

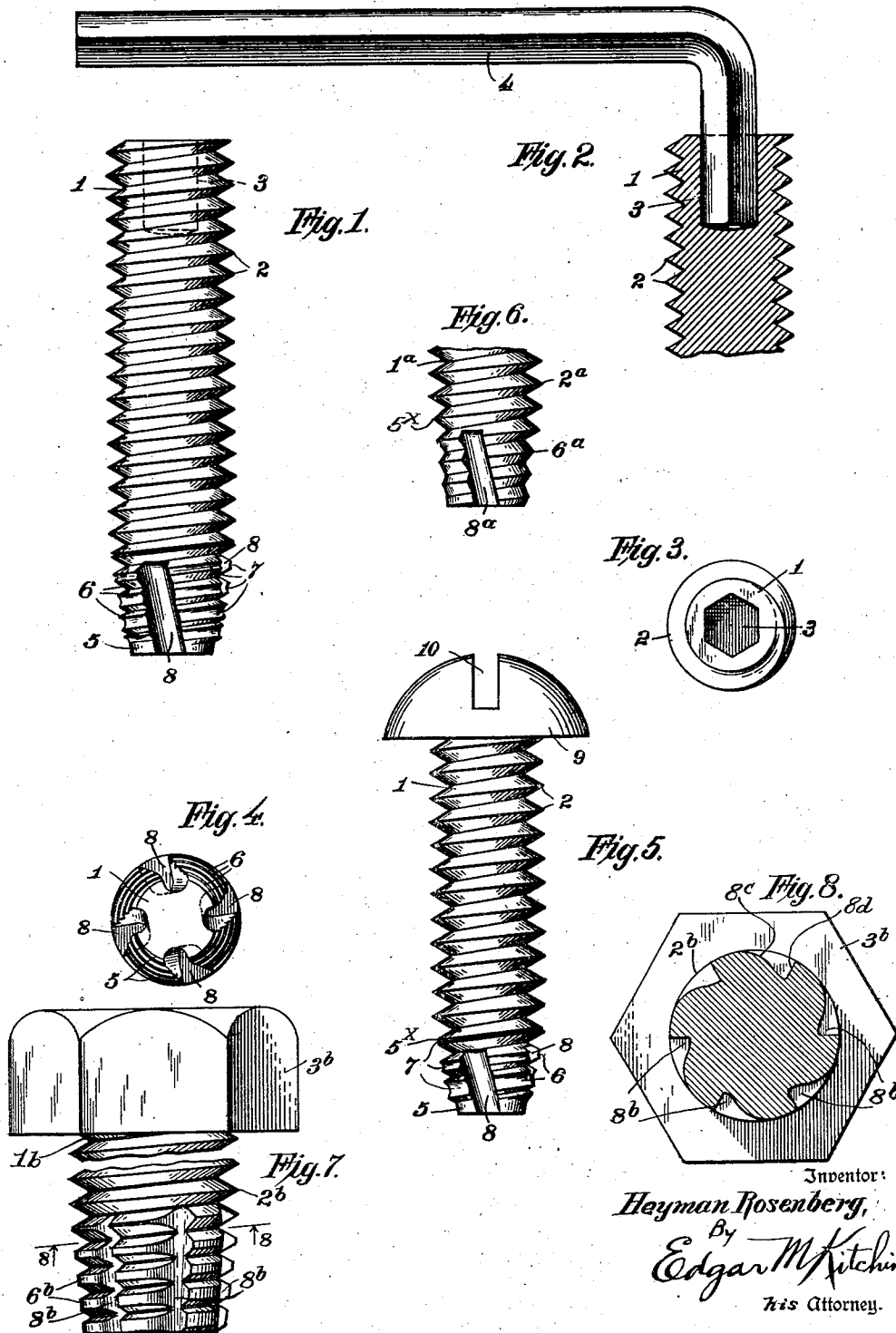
July 4, 1939.

H. ROSENBERG
ANCHORAGE APPARATUS

Filed Feb. 8, 1935

2,165,011

3 Sheets-Sheet 1



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ANCHORAGE APPARATUS
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2,165,011

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Fig. 16.

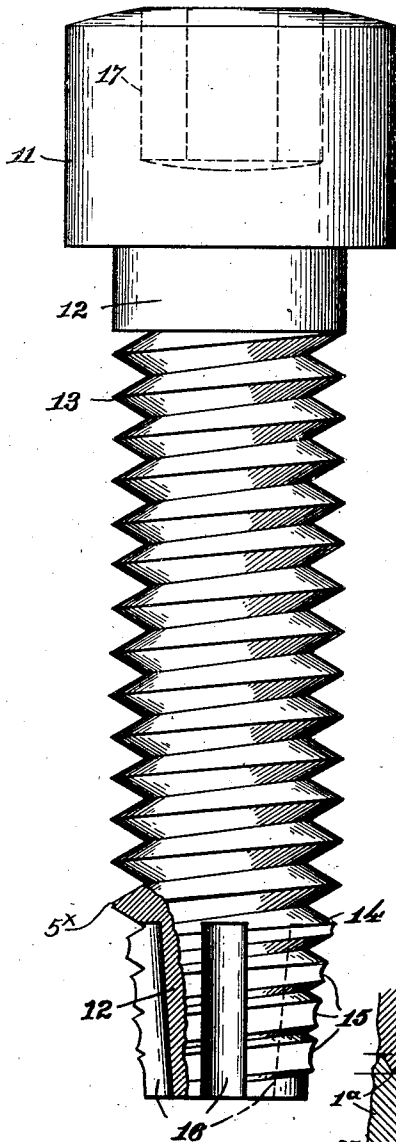


Fig. 17.

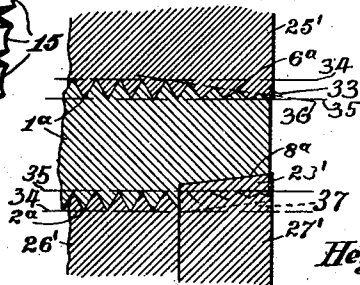
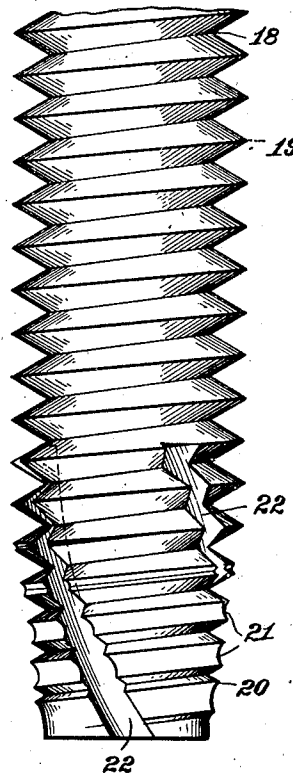


Fig. 6a

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Fig. 9.

