anvil 6 may be expressed by

$$h=2\pi R tn\,\beta \text{ and } \frac{1}{Rtn\,\beta}=\frac{2\pi}{h}$$

β being the angle of inclination of the oblique striking face and R the mean radius. If the striking operation is effected without any friction and the varying force between the striking weight and the anvil is $=p$ and acts on the mean radius R the energy impulse is

$$k=\int p dt$$

If this impulse is divided into an axial component k_a and a tangential component k_t, then

$$k_a=k\cos\beta$$

and the momentum of k_t

$$k_t.R=k\sin\beta.R$$

If m is the mass of the striking body and I its moment of inertia with regard to the axis of rotation and v_1 and v_2 the velocity of translation of the striking body before and after the shock, and w_1 and w_2 the corresponding angular velocities of the striking body then if v_1 is assumed to be negative and v_2 positive there is:

$$\text{(I)}\quad \begin{cases} m(v_2-v_1)=k_a=k\cos\beta \\ -I(w_2-w_1)=k_tR=k\sin\beta.R \end{cases}$$

If w_0 is the angular velocity of the driving shaft, the condition for shockless running in the sleeve is

$$\text{(II)}\quad \begin{cases} w_1=w_0-\frac{2\pi}{H}\cdot v_1 \\ w_2=w_0-\frac{2\pi}{H}\cdot v_2 \end{cases}$$

From II is obtained

$$w_2-w_1=\frac{2\pi}{H}(v_1-v_2)$$

which inserted into (I) is

$$\begin{cases} m(v_2-v_1)=k\cos\beta \\ \frac{2\pi.I}{H}(v_2-v_1)=k\sin\beta.R \end{cases}$$

and by division

$$\frac{Hm}{2\pi.I}=\frac{1}{Rtn\beta};$$

but

$$\frac{1}{Rtn\beta}=\frac{2\pi}{h};\ \therefore\ \frac{Hm}{2\pi.I}=\frac{2\pi}{h}$$

and

$$H.h=\frac{4\pi^2 I}{m}$$

If the striking operation takes place under friction, the medium friction may be determined by the angle of friction ρ. If the same deduction as above is carried out there is, as will be readily seen

$$h.H=\frac{4\pi^2 I}{m}\cdot\frac{tn\beta}{tn(\beta+\rho)}$$

From this it is clear that if the shape of the striking body 3 is determined, i. e. if the values for m and I are chosen, the inclination H of the groove in the driving shaft 1 will solely be determined for a certain value of the inclination h of the striking face 9 of the anvil 6, and this without dependence on the striking velocity v_1, viz independent of the striking capacity of the striking body and independent of the ratio between v_2 and v_1, viz independent of the elasticity of the support.

Thus, if the inclinations h and H are correctly determined, the striking body 3 will under all circumstances run without shocks in its guide groove 2, irrespective of the striking capacity, the number of revolutions of the motor and the elasticity of the support, which latter varies, for instance in riveting, chiselling or boring in rocks etc. The motor output is, thus, taken out smoothly and without shocks during the time the striking body does not touch the anvil.

From the above formulæ it is also clear that the strength and tension of the spring or the like, by means of which the striking body is connected with the driving shaft, has no influence upon the shockless running. For a certain number of revolutions of the driving shaft a variation of the spring tension will instead only cause a change in the number of strokes of the striking body, a stronger spring increasing the number of strokes.

By means of an arrangement according to this invention the number of strokes may be changed by a simple exchange of springs and by a suitable adjustment of the number of revolutions of the driving shaft and the spring tension, the number of strokes and, thus, the striking capacity may be adjusted to the conditions claimed for each special purpose of use.

From the formula

$$H.h=\frac{4\pi^2 I}{m}$$

it is also clear that if the moment of inertia is made very great and the angle of inclination of the striking face is constant the angle of inclination of the groove in the driving shaft approaches 90° viz $w_1=w_0=w_2$.

In this case the movement of the striking body 3 in relation to the driving shaft 1 will therefore be axial, while, if α is smaller than 90°, the axial movement of the striking body 3 is combined with a peripheral movement as explained above.

Further it is not necessary to guide the striking body 3 peripherally by means of a groove 2 or journal or wedge as aforesaid, but this guide may be carried out in many other ways. So, for instance, the striking body may be constructed as a nut and the rotary shaft, sleeve or the like as a correspondingly threaded spindle or vice versa. Further the rotation of the motor need not necessarily be transmitted to the striking body, compulsorily as above, but in an elastic manner by the spring-device if this is connected with the striking body and the driving shaft in such a way that the spring at the recoil movement of the striking body will not only store energy by axial contraction or expansion but also by torsion.

As storers for the energy of translation of the striking body during the recoil movement many other devices than springs may, of course, be suggested. For instance, the striking body may be a movable part of an air compressor.

If as already stated, a combined axial and peripheral guide is used for the striking body in such a manner that a smaller number of revolutions on the recoil movement is obtained than during the movement in the opposite direction, there will besides shockless running, be the advantage that the energy storer will not have to absorb all the energy necessary for the stroke since this energy, in such an arrangement is due to a great part to the energy absorbed from the striking body by the decrease of the angular velocity, to which the striking body is exposed when changing from striking movement to recoil movement. When suitably dimensioned this last mentioned part of energy may amount to 75% of the total energy claimed for the stroke. According to the present invention it is suitable to provide for that the whole of the striking face of the hammer or of the anvil or both, is constituted by a single cam-like surface or by continuous cam-like surfaces so that at the moment of impact of the hammer or the anvil the contact is always between opposing oblique surfaces, whereby both the rotary and the translatory motions of the hammer are utilized for generating the striking movement imparted to the tool carried by the anvil.

