Feb. 7, 1967 J. RANISZEWSKI 3,302,470

VIBROHAMMER

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Fig. 1.

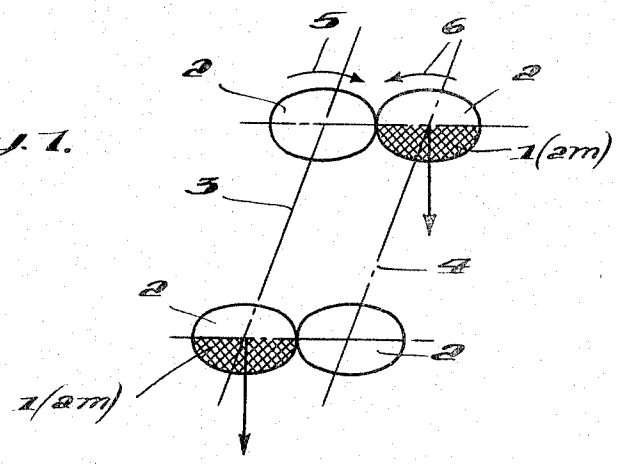
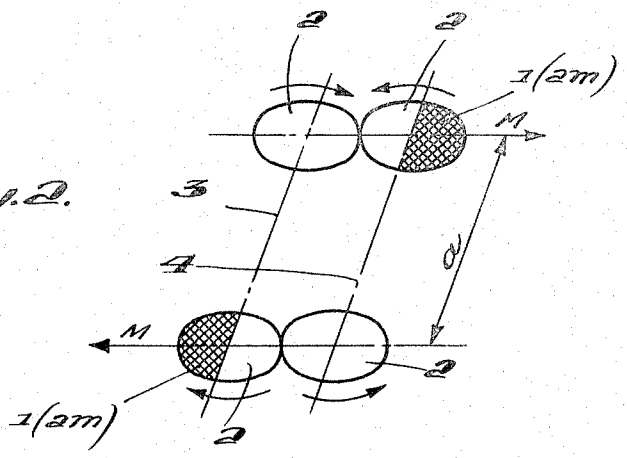


Fig. 2.



INVENTOR
JOZEF RANISZEWSKI,

BY Larson and Taylor

ATTORNEYS

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Fig. 3.

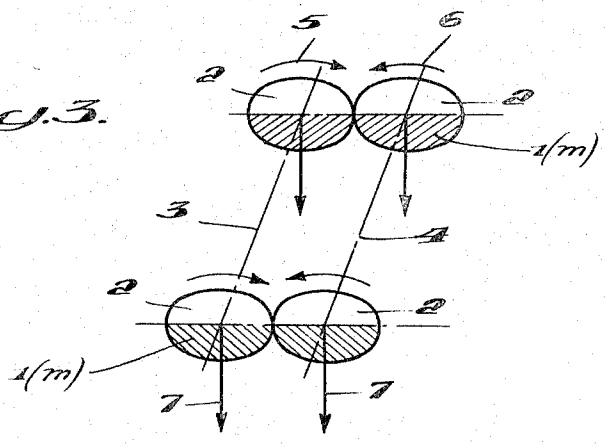


Fig. 7.

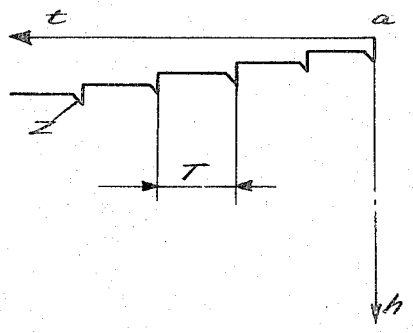
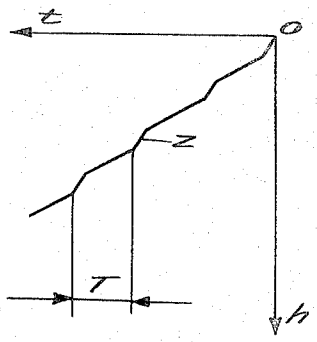


Fig. 8.



