No. 798,352. PATENTED AUG. 29, 1905.

W. A. LEONARD.
THREADING DIE.

APPLICATION FILED APR. 26, 1904.

2 SHEETS—SHEET 1.

Fig. 1

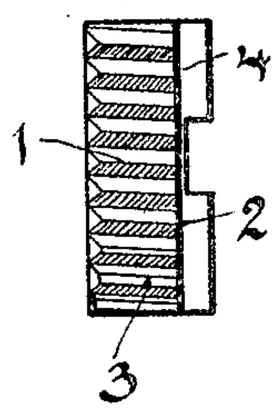


Fig. 2

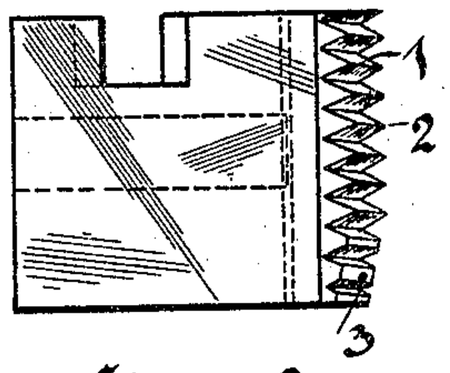


Fig. 4

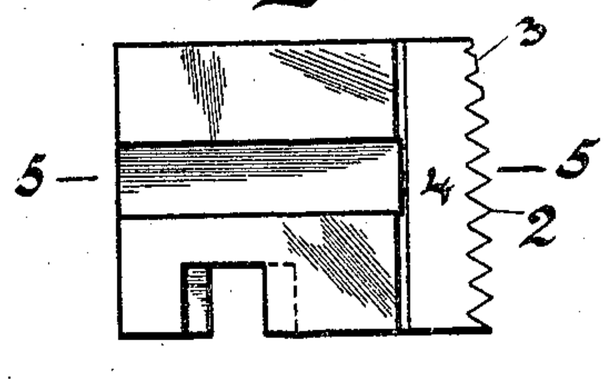


Fig. 3

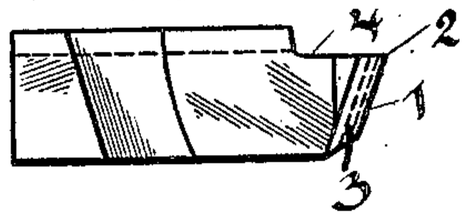


Fig. 5

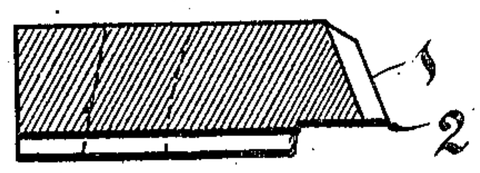