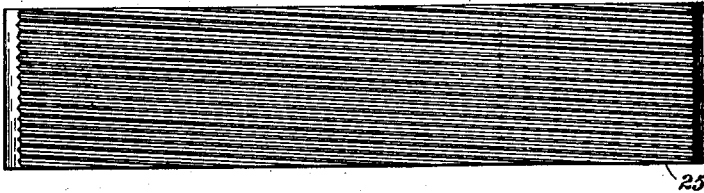


Fig. 10.

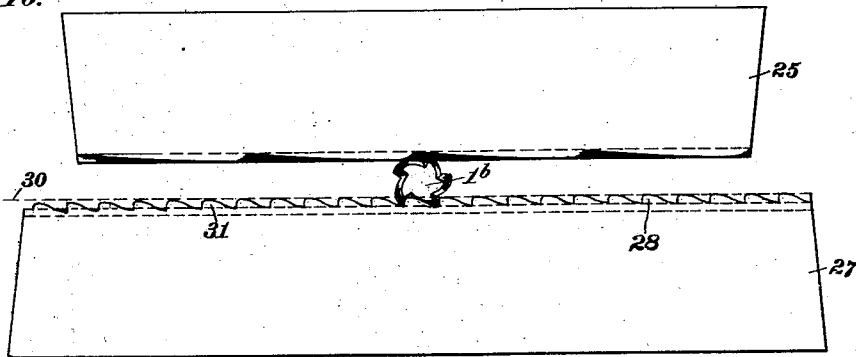


Fig. 11.

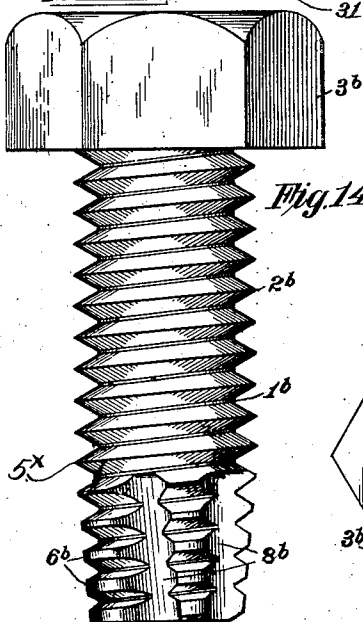
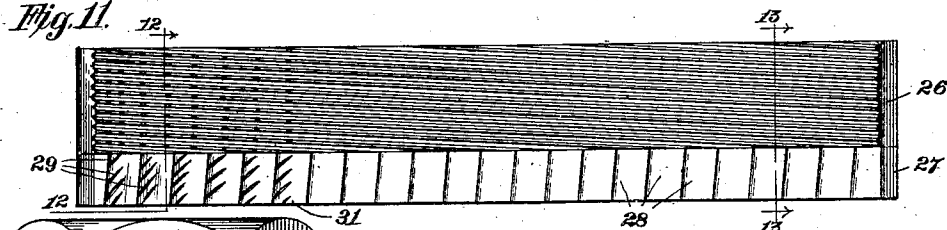


Fig. 12.

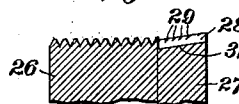


Fig. 13.

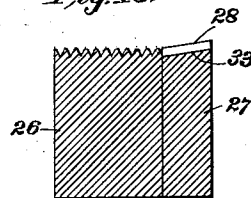
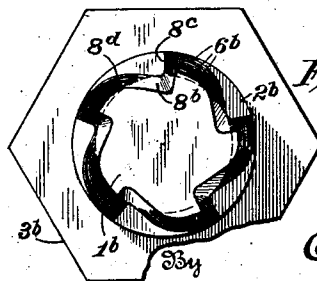


Fig. 15.



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UNITED STATES PATENT OFFICE

2,165,011

ANCHORAGE APPARATUS

Heyman Rosenberg, New York, N. Y.

Application February 8, 1935, Serial No. 5,661

6 Claims. (Cl. 85-47)

In the anchoring of parts of building structures and other fabrications, it has long been standard practice to employ threaded fasteners and to introduce the same, where they are of the machine screw type, by first forming an internal path or thread by the use of a tap or a succession of taps, and then inserting into such path a machine screw designed and adapted to be received therein, and it has also been standard practice, particularly in wood fabrications, to anchor or connect parts together by inserting a screw and causing it to pull itself into the work by rotating it therein without a previously formed opening or a previously formed internal thread, and since the grant of my Patents Nos. 1,299,232 and 1,809,758, and patents on kindred and related inventions, it has become popular practice to form an opening in metal work and insert a hardened thread screw therein without the previous preparation of an internal path of internal thread, and this practice has proved highly satisfactory. The action of the screw in forming its own path while pulling itself into the metal, regardless of its thread pitch, depth or form, may be compared to a wood screw action rather than a machine screw action, but actually differs from both in the performance of the metal work entered and the great capacity of the resulting anchorage to resist loosening of the screw under vibration of the most severe and persistent kind, and also to resist loosening under temperature variations. Automobile and other transport mechanisms that are subject to great and constant vibration during use and, at places such as the engine, to temperature variations, do not cause loosening of such screws.

It is known that whenever a screw of this general type is used, a bore or opening must be formed in the mass or block of the work material, which bore has a sufficiently greater diameter than the root diameter of the screw to be inserted to leave clearance in the valleys between the thread helices to accommodate metal of the work extruded by the thread entering the mass of the work. This difference in diameter between that of the bore in the work and that of the body of the screw affords a clearance without which the torsional strain on the screw would have to be sufficient to actually cause the entered metal to be wholly compressed within the body of the mass of the work, an action that can be accomplished with the fasteners of smaller diameters when inserted in highly malleable metal. But a screw as small as three thirty-seconds of an inch in diameter when inserted without clearance into

mild steel is liable to offer such resistance to rotation as to be very difficult to be forced in, and with the larger screws it is impossible without suitable clearance. The clearance is, of course, made to vary as to size, and it is highly desirable to provide such clearance in each instance as will insure at least some compression of the metal work to set up therein a reactive force causing the work to firmly grip the faces of the thread and hold it against vibration loosening.

To sufficiently limit the torsional stress to which the screw is subject when of the larger diameters to avoid injury to the screw or to the rotating tool or mechanism, quite a little clearance is needed especially for screws of a half-inch diameter or larger. Of course, the greater the clearance provided for a given size, the less the depth to which the screw thread will enter the work. It is, of course, true that the greater the depth of entry of the thread into the work without injury to the screw or to the work, the stronger the anchorage. It is an object of the present invention to increase the depth to which the thread of such a fastener may enter the harder metals (such as soft iron or soft steel) with substantial facility, without danger of twisting off the screw body, without danger of injury of the tool or rotating machine, and, when hand turned, without such resistance to turning movement as to become exhausting to the operator.

