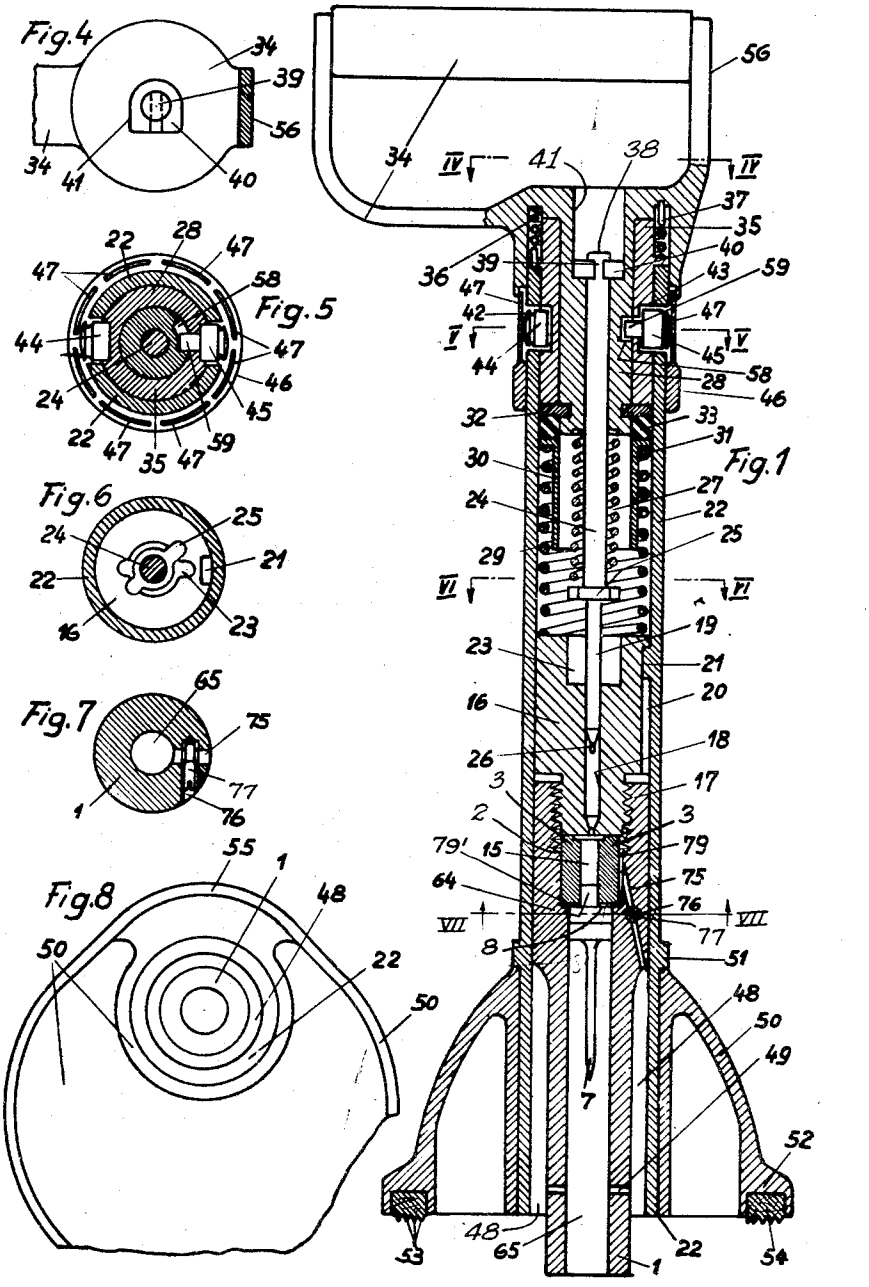
Jan. 1, 1957 M. HILTI 2,775,762

EXPLOSIVELY ACTUATED FASTENER DRIVING TOOL

Filed Sept. 10, 1951 6 Sheets-Sheet 1



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EXPLOSIVELY ACTUATED FASTENER DRIVING TOOL

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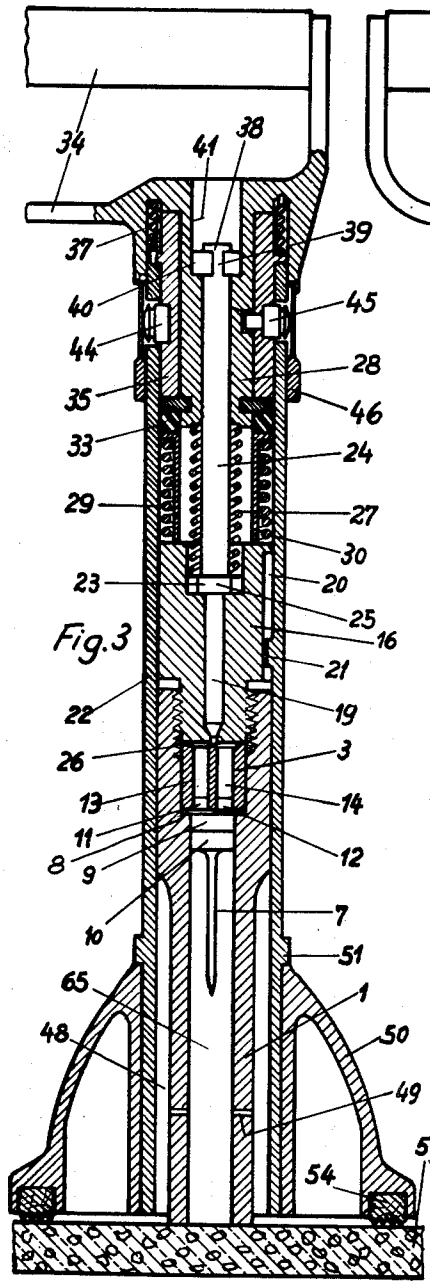

