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[54] **PRODUCTION OF EXTERNALLY THREADED BOLTS OR THE LIKE WITH INTERSECTING RIGHT-HAND AND LEFT-HAND HELICES**

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[51] **Int. Cl.**.. **B21k 5/20**
[58] **Field of Search**................ 76/107 R; 72/88, 469

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[57] **ABSTRACT**

The shanks of metallic bolts are provided with external threads, including intersecting right-hand and left-hand helices, in a thread rolling machine wherein at least one of the dies has a profile which is complementary to the profile of a finished shank so that the right-hand helices are rolled simultaneously with the left-hand helices. The rolling dies are produced by making a master die whose profile is formed by grinding, milling or electrolytic grinding and is thereupon transferred onto the blank of a rolling die by electrolytic sinking or electroerosion.

8 Claims, 6 Drawing Figures

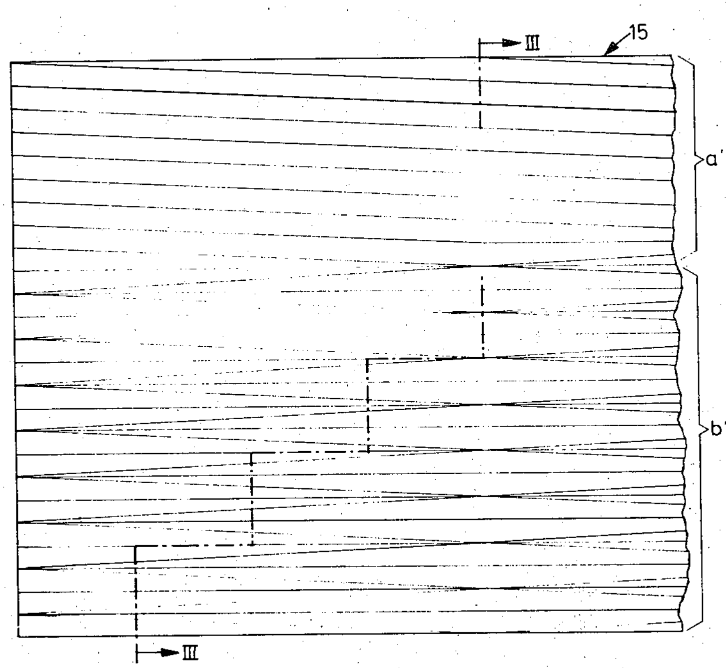
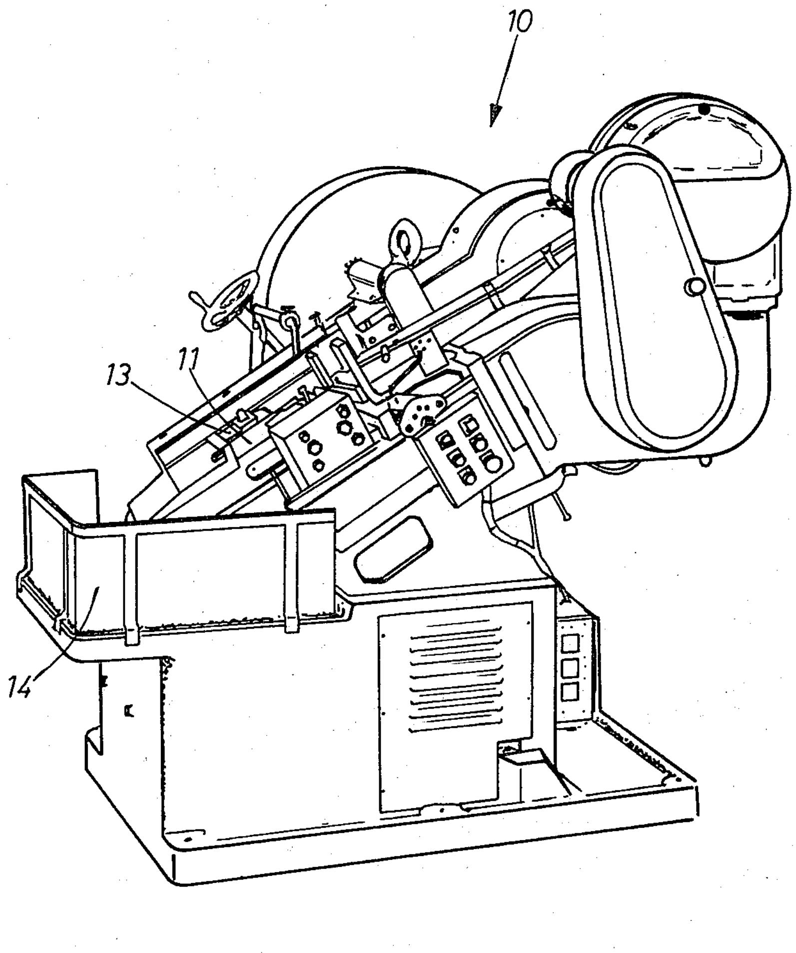


