SPRING ACTUATED NAILERS

Filed Feb. 4, 1964 3 Sheets-Sheet 1

Fig.1

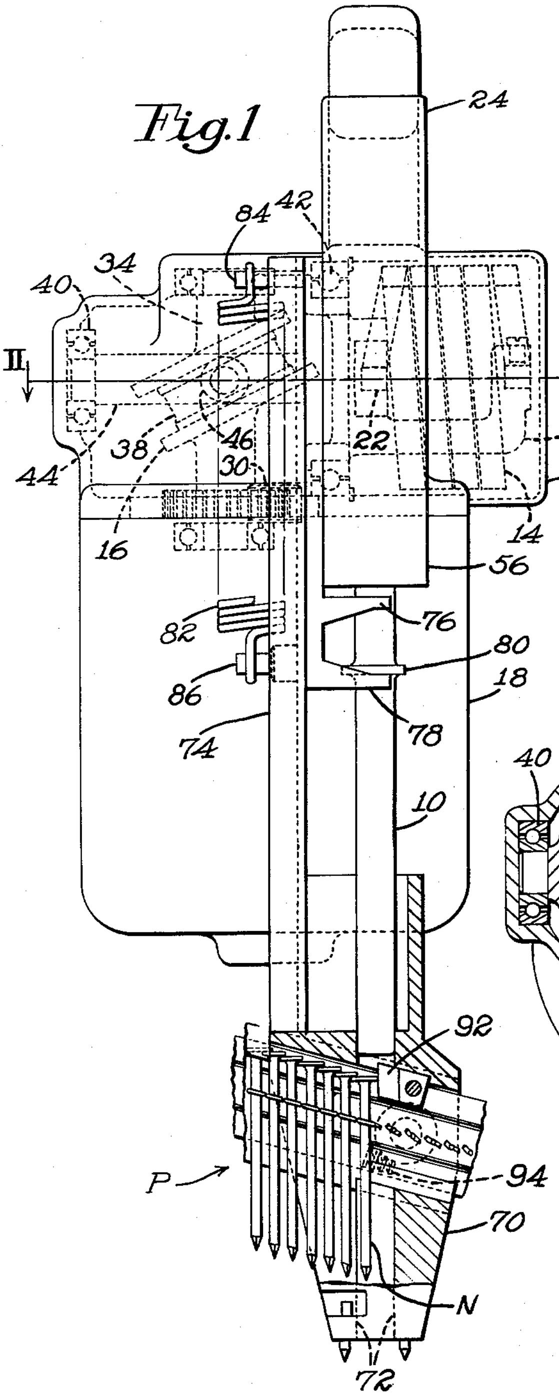


Fig.2A

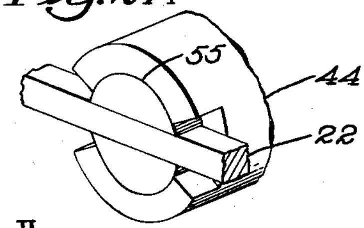
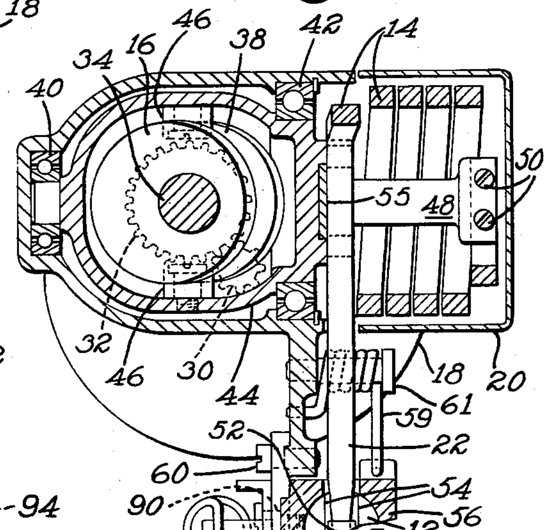