Fig. 3

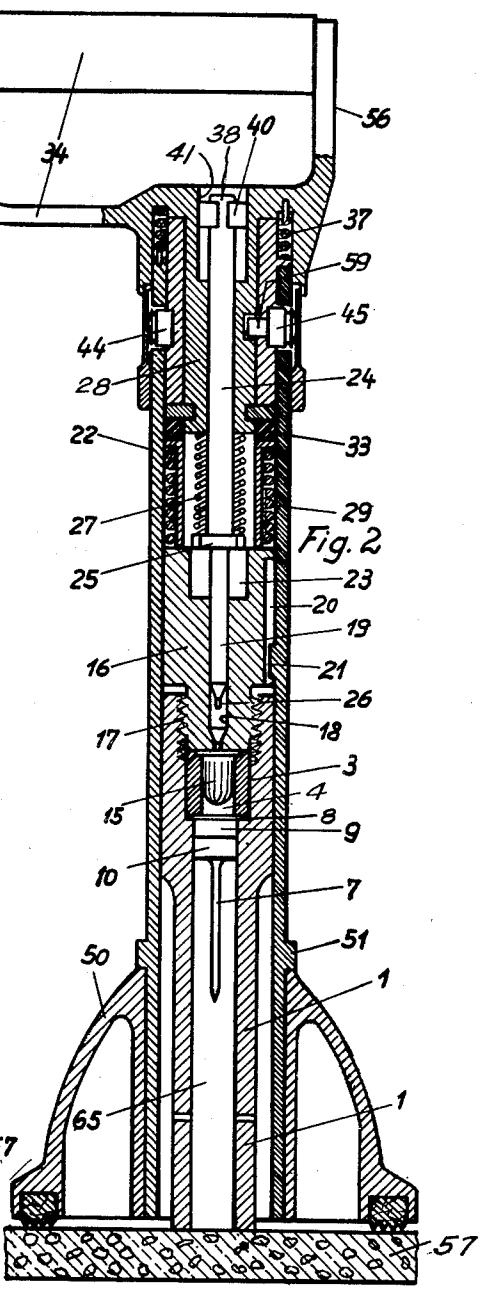

Fig. 2

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Fig. 1a

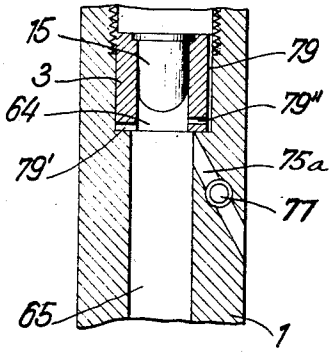


Fig. 3a

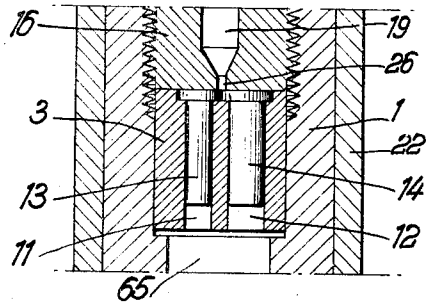


Fig. 10

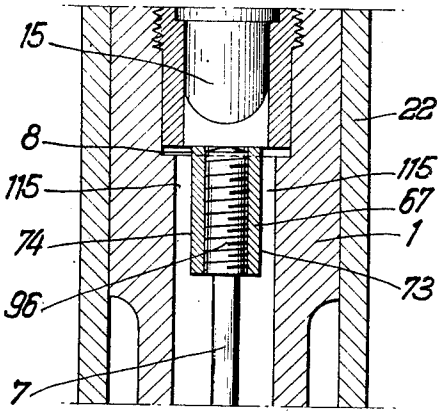


Fig. 9

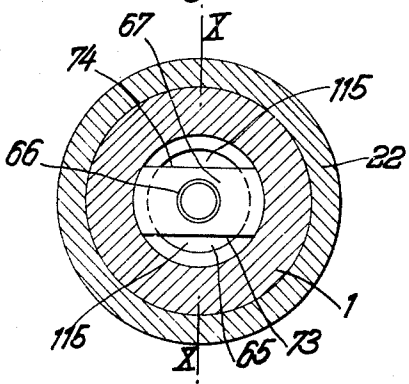


Fig. 16

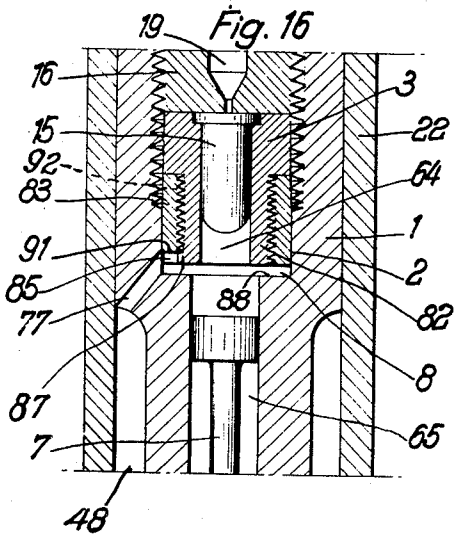
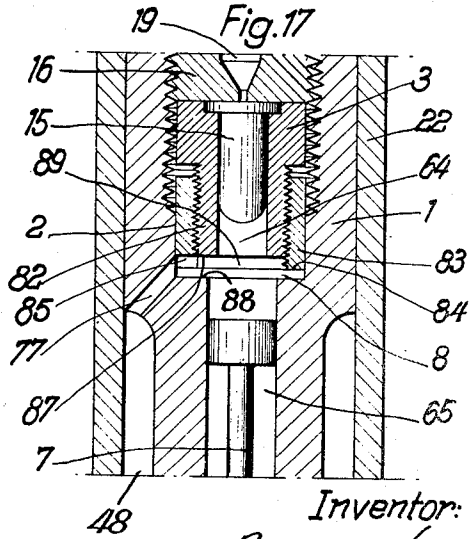


Fig. 17



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EXPLOSIVELY ACTUATED FASTENER DRIVING TOOL

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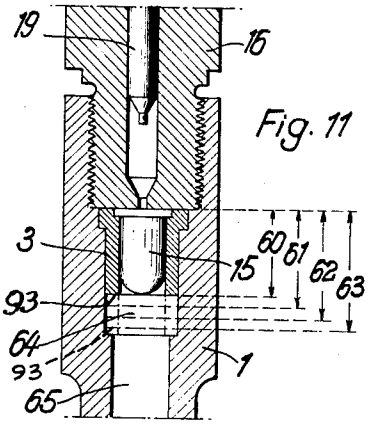


Fig. 11

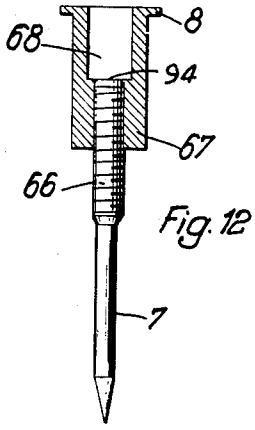


Fig. 12

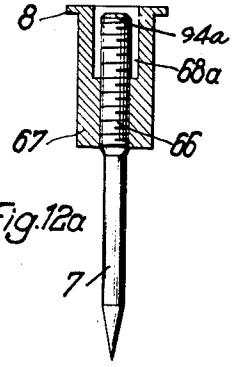


Fig. 12a

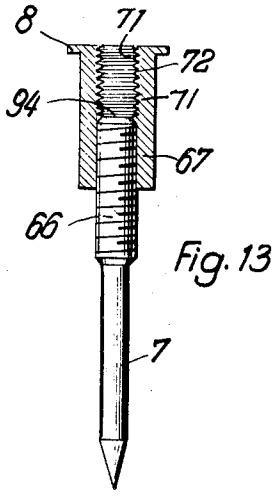


Fig. 13

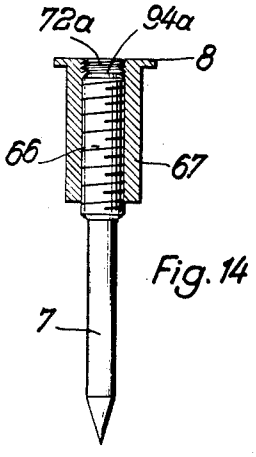
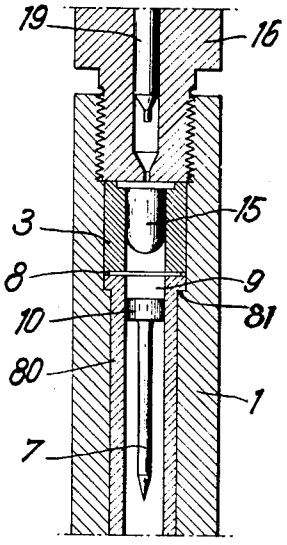