In the embodiment shown in Fig. 8, 1 is the driving shaft, 2 the guide grooves therein and 3 the striking body adapted in this case to slide in the hollow end of the driving shaft, said striking body being again provided with trunnions 4 taking into the guide grooves 2. 6 is the anvil sliding in the frame part 5, and provided with oblique striking faces 9 co-operating with corresponding striking faces 8 on the striking body 3.

The storage of energy during the recoil movement of the striking body 3 is effected by compression of air in a chamber 14 located behind the striking body 3 in the hollow end of the driving shaft.

The embodiment in Fig. 9 differs from that shown in Figs. 2–7 in that the grooves 2 on the driving shaft 1 consist of screw threads in the end of driving shaft 1, cut at a suitable inclination, the storage spring being a compression spring 10 confined in a manner similar to Fig. 2.

It is to be pointed out that with the expression "oblique striking face" is to be understood all such faces by means of which the rotating striking body 3 may be given its recoil movement. Thus the oblique striking faces on the striking body and/or the anvil 6 may be curved, for instance spherical.

Having now particularly described the nature of my invention and the manner of its operation, what I claim is:

1. A mechanism of the class described for the conversion of rotary movement into a striking movement comprising an axially reciprocating striking body, rotating means for imparting rotary movement to said body, an oblique striking face on said body, an axially movable sliding anvil, an oblique counter face on said anvil presented for engagement by the oblique striking face, an energy storing device cooperating with the striking body and adapted to be supplied with energy for a

striking movement of the striking body by the recoil movement of the rotating striking body effected by the coaction between the oblique striking face of the rotary striking body and the oblique striking face of the anvil at the moment the strike takes place.

2. An arrangement as claimed in claim 1 including means for effecting peripheral movement of the striking body relative to the rotating means during axial reciprocation of the striking body.

3. An arrangement as claimed in claim 1 including means for effecting a spiral movement of the striking body relative to the rotating means during axial reciprocation of the striking body.

4. An arrangement as claimed in claim 1, including a spiral guide for the striking body on the rotating means and an oblique striking face on the anvil of an inclination such as to result, in the absence of friction, in:

$$H.h=\frac{4\pi^2 I}{m}$$

H being the inclination of the spiral guide of the striking body, h the inclination of the oblique striking face of the anvil, I the moment of inertia of the striking body and m the mass of the striking body.

5. In arrangements for the conversion of rotary movements into striking or hammering movement, an anvil, a rotary striking body, cam surfaces on the anvil and the striking body, the striking body and anvil being substantially coaxial and the cam surfaces being presented one to the other in any angular position of the striking body relative to the anvil.

6. A mechanism of the class described for the conversion of rotary movement into a striking movement, including an axially reciprocating striking body, rotating means for imparting rotary movement to said body, an axially movable and non-rotatable sliding anvil, an oblique counter face on said anvil presented for engagement by the oblique striking face, an energy storing device cooperating with the striking body and adapted to be supplied with energy for a striking movement of the striking body by the recoil movement of the striking body effected by the coaction between the oblique striking face of the striking body and the oblique counter face of the anvil at the moment of engagement.

7. A mechanism of the class described, including an axially reciprocable striking body, means for imparting rotary movement to said body, an anvil mounted for axial movement imparted thereto by the striking body, an energy storing device associated with the striking body and adapted to be rotated incident to the recoil movement of the striking body, and means for effecting peripheral movement of the striking body relative to the rotating means during axial reciprocation of the striking body.

8. A mechanism of the class described, including an axially reciprocable striking body, means for imparting rotary movement to said body, an anvil mounted for axial movement imparted thereto by the striking body, an energy storing device associated with the striking body and adapted to be rotated incident to the recoil movement of the striking body, and means for effecting a spiral movement of the striking body relative to the rotating means during axial reciprocation of the striking body.

9. In combination, a non-rotatable anvil, a rotary driving element, a reciprocable striking body rotated by the driving element, cam means acting incident to engagement of the rotating striking body with the anvil to cause recoil of the striking body, and an energy storing device rotated during recoil movement of the striking body to effect the following striking movement of the latter.

10. In combination, a non-rotatable anvil, a rotary driving element, a reciprocable striking body rotated by the driving element, cam means acting incident to engagement of the rotating striking body with the anvil to cause recoil of the striking body, and an energy storing device rotated during recoil movement of the striking body to effect the following striking movement of the latter, and means connecting the driving element with the striking body permitting limited rotation of the latter relative to the driving element during recoil movement.

11. In combination, a non-rotatable anvil, a rotary driving element, a reciprocable striking body rotated by the driving element, cam means acting incident to engagement of the rotating striking body with the anvil to cause recoil of the striking body, and an energy storing device rotated during recoil movement of the striking body to effect the following striking movement of the latter, and means connecting the driving element with the striking body permitting limited rotation of the latter in opposition to the energy storing device relative to the driving element during recoil movement.

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