Fig.2



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SPRING ACTUATED NAILERS

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Fig. 4

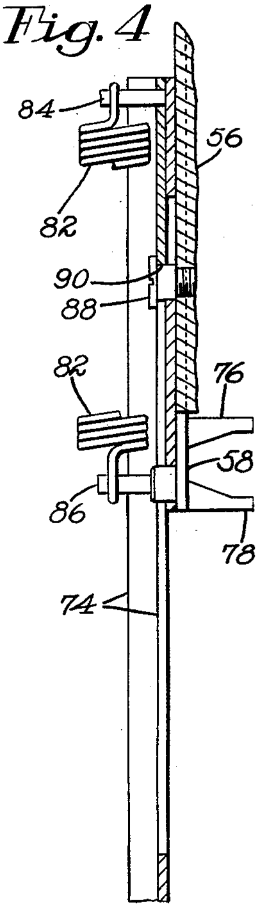
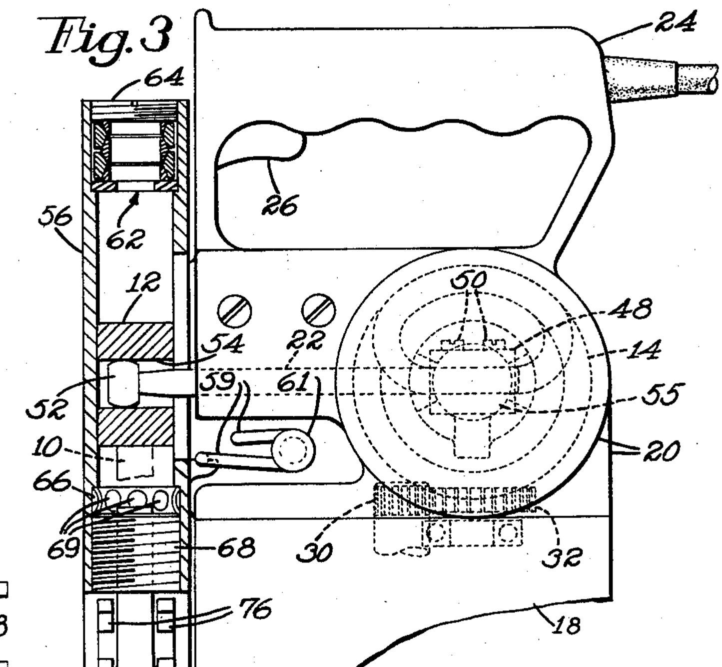


Fig. 3



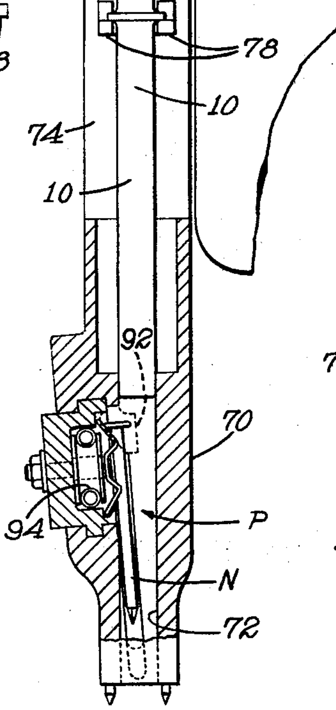
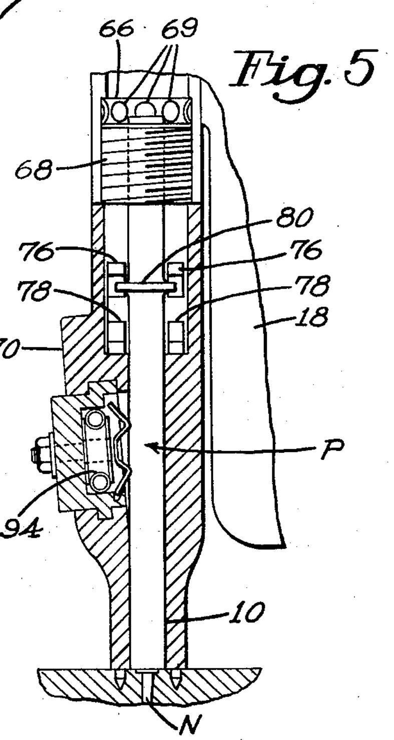