Fig. 14

Fig. 15



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EXPLOSIVELY ACTUATED FASTENER DRIVING TOOL

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Fig. 21

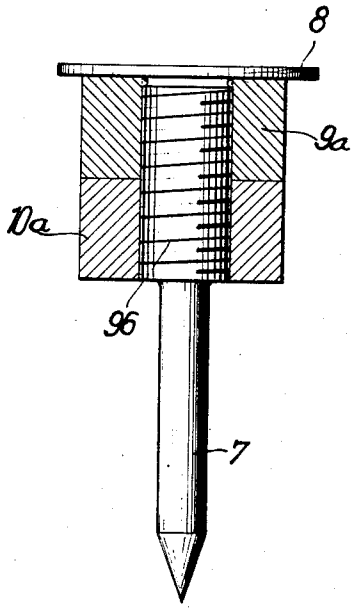
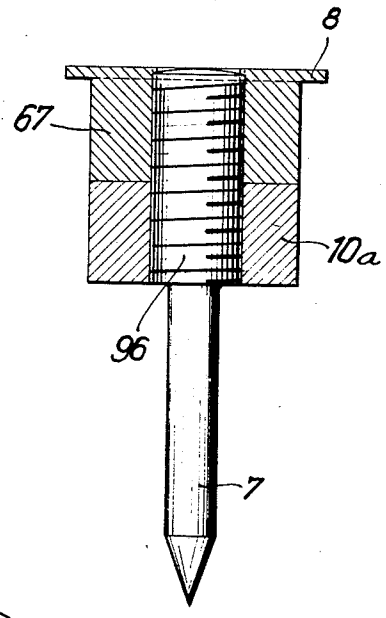


Fig. 22



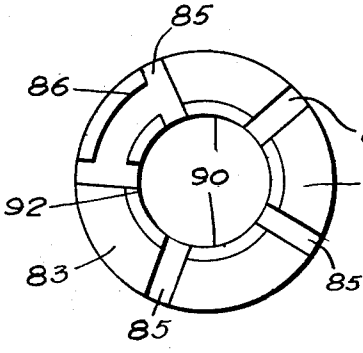


Fig. 18

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EXPLOSIVELY ACTUATED FASTENER DRIVING TOOL

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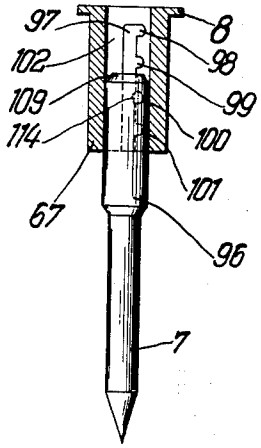

Fig. 19

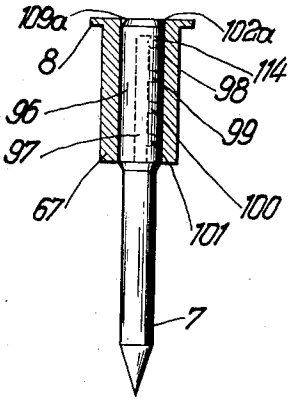

Fig. 19a

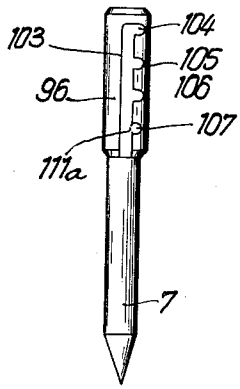

Fig. 19b

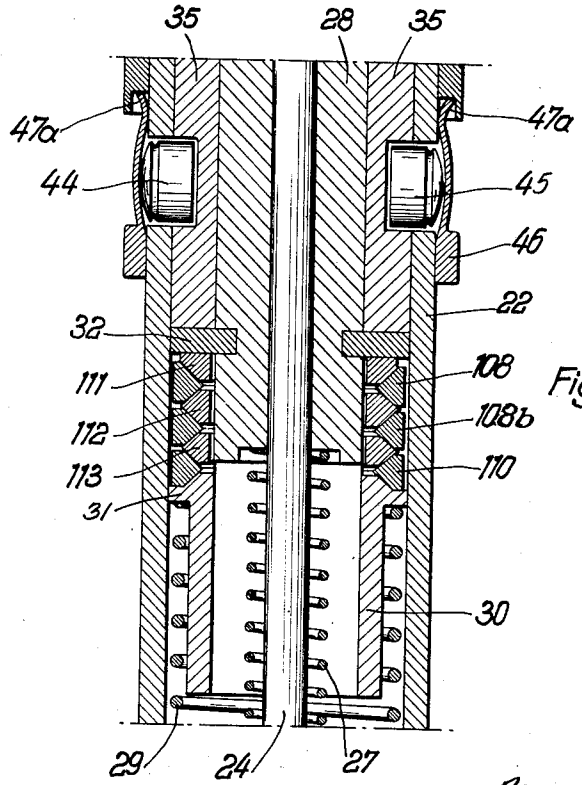

Fig. 20

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United States Patent Office 2,775,762 Patented Jan. 1, 1957

2,775,762

EXPLOSIVELY ACTUATED FASTENER DRIVING TOOL

Martin Hilti, Vaduz, Liechtenstein

Application September 10, 1951, Serial No. 245,912

10 Claims. (Cl. 1—44.5)

The present invention relates to explosively actuated driving tools for propelling or shooting a bolt or other fastening device into solid materials of all kinds, such as concrete, cement, metals, masonry and mortar work, gypsum and other wallboards, prefabricated walls, natural stone work, basalt, and the like.

It is one of the objects of the present invention to provide an explosively actuated fastener driving tool which is so constructed that even on falling or on impact, it cannot be discharged and thereby endanger its surroundings.

It is a further object of the invention to provide an explosively actuated fastener driving tool which is so constructed that it cannot be employed as a pistol-like weapon against its surroundings.

In accordance with the invention, the barrel of the explosively actuated driving tool is movable against spring pressure in such tool and so arranged that only upon positioning and pressing of the device against the solid material into which the fastener is to be driven, does the cartridge which serves for developing the propelling gas for the fastener member, come into a position in which it can be reached by the firing pin upon release of the latter. In order that the barrel may not accidentally arrive at a position in which the cartridge is detonated by actuation of the firing pin, the barrel is, in accordance with the invention, spring-pressed by very powerful springs against a barrel guide. In consequence, the explosively actuated fastener driving tool can be brought into the position in which the cartridge can be fired, not by means of hand power alone, but through the action of the body force of the operator.