Fig. 6

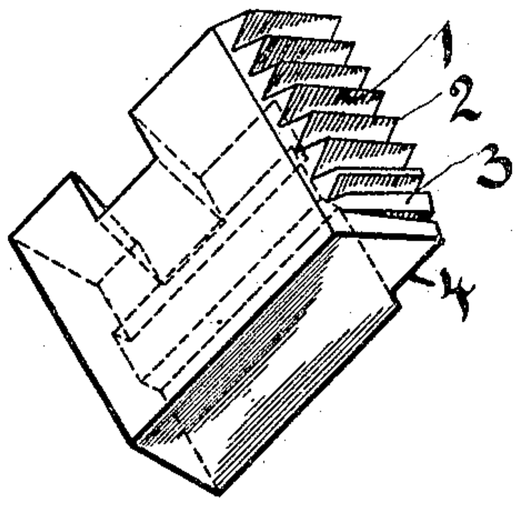


Fig. 7

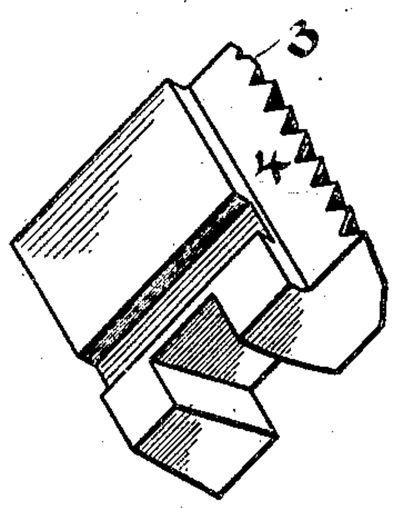


Fig. 8

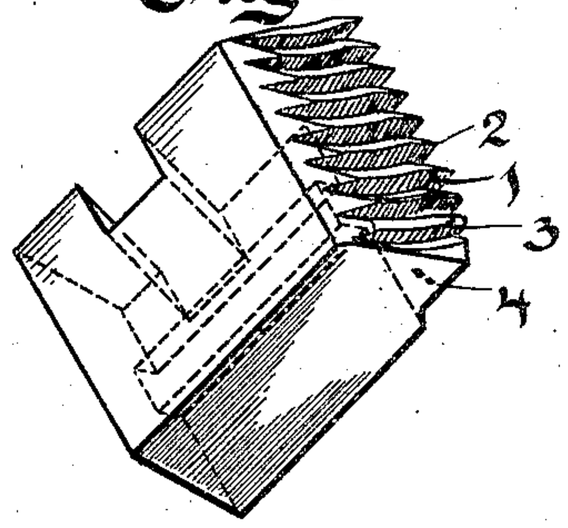


Fig. 9

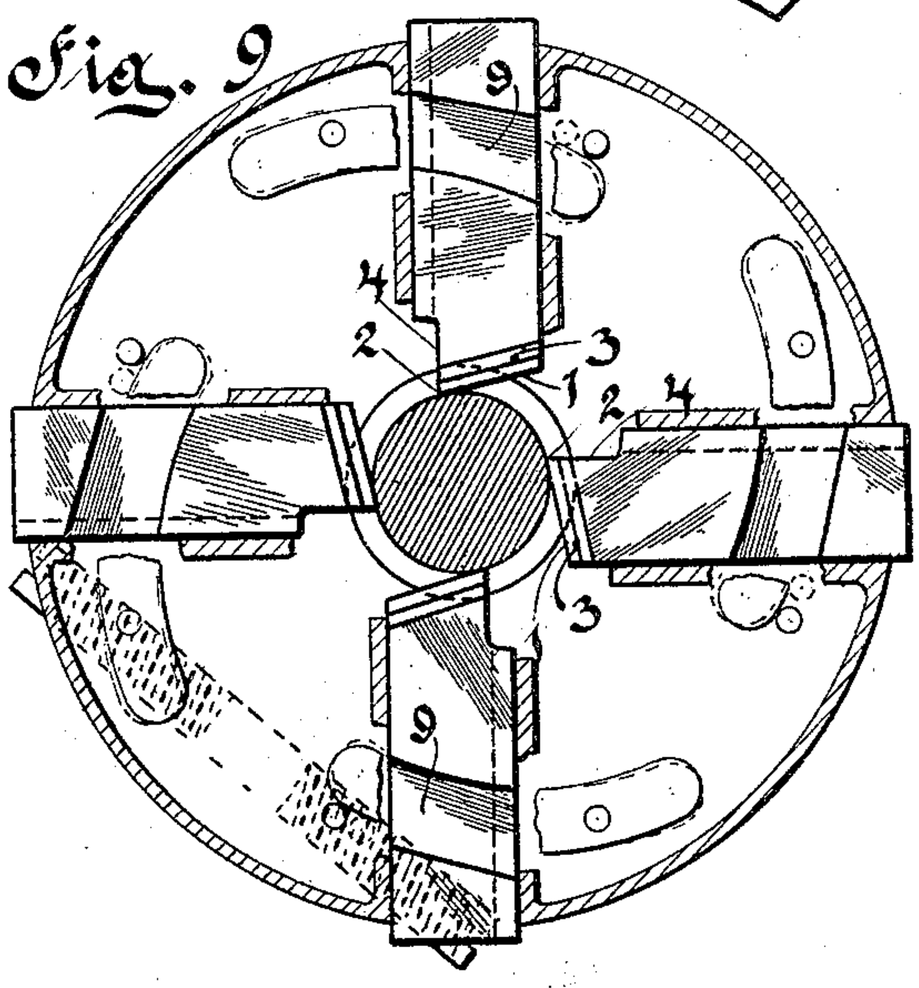
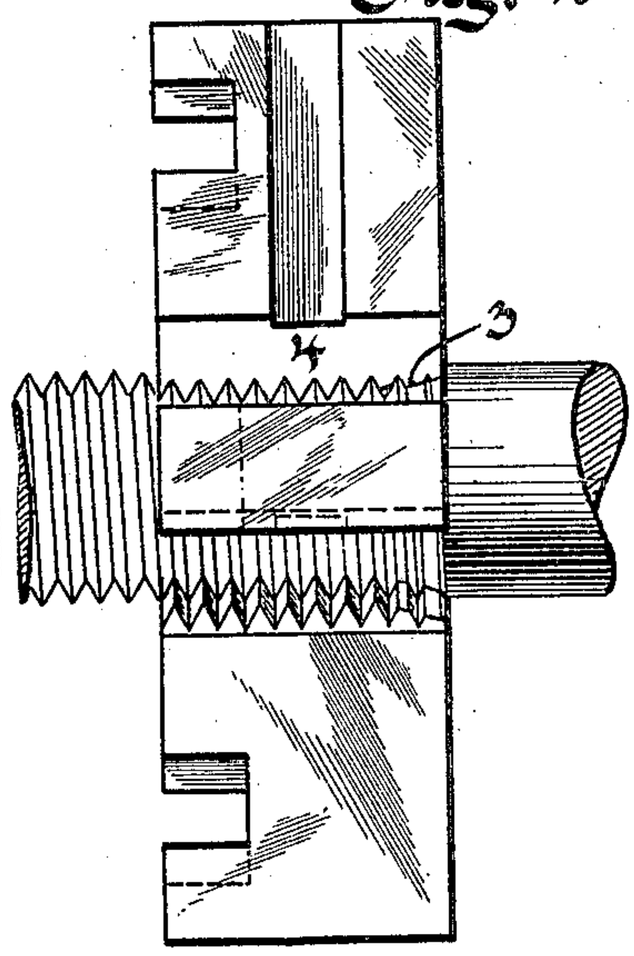


Fig. 10



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No. 798,352. PATENTED AUG. 29, 1905.