Fig. 5



March 29, 1966 H. F. SCHAEFER, JR., ETAL 3,243,093

SPRING ACTUATED NAILERS

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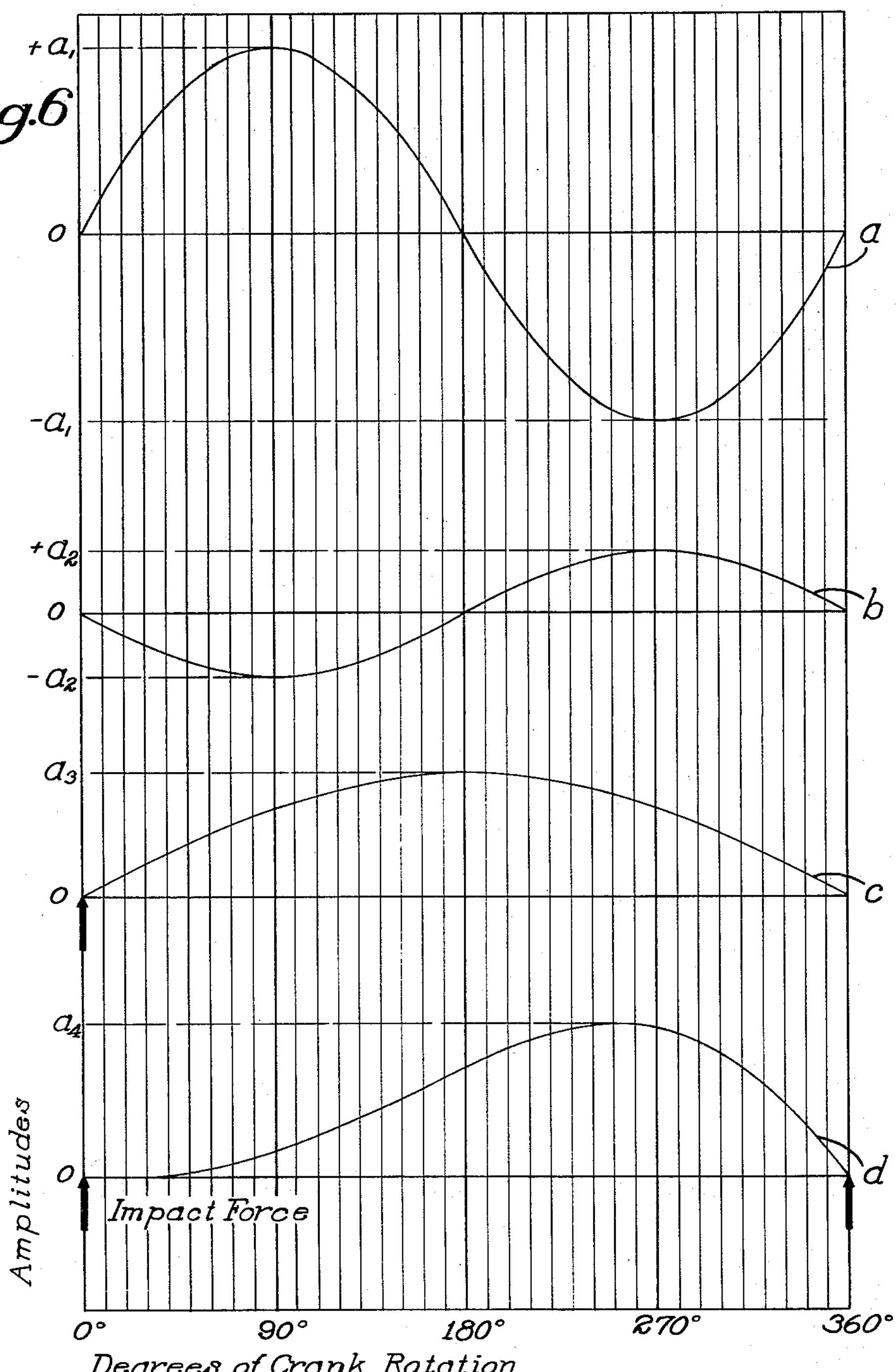
Fig.6



United States Patent Office

3,243,093

Patented Mar. 29, 1966

3,243,093

SPRING ACTUATED NAILERS

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Filed Feb. 4, 1964, Ser. No. 342,466