It is a still further object of the invention so to construct the firing pin cocking means that its actuation does not interfere with the exertion of the force of the operator's body necessary for pressing the device against the solid material into which the fastener member is to be driven.

In accordance with the invention, the tool is operated in such manner that a force applied by the body is required for accurately centering the device. Such centering is possible, however, only when the second hand of the operator can grasp the device in the region of the muzzle and in this way hold it in the centered position. In this connection, it is a further object of the present invention to construct a device of the type indicated in such manner that the hand necessary for centering does not need to be utilized for operating the cocking means of the firing pin; that is, to construct the explosively actuated fastener driving tool in such manner that it is possible for the hand which transmits the body force to the spring-pressed barrel to accomplish the cocking without disturbing such force transmission. This is particularly important for driving fastener members into the corners of rooms or in confined spaces in which the fastener driving tool must be pressed almost parallel to one of the confining walls and against the other.

A still further object of the invention is to provide a

construction such that the firing pin cannot be left suspended by the sticking or binding of any parts through rust, powder residue, dirt, splinters broken off on firing, the developed dust and grit, or by other influences to be accidentally self-released on assembly or disassembly, so that the cartridge becomes detonated and the firing of the fastener member endangers the surroundings.

Another object of the invention is to provide a device of the type indicated in which the operator is protected against the pneumatic, optical, thermal and mechanical effect of the generation of explosion gases; in other words, to damp the explosive report, to protect the eyes against the effects of light, and to protect the operating hand against the action of the hot and high pressure propelling gases, to reduce or eliminate the recoil of the device against the operator, and likewise to eliminate cross-fire, rebounds, and misfiring.

Additional objects of the invention are to relieve the operator from the calculation and choice of different cartridges for driving the fastener member to different depths into the solid material; to construct a device of the type above described in such manner that by slight changes or adjustments or by additional devices therefor, it is possible to drive the fastener member to different depths without in any way endangering the operator; to construct the explosively actuated driving tool in such manner that no tools are necessary for assembling or disassembling the same beyond those which the workmen at the various working and building sites usually have available to them; and to construct an explosively actuated fastener driving tool with completely smooth, uninterrupted external surfaces and to avoid completely projecting threaded members or other parts, so that possible injury to the operator is eliminated.

On the accompanying drawing is shown by way of example an embodiment of the invention in which all of the above objectives are realized in one and the same explosively actuated fastener driving tool. In said drawing,

Fig. 1 is a longitudinal sectional view showing my improved explosively actuated fastener driving tool after being loaded but before being applied against a wall or the like into which the bolt or other fastener element is to be driven;

Fig. 1*a* is a fragmentary section showing a modification of the gas by-passing means;

Fig. 2 is a similar view showing the device in position pressed against the wall or the like and ready for the discharge of the bolt, the firing pin being in cocked position, a slightly different cartridge case from that of Fig. 1 being shown;

Fig. 3 is a similar view showing the bolt propelling device in the condition immediately after the discharge of a cartridge, but with the bolt missile still in the barrel, a rim-firing type of cartridge and a multiple-chambered cartridge case being shown;

Fig. 3*a* shows the cartridge-supporting case of Fig. 3 on an enlarged scale;

Fig. 4 is a plan view in partial section taken along the line IV—IV of Fig. 1 and shows the positive interlock between the handle and firing pin, whereby the latter follows the rotational movements of the handle but is capable of moving longitudinally relative to the handle;

Fig. 5 is a cross section along the line V—V of Fig. 1 through the mechanism which determines the firing pin releasing position of the handle, and releasably interlocks the handle with the barrel guide;

Fig. 6 is a cross section taken along the lines VI—VI of Fig. 1 and shows the firing pin in the inoperative or cocked position in which it cannot accidentally detonate a cartridge.

Fig. 7 is a cross section taken along the line VII—VII of Fig. 1 and illustrates means for regulating the by-pass-

ing of propelling gases to control the depth of penetration of the bolt;

Fig. 8 is a front end view of the muzzle;

Fig. 9 is a top plan view showing a modification wherein the guide bushing is constructed to permit by-passing of part of the propelling gases and thereby to vary the propelling force acting on the bolt missile;

Fig. 10 is a central longitudinal section along the line X—X of Fig. 9;

Fig. 11 is a fragmentary longitudinal sectional view showing a construction in which the cartridge supporting case is exchangeable with others having different axial lengths for changing the propelling gas space;

Fig. 12 shows a construction of a guide sleeve for a bolt or other fastener with a gas space therein whose volume is gradually variable by adjustment of the bolt which is threaded into said sleeve, whereby the total propelling gas space, and hence the depth of penetration by the bolt may be varied.

Fig. 12*a* shows the bolt of Fig. 12 in a different position;

Fig. 13 illustrates a modified form of the device shown in Fig. 12, in which the threaded bore of the guide sleeve or bushing of the bolt missile is of uniform diameter;

Fig. 14 shows the parts of Fig. 13 in a different relative position;

Fig. 15 is a fragmentary central section illustrating a modification wherein the main barrel is provided with a liner tube;

Fig. 16 is a longitudinal sectional view of a further modification of the mechanism for regulating the propelling gas thrust;

Fig. 17 shows the cartridge supporting case according to Fig. 16, in the position in which the propelling gas thrust is diminished, so that a smaller depth of penetration by the bolt results;

Fig. 18 is an end view showing the threaded sleeve of a cartridge case as shown in Figs. 16 and 17;

Figs. 19, 19*a* and 19*b* show details of a bayonet type of connection;

Fig. 20 shows a modification of the buffer device; while Figs. 21 and 22 show different constructions of the shear plate, being secured to the bolt in Fig. 21 and to a threaded bushing in Fig. 22.

Briefly described, the present invention provides an explosively actuated fastener driving tool wherein a fastener device, such as a bolt or other missile is propelled or discharged through a barrel by the explosion of one or more cartridges. The tool includes an outer tubular guide through one end of which the barrel normally projects, while at the other end there is disposed a handle by means of which the tool is pressed against the wall or other structure into which the fastener device is to be anchored. On further application of pressure to the handle, it is moved toward the stationary barrel and against spring pressure, and carries the barrel guide with it until the guide likewise engages the wall; and during this movement the firing pin of the device is cocked. The firing pin and associated parts are so constructed that the firing pin cannot be released until after the handle has been deliberately rotated on the tubular guide by the operator. There then follows the detonation of the cartridge and the discharge of the fastener device.

One of the features of the present invention is that the parts can be assembled and disassembled, as for the insertion of a new cartridge, without the aid of any tools. A further feature of the invention resides in the provision of various means for controlling the depth of penetration of the fastener device, while employing the same cartridges. This control is effected by varying the size of the propelling gas space to the rear of the fastener device, so that the maximum explosion gas pressure is regulated, or by by-passing and venting a part of the propelling gases, so that such part does not act on the missile. Means are also provided for eliminating the possibility of injury to the operator by the discharged gases.

Other features of the invention will be set forth in the following detailed description thereof.