A further object in view is the provision of means for cutting away a part of the metal of the work by the fastener of the present invention without cutting away that amount which would produce a complete thread path, so that enough of the body of the work is left along the line of the thread path outline by the cut-away portions to require the full depth thread of the fastener to enter the metal work and flow the metal or compress it to complete the path, so that while the introductory movement of the fastener is accomplished with substantially less resistance for any given depth than is experienced when a screw such as disclosed in my Patent No. 1,809,758, is applied, there is nevertheless a substantial reactive force set up in the metal work against the faces of the entering thread incident to the compression of the surrounding work causing gripping or clamping of the thread and thereby effectively retaining the fastener in its seated position in engagement with the work against vibration loosening.

As seen in my Patent No. 1,465,148, and in various other patents, flutes or cut-away portions have been employed to cause the thread sections

to act somewhat like the cutters of a tap, but where such flutes or cut-away portions extend across a full depth thread, that is a portion of the thread at a helix of maximum outstanding depth, the tendency is to remove so much of the material of the work that the thread path is substantially completed for receiving the thread of the fastener, and little, if any, opportunity is offered for flowing the metal of the work or compressing it to a state having the reactive force mentioned above and desirable to prevent it from vibrating loose after application.

Also, it has been proposed, as shown in my last-named patent and other patents, to provide flutes or grooves by employing cutting or abrading instruments for removing the material to leave such flutes or grooves, but such operations are relatively highly expensive even in quantity production and do not provide the character of finished surface which results from flowing the metal of the fastener before it is hardened to the desired shape including the grooves. Embodiments of screws having longitudinal grooves cut through their thread helices and into the body of the screw as set forth in my last-mentioned patent have not been marketed by me, up to the time of the present invention, though millions of said screws without said grooves have been daily manufactured and marketed by me, because of the expense of cutting the grooves, and no other method of practical production of said grooves was available.

In my co-pending, companion application filed October 23, 1934, Serial No. 749,643, I have illustrated and claimed the production of such grooves by a rolling operation simultaneously with the rolling of the threads on the fastener, and this action in kneading, manipulating, and cold flowing the metal of the fastener body to the grooved condition provides finished walls for the grooves and for the thread terminals along the grooves.

An object of the present invention is provision of a fastener instrument capable of a high degree of efficiency and provided with grooves formed and located to afford maximum efficiency in reducing the labor of inserting the fastener instrument without destroying its capacity of effective anchorage in work capable of resisting vibration loosening, and a further object is the accomplishment of this result by such an instrument having cutting edges provided by the presence of grooves produced without cutting action; and a still further object is the highly efficient condition of such cutting edges incident to the production of the grooves by a metal flowing action and a compression of metal of the fastener before it is hardened, such as by having the grooves formed by a rolling operation.

A still further object in view is the provision of a fastener instrument possessing to a high degree at a very low expense characteristics and capacities of a screw-threaded anchorage device and also of a thread-forming tap, so that the instrument may be used either as a screw for anchoring parts together or as a substitute for a tap for preparing a path to receive another anchorage device.

Also, an object in view is the effective action of the cutter elements produced by the cross grooves, which effective action is enhanced by shaping each of such grooves to have an abrupt wall or shoulder at the side that does the cutting and a rounded or inclined wall flaring, that is opening gradually and rounded, outward like one side of a bell, at the opposite side of the groove

so as to leave a maximum amount of material and provide proportionally great strength of the outstanding parts between closely spaced grooves while affording maximum width of each groove, the greater width of the groove more readily enabling material of the work to expand under compression into the groove in the path of the cutting shoulder during the rotation of the instrument into the work; and a further object is to provide ample space in such a groove to accommodate chips or cuttings of the work material thus entered and severed so as to prevent clogging action of the oncoming threads of the fastener instrument by the presence of the cuttings or chips.

With these and other objects in view as will in part hereinafter become apparent and in part be stated, the invention includes a screw-threaded instrument having a tapered thread portion extending along the leading or entering end portion and interrupted by a groove to produce cutting edges of less outstanding depth than the full outstanding depth of the thread, while the full depth thread is not provided with such cutting edges.

The invention also comprises a fastener instrument of the threaded type having a groove extending across a portion of the thread and formed in the device by compression and flowing of the material of the device as distinguished from cutting.

The invention further comprises a fastener instrument of the threaded type having a groove rolled therein across a portion of the thread and produced simultaneously with the production of the thread.

The invention also comprises certain other novel constructions, combinations, and arrangements of parts as subsequently specified and claimed.

In the accompanying drawings—

Figure 1 is a view in side elevation of a fastener instrument embodying the features of the present invention, the tool-receiving socket being seen in dotted lines.

Figure 2 is a fragmentary, sectional view of the said fastener instrument with the operating tool shown in elevation applied in its operative position.

Figure 3 is an end view of the outer or trailing end of the fastener instrument.

Figure 4 is an end view of the entering or opposite end thereof.

Figure 5 is a view similar to Figure 1 of a slightly modified embodiment of the invention, the parts being seen on a reduced scale.

Figure 6 is a view in side elevation of the entering end portion of a fastener instrument embodying the invention and having a modified form of tapering thread terminal portion.

Figure 6a is a longitudinal section through the screw of Figure 6 showing the rolling dies in cross section completing the screw.

Figure 7 is a view similar to Figure 1 of an instrument incorporating another embodiment of the present invention seen on enlarged scale.

Figure 8 is a cross section therethrough taken approximately on the plane indicated by line 8—8 of Figure 7, and looking toward the trailing or head end.

Figure 9 is a view of an ordinary thread rolling die detached of the type usually employed as the stationary die in an automatic screw-thread rolling machine, the die being seen in elevation as considered in its position in the machine.

Figure 10 is an inverted plan view of the said die in its co-ordinated relation to a co-operating reciprocating die in the position of a partial stroke, a blank being seen therebetween in the course of being rolled.

Figure 11 is a view similar to Figure 9 of the co-operating, reciprocating die.

Figures 12 and 13 are transverse, vertical sections taken respectively on the planes indicated by lines 12—12 and 13—13 of Figure 11.

Figures 14 and 15 are views similar to Figures 7 and 8 of an embodiment having five of the cutter grooves.

Figure 16 is a view similar to Figure 1 of a further embodiment, the parts being seen on a larger scale.

Figure 17 is a view similar to Figure 6 of a still further embodiment.