FIG. 1



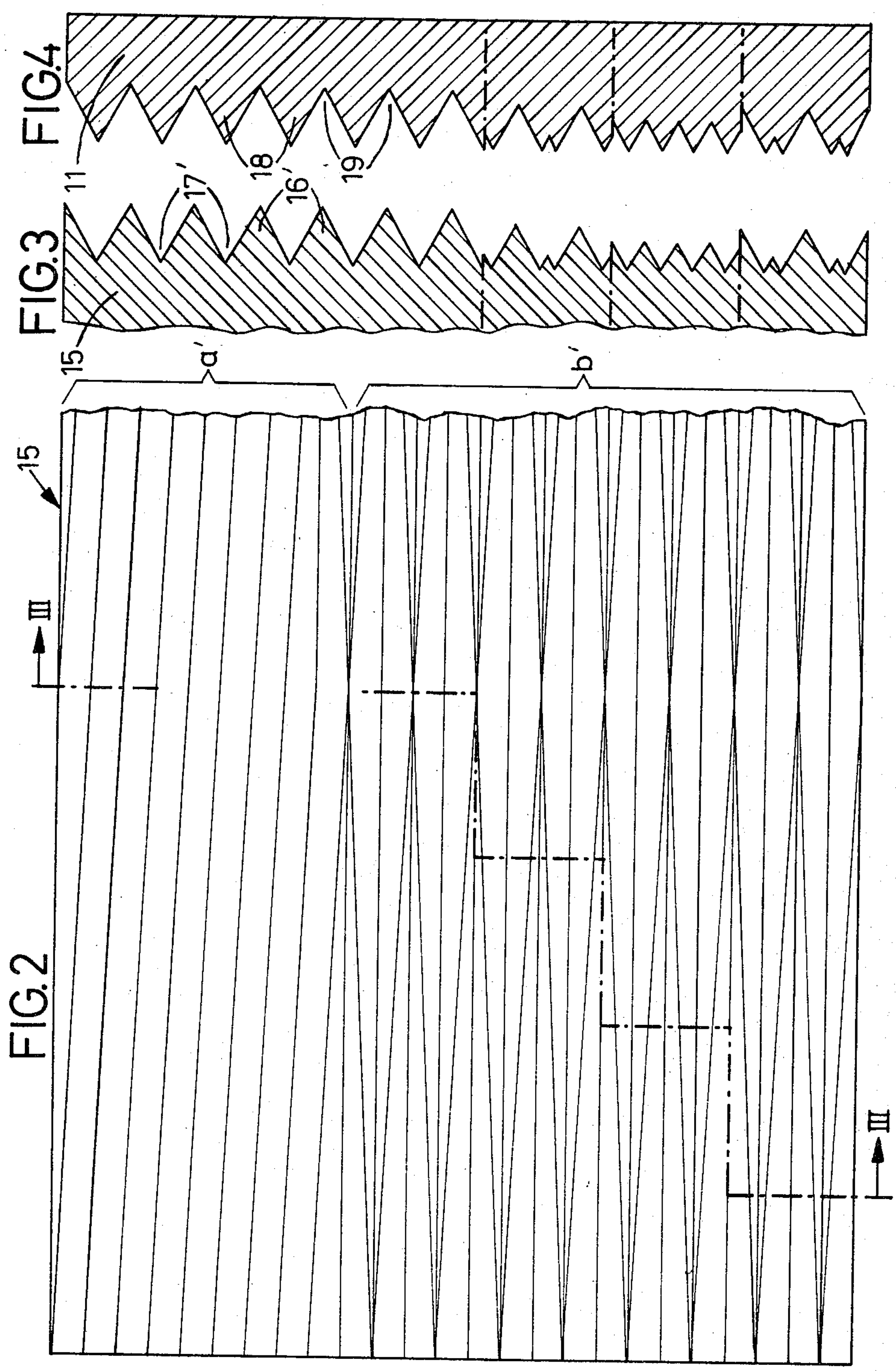


FIG.4
FIG.3
FIG.2
11
17'
18
16'
19
15
a'
b'
III
III

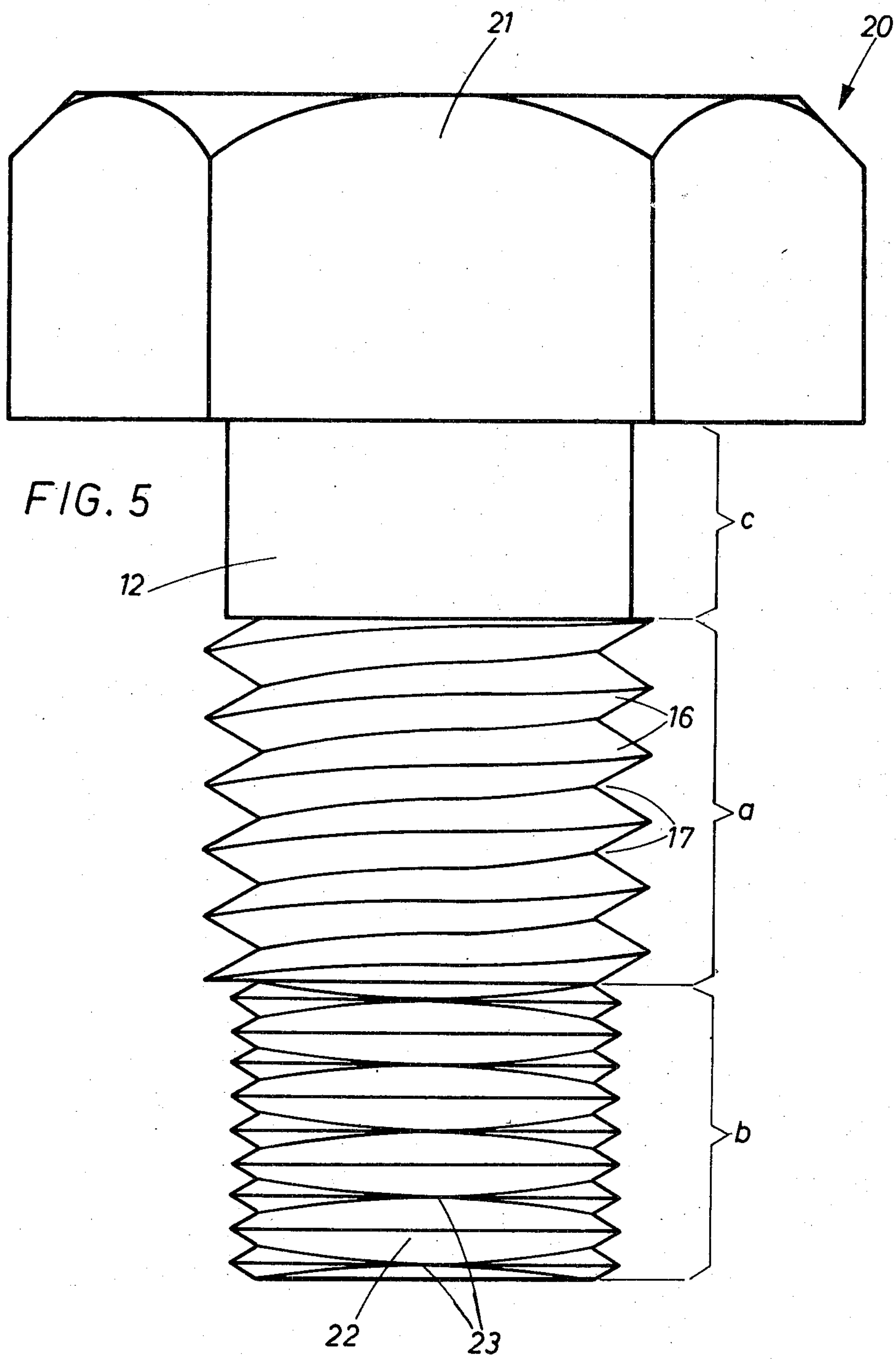


FIG. 5

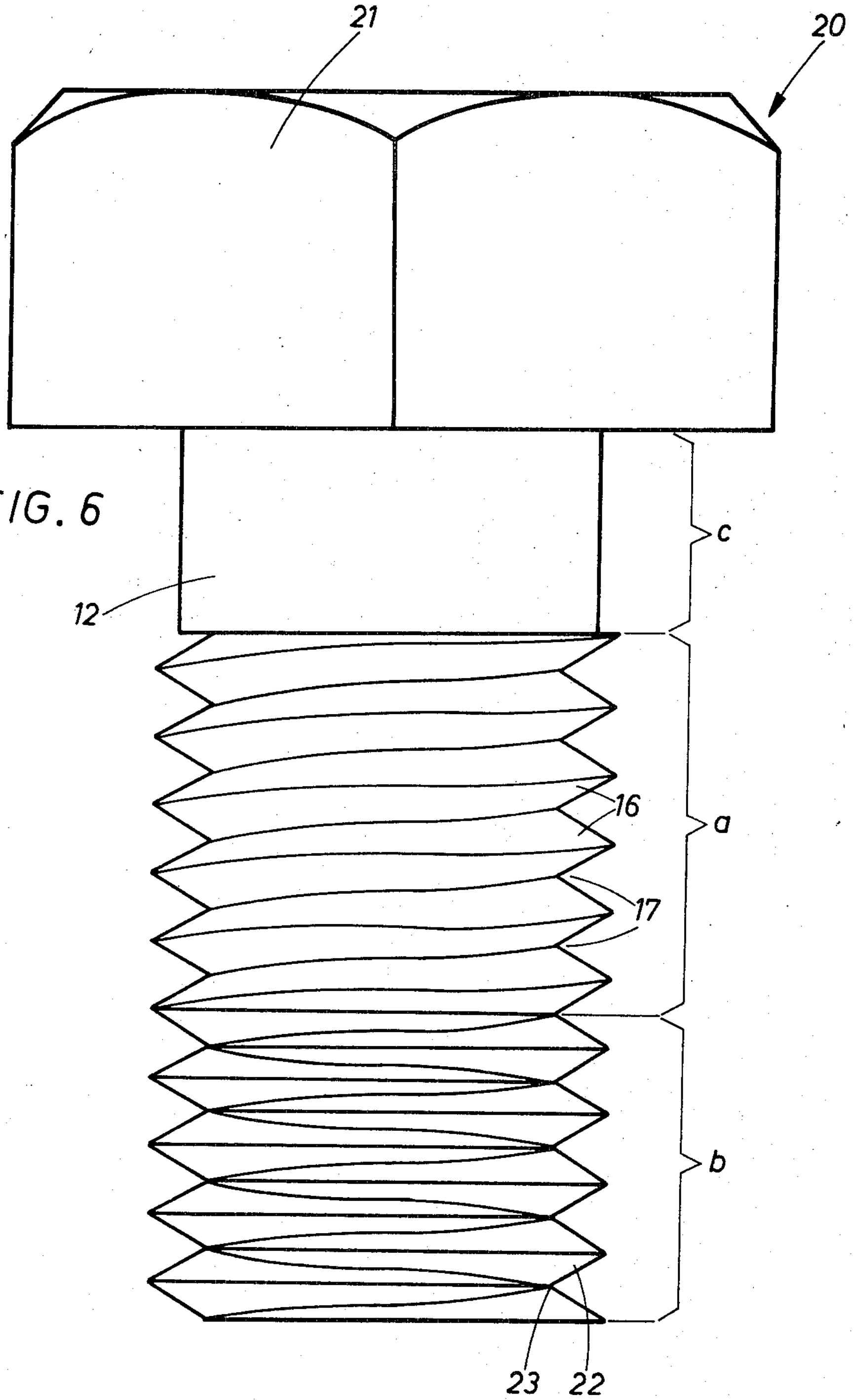


FIG. 6

PRODUCTION OF EXTERNALLY THREADED BOLTS OR THE LIKE WITH INTERSECTING RIGHT-HAND AND LEFT-HAND HELICES

BACKGROUND OF THE INVENTION

The present invention relates to a method of rolling threads on elongated metallic blanks to convert the blanks into externally threaded bolts, feed screws, pins, shafts or analogous articles. More particularly, the invention relates to improvements in a method of converting metallic blanks into bolts or analogous articles (hereinafter called bolts) which are provided, along at least a part of their surfaces, with crossing right-hand and left-hand external threads. The invention further relates to improvements in rolling dies which are used for making of the articles and to a method of producing such rolling dies.

In accordance with presently prevailing practice, bolts or like articles are provided with crossing left-hand and right-hand threads by resorting to a complex and costly grinding, milling or turning operation. Attempts to provide bolts or analogous metallic articles with crossing right-hand and left-hand threads by resorting to thread rolling techniques have failed, mainly due to problems which arise in connection with the making of rolling dies. It was found that the presently utilized procedures for the making of rolling dies which are employed for the rolling of right-hand or left-hand threads on elongated metallic blanks are unsatisfactory for the making of dies which could be used for simultaneous rolling of right-hand and left-hand threads. As a rule, the dies for rolling of left-hand or right-hand threads are obtained by grinding, milling or turning. Such precision-making techniques are