United States Patent

[11] **3,566,978**

[72] Inventor **Karl-Ernst Udert**
Triesen, Liechtenstein

[21] Appl. No. **792,033**
[22] Filed **Jan. 17, 1969**
[45] Patented **Mar. 2, 1971**

[73] Assignee **Hilti Aktiengesellschaft**
Schaan Furstentum, Liechtenstein

[32] Priority **Jan. 29, 1968**
[33] **Germany**
[31] **P 16 03 852.1**

---

[54] **APPARATUS FOR DRIVING ANCHORING ELEMENTS FOR A PREDETERMINED DEPTH OF PENETRATION**
8 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **173/139,** 227/10
[51] **Int. Cl.** **B25c 1/14**
[50] **Field of Search** 173/115, 139; 92/85; 227/8, 9, 10; 166/237; 60/26.1

[56] **References Cited**

UNITED STATES PATENTS

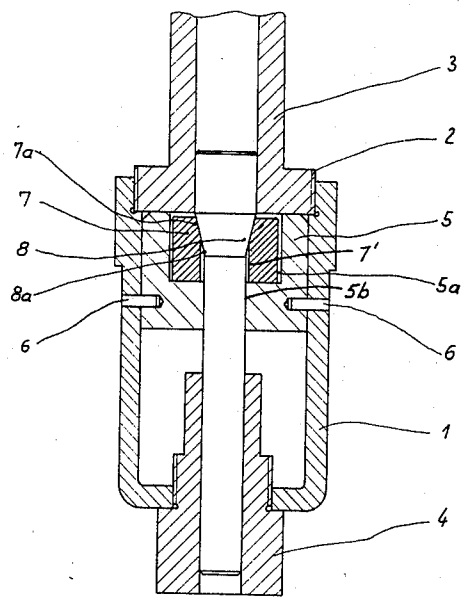
2,308,143	1/1943	Amtsberg et al.	173/139
2,836,247	5/1958	McCulloch	166/237X
2,845,908	8/1958	Maier	60/26.1
3,016,539	1/1962	Marsh et al.	227/10
3,115,637	12/1963	Elliott	227/10
3,297,224	1/1967	Osborne	227/10
3,465,942	9/1969	Diehl	227/10
3,469,504	9/1969	Neighorn	173/139X

FOREIGN PATENTS

858,618	5/1958	Great Britain	173/139

Primary Examiner—Ernest R. Purser
Attorney—McGlew and Toren

ABSTRACT: An arrangement for driving anchoring elements into a target material to obtain a predetermined reproducible depth of penetration is achieved by providing a driving force in excess to that necessary to fix the anchoring elements in place. After an anchoring element is driven to a predetermined depth the excess energy supplied is transformed into thermal energy by placing the member driving the anchoring element in frictional contact with a stop member. The portion of the excess energy not transformed into thermal energy is transferred from the stop member to another member.