It is well known that taps are quite expensive instruments, and that, because of the high degree of their tempering or hardening to enable them to function satisfactorily and resist wear, they break all too easily under comparatively slight unusual strain or with any substantial lack of skill in handling. The present invention contemplates the provision of an effective substitute for such a tap by providing an instrument well adapted for forming an internal thread in work of the harder metals, such as soft iron or soft steel, and in cast iron and even in semi-annealed steel having a somewhat higher carbon and manganese content than the usual stock of soft steel. The present improved fastener instrument is here referred to as a substitute for a tap rather than being actually a tap, both because it is preeminently and essentially a permanent fastener not intended to be removed after it has once been inserted, and because it does not tap a thread with a clearance as a tap does, as herein-after pointed out.

Referring to the drawings by numerals, 1 indicates the body of a fastener instrument having the features of one embodiment of the present invention, which body is customarily referred to in shop practice as the root diameter, signifying that diameter measured between lines tangent to the bases of the grooves or valleys between helices of the thread. The body 1 is formed with a thread 2 which may be of any desired cross section or pitch within the range of screw-threaded fasteners known as machine screws, wood screws, studs, bolts, and the like. In this connection it should be understood that a wood screw essentially differs from a machine screw in the character of the intended use rather than in the details of construction or pitch of the thread, since many machine screws, such as those used for starter gears for internal combustion engines, for lathe spindles, for automatic screw-drivers, and for clamps of various kinds, such as carpenter's clamps and clamps for tennis racket frames, are much higher in pitch than the average pitch of the wood screw, though each of these is uniformly recognized as a machine screw. In other words, the present invention is not directed to the cross section of the thread, or the spacing of its helices, which of course involves its pitch, except that the pitch must be sufficiently low to be reasonably available for use by rotation of the fastener instrument for purposes of application as distinguished from the application of a fastener instrument by direct, axially-delivered stress exemplified in a hammer blow. While the body 1 may be provided with any desired or preferred shape of head, one effi-

cient embodiment omits the head altogether, and in lieu thereof is provided with a polysided socket 3 located axially in its outer or trailing end portion and adapted to be engaged by a correspondingly shaped operating tool 4, which tool affords ample leverage for delivering the desired turning stress to the fastener instrument. The entering or leading end of the body 1 in the blank from which the screw is to be made is tapered to provide a cone 5, which is preferably truncated, but may be otherwise constructed as desired. The thread 2 is preferably rolled on said blank and is extended about and along the tapering portion 5 preferably to or substantially to the end thereof in the form of tapering thread helices 6. The carrying out of the rolling operation producing the tapering thread portion 6 causes the material of the blank to flow in the form of the valley between thread helices until said valleys are of the same depth as those where the thread helices are of full outstanding depth. Thus the body or root diameter becomes cylindrical throughout when the thread is completed, except for a very short cone 5 when the thread does not extend entirely to the leading end of the instrument.

Thread helices 6 are tapered only in the dimension of their outstanding depth, and are preferably grooved at 7 along their median line, the groove flaring in the direction of the taper of the thread, or tapering in the converse direction, so as to flare and fade into the body 1 at the entering end thereof, and to taper to the vanishing point at approximately the place of meeting of the tapering thread portion 6 with the full depth thread.

Intersecting the helices 6 are grooves 8, 8, which are preferably of sufficient depth to extend slightly in the body 1, each groove 8 terminating at its outer or trailing end short of the first full depth helix of thread 2 and leaving an unbroken tapered thread expanding section 5x intermediate the lower tap section and the upper full-depth-thread or holding section. Each thread helix at each intersection by a groove 8 presents a cutting edge adapted to cut away material engaged by the anchorage instrument. Where it is desired to cause said cutting edges to have a shearing action in the course of rotation of the instrument, each groove 8 is inclined to the major axis of the body 1. The inclination, when employed, is preferably equal to the inclination of the tapering sides of the cone 5, so that each groove 8 is parallel or substantially parallel to a line corresponding to the inclined side of the cone 5 seen in elevation, as seen in Figure 1.

The grooves 8 are preferably produced without removal of any of the material of the work or blank from which the body 1 and its thread 2 are formed, and, to that end, the grooves 8 are preferably produced by being rolled into the instrument as the thread of the instrument is being produced by a rolling operation, as hereinafter briefly set forth, and also after the manner taught in my co-pending, companion application filed October 23, 1934, Serial No. 749,643, the disclosure of which co-pending application is incorporated herein by reference.

The grooves 8 can be produced at substantial added expense by being cut instead of rolled. Of course, a single groove can be cut, whereas a single groove can not be rolled, but the cutting of the stock aside from the added expense, is not preferred because there is no kneading of the material and raw edges as a result, whereas the

rolling operation compresses and kneads the material into a smoothly finished, closely compact condition where the fibers are not severed or presented as a raw edge. The grooves 8 can also be produced by a stamping or punching operation before the rolling of the threads, but this, like the cutting, requires an extra operation with added expense and has the decided drawback of leaving or being likely to leave extruded material as rough edges and flanges at the intersections of the grooves and threads. The production of grooves 8 by rolling while the thread is being rolled is thus far preferable to any other mode of production both for economy and superiority of results, and in the matter of economy makes possible a commercial production not heretofore available because of prohibitive cost of cutting grooves.

In Figure 5 is illustrated a further embodiment of the invention which differs from that above described only in that the head 9 is employed, and, of course, the socket 3 is therefore omitted. Obviously, the head 9 may be given any appropriate shape for receiving a tool, and the kerf 10, seen in Figure 5, is but one illustrative instance of tool-receiving means of the head 9. As the balance of the structure seen in Figure 5 is identical with that just above described, the same reference numerals have been applied to the drawings and the same description equally applies.

In Figures 6 and 6a, 1a indicates the body of the screw or fastener instrument having the full depth thread 2a and at the entering end portion having the tapering thread 6a tapering to the vanishing point in the body of the screw. Grooves 8a are formed, as by rolling or stamping, in the tapering portion of the fastener blank, and as many of such grooves are provided as desired. The structure of Figures 6 and 6a, therefore, aside from the groove 7 of the structure seen in Figure 1, corresponds identically with the latter structure with the further exception that a less number than four grooves 8a is indicated.