INVENTOR
JOZEF RANISZEWSKI,

BY Larson and Taylor

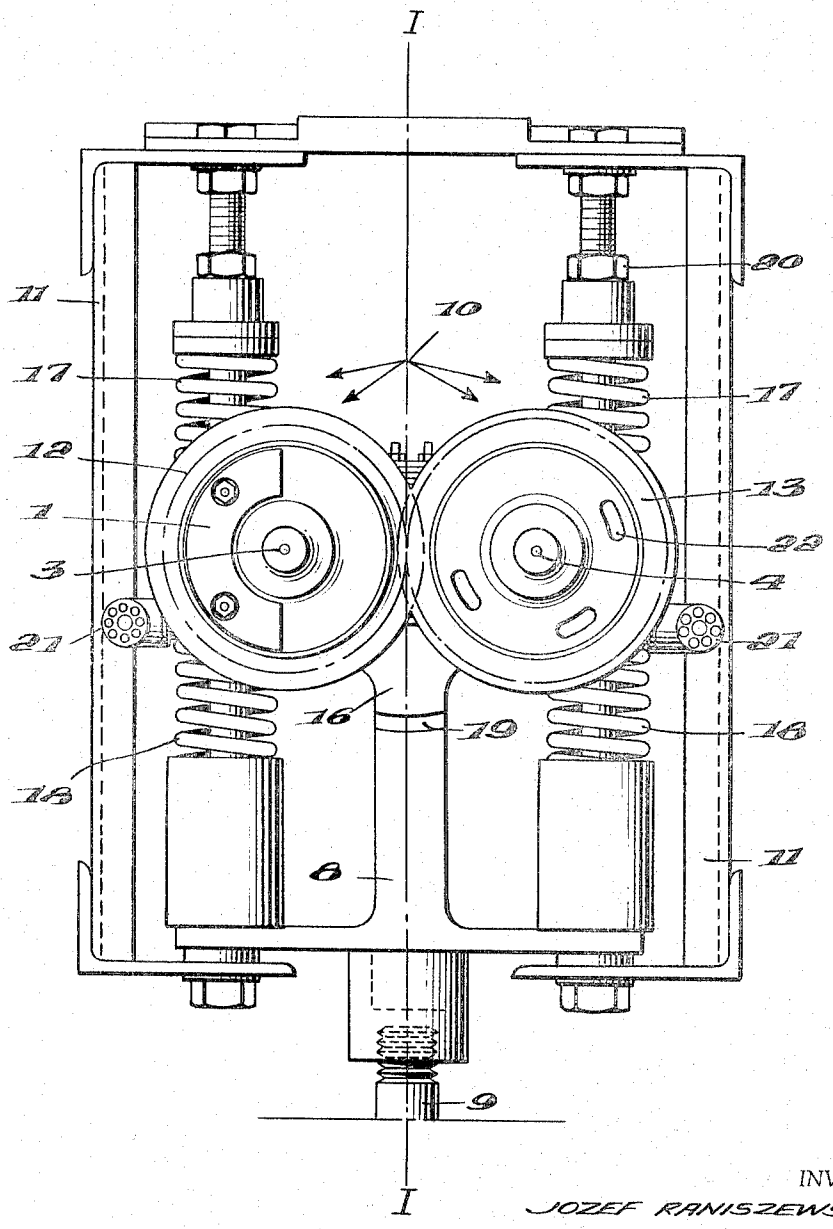
ATTORNEYS

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Fig. 4.