PATENTED MAR 2 1971

3,566,978

SHEET 1 OF 3

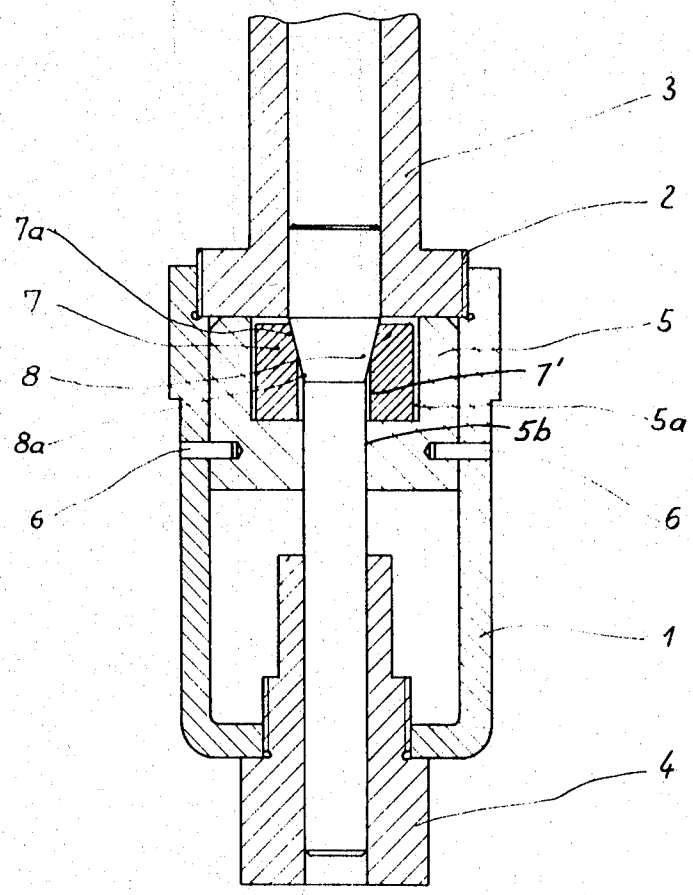


Fig. 1

INVENTOR
KARL-ERNST UDELT

BY
McGlew & Toren
ATTORNEYS

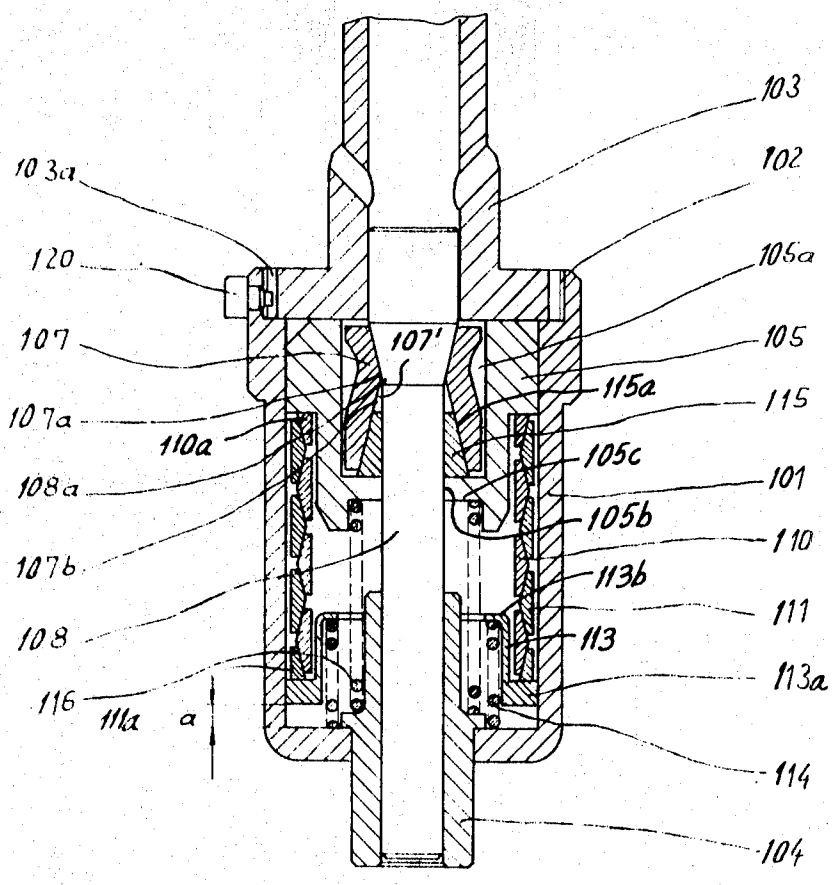


Fig. 2

INVENTOR
KARL-ERNST UDERT

BY
McGlew & Toren
ATTORNEYS

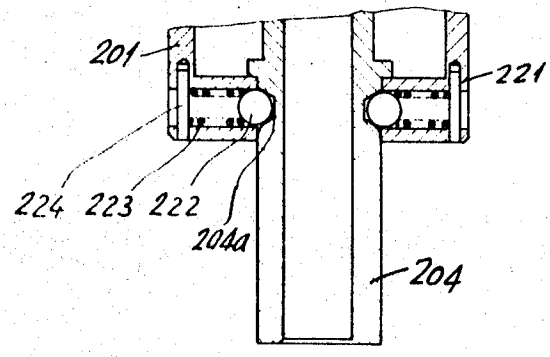


Fig. 3

INVENTOR
KARL ERNST UDERT

BY
McGlew & Toren
ATTORNEYS

APPARATUS FOR DRIVING ANCHORING ELEMENTS FOR A PREDETERMINED DEPTH OF PENETRATION

SUMMARY OF THE INVENTION

The present invention is directed to a method and apparatus for driving anchoring elements such as bolts, studs and nails into a hard target material, such as iron, concrete, asbestos cement, plastics and the like by means of an explosion driven device and, more particularly, it is directed to achieving a predetermined reproducible depth of penetration of the anchoring elements.