Screw 1a is thus the same as the fasteners of Figures 1 to 5 inclusive except that the groove 7 is omitted, a condition that is brought about by employing a die 25' similar to that used for rolling the screws of the other figures except that that edge portion 33 of the die corresponding to the leading or entering end of the fastener 1a is not flat but, as seen in Figure 6a, inclined toward the face of the opposing die sufficiently to correspond to the taper of the entering portion of the blank being rolled, the die 25' being provided with the corresponding thread-forming tapering ridges to produce the desired tapering thread 6a. As seen in Figure 6a, the inclined portion 33 inclines at the angle indicated by the diagonal dash line 36 extending from dash line 34 to its parallel dash line 35. Line 34 is tangent to the several outstanding edges of full depth thread helices 2a. Of course, the opposing die 26', with its cooperating edge part 27', has its corresponding edge portion 37 correspondingly and oppositely inclined, and its groove-forming teeth or ridges 28' correspondingly inclined. Die section 27' while usually made separate from the die body 26' is arranged to coordinate as a unit therewith, and these two parts with die 25' function the same as the corresponding parts herein-after described with respect to Figures 9, 10, and 11, except for the spacing of teeth 28' and the inclined edge 37.

The operation of fastener 1a differs from that of fastener 1 in that the tapered thread 6a does

not as readily engage and afford a "draw" under rotation, and in that the cutting edges of thread sections 6a cut away a greater quantity of material of the surrounding work incident to any given movement. Accordingly, fastener 1a is inserted with the necessary exercise of greater effort, but, after insertion, maintains anchorage with equal efficiency.

In Figures 7 and 8 is illustrated a further embodiment of the invention which differs from those above described, and particularly Figures 1 to 4 inclusive, in the contour and relative locations and number of the rolled grooves and the fact that the entering end portion of the thread is not itself grooved, but it should be understood that the embodiment of Figures 7 and 8 may well include, when desired, a groove similar to groove 7, and the longitudinal grooves may also be set at an angle when desired. In Figure 7 and 8, the structure includes a fastener instrument having a body 1b, a thread 2b, and a head 3b at the trailing end. The leading or entering end of the body 1b is formed with a thread portion 6b that tapers from the full depth thread to a position blending into the body, after the manner of the taper of the thread portion 6 or the thread portion 6a of Figures 1 and 6 respectively. The said leading or entering end portion is provided with a series of grooves 8b corresponding to the grooves 8, but differing therefrom in the form or contour of the grooves, that is differing in cross section. As clearly seen in Figure 8, each groove 8b is so shaped that one of its sides presents an abrupt, substantially radial shoulder 8c, and the other side is rounded off to provide a rounded tapering or inclined surface 8d, so that the material of work being entered by the improved fastener instrument will have an opportunity to expand or spring inward into the groove along the inclined or rounded surface 8d, and thereby place itself in the path of the cutting edges of the sections of thread 8b at the place of the shoulder 8c. This action, of course, is repeated for each groove 8b. Each of the grooves 8b is preferably of a sufficient size and depth to accommodate such cuttings or chips as are removed from the work entered that might otherwise clog in the thread channel or valley as the balance of the instrument enters the work.

The body 1b in the finished instrument is cylindrical as described above respecting body 1 of Figure 1. Of course, a tapered leading end portion may readily be provided, as seen in my Patent No. 1,827,615. While the thread section 6b is shown as tapered incident to reduction in the outstanding depth of the thread and a resulting flattening of the exposed edge of the thread, the thread section 6b may well be brought to an edge such as 6a in Figure 6, or provided with the grooves 7 of Figure 1, when and as desired or preferred. The number of grooves 8b is shown as six, but such number may be increased or decreased as preferred, but I find that six grooves require a condition and form of rolling die that affords especially satisfactory balance and effectiveness in the rolling operation. Aside from the desirability of the larger number of grooves 8b or corresponding grooves to facilitate ease and effectiveness of rolling, the number of grooves may vary from two upward, since it is impossible to roll a single groove.

In Figures 14 and 15 is illustrated a further very slight modification from the fastener instrument of Figures 7 and 8 in that in the latter the grooves are six in number, whereas only five

grooves are seen in Figures 14 and 15. The same description equally applies, but for this slight variation, and the same reference numerals are, therefore, employed. In Figure 15 is seen an end view that adds to the clearness of the showing of the tapering thread on a cylindrical body. Also, Figures 14 and 15 specifically illustrate the product of the dies seen in Figures 9 to 13 inclusive, and hereinafter described. Similar dies are used for rolling the fastener instrument of Figures 7 and 8, identical in details except for six instead of five teeth or projections to a series to represent the complete circumference of the blank to be rolled.

In Figure 16 is illustrated a fastener incorporating a further embodiment of the invention, differing from Figure 1 chiefly in the fact that the grooves in the entering end portion are not inclined but extend in the general direction of the length of the fastener, and, but for their pitch incident to the taper of the entering end portion of the fastener would be parallel to the major axis of the fastener. This location of the grooves eliminates, or largely eliminates, shearing action and requires the cutting edges to cut away the material of the work by direct thrust. Referring to Figure 16 by numerals, 11 indicates the head of a bolt or like screw 12 having the full depth threads 13 and the tapering thread portion 14 at the entering end of the fastener. The tapering section 14 of the thread is formed with the longitudinal groove 15, and the tapering portion of the fastener is also provided with the grooves 16, 16, extending generally lengthwise of the fastener and intersecting the thread section 14. There may, of course, be as many grooves 16 as desired, and four are indicated in Figure 16. They preferably terminate short of the upper extremity of the tapering thread portion 14 so as to leave material of work entered that must be flowed away by the advancing thread to provide a thread path of sufficient cross section to accommodate the full depth thread section 13. It will be noted that the grooves 16, which correspond to grooves 8, are, like grooves 8, of substantial depth in the body 12 and are of uniform depth throughout their length so as to provide pockets in which chips and cuttings may be deposited and thereby prevented from clogging in the path of the oncoming threads, and interfering with the ready and effective operation thereof. The tapered thread portion 14 corresponds with the portion 6 of Figure 1, and the groove 15 corresponds with the groove 7 thereof. The head 11 may have any appropriate tool-receiving means, such, for instance, as the socket 17 corresponding in contour and function to the socket 3.

In Figure 17 is shown the body portion 18 of a screw embodying features of the present invention and having full depth threads 19 and a leading end having a tapering thread section 20 forming a continuation of the thread 19 and corresponding to thread section 6 of Figure 1. The thread section 20 tapers to blending in the body 18 at its entering end, and is provided with a median groove 21 conversely tapering and corresponding to the groove 7 of Figure 1. Grooves 22 are rolled in the body 18 and are similar to grooves 8, except that they are extended beyond the tapering section 20, and intersect at least one full depth thread. Each groove 22 is otherwise the same as groove 8, being of uniform width and depth.