INVENTOR
JOZEF RANISZEWSKI,

BY Larson and Taylor

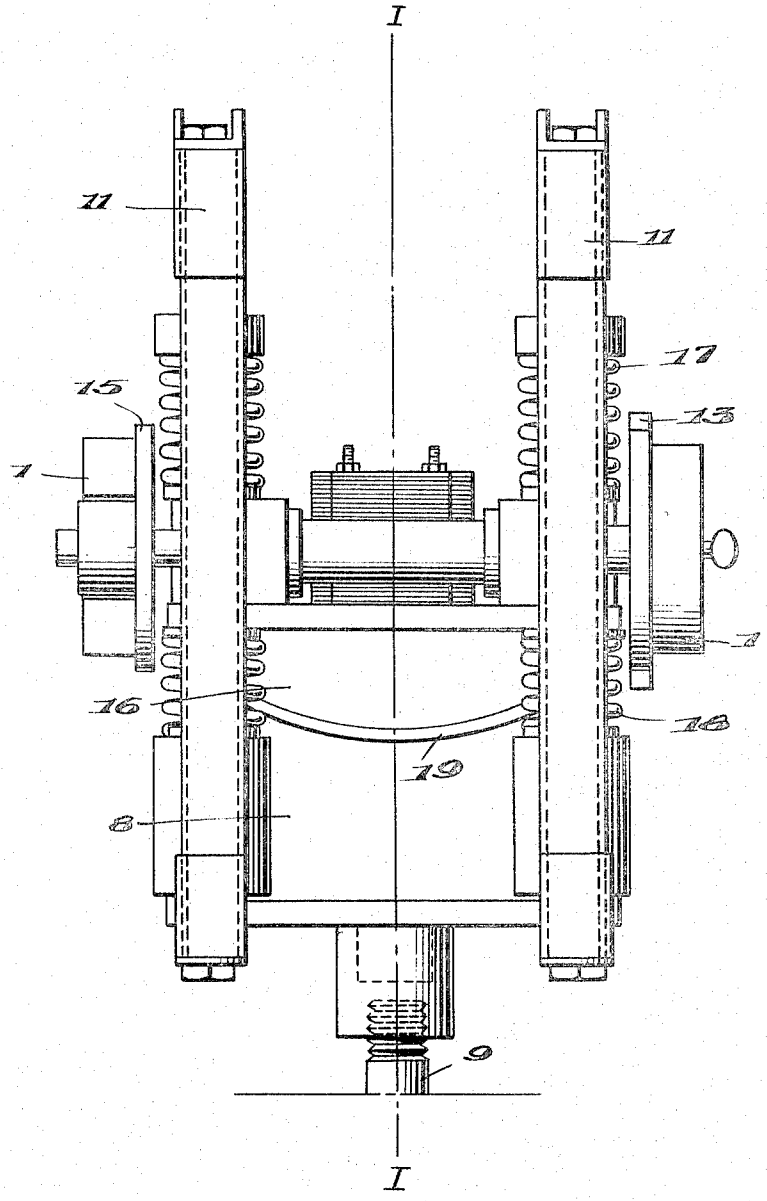
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Fig. 5.