With guns employing axially displaceable hammer pistons for inserting anchoring elements into a hard target material, such as the type mentioned above, a certain reproducible depth of penetration cannot be achieved when inserting anchoring elements such as bolts and the like. This results from several factors, for instance, the strength of the target material is not uniform, for example, in steel characterized as St37 the strength can range between 37—45 kp/qmm, and further, the thicknesses of the cartridges employed also effects the depth of penetration achieved. Accordingly, based on the strength of the target material at the point of insertion of the anchoring element and also the thickness of the cartridge used in driving the anchoring element, the depth of penetration into the target material will vary. In certain methods of fastening anchoring elements this inability to provide a reproducible depth of penetration is disadvantageous. If it is attempted to obtain a uniform depth of penetration with known guns of the type mentioned above, for example, by varying the initial combustion space, then, initially, it would be necessary to determine the strength of the target material at the point of insertion of the anchoring element. Such an arrangement for setting anchoring elements would be time consuming and cumbersome. Another possible solution of this problem would be to use the undamped impact, that is, by stopping the hammer piston at a certain point and transmitting the entire kinetic energy of the piston to another axially moving part. However, this arrangement cannot be realized with any justifiable expenditure in a device for setting anchoring elements because of the greater forces which are developed in such a device.

Therefore, the primary object of the present invention is to provide an arrangement for achieving a reproducible depth of penetration of anchoring elements into a target material.

Another object of the invention is to use an excess amount of kinetic energy in driving the anchoring element into the target material and, after the insertion of the anchoring element, transforming at least a major portion of the excess kinetic energy into thermal energy.

Still another object of the invention is to provide a spring arrangement for absorbing a portion of the excess energy employed in driving the anchoring elements.

Yet another object of the invention is to supply the driving piston and a stop member with frustoconically shaped surfaces for frictional interengagement when the hammer piston has driven the anchoring element into the target material for a predetermined depth.

Accordingly, in the present invention kinetic energy is transmitted to a hammer piston in a quantity in excess of that required to provide a predetermined reproducible depth of penetration of the anchoring elements. After the hammer piston has inserted the anchoring element for the predetermined depth the excess kinetic energy is transformed into thermal energy when the hammer piston passes into frictional contact with a suitably shaped stop member. The stop member is elastically deformable and the thermal energy is developed due to the frictional contact between the hammer piston and the stop member as the stop member travels through a short path because of its elastic deformation. Any residual kinetic energy transferred from the hammer piston to the stop member and not transferred into thermal energy is transmitted to means operatively positioned between the stop member and the housing.

Since the amount of kinetic energy transmitted to the hammer piston is greater than that necessary to achieve the depth of penetration, the required depth of penetration of the anchoring element is obtainable in every instance. Accordingly, once the anchoring element has been driven to the predetermined depth by the hammer piston the excess kinetic energy can be removed from the hammer piston. In the present invention it has been recognized that it is advantageous to transform a major portion of the excess kinetic energy, for example, about two-thirds, into thermal energy. The change of the kinetic energy supplied to the hammer piston into thermal energy is accomplished by affording frictional contact between the hammer piston and a stop member against which the hammer piston impacts when it has attained the desired depth of penetration for the anchoring elements. The hammer piston is arranged to extend through the stop member in achieving the insertion of the anchoring element.

Preferably, the stop member is formed of spring steel which is elastically deformable when the hammer piston strikes the stop member, and as a result, a reproducible path is available for the hammer piston. Due to the reproducible path, the forces to be absorbed by the stop member and the hammer piston do not become too great. Moreover, this fact is of considerable importance, since because of the possibly light weight of the device the stop member and the hammer piston can be correspondingly dimensioned within justifiable limits in accordance with the forces to be absorbed. However, the interception path afforded by the stop member should not be too short since this path provides the tolerance required for the depth of penetration.

The residual portion of the excess kinetic energy, which is not transformed into thermal energy, is transmitted to a body in operative connection with the housing part whose mass is of such an extent that the inertia of the body is sufficient to absorb the residual kinetic energy.