In all drawings **1** designates the barrel of the explosively actuated fastener driving tool, which at **2** has a chamber intended for accommodating the cartridge supporting case **3**. The barrel is constructed in such a manner that cartridge supporting cases of various shapes may be used. In the embodiment illustrated in Fig. 1, for instance, the aperture **64** of cartridge supporting case **3**, designed for reception of cartridge **15**, is arranged eccentrically to the axis of barrel **1**, so that it is possible to use a cartridge with rim firing. When the corresponding aperture **4** in Fig. 2 is arranged centrically in cartridge supporting case **3**, a cartridge **15** for core firing may be used. Instead of the arrangement of a single aperture or bore **64** (Fig. 1) or **4** (Fig. 2), a plurality of bores, for instance two bores, may be used, as shown at **11** and **12** in the embodiment illustrated in Fig. 3. In the latter, therefore, two cartridges **13** and **14** may be used, both of the rim firing type, so that they are detonated by the firing pin **19** regardless of whether they are used at the same time or separately. Thus, if cartridge supporting case **3** in Fig. 3 is charged with one cartridge only, then the depth of penetration of the fastener element is relatively shallow, while the depth of penetration is considerably deeper when the cartridge case **3** in Fig. 3 is charged with both cartridges **13** and **14**. In this manner, it is possible to set the depth of penetration of the anchoring missile at will with the aid of various cartridge supporting cases, and accordingly with different numbers of cartridges, without change of caliber.

The fastening device or anchoring missile itself consists, first of all, of part **7** (Fig. 2) which is designed to be embedded in a wall or the like. Part **7** has a guide at **9** which centers the missile in barrel **1**. This guide **9** has a shear head-plate **8** which supports the missile in the correct axial position with reference to barrel **1**. The part of the shear plate which protrudes beyond bore **65** of barrel **1** is torn off on detonation and the remaining ring piece is removed from the tool before inserting a new missile. In addition to guide **9**, an additional guide **10** may be provided, in order to increase the guiding length of guide **9**.

At **16** is shown a guide for the firing pin **19**, the guide being threadedly connected to the barrel **1** at **17**. Owing to the use of a coarse thread, this connection can be made, or loosened, without difficulty and without tools, so that this thread may be used without affecting the simplicity of construction and operation of the device. The releasable connection could also be effected without difficulty by means of a bayonet connection or the like of the type shown in Fig. 19 between the cartridge-supporting case and the missile, as described below.

The firing pin guide **16** has the central aperture **18** for guiding the stem of the firing pin **19**. The barrel **1** is disposed within an outer guide **22** the barrel and guide being slidable relative to each other, and the firing pin guide **16** has at **20** a longitudinal recess for receiving an inwardly extending projection **21** of the barrel guide **22**. Thus it will be seen that the firing pin guide **16** which is introduced from the handle end, cannot rotate relative to the barrel guide **22**. At **23** the guide **16** has another aperture, the cross-sectional shape of which is non-circular and is shown in Fig. 6. Between the lower stem of the firing pin **19** and the upper part **24** thereof but connected therewith, is a transverse plate **25**, the transverse section of which is likewise non-circular and is also shown in Fig. 6. In the position shown in Fig. 1, the transverse plate **25** is turned relative to the aperture **23**, as indicated in Fig. 6. Thus, the firing pin head **26** is normally prevented from reaching and penetrating into the cartridge **15**, regardless of any axial movements of the parts **19**, **25**, **24**, and of any forces whereby such

movements may be caused until the firing pin is deliberately rotated, as will presently be described.

The transverse plate **25** serves for supporting the spring **27**, which consists of a coil spring the other end of which bears against the guide **28** for the firing pin part **24**, such guide **28** constituting an extension of the handle **34**. A strong spring **29** lies between the guide **16** and the spring guide **30** disposed within the outer guide tube **22**. A recoil damping elastic buffer **33** is provided which may consist of a simple rubber ring, and lies between a collar **31** on guide **30** and a slotted disk **32** which is received in a groove in guide **28**. In larger embodiments, other means such as metal ring springs (see Fig. 20, described below), could replace the rubber ring.

The guide extension **28** of the handle **34** is received in an intermediate bushing **35**. Together with the handle **34**, this intermediate bushing forms at **36** an annular space for accommodating the torsion spring **37**, the handle end of which is fixed in the handle **34** whereas the other end is anchored in the end of barrel guide **22**. The upper end **38** of the firing pin is grooved or reduced to form a rectangular web **39** (see Figs. 1 and 4). The web **39** has mounted on it a slotted disk **40**, the non-circular shape of which is shown in Fig. 4. The disc is slidable axially in a correspondingly non-circularly shaped bore **41** in the handle **34**, so that any turning of the handle **34** will be transmitted to the firing pin **24**, **25**, **19**, whereas on the other hand, the pin can be axially moved, together with disk **40**, relative to the parts **28**, **34**, as indicated in Fig. 2.

In accordance with the invention, the necessary connection of the parts guided in the barrel guide **22** with the handle through the intermediate bushing **35** is effected without the aid of threaded connections. To this end, the parts **22** and **35** have aligned radial apertures **42**, **43** respectively (Figs. 1, 5 and 20). These apertures accommodate plugs **44**, **45** which serve as coupling or locking elements. To prevent outward radial movement of the plugs, a ring **46** with resilient tongues **47** is slidably guided on the barrel guide **22**, the upper ends **47***a* of the tongues being releasably retained in a recess at the bottom of the handle, as best shown in Fig. 20. These resilient tongues may have concave bulges or cuttings-out opposite to the convex bulging head faces of the plugs **44**, **45**, as shown in Fig. 20, so that a resilient snap lock is provided in the coupling position of the ring **46** as shown in Figs. 1 and 20. Hence, for removal of the handle, the ring **46** need only be moved toward the muzzle to expose the plugs **44**, **45**. After the latter have been removed from the device, the handle **34**, **28** can be pulled out of the barrel guide **22**, together with the firing pin, the intermediate bushing **35** and the disk **32**. Thus the damping device **33**, the spring guide **30**, and the spring **29** are released, so that when the barrel guide **22** is held upside down, the said parts drop out of the latter. The barrel can then be unscrewed from the firing pin guide **16** and withdrawn from the guide **22**. The cartridge shell can now be removed and replaced with a fresh cartridge after inserting a new bolt or missile. The assembly is effected in the reverse order, without loosening or fixing any screws, nuts, bolts, or the like.

