April 14, 1964 R. J. SERVICE ETAL 3,128,653

EXPLOSIVELY ACTUATED TOOL

Filed Oct. 14, 1960 4 Sheets-Sheet 1

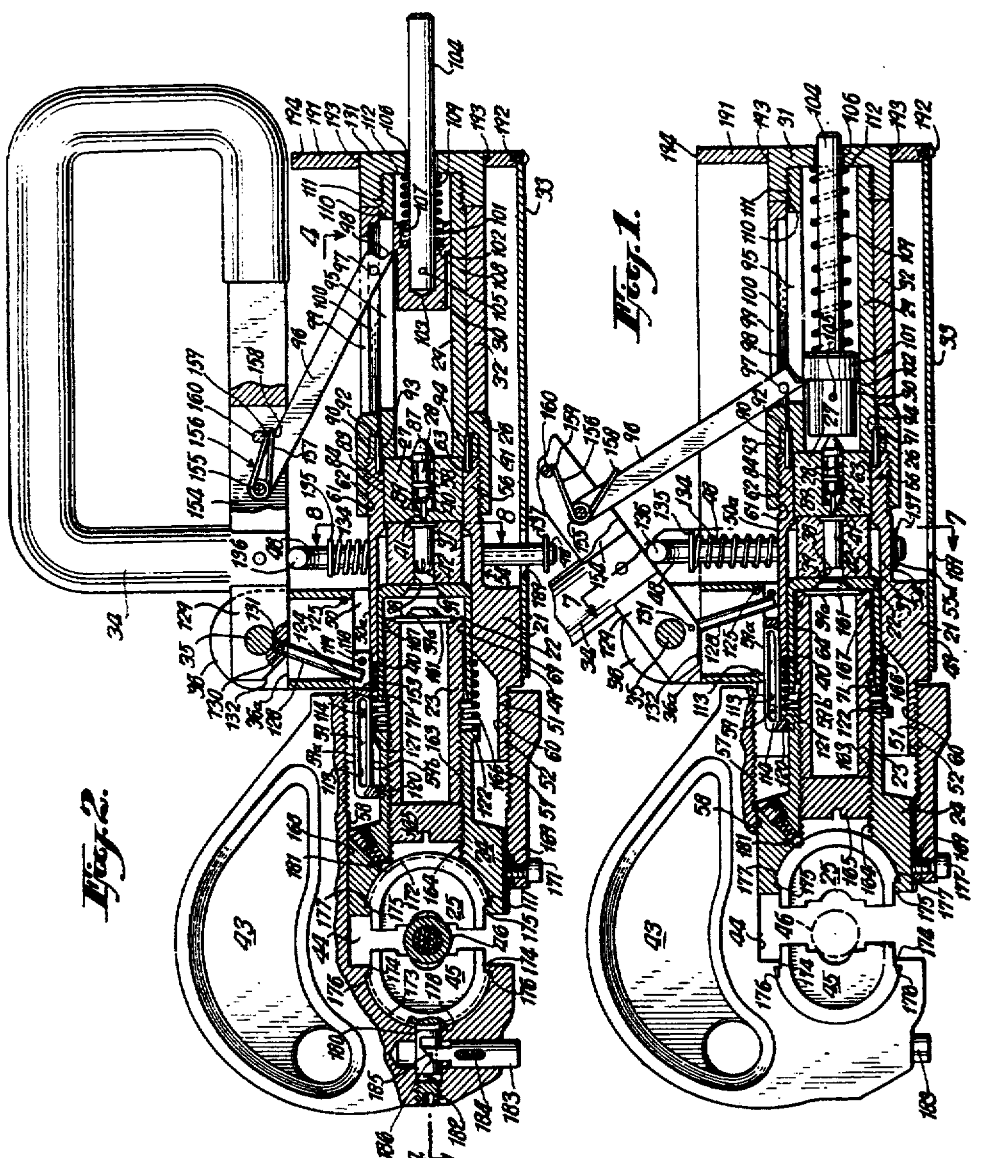


Fig. 2.

Fig. 1.

INVENTORS
ROBERT J. SERVICE.
PHILIP R. HASKELL

BY Ward, Neal, Haselton, Orme & McElhannon
ATTORNEYS.

April 14, 1964 R. J. SERVICE ETAL 3,128,653

EXPLOSIVELY ACTUATED TOOL

Filed Oct. 14, 1960 4 Sheets-Sheet 2

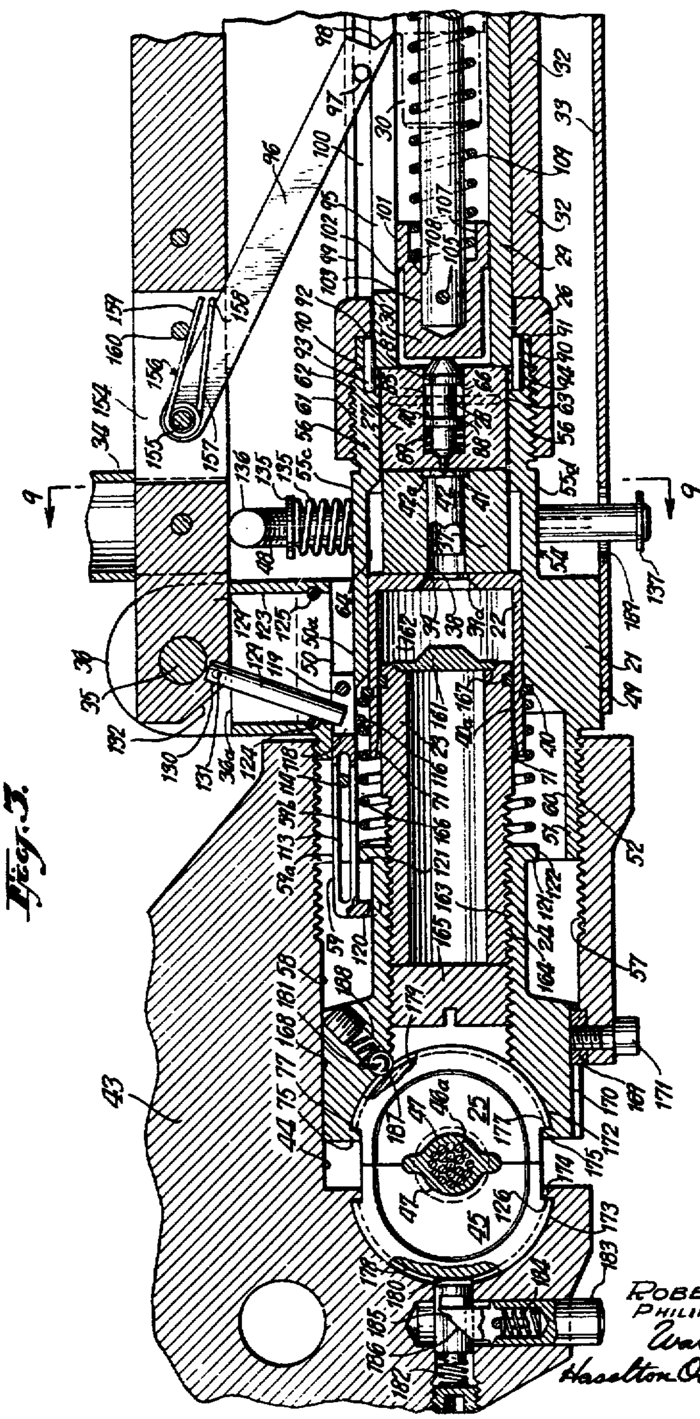


Fig. 3.

INVENTORS
ROBERT J. SERVICE
PHILIP R. HASKELL

Ward, Neal, Haselton, Orme & McElhannon
ATTORNEYS

April 14, 1964 R. J. SERVICE ETAL 3,128,653

EXPLOSIVELY ACTUATED TOOL

Filed Oct. 14, 1960 4 Sheets-Sheet 3

Fig. 4.

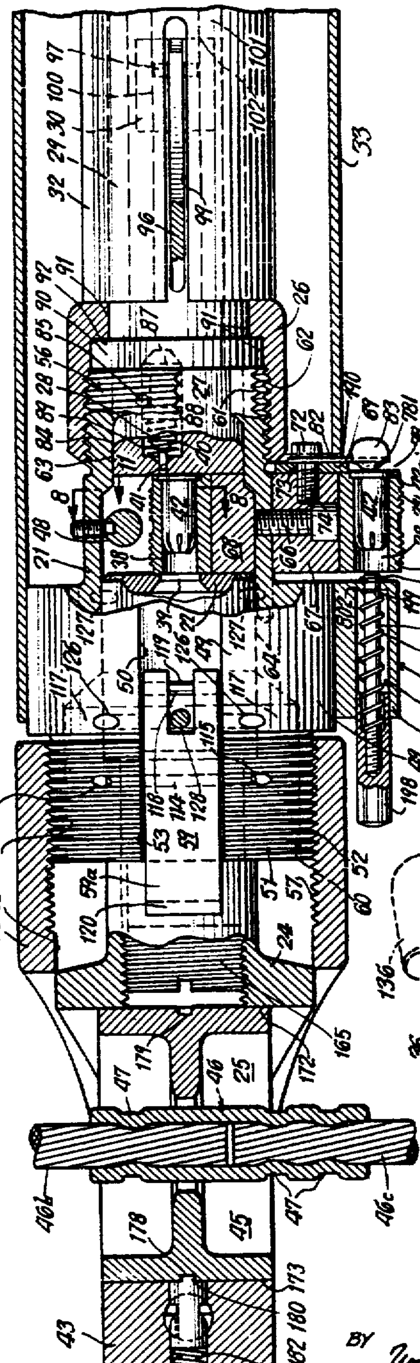


Fig. 5.