desirable because the rolling of threads necessitates the use of precision-finished dies in order to reduce the deviations from standard dimensions, particularly as concerns the tolerances in inclination of surfaces flanking the helical grooves and deviations from a desired lead. In addition to insuring a highly satisfactory reproducibility, a thread rolling operation exhibits a number of further advantages, such as unbroken flow lines, smoothness of the external surfaces of threads, and thread strength due to the cold-working action of thread rolling. Still further, a bolt which is provided with a rolled thread can rotate relative to a mating nut (or vice versa) with a minimum of friction (and hence with the exertion of a neglibigle force) during movement of the nut to its locking position and the bolt can stand higher stresses and longer periods of use than most otherwise produced bolts. The just discussed advantages of bolts which are provided with left-hand or right-hand threads are even more important for bolts having crossing left-hand and right-hand threads because a nut meshing with such a bolt subjects the latter to additional bending and shearing stresses due to uneven distribution of forces acting upon the mating threads.

It was already proposed to form the dies for use in a thread rolling machine which provides blanks with crossing right-hand and left-hand threads by resorting to a precision-finished master bolt. The master bolt was to be used for cold rolling of profiles into the faces of the blanks of rolling dies, and the thus obtained rolling dies were to be used for the rolling of intersecting left-hand and right-hand threads into cylindrical blanks. Flat plate-like blanks of rolling dies were placed at the opposite sides of the master bolt and were caused to roll therealong so that their bolt-engaging surfaces were formed