W. A. LEONARD.

THREADING DIE.

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2 SHEETS—SHEET 2.

Fig. 11

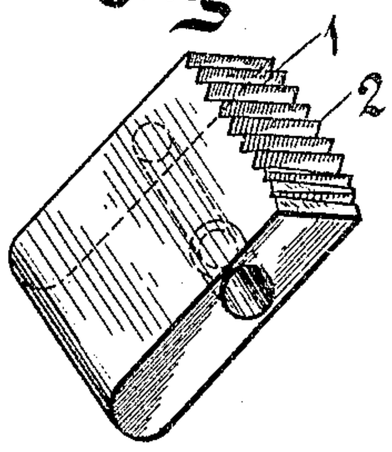


Fig. 12

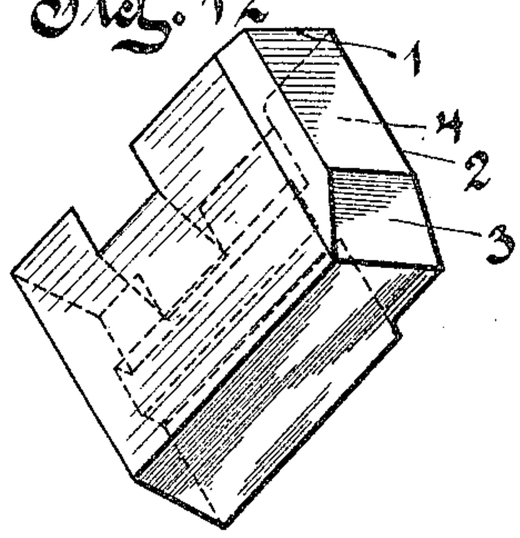


Fig. 13

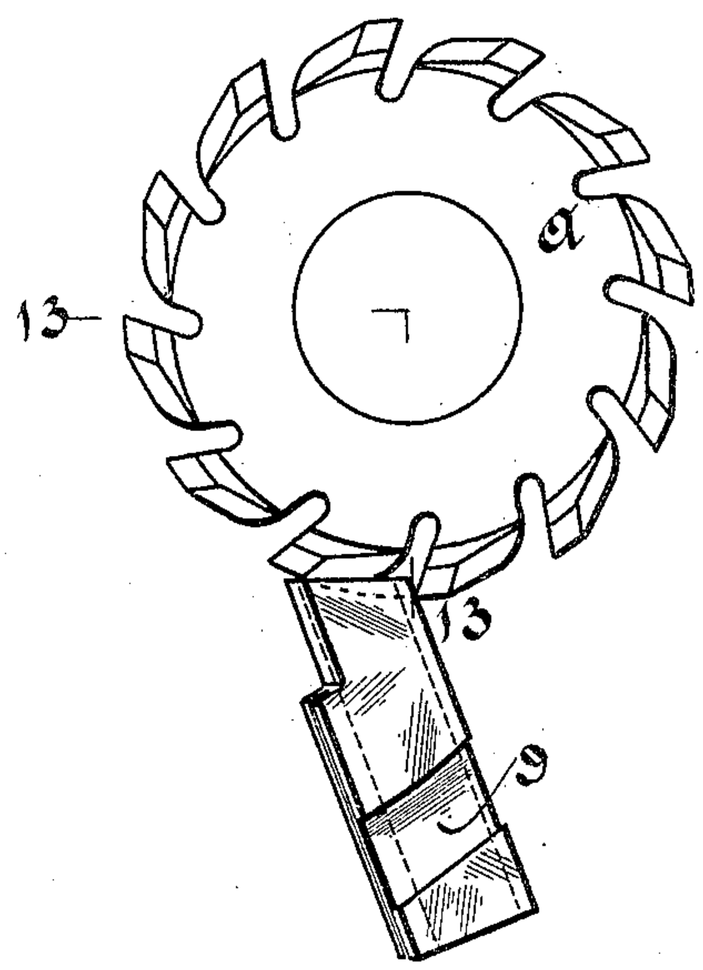


Fig. 14

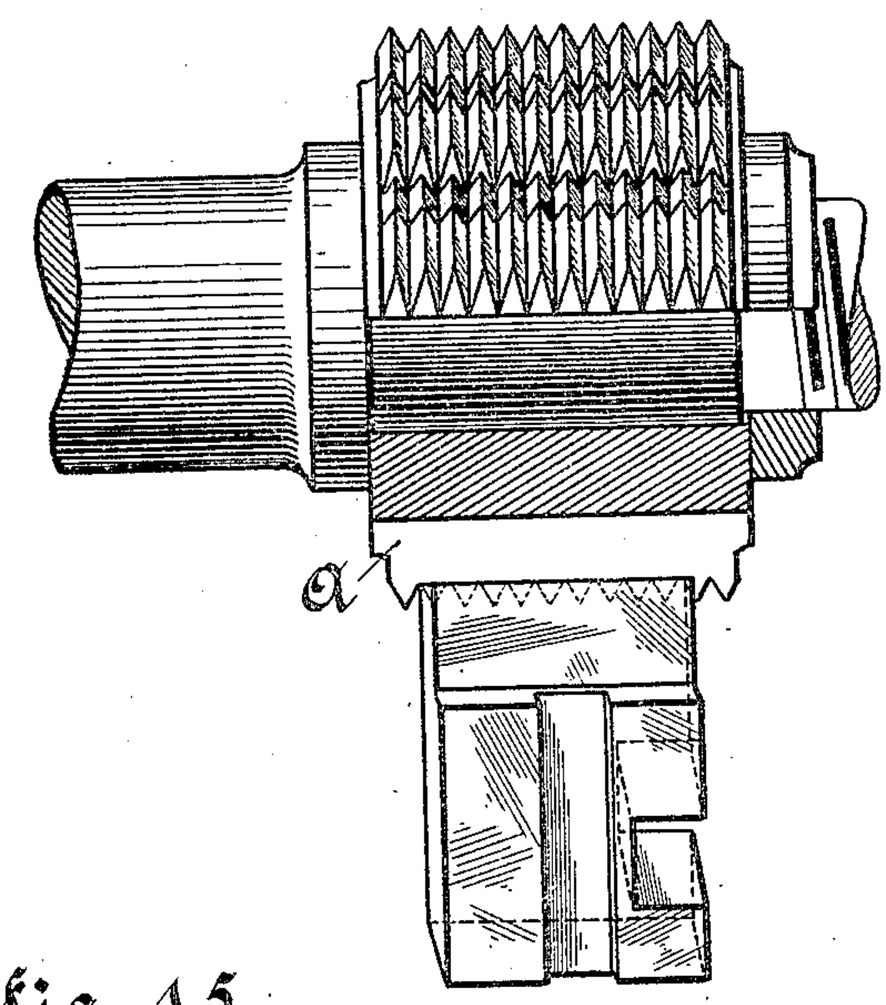
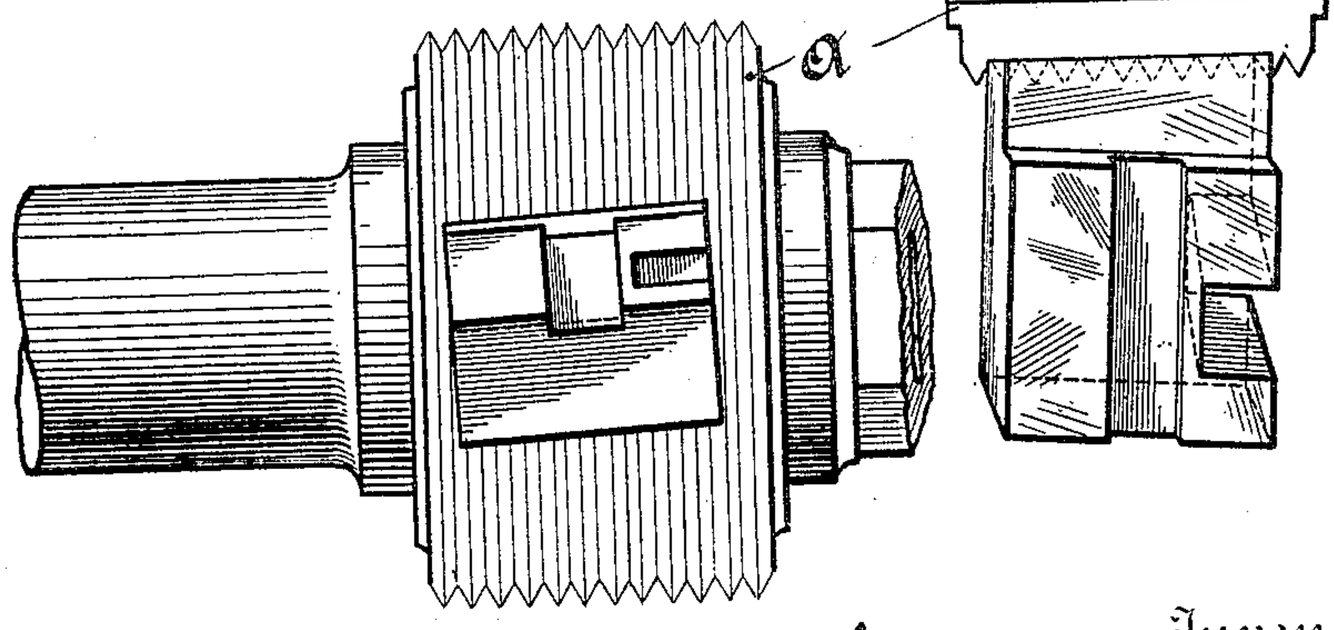


Fig. 15

Fig. 16



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UNITED STATES PATENT OFFICE.

WILBUR A. LEONARD, OF NEW HAVEN, CONNECTICUT, ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE GEOMETRIC TOOL COMPANY, OF NEW HAVEN, CONNECTICUT, A CORPORATION OF CONNECTICUT.

THREADING-DIE.

No. 798,352. Specification of Letters Patent. Patented Aug. 29, 1905.

Application filed April 26, 1904. Serial No. 204,928.

To all whom it may concern:

Be it known that I, WILBUR A. LEONARD, a citizen of the United States, and a resident of New Haven, Connecticut, have invented certain new and useful Improvements in Threading-Dies, the principles of which are set forth in the following specification and accompanying drawings, which disclose the form of the invention which I now consider to be the best of the various forms in which said principles may be embodied.