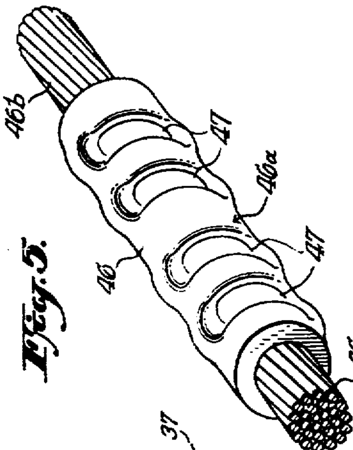


Fig. 10.

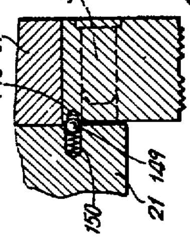
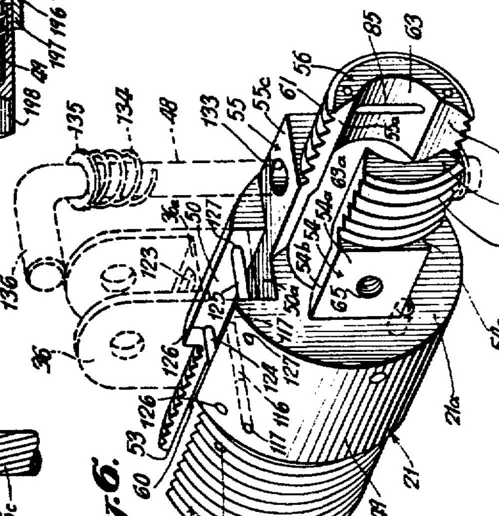


Fig. 6.



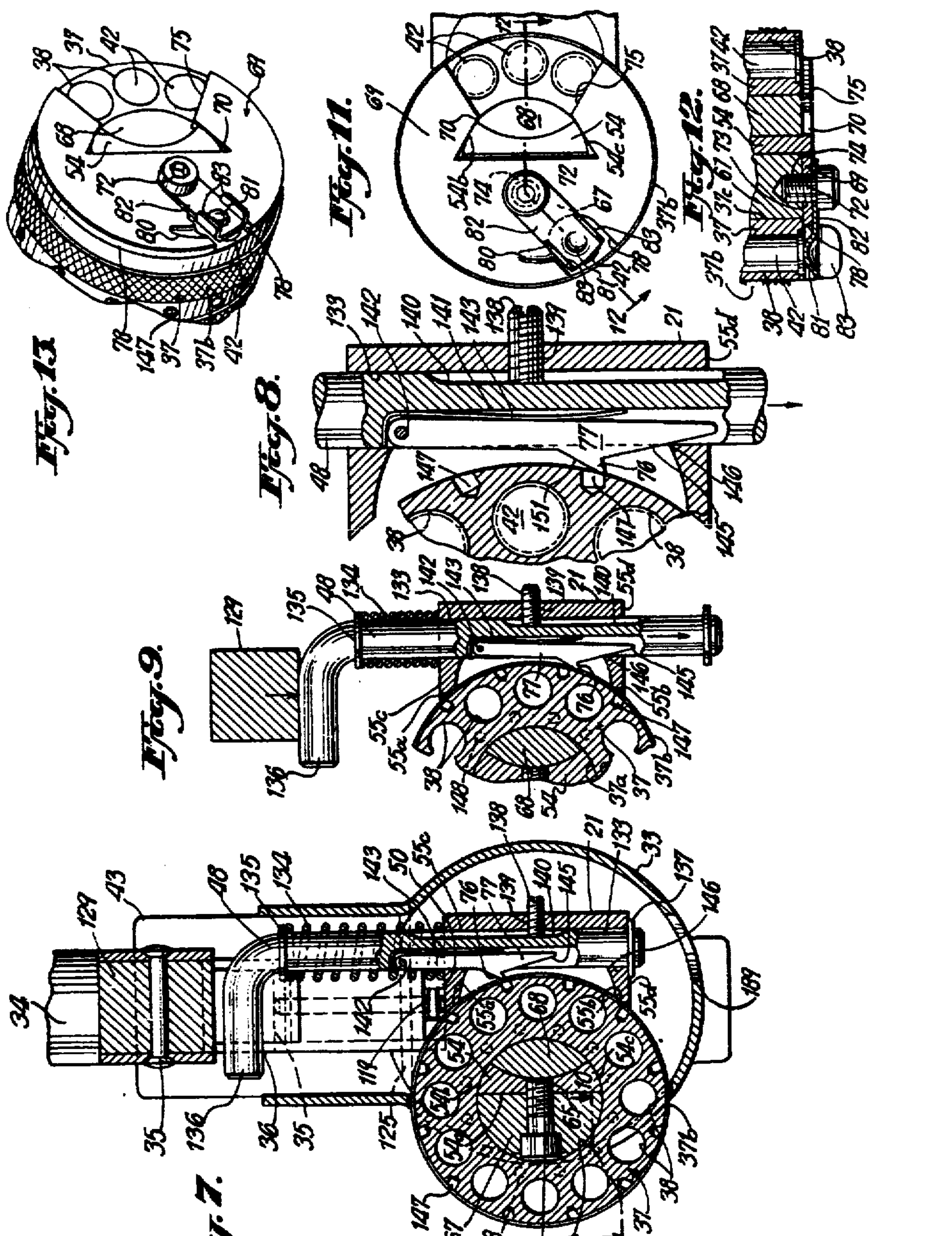
INVENTORS
ROBERT J. SERVICE.
PHILIP R. HASKELL

BY Ward, Neal, Haselton, Orme & McElhannon
ATTORNEYS.

April 14, 1964 R. J. SERVICE ETAL 3,128,653

EXPLOSIVELY ACTUATED TOOL

Filed Oct. 14, 1960 4 Sheets-Sheet 4



INVENTORS
ROBERT J. SERVICE.
PHILIP R. HASKELL

BY Ward, Neal, Haselton, Orme & McElhannon
ATTORNEYS.

United States Patent Office

3,128,653

Patented Apr. 14, 1964

3,128,653

EXPLOSIVELY ACTUATED TOOL

Robert J. Service, Middleville, N.Y., and Philip R. Haskell, Flossmoor, Ill., assignors to Remington Arms Company, Inc., Bridgeport, Conn., a corporation of Delaware

Filed Oct. 14, 1960, Ser. No. 62,589
7 Claims. (Cl. 81—15)

This invention relates to explosively actuated tools. While the principles of the invention may be applicable in explosively actuated tools adapted for a variety of uses, the invention is particularly useful in a preferred embodiment to be described, which is an improved cable swager of the type for coupling lengths of electric cables or the like by providing a compression fitting in the form of a tubular connector in which the cable ends are secured by indentations formed in the wall of the connector. However, it will be understood that the invention is not limited to the details and the preferred embodiment thereof to be herein disclosed, but includes all such variations and modifications as fall within the spirit of the invention and the scope of the appended claims.

In order to effect efficiency in cable swaging operations with which the tool will be used, it is desirable that the tool be capable of repetitive operation to provide a rather prolonged sequence of separate swaging operations without the need for reloading the tool. Moreover, the tool itself should be easily reoriented to its firing position for the next separate cable swaging operation after one has been completed. The tool should be safe and easy to use, and have relatively simple construction so that its manufacture and maintenance are comparatively inexpensive. In addition, the tool must be dependable and effective in operation and should have relatively few exposed parts which would be normally subject to breakage through inadvertence. It is intended by the present invention to provide these and other advantages, as will become apparent, in an explosively actuated tool such as a cable swager.

In one known manner of swaging the connector on to the ends of two pieces of cable to be joined, the tubular connector having the end of one cable appropriately inserted therein is positioned between the jaws of a cable swaging die of the tool and a powder charge in the tool, such as a blank cartridge, is fired, whereupon one of the jaws is urged towards the other to form an impression configuration in the wall of the connector and in the cable so that the connector becomes a compression type fitting at the cable end. The second cable end is then inserted in the other end of the tubular connector, whereupon the operation is repeated so as to join the cable ends.

In a firing of the tool, the indentor instrumentality need not attain high velocity prior to contacting the workpiece, and therefore swaging will be effective even when the movable die element, which forms the indentor, is against the workpiece when the tool is fired. Thus, the indentor element itself may also be arranged to function as a clamp to hold the workpiece in the tool in its proper position immediately prior to firing the tool. Heretofore, this dual function of the indentor has been achieved by providing a spring which is normally biased so as to urge the indentor towards its opposed jaw or backing die element, the indentor to be retracted against the bias of its spring to permit the cable connector to be positioned between the jaws of the swaging die. Releasing of the indentor from its retracted position then permits the spring to urge it against the workpiece to serve as a workpiece holding device. Incorporation of such feature in a swaging tool further serves to automatically adjust the amount of explosively actuated force imparted to the indentor in

proportion to the amount of force required to swage fittings of different diameter sizes, as will be understood.

However, although it has been recognized that the means which causes indentor retraction against the bias of its spring should be in some way operably associated with other tool elements, such as those whereby the tool is cocked for firing, so as to promote unitized tool operation, such interconnection of the parts has heretofore involved relatively complex mechanisms and arrangements thereof which are subject to malfunction, damage, increased maintenance, and the like. Moreover, in many cases, tool operation involves positioning the workpiece in the swaging die at a time when an explosive charge has already been positioned within the firing chamber of the tool, with the attendant possibility that the tool may be prematurely actuated to fire the charge before the workpiece has been correctly positioned. For safety reasons, and for dependability with respect to the accuracy of tool operation, it is manifest that the existence of such possibility is undesirable. To disassociate the indentor retraction means from the cartridge loading and firing elements of the tool introduces the same likelihood, but through human error. In repeater type tools, the likelihood of human error in this respect is increased.

Should the tool be fired accidentally without a workpiece therein, it is quite likely that the tool will damage itself, by the forces of impact which are generated, unless means are provided which will dissipate these forces in such event. In the past, relatively complicated and expensive shock absorbing systems have been incorporated in the tool construction for the purpose.