with threads complementary to external threads of the master bolt. It was found that such mode of making rolling dies for use in thread rolling machines is not only impractical but also that the thus obtained rolling dies are incapable of producing satisfactory bolts or like articles with crossing right-hand and left-hand threads. The material of the rolling dies is normally a tool steel which must be hardened subsequent to rolling of profiles by contact with a master bolt in order to insure that the dies can stand the deforming stresses which arise during rolling of threads into metallic blanks. The resistance which a tool steel offers to flow during rolling of a profile into the surface of a die blank is so great that it invariably prevents satisfactory shaping of crossing threads during rolling along a master bolt. If the angle between the surfaces flanking a helical thread is about 60°, repeated rolling of die blanks along the master bolt still fails to impart to the blanks the desirable thread profile which is exactly complementary to the external threads of a master bolt. At the very best, such treatment produces on the dies threads having a height between **33** and **50** percent of the desired height. Furthermore, the hardening of tool steel during rolling progresses at such a rapid rate that a conventional machine cannot furnish the pressures which are needed to urge the blanks of dies against the master bolt with a requisite force. Moreover, the extremely high resistance which the material (tool steel) of the die blanks offers to deformation by cold rolling and the changes in rotational speed of the master bolt invariably cause readily detectable distortion of rolled threads so that the dimensions of threads on articles which are being produced by the thus obtained rolling dies are without an acceptable range of tolerances.