This invention relates to improvements in that type of threading-dies or "chaser-cutters," so called, which are held in annular series in suitable die heads or holders and which have the surfaces of their operative ends, which are provided with the cutting-teeth, presented toward a space adapted to receive the stock to be threaded, which stock is moved longitudinally into such space while being rotated, as by a suitable lathe head-stock.

The various specific forms of standard die heads or holders used in the prior art are exemplified by the die-head disclosed therein. It is this standard type of die head or holder, well-known to those skilled in the art, which is used in connection with the dies constructed in accordance with this invention.

The invention consists in improvements in methods of manufacturing threading-dies of this type in which the teeth are on the end surface and in the resulting improvements in the construction of the dies themselves. The new dies may be used in any suitable die-head known to those skilled in the art.

Hitherto and throughout the long history of machine-tools the customary methods of making the only practicable threading-dies have been to either rotate a tap between the ends of a radially-grouped set of die-blanks or to rotate across the end of one or more die-blanks a tool having a single cutting edge or else to impart to a single die-blank and a milling cutter or hob relative movement toward each other, such that the hob would cut the teeth in the end of the die-blank. Various other kinds of threading-dies have been proposed, but have proved impracticable and have not gone into extended use.

Although practicable dies made as above possess many disadvantages which have been known to several generations of engineers and mechanics familiar with the art, it has seemed that these dies must be inherently incapable of radical improvement, for the reason that many attempts have been made to improve them, which attempts have uniformly resulted in complete or partial failure. Some of such disadvantages of the old dies above referred to are as follows: In making them it was necessary in cutting the teeth from the die-blank to remove a large amount of the metal from the blank. Also it has been necessary to adjust the dies angularly in their head or holder in order to obtain a proper clearance to prevent choking with the stock removed by the thread-forming cut. When the proper clearance was thus obtained, a proper control of the lead of the die was lost, and the pitch of the thread was thereby caused to be varied and to lack uniformity throughout the length of the threaded stock, which is a most serious defect in attempted accurate work. Also the toe or cutting edge of the die was operated practically on the center of the work with a resulting grinding or imperfect cutting action, requiring the expenditure of extra energy and a consequent strain on the parts and causing a chattering and resulting rough finish, which required a change of radial adjustment of the dies in the head and a second cut of the stock, and even then did not produce a perfectly-smooth finish. This imperfect cutting action also caused a variation in the lead and a consequent lack of uniformity in the pitch of the thread. Owing to the peculiar construction of the old dies they had a very limited range of radial adjustment to different diameters of uncut stock, and, furthermore, it was necessary to provide a separate set of dies for each and every different diameter of thread to be produced at a given pitch, and each such separate set of dies required for its production its own specially-designed milling cutter or hob. For this reason manufacturers of dies have been obliged to maintain a most expensive stock of hobs, and users of dies for the manufacture of threaded stock have been obliged to maintain large stocks or different sets of dies of great value. Threading-dies require to be frequently sharpened, and owing to the construction of the old dies they could be ground to only a very limited extent, beyond

which they could not be used for accurate work.

Attempts have been made to control the lead by modifying the construction of the old dies, but the results of such attempts have been subject to the other disadvantages above mentioned. Attempts have been made also to make practicable threading-dies with cutting-surfaces, either on the side or the end of the dies, which were not curved or hollowed out; but the results have been so disappointing that the only dies now in use, except the novel dies disclosed herein, are those above referred to as being made with curved teeth throughout their length by being tapped or made by hobs by the method specifically described above.

Threading-dies constructed in accordance with this invention possess none of the disadvantages named above, but possess many very important advantages which were wholly lacking in the old dies, which advantages are described hereinafter. The invention, although involving apparently small changes in the construction of the dies, is radical and revolutionary in character and is believed to be destined to entirely supersede the old dies which have been universally employed for so very many years.

The present invention is the result of an endeavor to so completely revolutionize the construction of the old threading-dies that their necessary functions might be executed by dies infinitely more simple in construction and lacking all the disadvantages and deficiencies in operation of the old dies, but possessing many valuable features lacking in such old dies. Nevertheless it has been the intention to retain the general method of operation of the old dies in order that the new ones may be used in the old die-heads, which are in use in such very large numbers. It may be said that the threading-dies made in accordance with this invention are so simple in construction that they approximate very closely, so far as simplicity of construction is concerned, to the ordinary simple lathe-tool sometimes employed, among various other purposes, to cut threads. It will be understood, however, by those skilled in the art that the cutting of threads in a lathe is very much more difficult than by dies of a practicable construction and that die-cut threads, especially when made with the novel dies disclosed herein, are much more accurate than threads made by a lathe-tool having a single cutting edge.

In order to produce a threading-die which requires the removal from the end surface of the blank during the process of manufacturing of less stock than has heretofore been required to be removed, I have devised a construction and a method of producing a die so constructed by which the removal of the stock between the points only of the teeth is sufficient to produce an operative die. Heretofore it has been necessary to remove a considerable quantity of stock from the die-blank before reaching the parts of the blank destined to serve as greater portions of the length of the outer edges of the teeth.