INVENTOR
JOZEF RANISZEWSKI,

BY Larson and Taylor

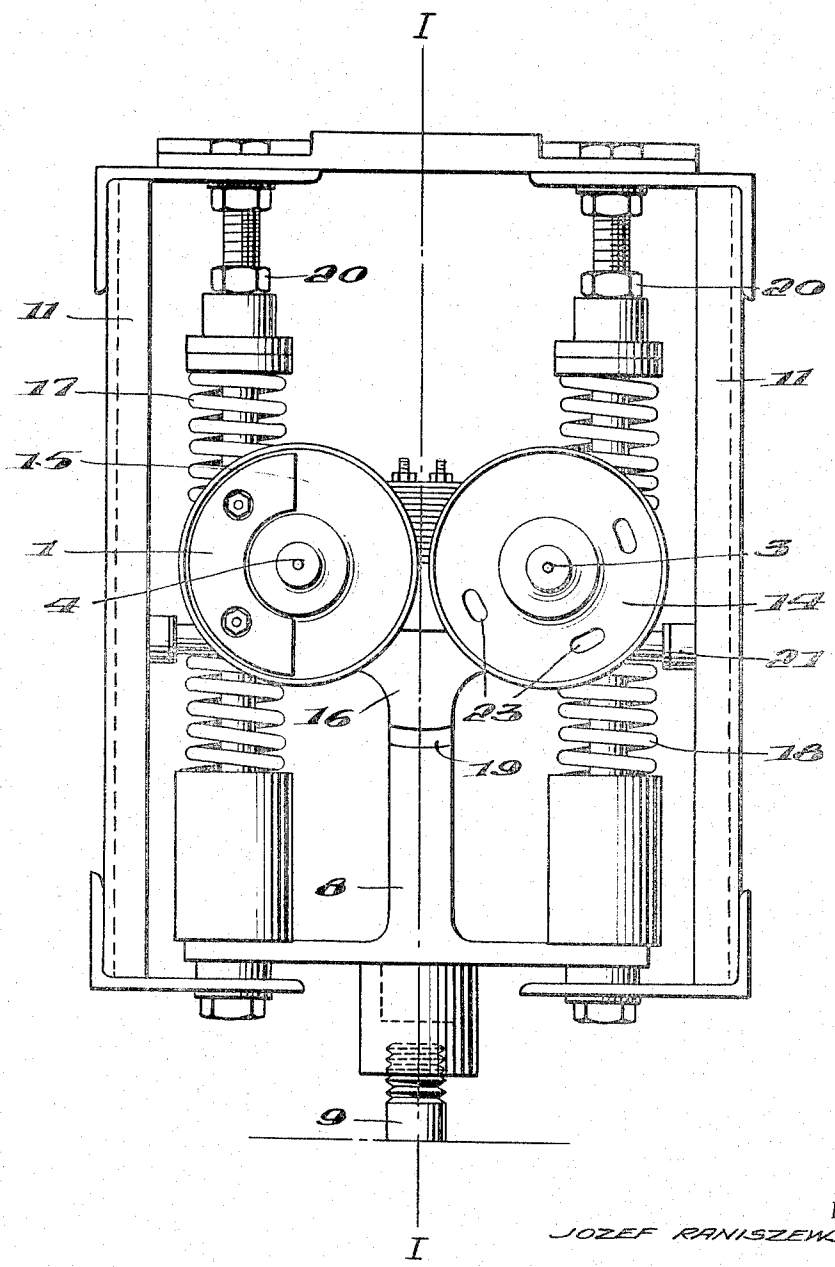
ATTORNEYS

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Fig. 6.



INVENTOR
JOZEF RANISZEWSKI,

BY Larson and Taylor

ATTORNEYS

United States Patent Office 3,302,470 Patented Feb. 7, 1967

3,302,470 VIBROHAMMER

Jozef Raniszewski, Warsaw-Bemowo, Poland, assignor to Zaklady Sprzetu Budowlanego Nr 2, Solec Kujawski, Poland

Filed Mar. 25, 1964, Ser. No. 355,150
3 Claims. (Cl. 74—61)

This invention is concerned with a vibrohammer for driving piles and steel pipes (called "elements" hereinafter) with forced vertical and simultaneous rotary motion of the element being driven.

It is the object of this invention to provide an improved device of the type referred to above.

In accordance with the invention, a vibrohammer of vertical and rotary action for driving piles, tubings and the like, comprises a frame constructed and arranged to be mounted on the upper end of an element to be driven, and including a transmitting member bearing against the element for transmitting vertical percussions thereto, and upright frame members connected to and extending upwardly from the transmitting member. Operatively mounted in the frame is a vibratory system or means for percussively striking the transmitting member vertically and for transmitting rotary vibrations to the frame, the vibratory means comprising a striking mass, a plurality of springs resiliently supporting the striking mass in the frame relatively above the transmitting member, means for adjusting the springs so as selectively to vary the at-rest clearance between the striking mass and the transmitting member, a plurality of bearing members extending from the striking mass and guidedly engaging the upright frame members for guiding the movement of the striking mass and transmitting rotary vibrations therefrom to the upright frame members, two parallel and horizontal shafts rotatably mounted on the striking mass horizontally adjacent each other, corresponding gear wheels mounted on corresponding first ends of the shafts for ensuring equal but opposite rotation of the shafts, corresponding disc members mounted at the other corresponding ends of the shafts, masses eccentrically mounted on the gear of one shaft and on the disc of the other shaft for effecting vertical vibrations of the striking mass when both masses are at their lowermost or uppermost points of rotation and rotary vibrations about the element to be driven when both masses are at their horizontally innermost or outermost points of rotation, and means for rotating the shafts to effect vertical and rotary vibrations of the striking mass, and hence of the element to be driven.

Other and further objects, advantages and features of the invention will be apparent to those skilled in the art from the ensuing description of a preferred embodiment of the invention, taken in conjunction with the accompanying drawings, wherein:

FIG. 1 in the drawing enclosed shows a schematic diagram of the vibrohammer designed according to this invention, at the moment of its vertical action; FIG. 2, the schematic diagram of the vibrohammer at the moment of its rotating action; FIG. 3, the schematic diagram of certain vibrohammers used heretofore; FIG. 4, the vibrohammer designed according to the invention concerned and shown in the direction of the shaft axes from the gears side; FIG. 5, the vibrohammer in transverse view in relation to the shaft longitudinal axes; FIG. 6, the vibrohammer in parallel view in relation to the shaft longitudinal axes shown from the eccentric discs side; FIG. 7, the kinematic graph for a typical vibrohammer used heretofore; and FIG. 8, the kinematic graph for the vibrohammer designed according to this invention.