The hardness of the material of a rolling die should exceed the hardness of a blank by at least 40 percent. By the same token, the hardness of the material of a master bolt must exceed the hardness of the material of rolling dies by at least 40 percent. This is a prerequisite which cannot be met in actual practice due to the aforediscussed highly pronounced increase in hardness of the material of die blanks during rolling along a master bolt.

SUMMARY OF THE INVENTION

An object of the invention is to provide a novel and improved method of making externally threaded bolts or like articles with intersecting right-hand and left-hand helices.

Another object of the invention is to provide a novel and improved externally threaded bolt or a like article having intersecting right-hand and left-hand helices.

A further object of the invention is to provide novel and improved dies which can be used for the rolling of external threads into blanks, which are relatively inexpensive and which are provided with intersecting right-hand and left-hand threads.

An additional object of the invention is to provide a novel, improved, relatively simple and inexpensive method of making dies for use in rolling of external threads in blanks to be converted into bolts or analogous articles whereon the external threads form intersecting right-hand and left-hand helices.

A concomitant object of the invention is to provide a machine which utilizes the improved rolling dies.

One feature of the present invention resides in the provision of a method of forming at least a portion of the external surface of a rod-like metallic blank (for example, the shank of a bolt) with first and second threads which respectively include intersecting right-hand and left-hand helices. The method comprises subjecting the aforementioned portion of the external surface of a blank to the rolling action of a plurality of rolling dies which preferably consist of tool steel and at least one of which has a profile with ridges which are complementary to the first and second threads so that the first threads are rolled simultaneously with the second threads.

The method may further comprise the step of rolling into a second portion of the external surface of the blank an external thread constituting an extension or continuation of one of the first and second threads. The second portion of the external surface of the blank is preferably immediately adjacent to the first mentioned portion which is formed with first and second threads, and the rolling of threads into the second portion of the external surface preferably takes place simultaneously with the rolling of first and second threads into the first mentioned portion of the external surface. That portion of the external surface which is to be formed with first and second threads preferably surrounds a part of the blank which has an oval cross-sectional outline.

If only one of the rolling dies has a profile with ridges which are capable of simultaneous rolling of first and second threads, another rolling die is preferably formed with a profile with ridges which are capable of rolling the first or second threads.

Another feature of the invention resides in the provision of a novel rolling die which can be used for simultaneous rolling of first and second threads. The profile of the improved rolling die includes intersecting first and second ridges which, when pressed against the external surface of a rod-like metallic blank, provide the external surface with the first and second threads in response to relative movement between the surface and the profile, i.e., the profile can be in motion while the blank is caused to roll or the profile may be stationary while the external surface of the blank rolls therealong.

A second portion of the profile of the rolling die may further include ridges corresponding to one of the first and second ridges so that a portion of the surface of a blank can be formed with rolled external threads constituting a continuation or extension of one of the first and second threads. The material of the rolling die is preferably a tool steel.

A further feature of the invention resides in the provision of a method of producing rolling dies for simultaneous rolling of intersecting right-hand and left-hand threads into the external surfaces or rod-like metallic blanks. The method comprises the steps of making a master die having a profile which corresponds to the profile of a finished blank (e.g., the externally threaded shank of a bolt), and utilizing the master die for the production of a rolling die having a profile which is complementary to the profile of the master die.

The step of making the master die may include grinding the profile into a blank consisting of tool steel. Also, the step of making the master die may include milling or electrolytically grinding the profile into a blank of the master die.

The aforementioned utilizing or rolling die making step may include electrolytic sinking of the profile of the master die into a blank of the rolling die or profiling the rolling die by electroerosion of the master die.

A further feature of the invention resides in the provision of a novel article of manufacture which is a rod-like metallic member (e.g., the shank of a bolt) having an external surface at least a portion of which is provided with simultaneously rolled first and second threads including intersecting right-hand and left-hand helices.

The external surface of the article may include a second portion which is provided with a right-hand or left-hand thread constituting a continuation of the corresponding thread on that portion which is provided with intersecting right-hand and left-hand helices.