In order to produce a threading-die which when in use to cut threads is not required to be angularly adjusted in its head to obtain the proper clearance to prevent choking with the stock removed by the thread-forming cut, I have devised a die construction which inherently permits a permanent clearance, and therefore the die so constructed requires absolutely no adjustment in its head for this purpose. This improved construction, moreover, is obtained, in addition to the advantageous feature of requiring the removal of less stock from the die-blank, by the execution of the method above referred to.

In order to produce a die constructed with such permanent clearance and by said method and yet retain control of the lead to prevent the slightest variation in the pitch of the thread, I have devised a die construction whereby the toe or cutting edge of the die can engage the stock at a point far above the center, thereby obtaining a perfect cutting action of a shearing nature without any grinding or chattering, thus maintaining control of the lead and keeping the pitch absolutely constant and uniform irrespective of the length of the threaded stock. This is a very important feature of the new dies. Further results of such construction are that less power is required to effect a cut of a given depth and a deeper cut can be made without disturbing the uniformity of the pitch as compared with the old dies. Thus with a given amount of power required to make a cut of a given depth by means of the old dies a very much deeper cut may be made with the new dies, which cut will produce not only a much smoother surface, but also a thread the pitch of which approaches infinitely nearer to the limit of theoretical or absolute perfection.

Actual observation and comparison of the work done by the old dies and the new dies demonstrate better than words can the difference between the results of the operation of the respective dies.

A further advantage of the new die construction is that when a piece of work is required to be threaded to a certain diameter from stock of much greater diameter it can be threaded by a single cut with the new dies, whereas two or more cuts have been required in such instances by the old dies by reason of the defects of the latter above described and owing to their inability to properly operate upon stock of much greater diameter than the diameter of the finished threads which they were specifically designed to form.

In order to produce a die which is not lim-

ited, as were the old dies, to cutting a thread of a given pitch and of a given diameter, I have dispensed with the curved teeth with which the old dies were provided on the surface of their operative ends, and thereby, in connection with other changes in construction to be described hereinafter, have obtained a die which can be made by the method above referred to, so as to possess all the above-enumerated novel features, and which can be used to cut a thread of a given pitch, but of any desired diameter within very wide limits, and which therefore has a very greatly increased operative range of radial adjustment as compared with the old dies. In the new die the diameter of the thread to be cut is entirely independent of the die construction within very wide limits, but is dependent chiefly upon the radial adjustment of the dies in the head and upon the relative arrangement of the teeth of the respective dies in the head, as described hereinafter. Thus one set of the new dies designed to cut threads of a given pitch will suffice in place of a large number of sets of the old dies, of which one set was required for each and every thread of a different pitch and diameter. However, one set of the new dies should not be used to cut threads of absolutely all diameters of a given pitch, and for large variations in diameter the lead-angle of the die-teeth should be correspondingly varied in order to obtain the best results; but a single hob may be used in pursuance of this invention to produce dies for cutting all threads of a given pitch absolutely irrespective of the diameter of the thread and the corresponding lead-angle of the die-teeth. This is due to the peculiar nature of my novel method, as described hereinafter. For making each set of the old dies, which sets, respectively, were designed to cut threads of different diameters, there was required a different and specially-designed hob. This economic importance of the invention is obvious to all those skilled in the art, who well understand the cost and value of this class of tools.

A further advantage of the last-described feature of construction is that the operations of grinding for sharpening and of repairing with respect to the new die are much more simple and easy than those operations as they were required to be performed with respect to the old dies. For the purpose of successive sharpening the new dies can be ground back from the original cutting-points nearly as far back as the center of the die without so changing the die as to cause it when in use to chatter or affect the lead, and consequently vary the pitch of the threads, all of which occurred in the old dies when they were ground for sharpening more than a very limited extent indeed.

All of the above-enumerated improvements are embodied in accordance with this invention in dies of very simple construction, as will be understood upon reference to the accompanying drawings, which illustrate the dies in their natural size, and of which—

Figure 1 is a plan of the surface of the operative end of a die. Fig. 2 is a plan of the die of Fig. 1 turned ninety degrees to the right. Fig. 3 is a plan looking upwardly at Fig. 2. Fig. 4 is a plan of the reverse side of Fig. 2. Fig. 5 is a section through 5 5 of Fig. 4. Figs. 6 and 7 are perspective views of the die. Fig. 8 is a perspective view of a die in which the teeth do not extend entirely across the surface of the operative end of the blank. Fig. 9 is an end elevation of a piece of work in process of being threaded and showing four dies in operative positions, the dies being radially adjustable to the work in the direction of their longitudinal axes in the ordinary standard commercial type of die-head well known to those skilled in the art, which is exemplified in this Fig. 9. Fig. 10 is a side elevation of Fig. 9, showing the respective dies having their teeth relatively offset to properly cut the thread. Fig. 11 is a perspective view of a die having teeth extending entirely across its end and having never been ground for sharpening. Fig. 12 is a perspective view of an uncut die-blank for the die shown in Figs. 1 to 7, inclusive. Figs. 13, 14, and 15 are views showing the method of cutting the blank of Fig. 12 to form the teeth thereon, the hob A in Fig. 14 being shown in section through the line 13 13 of Fig. 13; and Fig. 16 is a view showing the specific method of cutting-dies adapted to form tapered threads, which method is executed in connection with the broad method illustrated in Figs. 13, 14, and 15.