The mode of operation of the parts so far described is as follows:

When the barrel **1** is removed as above described, one of the cartridge supporting cases **3**, shown in Figs. 1 to 3, is introduced first, the choice of type and caliber depending on the kind of material into which a bolt is to be shot. In this connection, the dimensions and shape of the bolt **7** and the depth of penetration desired are also significant. Now the barrel **1** with the cartridge supporting case **3** and one or several of the cartridges **13**, **14**, **15** disposed in such case, is screwed to the protruding threaded extension **17** of the firing pin guide **16**, which cannot be turned owing to the projection **21**. After assembly with the other parts, the device is ready for firing. It is then

moved from the position shown in Fig. 1 into that shown in Fig. 2 in which the handle **34** and the parts connected therewith, including guide **22**, are depressed after the projecting end of the barrel has been placed against the target material **57**. Thereby the springs **27** and **29** are tensed and the firing pin is cocked, but no discharge is possible because, as shown in Figs. 2 and 6, the transverse plate **25** bears against the striker guide **16**. Hence, the relative movement of the barrel into guide **22** carries with it the firing pin guide **16**, and the latter, engaging non-circular plate **25** of the firing pin, causes the upper portion **24** of the pin to penetrate further into bore **41** of the handle, as is clearly shown in Fig. 2, at the same time compressing firing pin spring **27** and thereby cocking the firing pin. The firing pin is released only after the handle **34** has been deliberately turned by the operator, so that the transverse plate **25** and the similarly non-circular aperture **23** are in register. From the position of Fig. 2 the firing pin moves into that of Fig. 3, in which the striker head **26** has penetrated into the rims of cartridges **13**, **14**, or into the central core of cartridge **15**, respectively. Thus the bolt is discharged and the bolt missile penetrates into the material **57**.

To ensure the proper position of the handle **34** for effecting the discharge, the firing pin guide **28** has at **58** (of Fig. 5), a ring-segment-shaped recess, into which an arresting projection **59** of the plug **45** extends. Thus the correct end position of the handle **34** can be provided for, with the transverse plate **25** and the aperture **23** in register.

From the foregoing, it is apparent that any unintended discharge of a bolt is precluded. It will be seen that the relative axial movements of parts **1** and **22** must be combined with a relative peripheral rotation of parts **25** and **16** to release the firing pin. The firing pin head **26**, except at the end of these combined movements, is always spaced from the cartridges **13**, **14**, and **15**, sufficiently so that even when the cartridges have not been fired, but are allowed to remain in the device, any accidental contact between the cartridge and the firing pin head is precluded.

At **48** the barrel **1** is set off from the barrel guide, so that an annular expansion space is formed, which can receive discharging propelling gases. To this end, bores **49** near the muzzle discharge the propelling gases into the expansion space **48** without whistling, if the muzzle is more or less clogged so as to hinder the discharge of the propelling gases. The front end of the barrel guide has mounted on it a bell-shaped safety cup **50**, which adjoins the barrel guide **22** and is provided with a radially extending flange at its forward edge. This cup bears against an annular projection **51** of the barrel guide **22**. The rim **52** of the safety cup **50** accommodates the packing **54** having several grooves at **53**. Thus propelling gas, rebounding bolts, and chipped-off fragments of the material of the wall being penetrated by the bolt are caught and rendered harmless in the bell **50**. Where the tool must be pressed into a corner, it is of advantage to shape the safety cup as shown in Fig. 8, the largest transverse dimension of the cup corresponding with the direction of the handle **34**, so that the peripheral edge **55** lies approximately in the same plane parallel to the longitudinal axis of the bolt propelling device as the surface delimiting the handle **34** at **56**.

It has already been proposed to construct explosively actuated fastener driving tools in such manner that by changes in the tool itself, the depth of penetration of the fastener element can be varied, since the unskilled workman can generally not be relied upon to determine which of a number of different cartridges, or which explosive or powder charge must be employed to obtain a certain penetration. These known measures have, however, been restricted to various ways of discharging a part of the generated explosion gases directly into the

atmosphere so that the pressure acting on the fastener element would be reduced.

This known construction has, however, the serious disadvantage that the by-passed gases are apt to strike the workman or at least his hands, so that the danger of injuries and especially of burns, was always present.

As indicated hereinabove, it is one of the features of the present invention that the tool is so constructed that variation in the depth of penetration can be accomplished without in any way endangering the working crew. This is accomplished in accordance with the invention in a number of ways which can be used singly or together. In accordance with one mode of realizing this objective of the present invention, the space occupied by the explosion gases is made variable, so that the specific gas pressure acting on the fastener element at the instant of explosion can be altered. The present invention also contemplates leading off a part of the explosion gases, but in an axial direction and in such manner that such ineffective portion of the gases travels more or less axially in the same direction as the active portion of the propelling gases.

Finally, the size of the fastener element area acted upon by the gases can be varied, as by employing barrel liner tubes or sleeve inserts, so that with the same size of cartridge, the total gas thrust upon the fastener element can be varied.

In accordance with the present invention, simple and reliable means are provided whereby the depth of penetration can be regulated independently of a change of the cartridges, which is not always possible. According to one mode of regulating the depth of penetration in accordance with the invention, the cartridge supporting case 3 shown in Fig. 11, can be made of different lengths **60**, **61**, **62**, and **63**, and be interchangeable, so that the volume of the propelling-gas-filled space **64** and thus the effect upon the propelled bolt **7—10** situated in the bore **65** of the barrel **1** are changed. Whereas cartridge supporting cases of the length **63** correspond to extremely high propelling gas thrusts, and in accordance therewith to large depths of penetration of the bolt, these depths of penetration, determined by the front surface **93**, progressively decrease by the application of cartridge cases having the lengths **62**, **61**, and **60**.

In the embodiment shown in Fig. 12, a threaded guide bushing **67** is screwed to bolt **7** by means of the threaded extension **66** on the bolt **7**. This guide bushing is discharged with the bolt and has the function of guiding the bolt **7** coaxially to the barrel axis and also protects the thread on extension **66** when the bolt is being driven into the material. Since the bolt **7** is to be driven in only to such a depth that the threaded portion **66** protrudes from the surface of the material in which the bolt **7** is to be anchored, it becomes necessary to regulate the propelling gas thrust so that only the said depth of penetration results. To this end the guide bushing **67** has at **68** a bore which faces the propelling gas space **64** and may be of various dimensions, so that by a larger or smaller increase of the propelling-gas-filled space, the propelling gas thrust is reduced or intensified, respectively, with a resulting reduction or increase of the depth of penetration. It is also possible to screw the bolt **7**, **66** to a greater or lesser depth into the bore **68** as shown in Fig. 12*a*, so that when guide bushing **67** of the same construction is used, the depth of penetration can be regulated as required by a mere axial adjustment of the bolt **7**, **66** and the volume of bore **68** reduced, as indicated at **68***a*. To this end, index marks may be provided on the part **66** corresponding to the depth of penetration with a given cartridge. Of course, in place of a threaded connection, other means such as a bayonet-like fitting of the bolt into the guide bushing, with various seats, can be employed, as described below.

In the embodiment shown in Fig. 13, the thread **71** of the guide bushing **67** extends over the entire length of the guide bushing **67** to permit of altering the space **72** within even wider limits, as indicated also in Fig. 14 at **72***a* and **94***a*, wherein the upper surface **94** of the missile **7**, **66** has been adjusted to the position indicated at **94***a*.