In other prior devices, no provision is made for adjustment of tool force to compensate for the different amounts of indentor force which are required in operations performed on workpieces of varying size or, where such provision is made, the means have been sometimes ineffective. In addition, many prior devices incorporate relatively heavy indentor elements, thought to be required for strength reasons which, in turn, requires that the explosive charge be made more powerful in order to overcome the inertia of the heavy indentor element. To withstand the enlarged power requirement, all of the tool elements have been made proportionately larger with the result that many prior tools are inconveniently heavy.

The present invention provides a repeater type explosively actuated tool, such as a swaging tool, which avoids these and other difficulties of prior devices of its kind, and which has all of the referred to desirable features. Its general arrangement includes a main body portion, at the so-called muzzle end of which are the opposed swaging die elements, and a handle lever generally disposed parallel, and which is pivotable about one of its ends with respect to the body portion. When the handle is pivoted to an angle of about thirty degrees away from the tool body, the swaging die elements will be separated by retraction of one of them, to receive a workpiece therebetween. Thereafter, by a single, simple pivoting of the handle towards the tool body portion, the movable die element moves against the workpiece to effect a clamping in place thereof, a cartridge is indexed into juxtaposition with the firing means of the tool, and the tool is cocked and then triggered to fire the cartridge to swage the workpiece by impelled further movement of the movable die element which serves as the workpiece indentor instrumentality. The swaged workpiece is released from the tool by again pivoting the handle back to its angular position with respect to the tool body portion, whereupon the movable die element or indentor will be again retracted. It will be observed that all of these actions within the tool occur in proper sequence or simultaneously, as desired, and that after a swaging operation has been performed, the tool is automatically in condition for the next operation.

In addition, the tool incorporates means for adjusting tool power in proportion to that which is required by the workpiece, yet not generally requiring that the size of the main powder charge be made larger or smaller. Moreover, a "no work shot" safety feature has been incorporated which is extremely simple and inexpensive in construction, yet which is effective to dissipate tool force to prevent its injury in the event of accidental firing not in the presence of a workpiece.

A light weight, but very rugged piston element effectively reduces the total power requirements of the tool and, consequently the weight of the tool making it comparatively convenient to use.

In a tool for the purpose which has a barrel element and a piston slidable therein in response to explosion of a blank cartridge for impressing an attached swaging or indentor element into the workpiece, these objects are obtained by providing a die cam extension means operably associated with the pivotal movement of the handle for retracting an associated die cam which, in turn, causes retraction of the indentor element from its normal spring biased association with its opposed workpiece backing element, and further providing a pivotable action bar element, also operably associated with the pivotal movement of the handle, for engaging the spring biased firing pin hammer element of the tool first to cock, and then to release or trigger the same so as to fire the tool upon pivoting the handle towards the barrel section. In addition, a revolver type cartridge chamber cylinder of the tool is provided with an indexing mechanism, also operably associated with the pivotal movement of the handle, to automatically index one of the several cartridge chambers thereof into line with a rim-type firing pin element during each successive tool firing movement of the handle, but only after clamping of the workpiece between the swaging die element has been effected and, further, only just prior to the time when the tool has been fully cocked for firing. Thus, a live cartridge is not in a position to be fired until the workpiece is properly positioned and the hammer has been almost fully cocked for its tool firing action. Convenient cartridge ejection and loading means are provided, but deliberately disassociated with the referred to coordinated actions of other tool elements for safety and for other reasons, as will be understood.

The indentor instrumentality is attached to a carrier element which, in turn, is in threaded engagement with the piston of the tool to provide adjustment of the "boiler space" distance of the head of the piston from the powder charge. Thus, this distance can be varied to provide a larger or smaller expansion chamber immediately in front of the powder charge to vary the effective force of the explosion on the tool indentor, though using the same size powder charge. In addition, the piston element has hollow construction, thereby reducing its weight and therefore its inertia which must be overcome by the force of the expanding powder gases. As a result, the normal powder charge can be smaller, and the total weight of the tool can be reduced.

The barrel element of the tool has comparatively short length and a slight, interiorly disposed peripheral chamfer at its muzzle end, as will be described, which promotes rapid dissipation of the force of explosion of the powder gases upon completion of the piston stroke. The gases will expand in an enlarged gas expansion chamber at, and surrounding the muzzle end of the barrel as will be seen. Due to the arrangement and construction of the die cam and die cam extension, as will be seen, closing of the die jaws to clamp the workpiece in position is permitted only during the cocking and firing rotative movement of the handle, and prior to full cocking and firing of the tool. This action also results in a greater or lesser amount of "boiler space" being provided at the time the tool is fired, depending upon the size of the workpiece.

It will be apparent that a "no work shot" safety feature is provided since, in such event, the piston will be located farther away from the exploding cartridge whereupon substantially instantaneous dissipation, through the shortened barrel, of the explosive force of the powder charge can be achieved, thereby reducing the impact with which the indentor element will strike its associated backing die element. Of course, the hollowed piston configuration, by reducing its weight, also contributes to the prevention of tool injury upon an accidental "no work" discharge thereof by reducing the momentum and therefore the amount of kinetic energy which will be released in the event.

These and other objects and features of the invention will become more fully apparent by reference to the following detailed description of the referred to preferred embodiment thereof when taken together with the accompanying drawings, wherein:

FIGURE 1 is a fragmentary sectional side elevation of a tool made in accordance with the invention as it would appear in condition preparatory to receiving a workpiece between the swaging jaws thereof;

FIGURE 2 is a full sectional side elevation similar to FIGURE 1, but showing the tool as it would appear in cocked condition just prior to the triggering thereof to swage a workpiece which is shown in place;

FIGURE 3 is a fragmentary sectional side elevation similar to FIGURES 1 and 2, but showing the tool as it would appear in its condition immediately upon firing;

FIGURE 4 is a fragmentary plan view, in cross-section taken at lines 4—4 of FIGURE 2, showing the tool in the same condition as in FIGURE 2, but showing additional details thereof;

FIGURE 5 shows in perspective a compressed fitting swaged in place by the described embodiment of the tool provided by the invention and joining together two lengths of electric cable;

FIGURE 6 is a perspective view of the adapter member of the tool to show the details of its construction;

FIGURE 7 is a cross-sectional view of the tool taken at lines 7—7 of FIGURE 1 to show the details of the chamber cylinder indexing mechanism of the tool;

FIGURE 8 is a fragmentary sectional view similar to FIGURE 7, but taken at lines 8—8 of FIGURES 2 and 4, to show the cylinder indexing mechanism actuated to its position corresponding to the tool condition shown by those figures;

FIGURE 9 is a view similar to FIGURE 8, but taken at line 9—9 of FIGURE 3, to show the cylinder indexing mechanism actuated to its position corresponding to the tool condition shown by that figure;

FIGURE 10 is a fragmentary sectional view of a portion of the tool, taken at lines 10—10 of FIGURE 7, to show further details of the indexing mechanism;

FIGURE 11 is a fragmentary sectional view of the tool taken at lines 11—11 of FIGURE 4 to show details of the cartridge loading and ejecting means;

FIGURE 12 is a sectional plan view taken at lines 12—12 of FIGURE 11; and

FIGURE 13 is a perspective view of the sectional elevation of the tool shown by FIGURE 11.

The general arrangement of a repeater type swaging tool which is provided by the invention is best understood by reference to FIGURES 1 to 4, inclusive, and FIGURE 7 of the drawings. It will be observed that the main body portion of the tool generally comprises a centrally located adapter member **21** (its configuration shown by FIGURE 6) within the hollow of the forward, or muzzle end of which is attached a barrel element **22** containing a slidable piston **23**, the latter having an attached carrier **24** for the indentor instrumentality **25** of the tool. Attached to the other end of the adapter **21**, by a breech cap **26**, is a breech bolt **27** containing a slidable firing pin **28**, and a tubular hammer slide member **29** which contains a slidable firing pin hammer **30** therein. The hammer slide 29 is enclosed at its rearward end by a cap 31 which also holds in place a hammer slide cover 32 which surrounds the hammer slide 29 for a purpose to be described. Surrounding and enclosing these elements, and in spaced relation thereto as shown, is a shroud 33 which provides a convenient hand grip surface of the main body portion of the tool.

A handle 34, perhaps better described as a tool actuating lever, is pivotally attached at one of its ends, as by hinge pin 35, to a hinge member 36 of the main body portion which is located, generally speaking, at a central location therealong. As will be seen, the handle 34 is limited in its pivotal movement with respect to the main body portion between its position parallel thereto corresponding to a fired condition of the tool, as shown by FIGURE 3, and an angle of about thirty-degrees, more or less, with respect thereto corresponding to a "ready" condition of the tool, as indicated in FIGURE 1.

As more clearly shown by FIGURE 7, a revolver type cartridge chamber cylinder 37, having cartridge chambers 38 therein for cartridges 42, is rotatably mounted between the muzzle-facing end of the breech bolt 27 and the breech end of the barrel 22, the longitudinal axis of rotation of the cylinder 37 being eccentrically located with respect to the central longitudinal axis of the tool so that, upon its rotation, each chamber 38 is successively brought into alignment with the barrel bore 39. Indexing of the cylinder 37 to bring each successive cartridge 42 into firing position is effected by a downward movement of an indexing slide 48 in conjunction with the downward movement of handle 34 which causes cocking and firing of the tool.

A C-shaped workpiece support 43 extends from the muzzle end of the tool, being attached to the adapter 21. At the forward end of its hook aperture 44, the workpiece support 43 is adapted to receive the fixed jaw 45, or backing die element of the swaging die pair 25, 45. When the opposed dies are separated by counterclockwise pivoting of the handle 34 which causes retractive movement of the indentor 25, or movable jaw element to its position shown in FIGURE 1, a workpiece 46 to be swaged may be positioned therebetween.