Still further, the external surface of the article may include a third portion which is smooth (i.e., without any threads), and the second portion of the external surface of the article is preferably disposed between the first mentioned and third portions. For example, the first mentioned portion may be located at the free end of the shank of a metallic bolt and the third portion may be adjacent to the head of the bolt.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved dies themselves, however, both as to their construction and the mode of making the same, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a perspective view of a thread-rolling machine utilizing rolling dies which are produced in accordance with the method of the invention;

FIG. **2** is a fragmentary plan view of the profile of a master die;

FIG. **3** is a sectional view as seen in the direction of arrows from the line **III—III** of FIG. **2**;

FIG. **4** is a similar sectional view of a rolling die having a profile which is complementary to the profile of the master die shown in FIG. **2**;

FIG. **5** is a first elevational view of the bolt whose shank is provided with external threads by resorting to rolling dies of the type shown in FIG. **4**; and

FIG. **6** is another elevational view of the bolt.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** shows a reciprocating flat-die thread rolling machine **10**. The exact details of this machine, save for the design and the method of making the flat rolling dies, form no part of the invention. The reciprocating flat die is shown at **11**. The other flat die is fixedly mounted in the frame of the machine **10** and the blanks are fed between the two dies to be provided with intersecting external right-hand and left-hand threads while the illustrated die **11** moves relative to the stationary die. The die **11** is mounted in a carriage or slide **13** which is movable along stationary ways and receives motion from a suitable prime mover. The length of the reciprocating die **11**, as considered in the direction of movement of the carriage **13**, normally exceeds the length of the stationary die. The blanks are delivered between the dies by an automatic feeding mechanism of known design, and the finished bolts **20** (see FIGS. **5–6**) are collected in a magazine **14** into which they preferably descend by gravity.

The dies which are used in the machine of FIG. **1** have profiles which can provide blanks of bolts with external threads including intersecting left-hand and right-hand helices. Such intersecting helices may extend along a portion of or along the entire shank of a metallic blank which is to be converted into a bolt or an analogous article. That portion of a bolt which is not formed with external threads having intersecting left-hand and right-hand helices may be provided only with a left-hand thread or only with a right-hand thread. In actual use of such a bolt, a first nut which surrounds at least some of the intersecting helices can be locked by a second nut which surrounds only that part of the bolt which is formed with left-hand and right-hand threads. It was found that such locking of the first nut is much more likely to prevent loosening in response to vibration, even at very high frequencies and at high amplitudes. When the first nut is locked by the second nut, the locking action furnishes an additional force which insures more uniform stressing of the first nut. When a combination including a bolt which is produced in the machine of FIG. **1**, a first nut which surrounds one or more helices on the bolt portion having intersecting left-hand and right-hand threads and a second nut which also surrounds the portion having left-hand and right-hand threads is subjected to vibratory stresses, a torque which tends to loosen one of the nuts acts counter to the torque tending to loosen the other nut which insures an even more satisfactory locking of the two nuts and excludes any loosening of nuts even if the combination vibrates at a high frequency and at a high amplitude.

At least one of the rolling dies which are used in the machine of FIG. **1** or an analogous machine must be provided with intersecting left-hand and right-hand ridges which are complementary to threads to be formed on the blank. It is preferred at this time to provide both dies with profiles having intersecting left-hand and right-hand ridges so that the rolling of threads into a blank which is placed between the dies is effected by complementary ridges of both dies.

The profile of a rolling die which is to be used to provide blanks with intersecting left-hand and right-hand threads is quite complex and cannot be formed by grinding, milling or an analogous technique. In accordance with the present invention, the making of rolling dies for use in the thread rolling machine involves the making of a master die **15** shown in FIGS. **2** and **3**. The profile of the master die **15** is formed by the just mentioned technique of grinding, milling, electrolytic grinding or the like. The profile of the master die **15** shown in FIGS. **2** and **3** includes a portion *a'* having grooves and ridges corresponding to left-hand or right-hand threads on a finished article. The portion *b'* of the profile of the master die **15** is configurated in a way to insure the formation of intersecting left-hand and right-hand threads on the article. In the shaping of the profile of the master die **15**, the entire surface shown in FIG. **2** is first provided with ridges and grooves corresponding to a right-hand or left-hand thread on the finished article. The partly finished master die **15** is thereupon severed in the plane extending between the portions *a'* and *b'*, and the portion *b'* is thereupon provided with ridges and grooves corresponding to the left-hand or right-hand thread of a finished article. In the next step, the previously severed portions *a'* and *b'* are reunited to form the finished master die **15** shown in FIG. **2.**

As best shown in FIG. **3**, the master die **15** is formed with ridges **16'** which correspond to the threads on a finished article. The grooves **17'** which alternate with the ridges **16'** are of identical depth and are formed by removing from the blank of the master die material by grinding, milling or an analogous procedure.