22 Claims. (Cl. 227—146)

This invention relates to impact devices and more particularly to spring actuated, multiple-blow type fastener inserting tools such as nailers. As herein illustrated, the invention is embodied in a hand-held type of tool or nailing machine wherein energy for driving a hammer is derived from an electric motor and imparted via a tuned spring. Although the illustrative impact tool is shown herein as operating on a nail package, for instance a nail strip of the type disclosed in an application Serial No. 231,223, filed October 17, 1962 in the name of H. T. Decot, et al., now Patent 3,167,778, issued February 2, 1965, it will be understood that in this and other respects application of the invention is not necessarily limited. Merely for purposes of convenience in illustration then, the tool is shown as being provided with a nosepiece adapted to receive such a strip, the nosepiece being essentially as disclosed in an application Serial No. 243,343, filed December 10, 1962 in the name of H. T. Decot, et al. now Patent 3,157,884, issued November 24, 1964.

It is a primary object of the invention to provide a lightweight, inexpensive, spring-actuated, impact tool having a high driving rate which shall be electrically powered and reliable for use in construction and wood fabrications trades. To this end, and in accordance with a feature of the invention, there is provided in a nailing machine having a driver, and a hammer arranged to deliver nailing blows to the driver, a source of power preferably in the form of an electric motor, and a tuned spring for imparting energy from the power source to the hammer. As herein illustrated the spring is preferably of a coiled, helical torsion type having a driving end riding in a slot formed in the hammer, and a driven end operatively connected to a rotary cam. The latter, for smoothness in operation and as herein shown, is a wobble type conjugate cam journaled in the machine frame. The cam is arranged to oscillate a yoke about an axis of the spring normal to the axis of rotation of the cam, the yoke being rotatably supported and having a portion secured to the driven end of the spring.

A further feature of the invention consists in the provision, in a fastener inserting tool, of a driver, a hammer having a weight on the order of one to three times that of the driver for delivering impact to an end of the driver, means for coaxially guiding the driver and the hammer, spring means for reciprocating the hammer in the guide means, motor mechanism for energizing the spring, and energy absorbing or dissipating stops mounted within said guide means and spaced from the hammer to limit its motion and its velocities and thereby enable the mechanism quickly to attain desired operating speed. Preferably, and as shown herein, the stop for braking of the hammer at its lower or driver-engaging limit consists of a corrugated, hardened metal ring affixed in the guide means and operative to enable the motor, on starting, quickly to come up to a desirable operating speed in excess of the natural frequency of the spring and hammer. This stop or brake for the hammer also serves advantageously to relieve the driver of unwanted and unnecessary axial stress when the nail has been fully driven into a work piece.

The above and other features of the invention, including novel details and combinations of parts will now be

described with greater particularity in connection with an illustrative nailing tool and with reference to the accompanying drawings, in which:

FIG. 1 is a view in elevation of a hand held nailer in its rest condition, the nozzle end of the tool being partly broken away to reveal a reciprocating nail driver and a slidable nail pack of the type disclosed in the Decot et al. Patent No. 3,167,778 above mentioned;

FIG. 2 is a section taken on the line II—II of FIG. 1 and clarifying drive mechanism for the hammer;

FIG. 2A is a perspective view of spring guide means shown in FIG. 2;

FIG. 3 is a view similar to FIG. 1 but with the tool turned 90° about a vertical axis and a portion being in section to disclose construction details;

FIG. 4 is a vertical section showing a portion of the tool as seen in FIG. 1 and illustrating means for yieldingly restraining advancement of the driver;

FIG. 5 is a view corresponding to a portion of FIG. 3 but showing the driver at the end of a nailing; and

FIG. 6 is a derivation chart illustrating displacement versus rotation curves *a*, *b*, *c*, and *d* for one cycle of operation according to tuned spring theory developed herein, the steep portion of FIG. 6 (*d*) indicating maximum velocity just prior to hammer impact.

Referring mainly to FIGS. 1 and 3 the illustrated tool essentially comprises a driver **10** for driving a fastener, for instance a nail N, a hardened steel or tungsten hammer **12** for directing axial blows to an end of the driver, a torsion spring **14** for thus actuating the hammer, and an electric motor (not shown) for imparting driving energy through a cam **16** to the torsion spring. A light weight control handle in the form of a metal casting provides a housing **18** for the motor, and a handle or grip portion **24**. A removable lightweight cover portion **20** mounted on the casting encloses all but a straightened, laterally projecting driving end **22** of the otherwise helical, coiled spring **14**. The portion **24** is normally used to apply the tool to a work area to be nailed and is provided with a trigger **26** for controlling the motor which may desirably be of low weight-to-power ratio and operable on 110 volts, single phase, 60 cycle alternating current. The mechanical means by which the motor causes the nail N to be driven will next be described.