During its clockwise movement, as shown by the drawings, the handle 34 will pass through a slightly angulated position with respect to the main body portion to condition the tool as shown in FIGURES 2 and 4, wherein the indentor, or movable jaw 25 has moved against the workpiece 46 to effect a clamping action thereon shortly before the tool is triggered. Movement of the handle 34 beyond this position, towards its position against the main body portion, will trigger the tool, in a manner as will be described, to its fired condition as shown by FIGURE 3 wherein the indentor 25 will have been impelled, in response to the cartridge explosion, a further short distance forward to thereby impress into the workpiece 46 one of the swaged configurations 47 of the fully swaged fitting 46*a* shown by FIGURE 5. By providing a suitable number of appropriately placed configurations 47, as indicated by FIGURES 4 and 5, two cable ends 46*b* and 46*c* may be joined together by the compression fitting 46*a*.

Having generally described the tool, the details of its construction and operation will now be described.

In FIGURE 6 there is shown in detail the shaped adapter member 21 which provides a starting point for building the tool by attachment of its other elements. The adapter is a relatively heavy steel member which may be formed having unitary construction by appropriate and well known machine opeartions. It has a central cylindrical portion 49 having a longitudinally extending slot 50 therein; a somewhat smaller muzzle end cylindrical portion 51 having external threads 52 and a longitudinal slot 53; a longitudinally extending chamber cylinder mount 54 and a similarly extending chamber cylinder indexing slide mount 55, both of which protrude from the breech end of the central portion 49; and a breech cap engagement mount 56 formed by both of the breech ends of the chamber cylinder and indexing slide mounts 54, 55.

The external threads 52 of the muzzle end cylindrical portion 51 of the adapter are for engaging the internal threads 57 in the carrier slide bore 58 of the C-shaped workpiece support 43, as will be understood upon reference to FIGURE 4, for example. The slot 53 is for slidably receiving a slide-type die cam 59, as also seen in FIGURE 4. Note that the depth of the slot 53, corresponding to the wall thickness of cylinder 51, is such that the upper surface 59*a* of the die cam 59 will freely pass the threads 57 of the workpiece support 43. Moreover, the diameter of the internal gas expansion chamber bore 60 of cylinder 51 is such as will be generally in line with the bottom surface 50*a* of slot 50 in the central cylindrical portion 49 so that the bottom surface 59*b* of die cam 59 will ride thereon when slidably retracted in the manner to be described.

Referring now to the elements at the breech end of the adapter 21 as shown by FIGURE 6, the height of the flat surface portion 54*a* of the chamber cylinder mount 54 is somewhat smaller than the diameter of the axially extending central bore 37*a* of chamber cylinder 37, and its upper and lower surfaces 54*b* and 54*c* are shaped to correspond with the radius of chamber cylinder bore 37*a* so that the chamber cylinder 37 will be rotatably received therearound, as will be apparent by reference to FIGURE 7. As is also shown particularly by FIGURE 7, the upper and lower interior side surfaces 55*a*, 55*b* of the slide mount 55 are similarly configured to correspond in shape with the outer periphery 37*b* of the chamber cylinder 37 for passage thereof.

For manufacturing convenience, the chamber cylinder and indexing slide mounts 54, 55 may be at first formed integrally by milling a block shape in the metal at the breech end of the central cylindrical portion 49. Similarly, the cylindrical breech cap engagement mount 56, together with its external threads 61 for engaging internal threads 62 of the breech cap 26, may be formed in a straight-turning machining operation. A breech bore 63, for receiving breech bolt 27 may then be bored centrally through the length of the adapter 21, whereupon the surfaces 54*b*, 54*c*, 55*a* and 55*b* may be formed by milling and shaping appropriately located longitudinal slots (not numbered) through the upper and lower portions of the breech cap engagement mount and the referred to block portion. This will be observed upon a study of FIGURE 6. The somewhat larger barrel receiving bore 64 and still larger gas expansion chamber bore 60 may then be formed, as more clearly shown in FIGURE 4, for example, in a sequence of boring operations initiated from the other, or muzzle end of adapter 21.

Probably the most convenient first step in assembling the tool elements is to attach the barrel 22 to the adapter 21. The barrel is press fit into the barrel receiving bore 64 of the adapter so that its breech end exterior surface is generally in line with the plane of the breech end surface 21*a* (FIGURE 6) of the adapter central cylindrical portion 21. The carrier spring engagement ring 40, which has split ring construction, should be snapped in place within the annular groove 40*a* of the barrel, as shown.

Cartridge cylinder 37 may be then mounted on the tool as will now be described.

Referring to FIGURES 6 and 7, it is seen that a threaded hole 65 is provided in the cylinder mount 54, extending laterally through the element from the exterior side surface 54*a* thereof, for receiving the attachment screw 66 which attaches the cylinder bearing 67 to become an intergral part of the cylinder mount 54. Similarly, it is seen that, by reason of the manner of forming the breech bore 63, an appropriately shaped inner cylinder bearing piece 68 will be necessary to provide a full 360 degree, bearing surface for the chamber cylinder central bore 37*a*. It now becomes apparent that the chamber cylinder 37 may be mounted for rotation on the cylinder mount 54 by attaching the bearing 67 and then sliding the chamber cylinder first over the portion at the end of the cylinder mount which forms part of the breech cap engagement mount, and then into its proper position on the cylinder mount 54, and thereupon inserting the inner bearing piece 68. The chamber cylinder periphery will pass between the upper and lower slots (not numbered) which form the surfaces 54*b*, 54*c*, 55*a* and 55*b*.

Referring now to FIGURES 4, and 11–13, it will be observed that a cylinder cover 69 is slotted, as at 70, to form a wedge-shaped half-diameter interior slot the upper and lower surfaces of which will tangentially engage surfaces 54*b* and 54*c* of the cylinder mount 54 when it is placed in engagement therewith in the same manner as was the cylinder 37, by passing over the breech cap engagement mount portion at the breech end of the cylinder mount 54. By a cylinder cover screw 72 which extends through a hole 73 of the cylinder cover 69 and thence into the threaded, longitudinal extending hole 74 of the cylinder bearing 67 (cooperatively with the tangential engagement of the cylinder cover with surfaces 54*b*, 54*c*, as aforesaid), the cylinder cover 69 will hold the cylinder 37 in place to permit its rotation, yet not permit its slidable movement in longitudinal direction away from the barrel bore 39. The cylinder mount 54 and its associated bearing pieces 67, 68 are made long enough, in longitudinal direction, to appropriately receive both the cylinder 37 and its cover 69. It will be noted that the cover slot 70 is widened, as at 75, at the periphery thereof to provide clearance for both the firing pin 28 and the indexing protrusion 76 of the slide cam 77 which is pivotally mounted in the indexing slide 48, as will be seen in FIGURE 7.

It will be also seen by reference to FIGURES 4, and 11–13 that the cylinder cover 69 has a cartridge loading and ejecting slot 78 formed in its periphery appropriately to be in line with the cartridge ejector mechanism 79 which is attached to the central cylindrical portion 49 of adapter 21, and which will be described. The slot 78 has a cam surface 80 so that the button portion 81 of the rotatable chamber cover 82 will ride easily thereon when any cartridge chamber 38 which appears under the slot 78 is to be uncovered. The chamber cover 82 is rotatably mounted on the cylinder cover screw 72, and has protruding finger grip portions 83 to facilitate manual rotative movement thereof for the purpose. Each chamber 38 may be manually indexed past the cover slot 78, by thumb pressure on the knurled peripheral surface 37*b* of cylinder 37, for insertion of a blank cartridge 42 therein. When the desired number of chambers 38 have been filled with a like number of live cartridges, the chamber cover is appropriately rotated to cover the slot 78, its button portion 81 exerting biasing pressure on each cartridge to avoid the possibility of its jamming when passing under the cylinder cover 69 upon indexing of the cylinder during tool operation.

After the cylinder 37 and cylinder cover 69 have been assembled on the tool, the breech bolt 27 will be inserted in press-fit engagement as at 84, into the breech bore 63. A vertically extending pin 85 (see FIGURES 3, 4 and 6) will be passed through the breech bolt 27, extending across the breech cap engagement mount 56, both to insure against any rotative movement of the breech bolt 27 and to engage the firing pin peripheral slot 86, formed between end flange 87 and centrally located flange 88 of the firing pin 28, so as to hold the firing pin 28 in place within the firing pin bore 40 of the breech bolt. The location of pin 85 is such as will permit limited longitudinal movement of the firing pin 28 within the bore 40 in response to the bias of its spring 89 so as to normally hold its firing pin head 41 a short, standoff distance away from engagement with a cartridge 42, and against the bias of its spring 89 to engage the cartridge in response to a blow of the hammer 30.

By reference to FIGURE 4, it will be noted that the central longitudinal axis of the firing pin bore 40 in the breech bolt 27 is located eccentrically with respect to the central axis of the tool and, consequently, also eccentrically with respect to the central axis of any cartridge chamber 38 which is positioned in line therewith. The eccentric displacement of the firing pin bore 40 from the tool axis is approximately equal to one-half the diameter of a cartridge so that, upon firing the tool, the firing pin head 41 will strike the rim 42*a* of a cartridge 42 which has been positioned for firing. Moreover, the eccentric displacement of the firing pin bore 40 from the tool axis is in direction towards the side of the tool which is opposite from that side towards which the axis of the chamber cylinder 37 has been displaced so that, unless a cartridge 42 is properly aligned with the barrel bore 39, a triggering of the tool will not cause the firing pin head 41 to strike and consequently fire the cartridge, but rather will strike the main body of cylinder 37. In conjunction with the arrangement and operation of other tool elements, this provides a safety feature of the tool.