In constructing the apparatus, in accordance with the present invention, both the hammer piston and the stop member are each provided with a frustoconically shaped surface converging in the firing direction of the device with the surfaces arranged to be in frictional contact after the desired depth of penetration of the anchoring element has been achieved. Further, the elastically deformable stop member is supported within the device by the member which is arranged to absorb the excess kinetic energy not transformed into thermal energy.

Due to the frustoconical arrangement of the contacting surfaces of the stop member and the hammer piston a force is exerted in the radial direction when the hammer piston impacts against the stop member which causes the stop member to widen. By providing a certain amount of radial play for the stop member within the member supporting it, and by properly dimensioning the stop member, it is only elastically deformed when it is struck by the hammer piston. Because of the bearing arrangement of the stop member on the member within the housing and the interengagement of the member with the housing, the excess kinetic energy which is not transformed into thermal energy is readily transmitted to the member.

For improved absorption of the forces transmitted from the hammer piston to the stop member and also to improve the dimensioning of the stop member and the hammer piston, the stop member is provided with a second frustoconically arranged surface diverging in the firing direction and mounted on a frustoconically shaped inner ring to provide both elastic deformation and axial displacement. In this arrangement the inner ring bears directly against the member within the housing which absorbs the excess kinetic energy from the stop member.

If the excess energy transmitted by the hammer piston is greater than about 8 kpm., several elastically deformable inner and outer rings are disposed in an alternating arrangement extending between the member supporting the stop member and another member in engagement with the housing of the device. In this arrangement the outer faces of the inner

rings and the inner faces of the outer rings have similarly contacting tapering surfaces to provide a spring effect when the hammer piston impacts against the stop member and the stop member in turn impacts against its support member. Because of the arrangement of the inner and outer rings the interception path for the hammer piston is greater and, as a result, higher excess energies can be absorbed with the same dimensions of the hammer piston within the elastic range of the materials.

Another feature of the apparatus, in accordance with the present invention, concerns the possible damage to impact-sensitive materials, such as wood, plastics, and the like, and also to thin metal plates, which can be avoided by mounting the parts of the apparatus within the housing so that they are axially displaceable and, as a result, do not exert a direct impact on the housing and in turn on the target material when the excess kinetic energy is transferred from the hammer piston. To afford this axial displacement without affecting the housing of the apparatus, a pair of spring members are disposed within the housing for absorbing or resiliently mounting the various parts of the apparatus within the housing. These annular springs and, in addition, the inner and outer rings afford a transformation of the excess energy into thermal energy. In the apparatus, a guide member is provided at the firing end which is axially displaceable within the housing under the impact provided by the hammer piston to avoid damage to the target material.

In devices or guns for inserting the anchoring elements which are provided with pressure safety devices, the guide member is connected to the housing preferably by means of a catch. The force of the catch is so great that the contact pressure is overcome, without the guide part being displaced relative to the housing part.

In inserting the anchoring elements to a predetermined length the hammer piston can be adjusted preferably by varying it to a minor extent by shifting the housing part containing the piston and stop member.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a longitudinal sectional view of the front or firing end of a device for inserting anchoring elements illustrating one embodiment of the invention;

FIG. 2 is a longitudinal sectional view similar to that shown in FIG. 1 illustrating a second embodiment of the present invention; and

FIG. 3 is a longitudinal sectional view of an alternate arrangement for securing the forward end of the device, shown in FIGS. 1 and 2, in position.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1, a device 3 for inserting anchoring elements into a target material is formed of a housing member 1 secured to the device 3 by means of threads 2. Located in the forward or firing end of the housing member 1 is a guide member 4 for aligning the anchoring elements prior to the insertion operation. Within the housing member 1, at its rearward end, a member 5 is secured to the housing member by shear pins 6. The member 5 extends transversely across the housing member 1. In its rearward face a recess 5*a* is formed in the member 5 and an opening 5*b* extends forwardly from the recess through the member. Located within the recess 5*a* is a stop member 7 with a certain amount of radial play provided between the outer periphery of the stop member and the juxtaposed surface of the recess. A hole or opening 7′ is formed through the stop member 7 coaxial with the opening 5*b* through the member 5. The rearward portion of the opening 7′ has a frustoconically shaped surface 7*a* which is in converging relationship in the firing direction of the device. Mounted for axial displacement through the device 3 and the housing member 1 is a hammer piston 8 which, as shown in FIG. 1, has its forward end supported within the guide member 4. Near its rearward end the hammer piston 8 has a frustoconically shaped surface portion 8*a* which is arranged to engage the correspondingly tapered surface 7*a* of the stop member 7. As can be noted, the surface 7*a* within the stop member and the surface 8*a* on the hammer piston are arranged in contacting engagement when the hammer piston is driven forwardly through the device 3 by an explosive force for driving an anchoring element, not shown, from the guide member 4 of the device.