As shown in Figs. 1, 2, 3, 5, 6, 9, and 11, the dies are in shape generally oblong, and the die-teeth are of such construction that the entire length of the outer edges 1 of the teeth is substantially coincident with the uncut surface of the end of the blank shown in Fig. 12—that is, the outer edges 1 of the teeth are right lines all lying in the same plane, which plane is, or is parallel and very close to, the uncut surface of the end of the die-blank. Hence in forming the teeth substantially the only material required to be removed from the blank is that lying between adjacent teeth and below the plane of the outer edges 1 of the teeth. Hitherto with the old dies it has been necessary not only to remove this material between the teeth, but also considerable material lying between the plane of the uncut surface of the blank and the final outer edges of the teeth. This feature of the new die construction is an advantage, as it not only saves power in cutting the teeth, but also saves considerable material, which is an important item in the manufacture of large numbers of dies.

As is best shown in Figs. 2, 3, 5, 6, 8, and

11. the plane, including all the outer edges 1 of the teeth, occupies an angular position with respect to the body of the die, thereby providing a very large and permanent clearance between the stock to be threaded and the parts of the teeth back of the cutting-points 2, as is shown in Fig. 9. In Fig. 9 the stock to be threaded is being moved away from the observer while being rotated in a clockwise direction. This clearance is ample to prevent choking the dies with the stock removed by the thread-forming cut. The die thus constructed requires no angular adjustment in its head, as the clearance is sufficient at all times irrespective of the depth of the cut, and the clearance angle may be made as great as desired in different dies. This clearance-angle feature is an important advantage of the invention, as it obviates the necessity of the angular adjustment of the dies in the head and the consequent danger of varying the pitch of the thread. This feature also is advantageously combined with the construction whereby the outer edges 1 of the teeth are in the same plane, and both features of construction are produced by the execution of the new method. This clearance-angle need not be different for each set of dies designed for cutting threads of different diameters of a given pitch; but as between wide limits of thread diameters the angle should vary inversely as the diameter. This is for the reason that a die adapted to coöperate with an ordinary die-head could not properly operate on stock of a very large diameter unless the clearance-angle were correspondingly reduced. If that angle were not so reduced, the die would be required to be made wider and would then require a die-head of special design; but all dies designed to cut a thread of a given pitch may be produced with any desired clearance-angle by means of only a single hob, and this is due to the peculiar nature of my novel method, as described hereinafter.

A very important advantage connected with the clearance-angle described is that it permits ample clearance without any loss of control of the lead, because owing to the clean shearing character of the cut, which is absolutely free from any grinding action, there is entire freedom from variable and harmful movements of the parts. Hitherto when the old dies were angularly set to obtain the proper clearance the consequent withdrawal from the stock of the heels of the dies (which heels would otherwise assist in supporting the stock) permitted a chattering which seriously impaired the character of the thread and which chattering was caused by the grinding and imperfect cutting action of the die, the cutting-points of which acted substantially on the center. This chattering and grinding action resulted in a rough finish of the threads and a variation of the pitch. As is shown in Fig. 9, the toes or cutting edges 2 of the new dies are permitted by the described construction to operate far in advance or above the center, thereby permitting a clean, even, and shearing cut which does not cause any chattering and produces threads of an absolutely uniform pitch and having surfaces which are in a smooth and polished condition. The dies are properly constructed so that the cutting edge acts at a point which is at a distance above the center which is equal to about one-tenth of the diameter of the stock to be threaded. This improvement therefore permits, with the expenditure of a given amount of energy, a very much deeper cut than the old dies, and is therefore of very great importance indeed. The angle described may be further varied in the different sets of dies in proportion to the distance above the center at which it is desired to permit the cutting edges 2 to operate.

The die-head shown in Fig. 9 is an exemplification of the standard commercial type of die-head long in use in the prior art and having suitable means for adjusting the dies toward the work. As shown, said adjusting means coöperates with the openings 9 in the dies, (which openings are substantially transverse to the greater dimensions of the dies,) so that the end surfaces of the dies, on which are the cutting-teeth, are moved broadside on toward or away from the center of the work. The four pivoted curved metal projections of the die-head engage in the openings 9 of the dies, so that when the adjusting-screws are operated and the pins (indicated by small circles) thereby cause to be moved or permit to be moved the free ends of the pivoted projections the dies will be moved with the projections toward or away from the work. The pins and metal projections are shown in dotted lines in their secondary positions. Any other die-head may be employed which is provided with means for adjusting the end surfaces of the die broadside on toward or away from the work. The opening in the dies may be of any kind so located or adapted in any way to coöperate with the adjusting means of the die-head, and it is immaterial to my invention whether or not the die is otherwise constructed with respect to the adjusting means—that is to say, the die might be provided with any other means than the opening, so as to be suitably adjusted in the holder. My invention relates in no wise to such feature, but relates to the novel character of the teeth on the end surface of the die, which is presented broadside on toward the work.