FIG. 3 is to show the different masses 1 (m) on eccentrics 2 which are mounted on the shafts 3 and 4 revolving in opposite directions. This diagram is concerned with hammers for vertical vibration. If the revolutions of the shafts 3 and 4 are opposite each to the other as shown by the arrows 5 and 6, then there is a summing up of forces acting in the vertical plane, and a composition of forces in the horizontal plane takes place. Thus, the only existing action is the vertical force sensed downwards and equal to the four times multiplied centrifugal force 7 alternating according to the cosine curve determined by the formula $m\omega^2 e \cos \omega t$ where m means the rotating mass; e=eccentricity; ω angular velocity of the rotating mass m; t=time in sec.

When maintaining the opposite rotation of shafts 3 and 4 if the mass $1(m)$ is shifted from the one end of the roller 4 to the corresponding end of the roller 3 and from the other end of the roller 3 to the corresponding end of the roller 4 so that the masses $1(m)$ are connected in couples, the system is obtained as in FIG. 1 constituting the function principle for the vibrohammer according to the invention concerned.

In the system as shown in FIG. 1 the force acting in the vertical plane is of the same value as in that in FIG. 3, but in the horizontal plane there is, instead of composing couples of forces, a force couple with an arm a and the turning moment M alternating according to the sine curve determined by formula $M=2a\omega^2 e \sin \omega t$ as it is shown in FIG. 2. Such mounting of masses $1(m)$ on eccentrics 2 fixed on rigid base with a mass 16 which is rested on springs will result in vertical vibration of the mass 16 and the rotating vibration of the same mass in relation to the vertical symmetry axis of the whole vibration-percussive system.

The vibrohammer designed according to this invention consists of a limiter or force transmitting member 8 to carry the steel pipe 9, the vibration system 10 complete with the rotation mechanism, and of frames 11 fixed to the limiter 8.

The vibration system 10 consists of two shafts 3 and 4 complete with the gears 12 and 13 mounted on the ends and with eccentric discs 14 and 15 mounted on the other ends, as well as of the base 16, called the percussive or striking mass hereinafter, to carry the shafts 3 and 4 and fixed between the upper springs 17 and the lower ones 18, as well as of the masses 1 to produce the vibration and fixed on the gear 12 and the eccentric disc 15 which are indicated by 2 in FIG. 3. To adjust the clearance 19 between the percussive mass 16 and the limiter 8 the nuts 20 have tbeen provided. The shaft 3 is driven by the motor e.g. by means of a flexible shaft and coupling, which are not shown in the said drawing. The percussive or striking mass 16 is provided with four antifriction bearings 21 sliding along the inner surfaces of the frames 11 by means of which the rotating vibration is transmitted to the limiter or transmitting member 8 with the element 9 being sunk.

The speed of driving the element into the ground as well as the operation efficiency of the whole equipment designed according to this invention is conditioned by a proper selection of parameters and the equipment components. The symmetrically displayed springs must be given a definite stiffness; the rotating masses to produce the percussive and rotating vibration have to be accurately balanced and designed with an appropriate weight and eccentricity e in relation to the number of revolutions as well as to the percussive mass 16 and the limiter 8. Also the clearance 19 between the percussive mass 16 and the limiter 8 should be properly adjusted.

After the said parameters are fixed, appropriate local conditions are chosen and the element fixed with the limi-

ter 8, starting the vibrohammer operation should be undertaken.

The motion of the shaft 3, driven by the motor, is transmitted by means of the gear 12 to the same size gear 13 and the shaft 4 complete with the eccentric disc 15 mounted on the shaft end. The rotating masses 1 eccentrically mounted on the disc of the gear 12 and on the eccentric disc 15 produce vertical, percussive vibration transmitted to the percussive mass 16 as well as rotating vibration transmitted by means of anti-friction bearings 21 to the frame 11 and the limiter 8 with the sinking element 9. Thus, the percussive mass $16/m_1/$ produces vertical and rotative vibration in relation to the symmetry axis I—I resulting in a rapid sinking of the element 9 in ground.