As indicated in FIGS. 1–3, a pinion **30** on an output shaft of the motor meshes with a spur gear **32** affixed on a cam shaft **34** having ball bearing mounting in the housing portion **20**. Integral with the shaft **34** is the cam **16** which preferably is a conjugate, wobble type cam having a circular, recessed cam track **38** which is inclined to the axis of rotation of the shaft **34**. Journaled in bearings **40, 42** (FIG. 2) in the housing portion **20** and extending at right angle to the shaft **34** is a yoke **44** carrying trunnion rolls **46, 46**. These are received in diametrically opposite portions of the cam track **38**, their common axis lying in a plane containing the axis of the cam shaft **34**. It will accordingly be understood that rotation of the cam **16** is effective to oscillate the yoke and a stub shaft **48** projecting eccentrically therefrom about an axis generally extending transversely of the tool and coincidental with the axis of the torsion spring **14**. A driven end of the spring is secured to an end of the stub shaft **48** by screws **50** (FIGS. 2, 3) and the driving end **22** of the spring is formed with a round bead or knob **52** (FIGS. 2, 3) arranged to ride in engagement with the walls of a slot **54** in the hammer **12**. For centering and slidably restraining the square-sectioned spring **14** at the inner portion of its driving end **22**, a hub of the yoke **44** is formed to receive a rockable, slotted insert **55** as shown in FIG. 2*a*.

The hammer is preferably heavier than the driver to attain more efficient operation. Its particular weight is desirably in the order of one to three times that of the driver and should be selected together with its shape for optimum operation with a given motor, driver, torsion spring and type of work to be performed. For guiding the hammer **12** in coaxial relation to the driver **10**, a tubular member **56** (FIGS. 1–4) is mounted in tongue and groove relation for sliding on a bracket **58** (FIGS. 2 and 4) which is secured by screws **60** (only one shown in FIG. 2) to the housing portion **20**. The hammer guiding member **56** is yieldably urged in the nail driving direction relative to the housing portion **20** by means of a spring **59** (FIGS. 2, 3) coiled on a pin **61** in the portion **20**, the spring being anchored at one end therein and having its other end bearing on a projection of the member **56**. For determining one limit of hammer movement relative to its slidable guide member **56** an end of the member **56** remote from the driver is slightly reduced in diameter to receive an energy absorbing stop generally designated **62** (FIG. 3) and preferably of the type commercially known as Edgewater rings. This stop is retained against a shoulder of the member by a screw **64**. In like manner the other end of the member **56** is formed to receive an energy absorber **66** (FIG. 3), its retaining screw **68** being annular axially to accommodate an end portion of the driver **10**. The energy absorber **66** may desirably be in the form of a friction ring (for instance of a commercial type known as a Star Tolerance Ring) having internal tangs or inward protuberances **69** circumferentially disposed to be engaged and yieldably displaced by the hammer in the course of braking action. If desired an externally actuated brake means controlled by a trigger or nosepiece may be provided for controlling hammer motion.