When the breech bolt 27 and firing pin 28 have been assembled in place within the breech bore 63, the tubular hammer slide 29 and the breech cap 26 are attached to extend from the breech end of the adapter 21. The hammer slide 29 has an end flange 90 for abutting engagement against the interior shoulder 92 of the breech cap 26 when the main tubular body portion of the hammer guide is passed through the breech cap bore 91 from its interior side. Before assembling the hammer slide and breech cap, however, the two longitudinally extending pins 93, 94 are press fit into approximately located drill holes in the flange 90 so as to protrude towards the muzzle end of the tool and engage the side surfaces 55*a*, 55*b*, respectively, of the breech cap engagement mount 56 when the hammer slide 29 is placed in tandem engagement with the latter. This engagement of pins 93, 94 is to prevent any rotative movement of the hammer slide with respect to the adapter 21 when the tool has been assembled. It will be noted that the annular location of pins 93, 94 is such that the longitudinally extending action bar slot 95 in the hammer slide 29 will be finally oriented in the vertical plane of the tool, in line with the pivotal movement of the handle 34. When the pins 93, 94 are in place and the hammer slide 29 has been assembled to the breech cap 26, as aforesaid, the hammer slide is first brought into abutting relationship with the breech cap engagement mount 56, with pins 93, 94 in engagement with the surfaces 55*a*, 55*b*, whereupon the breech cap 26 is threaded onto its engagement mount 56 until its interior shoulder 92 is tight against the hammer slide flange 90.

Next, the action bar 96 of the tool, which provides the cocking and triggering action as will be described, is positioned over the longitudinal slot 95 of the hammer slide 29, its laterally extending slide pin 97 resting on the upper, outer surface of the latter so that the hammer engagement protrusion 98 at the end of the action bar, as shown, will extend through the slot 95 into the interior of the hammer slide 29 when the tool has been finally assembled. The hammer slide cover 32 has a longitudinally extending slot 99 and an associated grooved recess 100 thereunder, both of which are open at their muzzle-facing ends, and it is seen that the cover 32 may be slid into place, surrounding hammer slide 29 and against the rearward-facing end of muzzle cap 26, so that the main body portion of the action bar will protrude through the slot 99 and the grooved recess will enclose the action bar slide pin 97. Thus, the grooved recess 100, together with the upper, outer surface of the hammer slide 29 above its slot 95, and the upper interior shoulder surface under the slot 99 of the slide cover 32, provides a slide passage for the slide pin 97 to guide the slidable movement of this end of action bar **96** for the purpose of cocking and triggering the tool as will be described.

The hammer **30** has a flange portion **101** at its rearward end which presents a muzzle-facing shoulder surface **102** for engaging the hammer engagement protrusion **98** of the action bar **96**. The hammer **30** also has an axial bore **103** for receiving an end of a hammer guide **104** which is attached as by pin **105** (FIGURES 2 and 3) to extend therefrom through the guide aperture **106** of the cap **31** when the tool is assembled. At the rearward end of the bore **103** there is a widened bore **107** to provide an interior shoulder surface **108** for abutment of the end of a coil type hammer compression spring **109**. The hammer guide **104** and hammer **30** are assembled and, after the hammer guide cover **32** is in place surrounding the hammer slide **29** with the main body portion of action bar **96** also protruding through its slot **99**, the hammer assembly is slid into the tubular hollow of the hammer slide, the hammer spring **109** is placed over the hammer guide **104** into abutting relationship with shoulder **108**, and the cap **31**, which has interior threads **110**, is threaded on to the exterior threads **111** at the rearward end of the hammer slide **29**. It will be noted that the muzzle-facing end of cap **31** will then be in abutment with the rearward end of the hammer slide cover **32** so as to secure this member in place. It will also be noted that the hammer spring **109** will be held in place by cap **31**, between the hammer shoulder **108** and the interior shoulder **112** of the cap **31**, so that the hammer **30** resides against the firing pin **28** which protrudes into the interior of the hammer slide at the muzzle facing end of the latter. It will be observed from FIGURE 3 that the vertical plane of the hammer shoulder surface **102** normally resides rearwardly of the forward end of slots **95** and **99** a distance sufficient to permit the protrusion **98** to engage shoulder **102** for the purpose of initiating the cocking action of the tool when the action bar has been slidably located to this end of the slots in response to counterclockwise rotation of handle **34**.

Before attaching handle **34** to the tool, the die cam **59** should be attached for slidable movement in the slots **53**, **50** of the adapter **21**. The arrangement and construction of die cam **59** is best understood from FIGURES 3 and 4 wherein it is shown that a longitudinal and laterally extending interior slot **113** is formed therein, and through which is passed the die cam slide pin **114**. The latter extends across the slot **53** of adapter cylindrical portion **51**, residing in press fit engagement in the aligned drill holes **115** thereof (FIGURES 4 and 6). Another laterally extending die cam guide pin **116** extends across the central cylinder portion **49**, at the level of the bottom **50***a* of slot **50**, to tangentially engage the lower surface **59***b* of the die cam **59**. This pin **116** is press fit into aligned drill holes **117** of the central cylindrical portion **49**. When these pins are in place, the die cam **59** is fully attached.

As more clearly shown in FIGURE 3 and 4, the die cam **59** has a longitudinally extending vertical slot **118** formed at its breech end, and across which there extends the die cam extension retainer pin **119**. The die cam **59** also has a downwardly protruding lip portion **120** at its muzzle-facing end for engaging a muzzle-facing shoulder surface **121** formed by a flange **122** on the carrier **24** to retract the carrier during tool action, as will be seen.

The hinge **36**, which has a vertically extending slot **123** therethrough (FIGURES 3 and 6), is attached to the adapter central cylindrical portion **49**, as by pins **124**, **125** which are press fit into the corresponding and aligned drill holes **126**, **127** and which extend across slot **50** above the slide passage for die cam **59**.

A die cam extension **128** is attached to a handle cam portion **129** of handle **34**, as by its extension into a bore **130** of the handle cam and provision of an attachment pin **131** through bore **130** and the contained end of the die cam extension **128**. As shown in the drawings, the bore **130**, and thus the die cam extension **128** extends at an angle with respect to the underside of the handle cam **129** and is in line with the location of the hinge pin **35**.

It should be noted that the handle cam portion **129** has a bevel **132** which limits the movement in counterclockwise direction to an angle of about thirty degrees, more or less (depending upon the relative lengths of action bar **96** and die cam extension **128** and the location of hinge pin **35**), the bevel **132** abutting against the flat surface portion **36***a* (FIGURES 1 and 6) of the hinge **36** when in its farthermost pivoted position. It therefore becomes apparent that the slide member **48**, which engages the underside of the handle cam portion, should be assembled on the tool before the handle **34** is attached.

As previously indicated, and by reference to the several figures of the drawings, particularly FIGURES 7–9, the slide **48** is mounted for vertical sliding movement within the bore **133** of the slide mount **55** (FIGURE 6). A slide spring **134**, which is shown to be a coil type compression spring surrounding the slide **48**, normally biases the slide upwardly against the handle cam portion **129** of handle **34**. At its lower end, spring **134** abuts against the flat top surface **55***c* of slide mount **55**, and at its upper end against a spring retainer clip **135** which has been snapped around the shank of the slide **48**, as shown. The slide shank is bent, as at **136**, to provide a handle engagement portion thereof. To limit its upward movement in response to the bias of spring **134**, and to prevent its disengagement from within slide bore **133**, the slide **48** at its lower end has a lower retaining clip **137** snapped thereabout in an appropriate annular groove (not numbered). The location of clip **137** below the flat, underside surface **55***d* of slide mount **55** is a distance which corresponds to the vertical distance of travel of slide **48**, in response to its spring bias, upon counterclockwise rotation of handle **34** to its aforesaid limit of movement, but to assure dependable cylinder indexing action by the slide **48**, as will be described, its actual limit of vertical movement should be determined by the location of clip **137** with respect to the indexing protrusion **76** of the slide cam **77**, the limit of upward vertical movement being determined by abutting contact of clip **137** against the underside **55***d* of slide mount **55**. To prevent rotative movement of the slide **48**, which would cause misalignment of slide cam protrusion **76** with the peripherally disposed cylinder detents **14** as will be seen, a key pin **138** is threaded into a laterally extending hole **139** in slide mount **55** to engage a longitudinally extending key slot **140** formed in the slide **48**, as shown in FIGURES 7–9, for example.

The slide cam **77** resides in a longitudinally extending slide cam slot **141** formed in the shank of the slide **48** on its side which faces cylinder **37**. The cam **77** is pivotally attached at an end thereof, as by a pin **142**, and is spring biased, as by a leaf type cam spring **143**, for pivotal movement of its lower end outwardly of slide **48** towards cylinder **37**. At the lower end of slide cam **77** there is an angulated cam surface **145** for engaging the interior edge **146** of slide mount **55** which is formed by the juncture of vertical slide bore **133** with a lower surface portion of the axial bore **63** of adapter **21**. Upon downward movement of slide **48**, against the bias of its spring **134** in response to clockwise movement of handle **34**, such engagement of cam surface **145** will cause pivotal movement of cam **77**, against the bias of its spring **143**, for a purpose to be described.