When the making of the master die **15** is completed, the die **15** is used for the making of rolling dies **11** which are to be utilized in the thread rolling machine of FIG. **1.** The rolling dies **11** can be formed by electrolytic immersion or sinking or by electroerosion. A finished rolling die **11** is formed with ridges **18** and grooves **19** which are respectively complementary to the grooves **17'** and ridges **16'** of the master die **15.** The thus formed rolling die **11** is then ready for use in the machine of FIG. **1** to shape rod-like or similar blanks by rolling into their external surfaces threads which are complementary to the grooves **19**, i.e., to roll threads which correspond to the ridges **16'** of the master die **15.**

If only one of the rolling dies **11** is provided with intersecting left-hand and right-hand ridges, the other rolling die is preferably provided only with left-hand or right-hand ridges. Thus, a blank can be caused to roll between two rolling dies each of which has a profile complementary to the profile shown in FIG. **2** or between a rolling die whose profile is complementary to that of the master die **15** and a rolling die whose profile is simpler than the one shown in FIG. **2** because it exhibits only one type of ridges, namely, left-hand or right-hand ridges.

The simultaneous rolling of first and second threads including intersecting right-hand and left-hand helices is desirable because such procedure insures that the left-hand helices are not deformed as a result of the rolling of right-hand helices, or vice versa. Such deformation of helices could take place if the left-hand helices were rolled prior or subsequent to rolling of the right-hand helices.

The method of making a master die **15** prior to the making of a rolling die **11** and of using the master die **15** for the making of rolling dies **11** exhibits the important advantage that the profiles of the rolling dies can be finished with a high degree of precision which is much higher than if the profile of each of a number of rolling dies were to be formed directly by grinding, milling or a like procedure which is satisfactory for the making of a master die. As mentioned above, if the rolling die is to be used in a machine for the making of bolts having first portions provided with intersecting left-hand and right-hand threads and second portions provided only with right-hand or left-hand threads constituting continuations of similar threads on the first portion, the master die is subdivided subsequent to completion of that portion of the profile which is to correspond to the profile of the first portion of a finished bolt shank and another portion of the profile on the master die is produced prior to uniting the separated portions to form a finished master die. The making of the profile on the master die by grinding, electrolytic grinding or milling has been found to be the least expensive way of making master dies.

The aforediscussed electrolytic sinking has been found to be particularly suited for the profiling of metallic blanks which are to be converted into rolling dies. This procedure insures accurate shaping of the profile independently of the stability of the tool steel of the blank which is to be converted into a rolling die. Also, the profile of the rolling die is formed with a surprising degree of accuracy, the surface finish of the profile on the rolling die is very satisfactory, and the procedure is sufficiently economical for the production of large numbers of rolling dies. The electroerosion has been found to be a satisfactory alternative to the profiling of rolling die blanks by electrolytic sinking.

FIGS. **5** and **6** show two views (in planes making an angle of 90°) of a finished article **20** which is a metallic bolt having a hexagonal head **21** and a shank **12.** The external surface of the shank **12** includes a smooth unthreaded portion *c* immediately adjacent to the head **21,** an end portion *b* which is provided with intersecting left-hand and right-hand threads, and a portion *a* located between the portions *b, c* and having only left-hand or right-hand threads. The right-hand or left-hand threads of the surface portion *a* constitute an uninterrupted continuation of the right-hand or left-hand threads on the surface portion *b*. If the threads on the portion *a* are right-hand threads, the shank **12** can take a first nut (not shown) which is formed with right-hand threads and which can surround the portions *a* and *b* so as to leave the lower part of the end portion *b* exposed. The left-hand threads on the lower part of the portion *b* are then brought into mesh with the left-hand threads of a second nut (not shown). If the second nut is rotated to the extent necessary to bear against the lower end face of the first nut, or if the first nut is rotated in a direction to move its lower end face against the upper end face of the second nut, the two nuts are locked against each other and cannot (or are highly unlikely to) become loose in response to vibration or other movements which would normally result in loosening of the first and/or second nut. As mentioned above, if the first nut (which is assumed to have righthand threads and to mesh with the right-hand threads of the surface portions *a* and *b*) is caused to bear against the second nut or lock nut (which is assumed to have left-hand threads and to mesh with the left-hand threads of the surface portion *b*), such locking is much more reliable than if the first nut were locked by a second nut having right-hand threads (i.e., the same type of threads as the first nut). Both nuts can be rotated simultaneously by means of a single wrench or an analogous tool whereby the second nut moves toward and locks the first nut. Experiments have shown that the thus locked nuts having right-hand and left-hand threads retain their axial positions even if the shank **12** is vibrated at a very high frequency and at very high amplitudes. Also, and as explained above, the force which the second nut exerts against the first nut insures a much more uniform stressing of the first nut, especially if the first nut meshes not only with the right-hand threads of the surface portion *b* but also with the right-hand threads of the surface portion *a*. Any tendency of one of the nuts to become loose results in tightening of the other nut, and vice versa, so that the locking action actually improves, even under circumstances which would normally result in loosening of the nuts.

The material of the bolt **20** can be any of the metals which are customarily employed to make blanks for treatment in conventional thread rolling machines serving to form the shank of a bolt with right-hand or left-hand threads.