In the illustrative tool a nosepiece **70**, generally of the type fully disclosed in the Decot et al. Patent No. 3,157,884 referred to above, has a bore **72** for slidably receiving the driver **10** and is integrally formed with a slide or guide rail **74** (FIGS. 1, 2, 4) offset from but extending parallel to the bore **72**. The arrangement is such that, when the nosepiece is placed endwise with its nozzle end against the locality of a work piece to be nailed and percussive blows are directed by the hammer **12** against the driver **10** to cause it to advance and thus eject the nail N from the bore and sink the nail in the work piece, the reciprocable hammer concomitantly advances stepwise, relative to the nosepiece and its guide rail **74**, together with the guide member **56**, the bracket **58**, and the housing portions **18**, **20** and **24**. To this end, as shown in FIG. 4, the bracket **58** carries two pairs of arms **76**, **76** and **78**, **78** respectively engageable with opposite sides of a collar **80** formed on the driver **10**. The arms **76** serve to limit axial movement of the driver toward the member **56**. More importantly, they limit driver travel so that hammer impact will occur at the optimum point, i.e. at the instant of maximum velocity in a cycle and when the full energy of the spring has been imparted to the hammer. The top of the driver **10** is then approximately in phantom position indicated in FIG. 3. The function of the arms **78** is to lift the driver clear of the nail package P when the tool is raised following a nail drive, thus allowing the next nail N to be positioned for driving. For this purpose a tension spring **82** connecting a pin **84** in the rail and a pin **86** in the bracket **58** acts to return the guide rail **74** and nosepiece when the operator removes the tool after a nail has been fully driven. A shoulder screw **88** (FIGS. 2 and 4) extends through a longitudinal slot **90** (FIG. 4) in the rail **74** and an alined slot in the bracket **58**, and has a reduced threaded portion extending into the housing **56** to maintain the latter in relative sliding relation to the bracket and to the rail. It will be understood that when the trigger **26** is released to stop the motor and the tool is raised from the driven nail, the spring **82** is effective to return the nosepiece **72** and the guide rail **74** relative to the driver, the member **56** and the housing portions.

Operation of the nailer will now be considered more analytically and with regard to FIG. 6 and our theory of tuned spring nailing. The cyclical behavior of the hammer **12** as shown in curve d is derived from amplitude curves a, b, and c. Referring first to curve a this is approximately a sine wave and represents movement of a cross head in response to rotation of a crank having a radius a_1 and driven by a conventional connecting rod. If, now referring to curve **6**(b), a mass is connected by a spring (a lineal system but in effect corresponding to one having the torsion spring **14**) to a crosshead for movement along the same axis as the cross head mentioned with reference to curve **6**(a), the mass will be forced to vibrate according to a formula

$$a_2=a_1\left(\frac{1}{1-(f_1/f_2)^2}\right)$$

where

$$f_1/f_2=\frac{\text{frequency of exciting force}}{\text{natural frequency of spring mass system}}$$

Where f_1/f_2 equals 2, $a_2=-a_1/3$, and this is true of the idling stroke of the mass as represented in curve **6**(b). It will be understood that f_1/f_2 could be a multiple of two as selected. If the crosshead is held stationary and the mass is given an upward velocity equal to the velocity in curve **6**(b), the motion will be as shown in curve **6**(c).

With the hammer-spring system idling as in curve **6**(b), when the crank rotation angle is zero degrees the driver can be brought into the path of the hammer to cause an impact and thus generate a nailing force. The hammer motion during the following cycle is the resultant of curve **6**(b) and curve **6**(c) and is as indicated in curve **6**(d), the steep portion in the latter indicating the maximum velocity of the hammer **12** just prior to impact upon the driver **10**. This cyclical motion of the hammer repeats as long as the upward force remains in the path of the hammer mass. As thus theoretically indicated above, the frequency of exciting force delivered by the motor through the cam **16**, that is to say the operating speed of the nailer, is desirably twice (or a multiple of) the natural frequency of the hammer **12** and the spring **14**.

It will be understood that, as disclosed in the Decot et al., Patent No. 3,157,884, for example, each endmost nail N of the pack P is laterally advanced into driving position against a stop **92** (FIG. 1) by a spring **94** to enable the driver **10** to exert force on the nail head repeatedly, the nail being detached from the pack as a consequence of the nail's initial axial movement in the bore **72**. Advancement of the driver for nailing is controlled by operator force applied to the handle **24** in opposition to the resistance of the spring **59**. Without the energy absorbing function of the ring **66**, or the equivalent thereof, the motor may not reach its most effective speed, but may only operate at a reduced or resonant frequency in phase with hammer motion. The friction ring **66** acts as a limit brake on the hammer **12** slowing it down so that less energy is dissipated and hence enables the motor to continue to accelerate and attain the desired operating speed. If the hammer is seized by the ring it will be released by relative upward motion of the driver when it is applied to drive the nail. Consequently the ring, in cooperation with the stop **62**, enables the electric motor to come up to its normal or desirable operating speed wherein its input frequency to the spring approaches twice that of the spring-hammer system. Again, the nail having been fully driven, whenever the hammer reaches the lower extreme of its travel relative to the members **56**, braking force of the ring **66** is, by reason of its position as shown in FIG. 5, automatically applied to the hammer to relieve the driver of unnecessary stresses, and either seizes the hammer or enables the hammer to return to an idle condition. This braking position of the ring **66** is determined by the upwardly extending projections of the nosepiece **70** having engaged and lifted the guide **56** relative to the hammer **12** and its operating mechanism. The hammer cannot return to idling motion until the driver and the ring **66** are restored to their positions shown in FIG. 3. All hammer blows cease, of course, upon release of the hitherto depressed trigger **26**, and upon retracting the gun from the driven nail, the extended spring **82** restores the gun to its original condition preparatory to driving the next nail. The trigger may be continuously depressed to drive a series of nails.