In the device illustrated in FIG. 1, when the hammer piston 8 has driven the anchoring element into the target material for the predetermined depth of penetration the frustoconically shaped surface 8*a* on the hammer piston impacts against the similarly shaped frustoconically surface 7*a* of the stop member. As a result, the kinetic energy in excess of that required for the insertion of the anchoring element is transferred over a path determined by the elastic deformation of the stop member 7 within the recess 5*a* of the member 5. Due to the frictional contact between the corresponding surfaces 7*a* and 8*a* the major portion of the kinetic energy is transformed into thermal energy. However, that portion of the kinetic energy which is not transformed into thermal energy is transferred through the stop member 7 to the member 5 which is secured to the housing member 1 by means of the shear pins 6 and thus to the remainder of the device. The shear pins 6 are dimensioned to shear when considerable excess energy is developed in the member 5 and before any of the other parts in the device are overstressed and damaged.

In FIG. 2 a second embodiment of the invention is set forth which operates in generally the same manner as the embodiment in FIG. 1, however, the arrangement is somewhat more elaborate and provides for a greater absorption of excess energy by spring means within the housing member. This second embodiment is formed of a housing member 101 engaged by means of threads 102 on the front end of a device 103. At the forward or firing end of the housing member a guide member 104 is resiliently positioned.

Within the rearward interior end of the housing member 101 a member 105 is positioned. As with the member 5 in FIG. 1 the member 105 has an axially arranged recess 105*a* extending forwardly from its rearward end and being axially located relative to the housing member 101. Positioned within the recess 105*a* is a stop member 107 having an axial opening 107′ extending therethrough and aligned with a similar opening 105*b* in the forward end of the member 105. The opening through the stop member 107 has a first frustoconically shaped surface 107*a* and a second serially arranged frustoconically shaped surface 107*b*. The surface 107*a* extends from the rearward end of the stop member for a portion of its length and the remainder of the opening through the stop member is provided by the second surface 107*b*. While the surface 107*a* converges in the firing direction the second surface 107*b* diverges in the firing direction and provides an open space within which a frustoconically shaped ring member 115 is positioned having its opening in axial alignment with the opening of the stop member 107. The outer surface of the ring member 115 is in diverging relationship in the firing direction of the device and is in contacting relationship with the similarly arranged second surface 107*b* of the stop member 107. The forward end of the ring member 115 bears against the bottom of the recess 105*a* in the member 105. A certain amount of radial play is provided between the exterior surface of the stop 107 and the juxtaposed surface forming the recess 105*a*. An axially displaceable hammer piston 108 extends

through the device **107** and the housing member **101**. Within the housing member the hammer piston passes axially through the spring **107'** in the stop member, the opening in the ring member **115***b*, the opening **105** in the member **105** and the guide member **104**. Near its rear end the hammer piston **108** has a frustoconically shaped surface **108***a*, converging in the firing direction, which impacts against the surface **107***a* of the stop member **107**.

At its forward end the member **105** has a smaller outside diameter than its rear portion providing an annular space between its outer surface and the opposite inner surface of the housing member **101**. Within this annular space and extending from the member **105** toward the forward end of the housing member **101** are a plurality of inner rings **110** and outer rings **111** disposed in an alternating arrangement. The outer faces of the inner rings and the inner faces of the outer rings taper in both directions from a midpoint. As can be noted in FIG. **2**, the tapered faces of the alternating inner and outer rings each contacts a similarly tapered surface on the adjacent rings, for example each full inner ring contacts two outer rings, one above it and one below it, as seen in FIG. **2**, and the same is true for each full outer ring. In this arrangement the tapered faces tend to ride on one another when the inner and outer rings are disposed in a compressed relationship.