The action of the slide **48** and its associated cam **77** during tool operation is best understood by reference to FIGURES 7–10, inclusive. When the handle **34** is in raised position as shown by FIGURE 1, the slide **48** will be in its position of farthermost upward movement, biased by its spring **134** into engagement, by its handle engagement portion **136**, with the underside of the handle cam **129**, the lower clip **137** in contact with the underside surface 55*d* of slide mount **55** as shown in FIGURE 7. During the movement of the handle downwardly to cock the tool for firing, the cam protrusion **76** is urged by its spring **141** into engagement with one of the cylinder detents **147**, which are peripherally disposed on the cylinder **37** and appropriately spaced and located between cartridge chambers **38**, as shown, so that the cylinder **37** will be rotatably indexed a distance corresponding to the distance between any two chambers **38**. The relationship between the extent of protrusion of protruding portion **76**, the angle of the lower cam surface **145**, and the location of the interior edge **146** formed by the juncture of bores **133** and **63** as aforesaid, is such that when a cartridge cylinder **38** has been brought into alignment with the barrel bore **39** (see FIGURE 4 for example), the protrusion **76** will become disengaged from its then associated cylinder detent **147** as illustrated in FIGURE 8. This would normally leave the indexed chamber **38** in line with the bore **39** except that, due to the freely rotatable mounting arrangement of cylinder **37**, the chamber may have a tendency to override its aligned position. To counteract this tendency, and to assure that an indexed chamber **38** will be properly in line with the bore **39** at the time that the tool is fired, there is provided an annularly disposed series of longitudinally extending cylinder detents **148** along the muzzle-facing side of cylinder **37**, each to be engaged in indexing sequence by a detent ball and spring arrangement **149** which resides in a longitudinally extending detent hole **150** formed in the breech end **21***a* of the adapter cylindrical portion **21**, as more clearly illustrated in FIGURES 4, 6, and 10. The bore **150** is appropriately located so that when one of the chambers **38** on the opposite side of cylinder **37** has been aligned with barrel bore **39** by the action of the slide cam **77** on one of the cylinder detents **147**, as aforesaid, the detent ball and spring **149** will be in biased engagement in one of the cylinder detents **148**, as shown in FIGURE 10, to prevent further rotative movement of the cylinder **37** beyond its indexed position. It should be noted that the ball and spring detent arrangement **149** should be assembled in its bore **150** prior to the time when the cylinder **37** is mounted on the tool.

Further downward movement of the handle, from its position as shown by FIGURE 2 wherein the tool is cocked, will cause the tool to fire as will be hereinafter described, but will also cause further movement in downward direction of the slide **48** beyond its downward position shown in FIGURE 8. It is seen, therefore, that when the handle has been moved to its tool firing position wherein the handle **34** has been brought into parallel relation with respect to the main body portion of the tool as shown by FIGURE 3, the slide **48** will have moved to its lowermost position as shown by FIGURE 9 wherein, due to the engagement of the lower cam surface **145** with interior edge **146**, the cam protrusion **76** will have been disengaged from its then associated cylinder detent **147**. After the tool has been fired, and when the handle **34** is again lifted to its "ready" position as shown by FIGURE 1, an upper cam surface **151** of slide cam **77**, which forms the upper edge of the cam protrusion **76**, will slidably engage the outer peripheral surface 37*b* of cylinder **37** between each of the peripheral detents **147** to urge the slide cam **77** against the bias of its spring **143** as the slide **48** moves upwardly in response to the bias of its spring **134**. Thus, during reorienting of the tool to its "ready" position for another swaging operation, the slide cam protrusion **76** will not engage the cylinder detents **147** in a manner which would cause reverse indexing of the cartridge chambers **38**.

After the slide **48** and its associated elements have been mounted on the tool, the handle **34**, which comprises handle cam portion **129** and an attached grip portion **152**, may be attached to the hinge **36** by a suitable hinge pin **35** about which the handle is pivotable. When making the hinge pin connection, it should be observed that the die cam extension **138** must first be positioned in the die cam aperture **153** which is formed by the die cam slot **118** and its associated retainer pin **119**.

After the handle **34** has been attached, the pivot end of the action bar element **96** (which is the end thereof opposite its hammer engagement protrusion **98**) is attached to the handle cam **129** in a slot **154** thereof for pivotal movement about the action bar pivot pin **155** which is appropriately attached extending laterally across slot **154**. When assembling this connection, the action bar spring **156** should be passed over the pin **155** in a manner so that its laterally bent portion **158** of its lower leg portion **157** engages the upper edge of the action bar **96** as shown by the drawings. It is intended that the action bar spring **156** will exert its bias tending to rotate the action bar **96** in clockwise direction, as shown by the drawings, when the handle **34** is lifted, or pivoted in counterclockwise direction to its position shown by FIGURE 1. It therefore becomes apparent from a study of the drawings that the upper leg **159** and lower leg **157** of action bar spring **156** are biased apart and that, to promote the aforesaid action of spring **156**, a spring retainer pin **160** should be attached extending laterally across the handle cam slot **154** in a location so that its underside will engage the upper surface of the upper leg spring portion **159**.

Attachments of the elements at the muzzle end of the tool may now be made, and during the description thereof reference will be had to FIGURES 1 through 4.

A piston diaphragm head member **161** is first attached, as by press fit engagement **162**, to the hollow piston element **23**. The piston **23** and indentor carrier **24** are then assembled in adjustable relationship, as by engagement of external threads **163** of the piston with internal threads **164** of the carrier. It is seen that the threaded connection between the piston and carrier elements permits adjustment of their total length, the parts being held in any predetermined relationship by a lock screw **165** which is threaded into the carrier **24**, along its internal threads **164**, into locking engagement with the forwardmost end of piston **23**. To adjust the overall length of the combined piston and carrier elements, the lock screw **165** needs only to be backed off from engagement against the end of piston **23** whereupon the carrier element can be threaded the desired distance either towards or away from the piston head, and the locking screw **165** may again be brought into locking engagement against the end of the piston.

In assembling the muzzle end elements, the carrier spring **166**, which is a relatively large coil type compression spring, is first inserted through the adapter internal bore **60** into abutting engagement with carrier spring retainer ring **40** on barrel **22**. The piston **23**, with the attached carrier element **24**, is then inserted centrally through the coils of spring **166** into the barrel **22**, the piston head preferably being provided with a coiled wire type compression ring **167**. It will be noted that there will be enough lateral play between the spring **166** and the die cam **59**, owing to the shortness of barrel **22**, so that the end flange **122** of carrier **124** can be conveniently positioned behind the downwardly protruding portion **120** of the die cam for spring biased engagement therewith of the flange surface **121**.

It will be observed from the drawings that the length of barrel **22** is relatively short so that the piston **23** will partially emerge therefrom during the terminal portion of its firing stroke as shown in FIGURE 3, for example. The muzzle end of the barrel **22** also has an internal, annularly disposed chamfer **71**. If the powder gases evolving from an exploding cartridge **42** have not fully expanded by the time the piston has completed its stroke, they may continue to expand through the then relatively short length of peripheral aperture between the piston and barrel into the enlarged region provided by the chamfer **71**, and thence out from the muzzle end of the barrel into the enlarged gas expansion chamber provided by the adapter bore **60**. The presence of piston compression ring **167** will not prevent this action of the expanding gases.

The barrel **22** also has an interiorly located conically shaped bore portion **39***a* which is in communication with the muzzle end of bore **39**, and which conforms in configuration to that of the piston diaphragm **161**. In a normal firing of the tool, these configurations promote a desirable pattern of gas expansion so as to distribute the resulting force more evenly on the piston head surface. Moreover, where relatively large size workpieces are to be swaged, the piston and carrier length may be adjusted, as previously described, so that the piston diaphragm **161** will normally reside within the barrel bore portion **39***a* whereupon the force resulting from the cartridge explosion will be initially concentrated on a smaller piston area so as to substantially increase initial pressure and impart greater impulsive movement to the piston for more effective tool operation.

When the piston, carrier and carrier spring elements have been assembled in the tool, the relatively heavy C-shaped workpiece support **43** is then attached to the adapter **21**, as by engagement of its internal threads **57** with the external threads **52** of the adapter cylindrical portion **51**. It will be observed that internal threads **57** are recessed in relation to the surface of the carrier slide bore **58** of the workpiece support **43** so that, in assembling the workpiece support **43** with adapter **21**, the internal threads **57** will clear the slide surface **168** of the indentor carrier element **24**.

To prevent rotative movement of the carrier **24**, a key **169** engages a longitudinally extending key slot **170** of the carrier, the key **169** being held in position by a key screw **171**.

It is seen that both the indentor carrier **24** and the workpiece support **43** are adapted, as by provision of the respective die apertures **172** and **173** therein, to receive, respectively, the indentor instrumentality **25** and its opposed fixed backing die element **45**. As illustrated in the drawings, the indentor and its backing die element comprise a swaging die pair which may be of any standard construction. Apertures **172, 173** are configured conventionally for appropriately attaching the opposed dies to the respective tool elements. Attachment of one such set of standard dies includes provision of die abutment means **174, 175** in the tool to prevent rotative movement of each die element by abutting engagement with die shoulder elements **176, 177**, respectively, when each die in the pair is positioned in the tool. Each die is semi-cylindrical in shape and is inserted in the tool in lateral direction from a side thereof to reside in correspondingly configured die apertures as, for example, the die apertures **172, 173**. To hold the dies in their respective tool elements, each die may have a centrally located, peripherally extending slot **178, 179**, respectively, which will be engaged by means provided on its associated tool carrier element. In the tool provided by the present invention, these die holding elements comprise a spring biased detent means **180** of the workpiece support **43**, and a spring biased detent means **181** of the indentor carrier **24**. The detent means **180** in workpiece support **43** may be conveniently urged against the bias of its spring **182** out of engagement with die slot **178** by thumb pressure on its associated plunger element **183**. The plunger is biased, as by its spring **184**, away from engagement with detent means **180**, and has a beveled end surface **185** for engaging a correspondingly beveled surface **186** of the detent means **180**, as more clearly shown in FIGURE 3. Thus, vertical movement of the plunger **183** towards the detent means **180** will exert a longitudinal force component on the beveled surface **186** of the detent to cause withdrawal thereof, against the bias of its spring **182**, out of engagement with the slot **178** of its associated die. Another arrangement of the die holding element is afforded by the construction of detent means **181** of the indentor carrier **24**. A ball element **187** is biased by a spring **188** into engagement with its associated die slot **179**. When the die **25** is to be removed, it is simply pressed towards the side of the tool, whereupon the detent means **181** will be retracted against the bias of its spring **188**, by the action of a side edge of the slot **179** on ball **187**, so that the die **25** may be expelled from its die aperture **172**.