The present improved anchorage instrument

is constructed as above described preferably of steel or iron and then case-hardened to a condition sufficiently hard for successfully entering the harder metals, such as soft iron or soft steel, or, if desired, steel of the higher carbon and manganese content, and cast iron, substantially without injury, that is without any apparent injury, to the thread 2 and its helices 6 even after repeated use in such metals. Of course, other methods of hardening may be employed, but one preferred method, because of its inexpensiveness and effectiveness, is the well known cyanide hardening by which the fastener, after otherwise being completed, is impregnated with carbon and then while at a high temperature, say in the neighborhood of 1600° F. is suddenly quenched in water or oil or other effective quenching liquid. The hardening operation is preferably carried out after the manner disclosed in any of my Patents Nos. 1,786,508, 1,806,503, and 1,834,872, and their companion patents and co-pending applications not yet patented, or by any other acceptable art or process whereby the threads 2 with their helices 6 and corresponding treads are conditioned to withstand the strain and wear of introduction into the harder metals, and also to withstand repeated introductions therein.

Thus, the anchorage instrument is well adapted for use either as a threaded fastener for anchorage in the harder metals, or for an anchorage device or fastener for permanently and dependably connecting two parts of such metal work together, or for forming internal threads in such work to receive screws having a thread formation corresponding to the full depth thread. Hence, the present improved anchorage instrument is not only a screw-threaded fastener, but is also a very inexpensive and efficient substitute for a tap, capable of being used somewhat as a tap, removed, and subsequently repeatedly used to be followed by the insertion of the properly threaded screw. Thus the present improved fastener is also well adapted, especially in emergency instances, for use by mechanics as a substitute for a tap to form an internal thread for the introduction of a screw or bolt of the commercial types now popularly used and usually formed of soft iron or soft steel. It is only necessary to back out by reverse rotation the present improved instrument to enable the insertion of an ordinary commercial screw, and the present improved instrument is then ready for another operation. The snug fit of the internal thread against the faces of the thread 2 which resists vibration and temperature variation loosening or other accidental or undesirable shifting of the present improved anchorage instrument does not prevent forcible withdrawal and does not preclude insertion of a commercial screw, but does give the commercial screw a sufficiently snug fit to materially assist in retaining such screw against vibration loosening or accidental withdrawal when the commercial screw is substituted for the present improved device. Accordingly, the present improved anchorage instrument is, in fact, at one and the same time both a screw-threaded fastener and an available substitute for a tap, and can be used as either at will.

The action of the present improved screw, or fastener instrument, is, of course, not that of the true or actual action of a tap because it does not provide for any clearance for the thread of the screw that is to be inserted, and this is true even of the embodiment seen in Figure 17. Of course, a true tapping action always provides for

clearance by forming a thread path slightly larger than the thread of the machine screw that is to be introduced into it. Even a body fit tapping operation does not contemplate any such contact
 5 as results from use of the present improved fastener instrument. The internal thread formed by the action of the present improved fastener instrument is not an actual, tapped thread, but is one that will serve in place of and in certain
 10 respects is superior to a tapped thread. Hence, the present improved fastener instrument is an instrument capable of and adapted to produce a thread path for the introduction of another fastener and also capable of and especially and particularly adapted to provide a thread path for
 15 itself in which it is intended to remain permanently mounted. The characteristic of the thread path produced by it is the stressed-tight fit which is accompanied by a reactance set up in the surrounding material of the work causing such material
 20 to clamp itself against the faces of the thread of the present improved fastener instrument, and thus effectively resist vibration loosening of the engagement. Not only does it resist vibration loosening, but also resists loosening
 25 under temperature variations whether high or low or rapid or slow.

When the present improved fastener instrument is first introduced into work, the operation
 30 preferably consists in providing a bore or passageway in the metal of the work corresponding generally to but slightly greater than the root diameter of the fastener. In fact, ordinarily, unless the metal is especially ductile and susceptible
 35 to compression, and the fastener instrument is of small size, a certain amount of clearance between the walls of the bore prepared in the work and the root diameter 1, 7, etc., must be accorded, and the bore is thus originally made proportionally larger in cross section than the cross
 40 section of the body 1, 1b, etc. Of course, the bore is of less diameter than the diameter measured from a line tangent to the outstanding edges of the full depth thread at one side to a corresponding line at the other side, so that the thread
 45 will have an opportunity to enter the metal of the work. In fact, the bore is usually and preferably of a diameter small enough to allow at least some portions of the tapering thread portion to
 50 engage the surrounding wall and to exert a draw or pull tending to force the anchorage instrument into the work incident to rotation of such instrument. The action of this tapering thread portion is largely that of the correspondingly
 55 grooved portions of thread of my Patents Nos. 1,809,758 and 1,827,615 modified however by the action of the cutting edges incident to the presence of the grooves 8, 8b, 16, and the like, which cutting edges cut away and remove chips, filaments, or particles of material of the surrounding
 60 work so that the thread 2 (and the like) when it reaches the full depth thread does not have to compress and flow away the whole or any very substantial portion of the mass of the
 65 metal work to be entered. Such whole mass must be flowed with the insertion of the screw of my Patents Nos. 1,809,758 and 1,827,615, but instead the full depth thread 2 or corresponding part merely flows away and compresses a comparatively small amount of the metal work to
 70 form a thread path for itself. The amount thus compressed and flowed away however is sufficient to smooth the surface of the engaged work and eliminate any row edges thereof, and is also
 75 enough to create by compression a reactive force

in the surrounding metal work tending to resist entrance and exit of the thread and to clamp the thread wherever it is left. Thus, the capacity to resist vibration and temperature variation
 5 loosening by the present improved fastener instrument when seated in work is similar in principle, though somewhat less in actual effect, to the screws of my Patent No. 1,809,758 or my Patent No. 1,827,615 when seated in work according to
 10 the teachings of those patents. However, the resistance to the entrance of the present improved fastener instrument to its engaged portion is less than said patented screws, while its resistance to loosening is ample for permanent and
 15 dependable connection. The reduction in resistance to entry of thread 2 is due to the removal of some of the material, and has the highly valuable effect of enabling the threads of the present improved anchorage instrument to enter ordinary
 20 soft iron or soft steel to a greater depth and with a less clearance between the surrounding work and the root diameter of the fastener than is possible with the fasteners of the last-named patents. Thus, while the present improved
 25 instrument is efficient and valuable for all sizes, it is especially effective for those sizes employed in heavy thicknesses or blocks of structural iron and steel work. This results, in practice, in enabling use with facility of screws embodying the present invention of larger diameters. For
 30 example, screws one-half, three-quarter, and one inch in diameter and larger embodying the present invention are being highly successfully used in structural iron and steel work, such as building framing and the like.

Repeated demonstrations have proved that the present improved anchorage instrument is capable of readily entering brittle cast iron quite
 35 effectively so as to produce a highly satisfactory anchorage therein or connection thereto without any previous tapping or other treatment of such metal outside of the formation of the requisite bore, and without cracking or other injury to the cast iron work.