Testing the vibrohammer designed according to this invention, carried out to determine how the speed of the element 9 sinking in the ground is affected by its rotating motion, justified the theoretical assumption, that the static friction and the elastic strain of the ground cease at the moment of the percussion rendered and therefore the total displacement of the element per unit of time has been considerably increased and the element may be sunk in a very quick way. It becomes quite clear from the diagrams showing the displacement h concerned related to the sinking time t.

FIG. 7 is concerned with a diagram for certain vibrohammers used heretofore; the T segments meaning the time intervals between subsequent strokes are horizontal and parallel to the co-ordinate axis t (time) to show that the element is in standstill between the said subsequent strokes. The same graph for the vibrohammer designed according to this invention is shown in FIG. 8 and makes clear, that the displacements h which take place at the moment of percussion z are comparatively bigger, and the time intervals held between individual strokes are horizontally inclined and it is obvious therefore, that at the moment of striking the element 9 is in motion and the static friction does not take place. A sharp drop of the step curve proves a high speed of sinking the element 9 in ground.

The device may be changed by shifting the masses 1 from the gear 12 to the gear 13 which is provided for this purpose with holes 22, and from the eccentric disc 15 to the eccentric disc 14 provided for this purpose with holes 23, as well as by compressing the springs 17 and 18 with the application of nuts 20.

The vibrohammer designed according to this invention has been provided with a vibration-percussive system complete with a rotation vibrator and proves to be especially efficient for sinking the elements in plastic soil (clays, silts) where the essential resistance against the sinking consists in friction involved by side walls of the element being sunk.

The vibrohammer designed according to this invention may be driven by means of special electric motors which are directly mounted on the percussive mass 16, or by means of ordinary electric motors or combustion engines fixed to the frames 11 and applicable for vibratory equipment only. The application of ordinary motors to drive the vibrohammer concerned results in driving cost decreasing and contributes to a considerable extent to the motors life extension.

I claim:

1. A vibrohammer of vertical and rotary action for driving piles, tubing and the like, comprising: a frame constructed and arranged to be mounted on the upper end of an element to be driven, and including a transmitting member bearing against the element for transmitting vertical percussions thereto, and upright frame members connected to and extendin gupwardly from said transmitting member; and vibratory means operatively mounted in said frame for percussively striking said transmitting member vertically and for transmitting rotary vibrations to said frame, said vibratory means comprising a striking mass, a plurality of springs resiliently supporting said striking mass in said frame relatively above said transmitting member, means for adjusting said springs so as selectively to vary the at-rest clearance between said striking mass and said transmitting member, a plurality of bearing members extending from said striking mass and guidedly engaging said upright frame members for guiding the movement of said striking mass and transmitting rotary vibrations therefrom to said upright frame members, two parallel and horizontal shafts rotatably mounted on said striking mass horizontally adjacent each other corresponding gear wheels mounted on corresponding first ends of said shafts for ensuring equal but opposite rotation of said shafts, corresponding disc members mounted at the other corresponding ends of said shafts, masses eccentrically mounted on the gear of one shaft and on the disc of the other shaft for effecting vertical vibrations of the striking mass when both masses are at their lowermost or uppermost points of rotation and rotary vibrations about the element to be driven when both masses are at their horizontally innermost or outermost points of rotation, and means for rotating said shafts to effect vertical and rotary vibrations of said striking mass, and hence of the element to be driven.

2. Apparatus as set forth in claim 1 wherein said springs comprise upper and lower coil springs extending respectively downwardly and upwardly between said frame and said striking mass, and said means for adjusting said springs comprise threaded nuts mounted on threaded bolt-like members for shortening or elongating the at-rest length of said springs, and hence varying the at-rest clearance between said striking mass and said transmitting member.

3. Apparatus as set forth in claim 2 wherein said frame includes four upright frame members rectangularly spaced about said frame and having vertical roller tracks formed therein, and said bearing members comprise four roller bearings connected to said striking mass and disposed in said vertical tracks for movement therein.

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FRED C. MATTERN, JR., *Primary Examiner.*

F. E. BAKER, *Assistant Examiner.*