It will thus be seen that in the embodiments illustrated in Figs. 12 to 14, the bolt or missile guide **9** is replaced by the guide bushing **67** threadedly connected to bolt **7**, which has threads **66** for this purpose. The guide bushing itself carries the shear plate **8**. The guides **9**, **10** or the guide bushing **67**, as already mentioned, is discharged together with the bolt. As the guide bushing **67** is used only when the bolts have a thread **66** which remains outside of the anchoring wall or the like after the bolt is shot thereinto, bushing **67** protects this thread upon penetration. After penetration, the guide bushing **67** is unscrewed and the exposed threads then serve for attachment to a threaded member which is to be secured to the wall or other structure.

Whereas in the embodiments shown in Figs. 11 to 14, the detonation space is altered, the embodiment shown in Figs. 9 and 10 is characterized by the fact that for regulating the propelling gas thrust and thus for setting the depth of penetration, larger or smaller quantities of propelling gas are discharged or by-passed from the detonation space without being effective on the bolt, so that only the desired remainder of the propelling gases is brought to act on the exposed surfaces of the bolt. In the embodiment shown in Figs. 9 and 10, this is achieved most simply by the fact that the guide bushing **67**, which is of the type shown in Fig. 13, is bounded by two diametrically opposite, plane-parallel surfaces **73** and **74**, which flat faces are continued in the shear plate **8** which locates the bolt and the guide bushing in their axial position in the barrel. Thus passages **115** are formed at both sides of the guide bushing. These passages lead from the detonation space directly into the part of the barrel bore in advance of the bolt, which is of smaller diameter than the barrel bore. Thus a larger or smaller part of the volume of propelling gas is discharged without being used, so that by changing the distance between the faces **73**, **74**, it is possible to vary the propelling gas thrust, and with it the depth of penetration, from a maximum to a minimum.

In the embodiment shown in Figs. 1 and 2, the gas by-passing passage is formed not by the guide bushing but in the barrel **1**. To this end, there is provided in the barrel **1** a passage **75** opening into the detonation space **64** by way of a longitudinal channel **79** and radial groove **79'** in the cartridge supporting case **3**, and having at **76** a transverse through bore in which a grub screw **77** is adjustable. One end of this grub screw enters more or less deeply into the passage **75**, so that a larger or smaller propelling gas portion is discharged from the propelling-gas-filled space through the passage **75** into the expansion space **48** in order that the operator of the device be neither injured nor endangered, the passage **75** being inclined towards the material being treated, so that the emerging gas stream is diverted away from the operator. The screw **77** may be replaced by the plug of a cock.

Fig. 1*a* shows another possible arrangement of the gas by-passing passage at **75***a* in the form of a bore in the barrel opening into the space occupied by the guide bushing of the missile before discharge. In this case, the guide bushing of the missile must have transverse and longitudinal passageways through which the propelling gas developed can pass into the passage **75***a*. The latter has a regulating screw **77**, and the cartridge supporting case **3** may have a longitudinal groove **79** and radial grooves and bores **79'** and **79''** to render ineffective a part of the gases.

A third possibility of varying the gas thrust is shown in Fig. 15, where the size of the exposed surfaces of the bolt is decreased by the arrangement of a liner tube **80** having a seat **81** in the main barrel **1**. Several liner tubes **80** of different inner diameters may be provided to enable

a different regulation of the effect of the propelling gas thrust. Since with the inner diameter of the liner tube, the mass of the bolt is varied to, as far as the radial direction is concerned, one may dimension the bolt in the axial direction by taking into account the square effect of its mass upon the depth of penetration, so that by a selection of the inner diameter of the liner tubes in conjunction with the selection of the mass of the bolt and of the guide box, one may achieve the most various depths of penetration.

Figs. 16 to 18 show a modification of a regulating device for the propelling gas thrust.

The barrel is again designated at **1**, the cartridge case chamber being shown at **2**, with one or more passages **77** connecting the propelling gas space into the extension space **48**. The following means are provided for feeding an accurately controlled quantity of propelling gas to the passages **77**.

The cartridge supporting case **3**, shown in the drawing with the cartridge **15** introduced into it, has at **82** (Figs. 16 and 17) a reduced threaded extension on which the tubular sleeve **83** having a female thread, is adjustable. This threaded tubular sleeve **83** has in its end face **84** facing the bore **65** of the barrel **1**, a number of slot-like radial recesses at **85**, which are so arranged that at least one of them adjoins at least one passage **77**. To this end, a peripheral connecting groove may be provided at **86** (Fig. 18) between two or more of the radial slots **85**. The entire arrangement is such that the threaded extension **82** of the cartridge supporting case **3** can be introduced into the threaded tubular sleeve **83** so deeply that the end face **87**, facing the bore **65** of the barrel **1**, lies in the plane of the end face **84** of the threaded tubular sleeve **83** and in this fully introduced position, can bear against the shear plate **8** of the missile (not shown in Figs. 16 and 17) resting on an annular step **88** lying between the cartridge supporting case chamber **2** and the barrel **1**. This position of the parts is shown in Fig. 16. This figure shows also the plug-like firing pin guide **16** in position to hold the cartridge supporting case **3** in position in the chamber **2**.

It is apparent that when the mutually adjustable parts **3**, **83** are in the position shown in Fig. 16, the full propelling gas thrust becomes effective upon the bolt missile **7**. The annular step **88** may have a recess for the shear plate **8** of the bolt missile and this recess may be provided in the end face **87** of the threaded extension **82**. In any case, the end face **87** of the threaded extension **82** of the cartridge supporting case **3** engages with the annular shoulder **88** or with the shear plate **8** thereon to provide initially a perfect seal for the propelling gas space **64** against the threaded tubular sleeve **83**. At the same time, the threaded extension **82** is introduced so deeply into the threaded tubular sleeve **83** as to seal completely the slot-like recesses **85** of the latter against any access of propelling gases. Thus, the passages **77** are also completely sealed against any escape of propelling medium, so that when the parts are in the position shown in Fig. 16, the largest possible depth of penetration will be achieved.

These conditions are different in the position of the parts in Fig. 17, because the threaded extension **82** has been turned somewhat out of the threaded tubular sleeve **83**. Nevertheless, the firing pin guide **16**, serving as a closing piece, firmly holds the cartridge supporting case **3**, **82** in the chamber **2**. However, because the threaded extension **82** has been turned out of the tubular sleeve **83**, a free space **89** has been formed between the end face **87** of the threaded extension **82** and the annular step **88**. At the same time, this turning of the threaded extension **82** out of the threaded tubular sleeve **83** has opened part of the discharge areas formed by the passages or bores **77** at the inner peripheral limiting surface **90** (Fig. 18) of the tubular sleeve **83**. Through the thus opened space **89** and the partially exposed slots **85**, a relatively large portion of the propelling medium may escape, as by way of the peripheral groove **86** (Fig. 18), to the passages **77**, so that a relatively small depth of penetration is achieved by the bolt. This depth can be further reduced to some extent by turning the threaded extension **82** so far out of the tubular sleeve **83**, that the end face **87** is flush with the top surfaces **91** bounding the slot-like recesses **85**. The top surfaces **91** are so arranged that they provide for the smallest depths of penetration utilizable in practice.