Determination of the proper bore for any work can be readily, sufficiently, definitely determined and fixed by a very simple test, though each different size of screw and each different material of the harder metals may and frequently preferably
 45 does require a bore and clearance specifically of its own to give the very best and most highly satisfactory results. In case of doubt, it is wise to give preference, when using the larger sizes of fasteners, to a slightly too large rather than too
 50 small bore, as a too small bore is liable to result in twisting the fastener in two while endeavoring to insert it. If the bore is entirely too large, the great ease of insertion will warn the operator of the fact, and if the bore is larger than actually required but small enough for successful
 55 use, the resistance to entry will indicate that the anchorage is sufficient and may be depended upon. The ideal diameter of bore is that which will, while permitting the screw to enter, at the same time cause the material of the work that enters the spaces or valleys between thread helices
 60 approximately to fill such valleys. But innumerable tests have proved that this ideal result is in no sense a prerequisite for success. Many of the present improved fastener instruments have stood up under the most severe and gruelling
 65 tests of vibration and separation stresses and temperature changes without loosening or giving, and yet which, when cross-cut by emery-wheel grinding (the fastener is too hard to be cut by the
 70
 75

average hack-saw), have been found to have the thread valleys not only not filled but in some instances filled only to a comparatively small extent. The objection to too little filling of the thread valleys is largely because of the resulting strain localized in the outer or free edge portions of thread 2 (or like thread), which should be relieved as much as reasonably possible by employing a thicker screw in the given bore or by employing a smaller bore for the given screw. Because of the wide range of successful use of this type of screw with bores of different diameters, and the desirability of at least approximately proper proportioning of the bore to the screw, a schedule of proper proportions, throughout the range of sizes of screws manufactured by me, has been prepared from scientifically conducted tests and measurements as above indicated, and such schedule is regularly furnished to customers. Yet without this scientific aid and merely from the rule of thumb above suggested of being governed by the resistance to entry of the screw, workmen readily become skilled in employing the proper sizes for the best results, and efficient and satisfactory results are obtained without previous skill or experience.

Production of grooves 8 or the corresponding grooves by rolling simultaneously with rolling of the threads has the advantage of cleaning the grooves and the threads of all burrs or extruded material, so that an efficient, clean, and perfect fastener, or substantially perfect within the needed requirements, is produced at a cost far below the cost of fasteners having a groove or grooves cut or formed therein before or after the rolling operation. The cost of production is thus rendered sufficiently low to enable fastener instruments embodying the present invention to be marketed at the same or substantially the same price as ungrooved, case-hardened rolled thread screws. Hence, these improved screws, which are herein mentioned as "fastener instruments" to indicate their available use both as screws and as substitutes for taps, are, in fact, designed and well adapted for popular use as permanent fasteners for every kind of metal fabrication. The smaller sizes of the fasteners of the present invention are highly efficient for and are extensively used in automobiles and airplanes, boats, ships, and other transport apparatus and elsewhere where vibration in use is practically incessant and where temperature changes are often radical and rapid. The fasteners do not loosen under the severe demands made by such uses.

The present invention is more efficient than a bolt or machine screw and the reason is found in the fact that when a group of machine screws or bolts is applied to hold parts together, it is not practicable, and probably not possible, to tighten each to exactly the same extent that the others are tightened. The tightest one of the group therefore is likely to carry more than its proportional share of the load to the point where it breaks or weakens and thus shifts the load to the next higher bolt which must carry in consequence a disproportionate load. This process of over-straining successive bolts may continue throughout the whole group without any two of them at any time equally sharing the load until the entire fastening is thoroughly weakened even to the shearing point because of this unbalanced condition. Catastrophes and disasters have occurred owing to this problem of structural engineering, and at least one great theater disaster

in the city of Washington was found to be due at least in part to this condition. One of the important advantages of the present invention is its capacity to provide screw-threaded fasteners as substitutes for machine screws and bolts which do not have the defect just indicated. Every fastener embodying the present invention, possibly except that in Figure 17, has such a fit in the engaged work and creates such reactive force in the surrounding metal that each fastener carries its full and substantially equal share of load continuously from the time of its insertion. No shifting of the load and no possibility of successive weakening of fasteners can or does therefore occur.

Reference herein to sizes and size ranges is only illustrative and in no sense restrictive, since, so far as downward limit is known, the invention has proven successful as applied to the smallest sizes capable of being produced by rolled-thread screw machines, so small as to be substantially microscopic in details. As to the upward limit, the largest possible size has not been determined, if there is an upper limit. All market demands for all sizes of screw-threaded fasteners have been successfully supplied, and if there is an upward limit, it will doubtless be found to be in common with all of the well known rolled screws heretofore popular on the market. The range of sizes varies according to use, and the present invention is particularly valuable with the larger sizes of fasteners intended to take the place of rivets, bolts, and machine screws and accomplish the work at less expense and more efficiently.

In operation, as instrument 1 of Figure 1 is screwed in, the engaged, surrounding mass of metal work is slightly compressed by the advancing leading end portion, so that the engaged metal springs or expands into each groove 8, etc., as the leading shoulder of the groove passes. Thus there is work in the path of the trailing shoulder as it advances, and the cutting action takes place. This action is true of all the embodiments above described, but is somewhat accentuated with the fastener instruments of Figures 7 and 8, and 14 and 15 where the grooves have their leading shoulders rounded and provide a wider space for the reaction of the surrounding work in expanding into the path of the trailing shoulder. The form seen in Figures 7 and 8 may, therefore, be considered preferred for many purposes. In operating screw 18, continuing rotation of the screw after reaching the first full depth thread, will cause the cutting action to cut away material of the surrounding work sufficiently to produce an internal thread or thread path to receive the thread 19 of practically the same cross section as the thread 19 without any surrounding work mass to be compressed. Thus, the full depth thread does not act to flow any material out of its path as it approaches, since such material has already been cut away, and therefore the power to resist vibration loosening or loosening under temperature variations is not present as it is when the other embodiments are used. So it is not preferable and often not desirable to use the form of screw 18 where likely to be subjected to vibrations or temperature changes. It is important to note that the grooves 22 are not produced by cutting away, abrading, or otherwise severing material from the fastener blank, but by compressing the material into the body of the blank and into the surrounding threads, so that the surfaces of the grooves 22 and the resulting edges on the ends

of the thread section 20 are smoothed off free from burrs and have that increased density incident to compression of the metal. Also, the fiber of the metal has not been cut and the parts thus acted upon produce the grooves 22 in that superior condition above indicated over a groove formed by cutting and removing material.