To complete the assembly of the tool, the shroud **33** and ejector mechanism **79**, should be attached.

The cross-sectional configuration of the shroud **33** is best shown by FIGURE 7. It is made of aluminum, vulcanized rubber, or similar material to provide a convenient hand grip surface of the tool. Referring to FIGURE 7 and the several illustrated side elevations of the tool, the shroud **33** has an opening **189** at the underside thereof for clearance of the slide **48** and its associated lower clip **137** during downward movement thereof. By additional reference to FIGURE 4 it will be understood that the shroud **33** is also appropriately slotted, as at **190**, for the outward extension through the side thereof of the cartridge chamber cylinder **37** and the ejector mechanism **79**. A shroud butt **191** (FIGURES 1 and 2) encloses the rearward end of the shroud **33** and is attached thereto, as by rivets **192**. The shroud butt is apertured as at **193** to fit over the rearward end of the cap **31** at the end of the hammer guide **29**. The shroud butt also has a handle abutment surface **194** to serve as a stop for the handle **34** in its downward, tool firing movement. The forward end of the shroud **33** is attached to the hinge **36** of the tool as by an extension of the hinge pin 35 (not shown).

The ejector mechanism **79** is suitably attached to the adapter central cylindrical portion **49**, as shown in FIGURE 4, so that its cartridge ejector element **195** will be aligned with a cartridge chamber **38** at the oppsite side of the cylinder **37** from that whereat another chamber **38** has been indexed in front of the barrel bore **39**. The ejector element **195** resides within a guide bore **196** of the ejector body portion **197**, and has an attached plunger portion **198** at one end thereof. At the other end, where it emerges through the smaller bore **199** of the body portion **197**, the ejector element **195** has a stop ring **200** to prevent its full retraction through the smaller bore **199** which would otherwise occur in response to the bias of its associated compression spring **201**. Spring **201** is a coil type which surrounds the ejector element **195** within the bore **196** and extends between the plunger **198** and the abutment shoulder **202**. It is seen that thumb pressure on the plunger **198**, against the bias of spring **201**, will cause projection of the cylinder facing end of the ejector element **195** into the aligned cartridge chamber **38**. If the chamber cover **82** has been rotated so as to open the slot **78** in the cylinder cover **69**, the ejector element **195** can be moved linearly through the interior of a spent cartridge therein and beyond the point of its engagement with the interior surface of the rim **42***a* of the cartridge to partially expel the empty casing through the slot **78** whereupon it may be wholly removed manually. Release of thumb pressure on the plunger portion **198**, of course, will permit the ejector element **195** to retract in response to the bias of its spring **201**, until the stop **200** engages the end surface of the ejector body portion **197**, so as to be clear of the cylinder **37** to permit further indexing rotation of the latter for emptying spent casings in this manner from all of the chambers **38**.

The tool is preconditioned to perform repetitive operations by loading an appropriate number of live cartridges **42** within the cylinder chambers **38**. Loading is effected by inserting the cartridges in succession through cylinder cover slot **78**, the chambers **38** of the cylinder **37** being indexed in succession past slot **78** by thumb pressure exerted tangentially on the knurled peripheral surface **37***b* of the cylinder. When the plurality of chambers **38** have been loaded, the chamber cover **82** is rotated to close the slot **78**, whereupon the tool is ready to perform a sequence of operations.

When a swaging operation is to be performed, the operator grasps the tool placing one hand on the shroud **33** and the other hand on the handle **34**. The handle is first lifted, or pivoted to its fully open position as shown in FIGURE 1 whereupon the indentor instrumentality **25** will be retracted away from its backing die **45** for insertion of the workpiece **46** between the swaging die elements, yet no cocking action of the tool will be effected. Retraction of indentor **25** is effected by the action of the die cam extension **128**, which moves in conjunction with handle **34**, against the die cam pin **119** which forms the rearward edge of the die cam aperture **153** wherein the free end of the die cam extension resides. The die cam **59** will be thereby forced to slide rearwardly, within the adapter slots **53**, **50**, causing its carrier engagement protrusion **120**, which is in engagement against the indentor carrier surface **121**, to exert pressure on the indentor carrier **24** to move the same rearwardly against the bias of carrier spring **166**, thereby also retracting the attached indentor instrumentality **25**. From FIGURE 1 it is seen that when the handle has been pivoted to its fully open position the action bar **96** will also pivot in clockwise direction with respect to handle **34** in response to the bias of spring **156**, causing the action bar slide pin **97** to slide within the grooved recess **100** towards the muzzle end of the tool to bring the action bar protrusion **98** into engagement against shoulder portion **102** of the hammer **30**. The recessed groove **100** has depth sufficient to permit limited vertical movement of the slide pin **97** to permit the protrusion **98** to ride over the end flange of the hammer. Coincidentally with all of these tool reactions, lifting of handle **34** also permits indexing slide **48** to move upwardly, in response to the bias of its spring **134**, to position its slide cam protrusion **76** adjacent that cylinder detent **147** which is below the chamber **38** wherein the live cartridge **42** next to be fired resides. It should be noted that the biasing force of spring **134** may be made sufficient, not only to lift the slide **48** and urge the slide cam surface **151** past the periphery **37*b*** of the cylinder, but also to bias the handle **34** normally to its open position of FIGURE 1 so that the tool is always normally disposed in its "ready" condition.

When a workpiece **46** has been positioned between the swaging die pair **25**, **45**, as indicated by dotted lines in FIGURE 1, the handle **34** is pivoted in clockwise direction to its position as shown in FIGURE 2, which movement of the handle cocks the tool for firing by causing retraction of the firing pin hammer **30** within the hammer slide **29** against the bias of its spring **109** and compression of the latter. This retraction of the hammer **30** is effected by the engagement pressure of the action bar protrusion **98** against the hammer shoulder **102** as the action bar **96** is forced by the handle movement to pivot in counter-clockwise direction, with respect to the handle, against the bias of its spring **156**. This counterclockwise movement of the action bar is due to the offset relationship in longitudinal direction between the respective locations of action bar pivot pin **155** and action bar slide pin **97** when the handle is positioned as shown in FIGURE 1, this relationship always causing the slide pin **97** to slide rearwardly in response to clockwise pivoting of the handle. It is seen from a comparison of FIGURES 2 and 3 that a slight additional distance of clockwise movement of the handle beyond its position shown by FIGURE 2 will cause the action bar protrusion **98** to ride vertically off the hammer shoulder **102**, due to its counterclockwise pivotal movement on the pivot axis provided by slide pin **97**. Hammer **30** will thereupon be released to move in response to the bias of its spring **109**, travelling in forward direction within the hammer guide **29**, to sharply strike the firing pin **28** at its protruding end portion **87** and thereby fire the tool.

It will be noted that as the handle is moved in clockwise direction to its cocked position as shown by FIGURE 2, the die cam extension **128** will also pivot in clockwise direction about the hinge pin **35**, thereby releasing its restraining pressure on die cam pin **119**, and hence upon the indentor carrier **24**, permitting the indentor carrier to move forwardly in response to the bias of its spring **166** until the indentor instrumentality **25** has contacted the workpiece **46**. In this condition, the biasing pressure of carrier spring **166** continues to urge the indentor instrumentality **25** in forward direction, even when the carrier engagement protrusion **120** of die cam **59** has become disengaged from the shoulder **121** of carrier **24** as shown by FIGURE 2, so that the indentor instrumentality **25** exerts clamping pressure on the workpiece **46**, the workpiece being restrained by backing die element **45**. It therefore becomes apparent that clockwise movement of the handle **34** may be momentarily interrupted when the workpiece has been so clamped to permit the tool operator to check the location of the workpiece whereat the impression **47** will be formed. Alternatively, the handle **34** may be moved in a single motion past its position as shown by FIGURE 2 to its fired position as shown by FIGURE 3.

Referring now to FIGURE 8 and by comparison thereof with FIGURE 7, it is seen that coincidentally with the aforesaid tool element reactions upon clockwise movement of the handle **34** to its tool cocking position as shown by FIGURE 2, the cylinder indexing slide **48** will be moved downwardly because of the engagement relation between its handle engagement portion **136** and the underside of handle cam portion **129**.

The bias of slide cam spring **143** urges the slide cam **77** towards cylinder **37** so that, during this downward movement of slide **48**, the protrusion **76** of the slide cam will engage that cylinder detent **147** which is below the cartridge to be fired to cause rotative movement of cylinder **37** only so much as is required to bring that cartridge in line with barrel bore **39**, it being seen from FIGURE 8 that when the cartridge has been so positioned, protrusion **76** will become disengaged from the detent by the action of its lower cam portion **145** on edge **146**. As previously noted, the ball and spring arrangement **149** (FIGURE 10) will engage the cylinder detent **148** when the cartridge has been brought in line with barrel bore **39**, whereupon indexing of the cylinder **37** is complete. Also as previously noted and as shown by FIGURE 9, the indexing slide **48** will continue to move downwardly upon further clockwise pivoting of handle **34** from its "cocked" position as shown by FIGURE 2 to its "fired" position as shown by FIGURE 3. It will be understood upon study of the cylinder indexing means which are provided, in conjunction with the tool elements which cause cocking thereof and clamping of the workpiece in position, that a live cartridge will not be fully indexed into a position in which it may be fired until the tool has been fully cocked for firing. In this connection, it will be observed that the eccentric location of the firing pin **28** with respect to the central longitudinal axis of the tool, which causes the cartridge to be rim fired, contributes to this safety feature.