A comparison of FIGS. **5** and **6** indicates that the part of the shank **12** which is surrounded by the surface portion *b* has an oval rather than a circular cylindrical cross-sectional outline. Thus, the diameter of that part of the shank **12** which is surrounded by the surface portion *b* is less in FIG. **5** than in FIG. **6.** The root diameter of threads on the surface portion *b* is constant. The oval configuration of the shank part surrounded by the surface portion *b* is due to the fact that the grooves **17** between the left-hand and right-hand threads **16** on the portion *b* intersect each other so that the height of threads **16** decreases in both directions from a maximum value (at **22**) to a minimum value (at **23**) where the grooves **17** between the left-hand and right-hand threads of the surface portion *b* intersect each other. At **23,** the height of the threads **16** is zero.

The width of threads **16** on the shank **12** determines the height of such threads. Thus, the magnitude of stresses which the threads **16** can withstand is a function of their width because the height of threads determines the stresses and the height is a function of the width of threads. The stresses which the shank **12** can withstand also depend on the axial length of nuts which are brought into mesh with the bolt **20.** Thus, if the first nut is one of considerable axial length, it can surround the entire surface portion *a* and a substantial part of the surface portion *b* so that a large number of internal threads on the first nut will made with a large number of external right-hand threads on the surface portions *a* and *b*. This enables the first nut to stand substantial stresses even if the right-hand threads of the surface portions *a* and *b* are rather narrow.

In order to even further reduce the likelihood of damage to or destruction of threads **16** on the shank **12,** the first nut is preferably moves to an axial position in which it mates with all or nearly all right-hand threads of the surface portion *a* and with a small number (for example, one) of right-hand threads on the surface portion on *b*. This leaves nearly the entire surface portion *b* exposed to mate with the second nut (lock nut). Thus, the internal threads of the first nut are then in mesh with the fully defined right-hand threads of the surface portion *a* to thereby insure a highly satisfactory retaining action.

The static and dynamic stresses which can be withstood by that portion of a shank which is provided with first and second threads including intersecting right-hand and left-hand helices are somewhat lower than the stresses which can be taken up by a shank having only right-hand or only left-hand threads. This is due to the fact that the right-hand and left-hand threads intersect each other in a manner as shown in FIG. **5** and that the height of both types of threads decreases in a direction toward the intersection, i.e., each right-hand and each left-hand thread includes a first portion of maximum height and two additional portions which flank the first portion and whose height decreases in a direction away from the first portion. As known, the ability of a threaded shank to stand static and/or dynamic stresses decreases with decreasing height of its threads. As mentioned before, the reduced resistance of threads on the surface portion *b* to static and dynamic stresses can be compensated for by using nuts of greater axial length and/or by using a first nut which mates mainly with the threads of the surface portion *a* and whose internal threads mesh only with one convolution or a few convolutions of the right-hand thread of the surface portion *b* (it being assumed that the thread on the surface portion *a* is a right-hand thread). The fact that the second nut or lock nut meshes only with the threads on the surface portion *b* is of no consequence because the second nut merely serves to prevent loosening of the first nut and the torque which is to be applied to the lock unit is usually between about 18 and 25 percent of the torque which must be applied to the first nut in order to hold it against a body through which the shank **12** of the bolt **20** extends.

The blanks which are to be treated in a machine of FIG. **1** are preferably configurated in such a way that the surface portion *b* of each blank exhibits an oval cross-sectional outline prior to rolling. This insures that the shifting of material of the blank during rolling is uniform in all zones which are surrounded by the surface portion *b* since the portion *b* of the finished shank **12** also exhibits an oval cross-sectional outline. The machine **10** of FIG. **1** is provided with customary means to properly guide a blank during rolling between the stationary die and the reciprocable die. It is further clear that the method of the present invention can be utilized for the making of cylindrical dies in place of flat dies. Also, the blanks which are to be treated in the thread rolling machine can be converted into feed screws, shafts or analogous articles having external threads which form intersecting right-hand and left-hand helices whereby such intersecting helices may be provided on a portion of or on the entire article with the remaining portion of the external surface of the article remaining smooth and/or being provided only with right-hand or left-hand threads.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for var-

ious applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of our contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

We claim:

1. A method of producing rolling dies for simultaneous rolling of intersecting left-hand and right-hand threads into the external surfaces of rod-like metallic blanks, comprising the steps of making a master die having a flat surface and forming in said flat surface a profile corresponding to the profile of a finished blank; and utilizing said master die for the production of rolling dies having profiles complementary to the profile of said master die.

2. A method as defined in claim **1**, wherein said forming step comprises grinding the profile into said flat surface of said master die.

3. A method as defined in claim **1**, wherein said forming step comprises milling the profile into said flat surface of said master die.

4. A method as defined in claim **1**, wherein said forming step comprising electrolytically grinding the profile into said said flat surface master die.

5. A method as defined in claim **1**, wherein said utilizing step includes electrolytik sinking of the profile of said master die into a blank of the rolling die.

6. A method as defined in claim **1**, wherein said utilizing step includes profiling a rolling die by electroerosion of said master die.

7. A method as defined in claim **1**, wherein said rolling dies are flat dies.

8. A method as defined in claim **1**, wherein said rolling dies consist of tool steel.

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