From the foregoing it will be clear that a compact, easily manipulated impact tool is provided. It has but a few moving parts, is rugged and dependable, and can efficiently deliver its operating blows in any desired direction, the only prerequisite being that a suitable source of electricity be available for energizing the motor. Although a torsion spring arrangement is preferred because of its compactness, it will be understood that any other form of compression spring or elastic medium may be used within the scope of this invention. A notable further advantage of this invention resides in the fact that the actuating mechanism (operating spring, cam and gears) of our tool is unstressed at the moment of impact.

Having thus described our invention, what we claim as new and desire to secure by Letters Patent of the United States is:

1. An impact tool comprising a driver, a hammer reciprocably mounted to deliver multiple operating blows to advance the driver stepwise, a source of power, and a tuned spring for imparting energy from the power source to the hammer consecutively to effect its advances and retractions.

2. An impact tool as set forth in claim **1** and further characterized in that the source of power is an electric motor, and the spring is of a helical torsion type having operative connection to the motor.

3. An impact tool as set forth in claim **2** wherein the helical torsion spring is integrally formed with a straight end portion operatively connected to the hammer, and input to the other end of the torsion spring is provided by a cam-operated yoke operatively connected to the motor.

4. An impact tool as set forth in claim **2** wherein the normal operating speed of the motor is selected to be twice the natural frequency of the spring-hammer system.

5. An impact tool as set forth in claim **2** wherein the spring is actuated by a wobble type conjugate cam driven by the motor.

6. A fastener inserting tool of the impact type comprising a housing, a driver for engaging a fastener, a repetitively reciprocable hammer for delivering axial impact to an end of the driver to advance the fastener stepwise into a work piece, means on the housing for axially guiding the driver and the hammer in operating relation, and motor-driven torsional spring means having a reciprocating portion for operating the hammer.

7. A tool as set forth in claim **6** wherein at least one energy dissipating means is provided to limit the velocity of strokes of the hammer during starting of the tool and thereby enable the motor driving the spring means quickly to attain desired operating speed.

8. A tool as set forth in claim **6** wherein the weight of the hammer ranges from 1 to 3 times that of the driver.

9. A tool as set forth in claim **7** wherein the energy dissipating means is a friction ring mounted on the means for guiding the hammer.

10. A nailer of the multiblow type comprising a nail driver, and a hammer reciprocably mounted for axial engagement therewith, and means for thus operating the hammer. the operating means including an electric motor, a torsion spring, and a cam operated mechanism operatively interconnecting one end of the spring to the motor, the other end of the spring being operatively connected to the hammer to impart driving energy thereto.

11. A nailer as set forth in claim **10** and further characterized in that the hammer operating means is bodily

movable during nailing advance of the driver to maintain operative engagements of the hammer therewith.

12. A multiblow type nailer comprising a nail driver, a hammer for driving the driver axially, guide means for the hammer, a housing supporting the guide means and containing actuating mechanism for the hammer, said mechanism including an electric motor, a torsion spring having a straightened end portion projecting for connection to the hammer, a yoke journaled in the housing and having driving connection with the other end of the spring, and a cam interconnecting the motor and the yoke to energize the spring and hence repeatedly actuate the hammer.

13. A nailer as set forth in claim **12** and further characterized in that a nosepiece is adapted to receive and axially guide the driver, the nosepiece having a yieldingly slidable relation to said hammer guide means, and the latter having a yieldingly slidable mounting on said housing.