Movement of the handle **34** fully to its position as shown by FIGURE 3 will release the hammer **30** to fire the tool as previously described. It is seen that the burning powder gases which result from the explosion of the cartridge **42** will expand through the barrel bores **39**, **39*a*** into the interior of the barrel **22** behind the piston head **161** to propel the piston **23**, the attached indentor carrier **24** and, consequently, the indentor instrumentality **25** a short distance forward into the compressible tubular connector **46*a*** to form oppositely disposed swage impressions **47** therein, as determined by the configuration of the indentor instrumentality **25** and its associated backing die element **45**. It will be noted that this forward movement of the carrier will not affect the location of the die cam **59** since, in the cocked position of the tool, the carrier engagement protrusion **120** of the die cam will be located out of engagement and a suitable distance forward of the carrier shoulder **121** corresponding to the distance of movement of the carrier.

By reference to FIGURES 2 and 3, it will be understood that adjustment of the total length of the combined piston **23** and carrier **24** elements, in the manner as previously described, will provide a greater or lesser amount of "boiler space" within the barrel ("boiler space" being that space between the piston head and the breech end of the barrel within which the powder gases will normally expand) which, in turn, results in a lesser or greater amount, respectively, of force being exerted on the piston head by reason of the altered pressure condition of the expanding gases.

It will also be understood that a greater or lesser amount of boiler space is provided in the tool depending upon the diameter of the workpiece **46** which is positioned therein which will determine the distance of forward movement of the indentor, its carrier and, consequently, the piston **23** in response to the bias of carrier spring **166**. This variation is in direct proportion to the greater or lesser amount of energy which will be required to perform an operation on a larger or smaller workpiece. In the case of a "no work shot," the location of the carrier and piston at their forwardmost position when the tool is fired results in a large free volume, or "boiler space" in the barrel with consequent low burning efficiency of the powder charge, low pressure and therefore low energy yield which will protect the tool against self-injury.

The piston **23** has relatively light weight, due to its hollowed construction, as has the hollowed and externally configured carrier element **24**, and therefore these elements present relatively little inertia to be overcome by the expanding powder gases upon firing the tool. This tends to cause a greater amount of the released powder energy to be transmitted and absorbed by the workpiece, as is desired, rather than being used to overcome the inertia of the tool piston and carrier elements, with the result that the initial powder charge may be made smaller. The light weight of the piston and indentor carrier also adds to the convenience with which the tool may be oriented to its "ready" condition since less resistance is offered to the movement of die cam extension **128**. In addition, the relatively massive work-piece support **43** sets up a considerable amount of reaction inertia when the tool is fired, thereby reducing tool "kick."

After the tool has been fired to swage the workpiece, handle **34** is pivoted in counterclockwise direction to its open position of FIGURE 1, whereupon the indentor instrumentality **25** will be retracted by the action of die cam **59** on the indentor carrier **24**, as previously described, so that the swaged workpiece may be conveniently removed or repositioned for another swaging operation. The hammer **30** will remain against firing pin **28**, and it is apparent that there is no possibility that the tool can be accidentally discharged while the handle is in its upward position whereat the die jaws are open since the bias of slide spring **134** and action bar spring **156** tend to prevent cocking and firing of the tool except in response to positive downward movement of the handle. Moreover, although the indexing slide **48** will move upwardly, the cylinder **37** will not be rotatively indexed to position another live cartridge in firing position. It is seen that at times when the swaging jaws are open to receive a workpiece, a spent cartridge, rather than a live cartridge, is aligned with firing pin **28** and there is no chance that the tool can be discharged while the handle is in upward position.

When the workpiece has been repositioned, or a new workpiece has been properly positioned between the swaging die jaws of the tool, a simple downward movement of the handle **34** will effect another swaging thereof. Because of the plurality of live cartridges already placed

in the tool, the tool is capable of repetitive operation over a somewhat prolonged series of swaging operations, and there is no need to reload the tool after each firing.

Thus an explosively actuated tool has been described which achieves all of the objects of the invention.

What is claimed is:

1. In an explosively actuated tool, the improvement comprising a barrel, a cylinder having a plurality of annularly and longitudinally disposed cartridge receiving chambers, said cylinder being rotatably mounted at one end of said barrel so that upon rotation thereof each said chamber successively communicates with the interior of said barrel, and tool firing means comprising a hammer mounted for movement between a cocked position and a tool firing position thereof relative to any said chamber communicating with said barrel interior, means normally biasing said hammer into its said tool firing position, a tool actuating handle mounted for movement between a first and a second position thereof, and means connected to said handle for engaging said hammer upon movement of said handle to its said second position whereby movement of said handle from its said second position to its said first position moves said hammer against the bias of its said bias means to its said cocked position and thereafter releases said engagement of the hammer to permit said hammer to move in response to the bias of its said bias means to its said tool firing position, and cylinder indexing means mounted for movement in engagement with said cylinder, said handle engaging said cylinder indexing means whereby, during each successive movement of said handle towards its said first position, said cylinder is rotated by said cylinder indexing means to successively index each said chamber into its said position communicating with the interior of said barrel.

2. In an explosively actuated tool, the improvement according to claim 1 wherein said cylinder has a plurality of circumferentially spaced detents along a peripheral portion thereof respectively correlated one with each of said cartridge receiving chambers, and said cylinder indexing means comprises an indexing slide mounted adjacent said cylinder for substantially tangential slidable movement with respect thereto, said indexing slide carrying a resiliently mounted cam element and means normally biasing said cam element for engagement with any one of said cylinder detents, spring means biasing said indexing slide into its said engagement with said tool actuating handle, and means defining a fixed edge portion of said tool, said cam element including a cam surface in slidable engagement with said fixed edge portion whereby, as each said chamber is so indexed, said cam element is cammed out of its said engagement with said one cylinder detent.

3. In an explosively actuated tool, the improvement comprising a barrel having a breech end and a muzzle end, cartridge receiving chamber means at said breech end communicating with the interior of said barrel, a piston slidable in said barrel, means for limiting the distance of movement of said piston in direction towards said muzzle end of the barrel, yieldable means normally biasing said piston towards its said movement limiting means, cartridge firing means comprising a hammer mounted for movement between a cocked position and a tool firing position thereof relative to said cartridge receiving chamber means, means normally biasing said hammer into its said tool firing position, a tool actuating lever mounted for movement between a first position and a second position thereof, and means connected to said lever for engaging said hammer upon movement of said lever to its said second position whereby movement of said lever from its said second position to its said first position moves said hammer against the bias of said bias means to its said cocked position and thereafter releases said engagement of the hammer to permit said hammer to move in response to the bias of its said bias means to its said tool firing position, slidable means engaging said piston, and means on said lever for engaging said slidable means to move said

piston against the bias of said yieldable means towards said breech end of the barrel upon movement of said lever towards its said second position, said means on the lever substantially releasing its said engagement with said slidable means during said movement of the lever towards its said first position to permit said piston to move in response to the bias of said yieldable means towards said muzzle end of the barrel.

4. In an explosively actuated tool, the improvement according to claim 3 wherein said piston has means defining a shoulder facing in the direction of said barrel muzzle end, and said slidable means comprises a die cam mounted for slidable movement parallel to said barrel, said die cam having an oppositely facing shoulder for engaging said piston shoulder and, further, having means defining an aperture, and said means on said lever comprises a lever extension having an end disposed within said aperture of the die cam.

5. In an explosively actuated tool, the improvement according to claim 3 wherein said cartridge receiving chamber means comprises a cylinder having a plurality of annularly and longitudinally disposed cartridge receiving chambers, said cylinder being rotatably mounted so that upon rotation thereof each said chamber successively ecommunicates with the interior of said barrel, and cylinder indexing means mounted for movement in engagement with said cylinder, said tool actuating lever engaging said cylinder indexing means whereby, during each successive movement of said lever towards its said first position, said cylinder is rotated by said cylinder indexing means to successively index each said chamber into its said position communicating with the interior of said barrel.

6. In an explosively actuated tool, the improvement comprising a main body portion having a muzzle end and a bore of enlarged diameter and substantial length extending inwardly from said body portion muzzle end, a barrel having a breech end and a muzzle end and being secured substantially adjacent its breech end to the interior end of said bore so that said barrel muzzle end projects into said enlarged bore, the projecting portion of said barrel having short length relative to the length of said enlarged bore, and said barrel having an outside diameter substantially smaller than the interior diameter of said enlarged bore, means for introducing an expansible fluid under pressure into said barrel at its said breech end, a piston slidable within said barrel in response to expansion of said fluid therewithin, and means including a part of said main body portion providing a large and substantially enclosed fluid expansion chamber exterior of and adjacent to said muzzle end of the barrel, thereby permitting substantial expansion of said fluid to occur within said enclosed fluid expansion chamber upon the effective stroke of said piston having been attained.

7. In an explosively actuated tool, the improvement according to claim 6 wherein a part of said means which provides said enclosed fluid expansion chamber is removably mounted on said main body portion and includes workpiece support means.

References Cited in the file of this patent

UNITED STATES PATENTS

1,326,820	Youdelman	Dec. 30, 1919
2,056,599	Brown	Oct. 6, 1936
2,133,364	Temple	Oct. 18, 1938
2,145,714	Davis	Jan. 31, 1939
2,221,157	Temple	Nov. 12, 1940
2,481,892	Wampler	Sept. 13, 1949
2,518,395	Sopris	Aug. 8, 1950
2,593,231	Wandel	April 15, 1952
2,716,813	Smyres	Sept. 6, 1955
2,848,915	Aitken et al.	Aug. 26, 1958
2,893,279	Haskell et al.	July 7, 1959
2,949,898	Haskell et al.	Aug. 23, 1960
2,976,638	Owens	Mar. 28, 1961

FOREIGN PATENTS

1,036,294	France	April 22, 1953