By the provision of a thread **92** of correspondingly small lead for connecting the threaded extension **82** and the tubular sleeve **83**, the regulation can be effected with any desired degree of accuracy. Index marks on the outside surface of the part **82** of the cartridge case, in conjunction with corresponding index marks on the outside surface of the tubular sleeve **83**, or one index mark in the tubular sleeve **83** and several numbered index marks on the outside surface of the part **3**, may provide for an easy setting of selected depths of penetration by the opening of correspondingly large cross sections of the spaces and apertures designated **89**, **85**, and **77**.

Figs. 19, 19*a* and 19*b* show the bayonet-type of connection between the bolt missile and its guide bushing referred to above. In these figures, **67** is again the guide bushing and is provided with a longitudinal groove **97** in the wall of its bore. Bayonet-type transverse grooves **98**, **99**, **100** and **101** extend laterally from the longitudinal groove **97**. The fastener element itself has a part **96** of increased diameter which carries a pin at **114**. If this pin **114** is inserted in groove **97** and the part **96** is turned relative to bushing **67**, then the pin enters, for example, into transverse groove **100**. Thereby a chamber **102** is formed in bushing **67** which constitutes part of the explosion gas spaces. If, however, as shown in Fig. 19*a*, pin **114** of bolt missile **7** is locked into transverse groove **98**, then the volume of explosion gas space contributed by bushing **67** is reduced to the size indicated at **102***a*, because the frontal surface **109** of the bolt has taken up the new position indicated at **109***a*. As the pin **114** on the fastener element **7**, **96**, might be undesirable in some cases, the kinematic reversal of the interlocking parts can be used, by arranging a longitudinal groove **103** and transverse grooves **104** to **107** on the part **96** of the bolt **7**, as shown in Fig. 19*b*. In this case, the guide bushing **67** will be provided with the pin **111***a* which is caused to enter selectively one of the transverse grooves **104** to **107**.

Fig. 20 shows in detail the metal ring springs referred to hereinabove for use in place of the elastic buffer **33**. The metal ring springs are shown at **108**, **108***b*, **110**, **111**, **112** and **113**.

These rings are closed rings which are capable of elastic deformation in the axial direction. They are capable of receiving and absorbing the highest explosion impacts, this action being aided by the considerable frictional forces between rings **108**, **108***b*, and **110**, on the one hand, and rings **111**, **112**, and **113**, on the other.

Figs. 21 and 22 show different constructions for the shear plate **8** of the missile, which is in the form of a bolt having a pointed shank portion **7** and a threaded portion **96** of larger diameter than the shank **7**. In the construction of Fig. 21, the shear plate **8** is secured to the top of the threaded portion **96**, while two round nuts or bushings **9***a* and **10***a* are threadedly mounted on the part **96**. In the construction of Fig. 22, the shear plate **8** is secured to or integral with the threaded bushing **67**, which, with the threaded bushing or nut **10***a* is mounted on the part **96**. By changing the distance between the parts **9***a* and **10***a*, or between the parts **67** and **10***a*, the guide length may be changed. This is of advantage in certain cases, particularly when the projectile is to be anchored in very hard material. The parts **9***a*, **10***a* and **67** can be unscrewed from the parts **96** after anchoring of the missile.

What I claim is:

1. An explosively actuated fastener driving tool comprising, in combination, a barrel for accommodating a fastener element, a guide for the barrel movable longi-

tudinally relative thereto, said guide being of tubular form and at least partially surrounding the barrel, a seat in said barrel for a fastener element, a firing pin guide within the barrel guide, a cartridge-supporting case opening into the interior of the barrel and disposed between the said seat and the firing pin guide, a firing pin for detonating a cartridge contained in said supporting case, means normally blocking movement of the firing pin into detonating position, a handle rotatably mounted on the barrel guide and movable longitudinally with the guide on being depressed relative to the barrel, said firing pin being movable longitudinally relative to said handle but being coupled thereto to rotate therewith, and a spring bewteen the firing pin and the handle and adapted to be placed under tension as the handle is depressed relative to the barrel, said firing pin being released from said blocking means upon rotation of the handle following the depression thereof.

2. A tool as defined in claim 1, wherein the blocking means comprises a member rigidly connected with the firing pin, the shape of said member in a plane extending at right angles to the movement of the firing pin being of other than circular cross-section, said firing pin guide lying in the path of said member on longitudinal movement of the firing pin under the action of said spring, said firing pin guide having an aperture which, in a plane extending at right angles to the movement of the firing pin, is of a shape congruent with that of said member, said member being normally out of registry with said aperture, but being brought into registry on rotation of the handle, whereupon the firing pin is propelled into firing position by said spring.

3. A tool as defined in claim 1, wherein said handle is provided with a tubular extension encasing the adjacent end of the tubular barrel guide.

4. A tool as defined in claim 1, wherein said handle is provided with a guide extension projecting into the barrel guide and rotatable with the handle relative to the barrel guide, an intermediate bushing between said guide extension and the barrel guide, said extension being rotatable within such bushing, means for securing the guide extension and bushing against relative axial movement, said barrel guide and bushing being provided with registering apertures, and a coupling plug in said apertures acting to lock the handle against relative axial movement with respect to the barrel guide while allowing the aforementioned rotation of the handle guide extension within the bushing.

5. An explosively actuated fastener driving tool comprising, in combination, a barrel for accommodating a fastener element which is to be driven into a wall, means within the barrel for supporting a cartridge, the barrel being of enlarged external diameter at a region remote from its muzzle, a tubular guide for the barrel slidable longitudinally relative thereto along the portion of enlarged external diameter and of such length that its muzzle end is substantially flush with the muzzle of the barrel when the latter is pressed against a wall, whereby an annular expansion space is formed between the barrel and its guide, which space is open in the region of the muzzle of the barrel, said barrel being provided with a bore leading from the explosion gas space within the barrel and debouching into the annular expansion space.

6. An explosively actuated fastener driving tool comprising, in combination, a barrel for accommodating a fastener element which is to be driven into a wall, a cartridge supporting case disposed within the barrel, said case being provided with at least two bores for accommodating rim firing cartridges, a firing pin and means for supporting and actuating the same, the bores being so arranged that the rims of the cartridges are situated in the range of the firing pin.

7. A tool as defined in claim 6, wherein the diameters of the bores in the cartridge supporting case are of different sizes.

8. A tool as defined in claim 5, wherein said cartridge supporting means comprises a cartridge supporting case, and wherein the bore in the barrel connects the propelling gas space in the cartridge supporting case and the expansion space between the barrel and its tubular guide.

9. An explosively actuated fastener driving tool comprising, in combination, a barrel for accommodating a fastener element which is to be driven into a wall, a cartridge supporting case disposed within the barrel, means providing an expansion chamber spaced from the cartridge carrying case, said case including means providing a radial passage connecting the propelling gas space in said case with said expansion chamber.

10. A tool as defined in claim 9, in which said last mentioned means is movable with respect to the case to adjust the cross-section of flow of the propelling gas through said passage.

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