14. A multiblow type nailer comprising a housing, a nail driver, a hammer for repeatedly exerting axial blows on the driver, a motor and a cam-actuated torsion spring energizable thereby mounted in the housing, one end of the spring having driving connection with the hammer, means mounted in sliding relation on the housing for guiding the hammer, means associated with said guide means for restraining relative axial advance of the driver in response to the blows of the hammer to cause its impacts substantially to coincide with its maximum velocity, and energy dissipating means engageable by the hammer to limit its stroke and thereby enable the motor quickly to attain its normal operating speed and exceed the resonant frequency of the spring and hammer.

15. In a fastener driving device of the type having a driver and hammer for repeatedly exerting impact on an end of the driver, electric motor means, a spring energizable continuously by the motor means for thus actuating the hammer, and friction means engageable by the hammer in the vicinity of its initial engagement with said driver end to dissipate some of the energy initially being imparted by the spring thereby to aid the motor means to build up to an operating speed wherein its input frequency to the spring is approximately twice the natural frequency of the spring hammer system.

16. A device as set forth in claim **15** wherein means is provided for guiding the hammer, and the friction means comprises yieldable protuberances mounted on the guiding means.

17. A fastener driving device comprising a motor driven spring, a hammer operated thereby, a driver driven by the hammer, means for axially guiding the driver for alinement with a fastener to be impact driven, said means including a nosepiece for engaging a work piece disposed to receive the fastener as it is driven, and means mounted on the driver guiding means and yieldingly movable toward the nosepiece in the course of a fastener driving operation and engageable with the driver to limit its travel stepwise so that impacts of the hammer will occur substantially at the instant of its maximum velocity.

18. A device as set forth in claim **17** and further characterized in that friction means engageable by the hammer is provided to retard it momentarily on starting to enable the motor-driven spring to quickly attain full operating speed.

19. A nailer comprising a driver for delivering impact to the head of a nail to be driven, a hammer, means guiding the hammer for striking engagements with the driver, said hammer guiding means being provided with projections spaced for stroke-limiting engagements with the driver to cause hammer impacts therewith to coincide with or near the instant of maximum hammer velocity, a slide mounted for relative movement in parallel relation to the hammer guiding means and having a hollow nosepiece portion formed for coaxially guiding the driver and the nail, mechanism interconnecting the slide and the hammer guiding means to urge the latter away from the nosepiece portion, a handle yieldably connected to the hammer guiding means and urging the latter toward the nosepiece portion, and a motor-driven spring mounted on the handle and operatively connected to the hammer, the arrangement being such that pressure may be manually applied to the handle to direct the nosepiece portion against a work piece to be nailed and simultaneously advance the handle, hammer, and driver relative to the nosepiece portion.

20. A nailer comprising a driver for delivering impact to the head of a nail to be driven, a hammer, means guiding the hammer for striking engagements with the driver, a slide mounted for relative movement in parallel relation to the hammer guiding means and having a hollow nosepiece portion formed for coaxially guiding the driver and the nail, mechanism interconnecting the guide and the hammer guiding means to urge the latter away from the nosepiece portion, a handle yieldingly connected to the hammer guiding means and urging the latter toward the nosepiece portion, a motor driven spring mounted on the handle and operatively connected to the hammer, and means mounted in the hammer guiding means frictionally engageable with the hammer in the vicinity of the impact-receiving end of the driver in order to assist the motor driven spring to approach an input frequency twice that of the spring-hammer system, the arrangement being such that pressure may be manually applied to the handle to direct the nosepiece portion against a work piece to be nailed and simultaneously advance a handle-hammer, and driver relative to the nosepiece portion.

21. A nailer as set forth in claim **20** wherein the friction means engageable with the hammer is annular in form and disposed axially to receive the driver whereby, if the hammer upon commencing a nailing operation is seized by the friction means, a manual force applied to the handle to press the nosepiece against the work piece to be nailed will cause the driver to free the hammer for continued operation by the spring.

22. A nailer as set forth in claim **19** wherein the nosepiece portion is recessed to receive said projections of the hammer guiding means during a nailing operation and permit abutment of said means with the nosepiece portion at the end of such operation, whereby subsequent relative retraction of the handle in removing the nailer from the driven nail is effective to restore the parts to their relative initial operating positions.

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