In Figures 9, 10, and 11 are seen rolling dies generally of the type disclosed in my above-identified co-pending application Serial No. 749,643, except that the groove-forming portions of the reciprocating die differ in details to provide differences in the form of the grooves in the finished fastener instrument. Reference may be had to my said co-pending application for details of the preferred method of operation of such dies, but it is important to note that by the form of dies seen in Figures 9 to 11 inclusive the abrupt shoulder 8c and the rounded portion 8d at the opposite side of each of the grooves 8b of the fastener instruments of Figures 7 and 8, and 14 and 15 may be produced by a rolling operation. To accomplish this result, the stationary die 25 is of the ordinary form commonly employed for platen rolling screws, while the opposing die or reciprocating die is made up of two sections, one, 26, corresponding in face formation exactly with the face formation of die 25, and the other consisting of a section 27 provided with outstanding teeth 28. Some of the teeth 28 are preferably provided with roughened places 29 to grip the blank to be rolled and aid in effecting the beginning of a rolling operation until the first impressions of the grooves 8b are produced. These beginning teeth 28, as seen in Figure 10, do not have the outstanding depth quite equal to the full outstanding depth of the balance of the teeth 28. The difference in outstanding depth is made particularly clear in Figure 10 by the presence of the dash line 30 which is tangent to the outer extremities of all the teeth 28 that are of the same outstanding depth, but fails to contact with the teeth 28 of less outstanding depth. Thus, one of said teeth indicated at 31 represents the end of the series of teeth of less outstanding depth than the balance, and, between the tooth 31 and the beginning end of the die section 27, the teeth 28 preferably not only outstand a less depth than the balance of the teeth 28, but the outstanding depth varies so as to comprise a taper in the direction from the tooth 31 to the beginning end of the die section 27. This graduated difference in outstanding depth or relative taper increases the ease with which the die grips the blank and begins the formation of grooves. Furthermore, as best seen in Figure 12, as contrasted with Figure 13, the upper end of the base line 32 from which the teeth 28 of less outstanding depth spring is not on a line with and is back of the line of the valleys between the thread groove forming ribs of the section 26; whereas the upper end of the base line 33 of the full outstanding depth teeth 28 is on the line of said valleys, as seen in Figure 13. The term "upper" refers to the position of the die in the machine and the base line end mentioned in each case is that against the section 26. The inward inclination of the base lines 32 and 33 (that is toward the die 25) enables each tooth 28 to outstand the same distance throughout its length and at the same time make a deeper impression at the extreme end of the fastener instrument than at the upper end of the grooves 8b. This result is plainly seen in Figure 15.

It will be observed (as seen in Figure 10) that

each tooth 28 of section 27 of the moving die has one side comparatively short and abrupt, and the other side long and rounded with a taper corresponding to the two sides to be produced in forming the grooves 8b.

The rolling operation is the same as described in my said co-pending application Serial No. 749,643, with the differing result only in respect of the difference in contour of the dies in producing a differently shaped leading or entering end portion for the fastener instrument. The stroke of the moving die 26, 27 across the stationary die 25 with a fastener blank properly started causes the blank to roll as indicated in Figure 10, and thereby produce the thread 2b 15 and thread section 6b and the grooves 8b, all of which are completed when the moving die completes its stroke across the fixed die and allows the thus completely shaped fastener to drop. Of course, the further treatment of the fastener will be carried out as above stated to prepare it for its intended use. It is plain that the die 25 rolls the thread section 6b while the teeth 28 are rolling the grooves 8b, and thus the two are produced at the same time and with a succession of treatments whereby any tendency of an early tooth 28 producing an extrusion in what ought to be a thread valley is met by the action of a thread forming portion of die 25 suppressing or removing such extrusion, and similarly any tendency of an early thread-forming portion of die 25 to produce an extrusion in conflict with any groove 8b will be followed by being suppressed or removed by a later tooth 28. Thus, the finished article is smooth, free from flanges and roughness, and provided with sharply defined and clean edges.

Die section 27 has its teeth spaced for a five-groove grouping, but otherwise the dies of Figures 9 to 11 inclusive could be used for rolling the fastener instrument of Figures 7 and 8. The only change needed for this purpose, assuming the instrument of Figure 7 to be the same diameter as that of Figure 14, is to space the teeth 28 sufficiently closer together so that six of them would occupy the same space which five of them occupies as seen in Figures 10 and 11.

What is claimed is:

1. A threaded fastener of hardened steel adapted to be driven into a bore in iron or steel having a diameter at least as great as the root diameter of the fastener, said fastener including a body, a full depth thread portion on the body of substantially uniform diameter for engaging the work to hold the fastener in place when the fastener is driven home, and a tapered thread portion which increases gradually in diameter through several turns from substantially the root diameter of the fastener to substantially the diameter of the full depth thread, said tapered thread portion comprising a tap section at the smaller end which is intersected by grooves to form a series of cutting faces of progressively increasing height for progressively cutting a thread in the work, and an upper uninterrupted thread expanding section of effective length for deforming the work metal and stressing it progressively to enable the full depth fastener threads to enter the internal thread and hold the walls of the internal thread stressed apart when the fastener is fully applied, the grooves being formed with rounded leading shoulders and abrupt trailing shoulders, the latter shoulders forming the cutting edges.

2. A tapping screw comprising a threaded

shank and tip, the tip only being tapered and having a longitudinal notch confined substantially thereto interrupting the threads; the leading wall of the notch, as regards the advancing direction of rotation of the screw, being gradually convexly rounded to the tops of the threads and the trailing wall of the notch being substantially radial.

3. A tapping screw comprising a threaded shank and tip, the tip only being tapered and having a longitudinal notch confined substantially thereto interrupting the threads, the leading wall of the notch, as regards the advancing direction of the rotation of the screw, being gradually inclined to the tops of the threads and the trailing wall of the notch being abrupt.

4. A tapping screw having a threaded shank and tip, the tip only being tapered and having a longitudinally extending spiral notch confined substantially thereto interrupting the threads, the spiral of the notch being contrary to the helix of the screw, the leading wall of the notch, as regards the advancing direction of rotation of the screw, being gradually inclined from the roots to

the tops of the threads and the trailing wall of the notch being abrupt.

5. A tapping screw having a threaded shank and tip, the tip only being tapered and having a longitudinally extending spiral notch confined substantially thereto interrupting the threads, the spiral of the notch being contrary to the helix of the screw, the leading wall of the notch, as regards the advancing direction of rotation of the screw, being gradually convexly rounded from the roots to the top of the threads and the trailing wall of the notch being abrupt.

6. A tapping screw comprising a threaded shank and tip, the tip only being tapered and having a longitudinal notch interrupting the threads, the leading wall of the notch, as regards the advancing direction of rotation of the screw, being gradually inclined to the tops of the threads and the trailing wall of the notch being abrupt, the tip threads having flat tops which become progressively wider toward the tip extremity and the notch extending up to the first full thread.

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