At the rearward end of the alternating inner and outer rings, a half inner ring **110***a* bears against the member **105** while at the opposite end of the rings a half outer ring **111***a* bears against a sleevelike member **113** which has a diameter slightly less than that of the inner rings so that it is positioned inwardly of the rings. At its forward end the sleevelike member **113** has a radially outwardly directed flange **113***a* which extends into contact with the inner surface of the housing member **101**. At its rearward end the sleevelike member **113** has a radially inwardly directed flange **113***b* which extends inwardly toward but is spaced from the outer surface of the guide member **104** at its rearward end. A first helical spring **114** bears against the inner forward face of the housing member **101** and extends rearwardly within the sleeve **113** and bears against the flange **113***b*. Spaced inwardly from the first spring **114** is a second helical spring **116** which bears against a shoulder formed on the guide member **104** and extends rearwardly and bears against the member **105** within a recess **105***c* formed in its forward face.

As mentioned previously, the housing member **101** is in threaded engagement with the remainder of the device **103** to afford a fine adjustment for the hammer piston stroke. When the hammer piston stroke is suitably adjusted a screw **120** can be engaged within a slot **103***a* in the threaded end of the device **103** to assure that the housing member **101** is secured against any accidental turning and displacement.

In operation the hammer piston **108** rides forwardly guided within the bore through the device **103**, the ring **115**, and the guide member **104** for inserting an anchoring member into a target material. Since the explosive force which drives the hammer piston forwardly through the device supplies an amount of kinetic energy in excess of that required for driving the anchoring element for its predetermined depth of penetration, when the predetermined depth of penetration has been achieved, the frustoconically shaped surface **108***a* on the hammer piston impacts against the similarly shaped surface **107***a* of the stop member and elastically deforms the stop member. While the action of the hammer piston **108** in the driving or firing direction against the stop member **107** tends to move the stop member in the firing direction and to cause it to widen at the same time the surface **107***b* of the stop member provides a compressing action on the inner ring **115**. Due to the frictional contact between the surfaces **107***a* on the stop member and the surface **108***a* on the hammer piston and similarly between the surface **115** *a* on the ring **115** and the surface **107***b* of the stop member, a major portion of the excess kinetic energy of the hammer piston is transformed into thermal energy. By employing the frustoconically shaped ring **115** the stop member **107** and the hammer piston **108** can be more easily dimensioned because the forces becomes smaller due to the longer interception path provided by this arrangement.

The remaining kinetic energy transferred to the stop member from the hammer piston is conveyed through the ring member **115** to the member **105** which is in sliding contact with the walls of the housing member **101**. The force or energy exerted on the member **105** tends to press forwardly against the spring **116** which bears at its forward end against the guide member **104**. In addition, the member **105** also exerts a force in the forward direction against the combined inner and outer rings **110**, **111** which at their forward end bear against the flange **113***a* of the sleeve member **113**. The inner and outer rings ride forwardly with the sleeve **113** for distance *a* compressing the helical spring **114** until the flange **113***a* contacts the forward end of the housing member **101** and then the inner and outer rings become compressed with their tapered faces sliding on one another. The compressing action of the inner and outer rings **110**, **111** develops friction between the oppositely disposed tapered faces of the rings and, accordingly, a major part of the kinetic energy transferred to the member **105** is transformed into thermal energy. The resulting residual kinetic energy of the body **105** is reduced to a point where it is no longer sufficient to cause any harmful impact on the target material.

In FIG. **3**, a catch or locking arrangement is shown between the housing member **201** and the guide **204** which can be employed in guns or devices with a pressure safety device. In this arrangement a number of bores **221** extend through the forward end face of the housing member **201** and open at their inner ends into a groove or recess **204***a*, formed in the exterior surface of the guide member **204**. For providing a locking arrangement between the housing member and the guide member, a ball **222** is inserted into each bore **221** and a spring member **223** held in place by a retaining pin **224** resiliently urges the ball into locking engagement with the recess **204***a* and retains the guide part within the forward end of the housing member.

I claim:

1. Apparatus for driving anchoring elements such as bolts, studs, and nails into a hard target material such as iron, concrete and the like to obtain a predetermined reproducible depth of penetration of the anchoring elements, comprises a housing member, a hammer piston axially displaceably mounted within said housing member for driving anchoring elements into the target material in response to an explosive force acting on said hammer piston, means mounted within said housing and arranged for receiving energy from said hammer piston, a stop member mounted within said housing and in contact with said means within said housing member, said stop member is elastically deformable and is arranged to be in frictional contact with said hammer piston when said hammer piston has a effected the predetermined depth of penetration of the anchoring elements and said stop member also being in bearing contact with said means when it is in frictional contact with said hammer piston, resilient means being positioned within said housing member for mounting said means in axially displaceable relationship within said housing member, said resilient means comprises a plurality of inner rings and a plurality of outer rings disposed within said housing member and being concentrically arranged about the axis of said hammer piston, said inner andouter rings being arranged in alternating arrangement with the outer faces of said inner rings being in frictional contact with the inner faces of said outer rings, whereby upon achieving the desired depth of penetration of the anchoring element said hammer piston contacts said stop member and the energy from the explosive force in excess of that required for inserting the anchoring element is transformed at least in part into thermal energy by the frictional contact between said stop member and said hammer piston and the portion of the energy not converted into thermal energy is transmitted from said stop member to said means within said housing member.

2. Apparatus, as set forth in claim 1, wherein the outer faces of said inner rings and the inner faces of said outer rings are tapered relative to the axial direction of said hammer piston and the tapered faces of each of at least a number of said inner rings and said outer rings being in frictional contact with the similarly tapered surface of the adjacent ones of outer and inner rings respectively.

3. Apparatus, as set forth in claim 2, wherein said resilient means comprises a sleeve located within said housing member and spaced inwardly from the inner surface of said inner rings, a radially outwardly extending flange secured to the forward end of said sleeve in the firing direction of the apparatus and extending outwardly into sliding contact with the inner surface of said housing member, at the rearward end of the alternating said inner and outer rings the rearward one thereof contacting said member and at the forward end of said inner and outer rings the forward one thereof contacting said flange on said sleeve.

4. Apparatus, as set forth in claim 3, wherein an axially displaceable guide member being located in the forward end of said housing member in the firing direction of said apparatus.

5. Apparatus, as set forth in claim 4, wherein said resilient means comprises a first helical spring extending between said sleeve and the inner surface of said housing member at its forward end, and a second helical spring extending between said member at the forward end thereof and said guide member.

6. Apparatus for driving anchoring elements such as bolts, studs, and nails into a hard target material such as iron, concrete and the like to obtain a predetermined reproducible depth of penetration of the anchoring elements, comprises a housing member, a hammer piston axially displaceably mounted within said housing member for driving anchoring elements into the target material in response to an explosive force acting on said hammer piston, means mounted within said housing and being arranged for receiving energy from said hammer piston, a stop member mounted within said housing and in contact with said means within said housing member, said stop member is elastically deformable and is arranged to be in frictional contact with said hammer for when said hammer piston has effected the predetermined depth of penetration of the anchoring elements and said stop member also being in bearing contact with said means when it is in frictional contact with said hammer piston, said stop member comprises a first annular part and a second annular part, said second annular part being disposed within said first annular part and located at the end thereof extending in the firing direction of the apparatus, said first and second annular parts having axial arranged-openings therethrough for receiving said hammer piston, whereby upon achieving the desired depth of penetration of the anchoring element said hammer piston contacts said stop member and the energy from the explosive force is excess of that required for inserting the anchoring element is transformed at least in part into thermal energy by the frictional contact between said stop member and said hammer piston and the portion of the energy not converted into thermal energy is transmitted from said stop member to said means within said housing member.

7. Apparatus, as set forth in claim 6, wherein the interior surface within the opening through said first annular part having a first frustoconically shaped surface extending from the rearward end of said first annular part in the firing direction of the apparatus toward the forward end of said housing member, a second frustoconically shaped surface extending from said first surface in the firing direction of said apparatus, said first frustoconically shaped surface converging in the firing direction and said second frustoconically shaped surface diverging in the firing direction, s and said second annular part having a frustoconically shaped outer surface arranged to engage said second frustoconically shaped surface of said first annular part, the forward end of said second annular part in the firing direction being in contact with same member.

8. Apparatus, as set forth in claim 7, wherein said means comprising a member mounted in said housing member to be axial displaceable therein, said member having an axially arranged recess in the end thereof directed away from the firing direction of the apparatus, said stop member being spaced within and radially inwardly from the recess in said member for permitting widening of said stop member within said recess.