As is shown in Figs. 6 and 11, the outer edges 1 of the teeth are straight throughout their length and have no inwardly-curved portions whatever. The other lines of the teeth are parallel to these outer edges, so that each tooth as a whole is straight throughout

its length. The teeth need not be straight throughout their length, as will be explained hereinafter with references to Fig. 8, which also embodies the invention. The old dies, owing to the limitations of their construction, could produce a thread of only one pitch and diameter for each set of dies. With the new dies a thread of any diameter within very wide limits and of a given pitch can be produced by any one set of dies designed for the given pitch. In other words, the new dies have a very greatly increased operative range of radial adjustment as compared with the old dies. This is partially due to the fact that the dies are operative in all respects with only the extreme forward portion of each tooth in contact with the stock, so that the operation of the dies is to a considerable degree independent of the diameter of the stock to be threaded and of the diameter of the thread itself. The shape of the teeth of the new dies may be modified so as to cut threads of different shapes—as, for example, square threads.

The lead of the die and the consequent pitch and direction of the resulting thread is determined by the angle of the teeth with respect to the plane which includes the cutting-points 2 of the teeth, which angle may be varied in different dies to vary the pitch of the thread or may be reversed to reverse the direction of the thread. This angle is shown in Fig. 1, the teeth being inclined from left to right downwardly, the die being thus adapted to cut a right-handed thread. All the teeth in each die are cut at the same angle, and each tooth is parallel with every other tooth. This is in addition to the fact above referred to that the outer edges 1 are all in the same plane throughout their length, which fact is only true with respect to such parts of the edges as are straight, as explained hereinafter with reference to Fig. 8. The additional facts stated in the last sentence constitute a further distinction from the old dies, wherein each tooth was cut throughout its length with a slight curve corresponding with the thread to be cut. In the new dies each tooth may be regarded as acting as a separate tool—as, for example, a lathe-tool—and the operative end surface of the die is substantially an integral assembly of a number of separate tools, but requiring only one tool-rest—that is, the die-head, which holds the remainder of the annular series of such dies. The new dies thus possess in combination in a single tool all the advantages of both the former methods of thread-cutting—*i. e.*, by lathe-tools and by the old dies—and the new dies possess none of the disadvantages of either of such methods.

All of the new dies which constitute a set adapted to cut a desired thread are alike, except that the teeth of each succeeding die are offset with respect to the teeth of the preceding die. This is for the purpose, as shown in Fig. 10, of bringing the teeth of the various dies (when placed in an ordinary die head or holder well known to those skilled in the art, such as that illustrated in Fig. 9) into proper coöperative positions for forming the thread—that is, the teeth are offset in the direction of the length of the stock to be threaded, as is shown in Fig. 10—and the dies so constructed are secured in the usual way in an ordinary die-head. In Fig. 10 the stock is being moved toward the left while being rotated. The teeth are offset, as described, for the reason that owing to their peculiar construction none of the dies embodies within itself a likeness to any portion of the thread to be cut. Each of a set of the old dies was so formed as to embody the form of a portion of the thread to be cut, and when a set was assembled it formed a pattern for the thread; but the new dies, having merely straight cutting-teeth in contact with the work, are arranged in a group, as were the old dies; but each die has its teeth offset, as described. Each of the dies of a set might be made identical with the other dies of the set with respect to the relative location of the teeth; but this would require each die to be bodily offset with respect to the other, and this would require a specially-designed holder. A single die-hob may be used to make all the dies of a set, as will be described hereinafter in connection with the novel method.

The part of the die which first engages the stock to be threaded is shown at 3 most clearly in Fig. 6. The tops of one or more of the teeth of this part 3 are ground off flat at an angle, so that the teeth 3 are slightly shorter than the rest of the teeth in the same general way as in the case of the old dies in order that the thread-cutting action may be commenced gradually; but there is this distinction, that whereas in the old dies these end teeth 3 were required to be carefully ground with an inward curve the new dies are ground simply at an angular plane—that is, the surface of the angular-ground portion is flat, as is shown at 3 in Fig. 6. This angular plane is inclined away from the stock to be threaded at a less angle than are the sides of the teeth. The grinding can therefore be quickly done on an ordinary grinder without the necessity of laborious filing with a round file or carefully grinding on a shaped wheel.

As is shown in Fig. 11, the teeth may extend the full thickness of the die, or, as shown in Figs. 1 to 7, inclusive, and Fig. 8, a part of the end of the blank may be cut away, as at 4. In either case in order to sharpen the die the upper or forward cutting ends of the teeth can be ground back nearly as far as the center of the tool—that is, the cut-away part 4 may be extended farther back to that extent without interfering with the accurate operation of the die or causing any chatter-

ing. This extended grinding range for sharpening was lacking in the old dies, for the reason that any more than a very slight grinding at the cutting ends of the teeth seriously affected the lead and caused a variation in the pitch of the thread. The new dies therefore have a very greatly increased duration of usefulness, and this is a very important feature of the invention.

Another important advantage of the new dies is the facility with which the teeth may be repaired when slightly defaced. Owing to the straightness of the teeth, an ordinary oilstone can be readily employed and with slight skill and effort to remedy such defacement. The old dies were much more difficult to repair owing to the complex curvature of the teeth and the consequent difficulty and practical impossibility of so remedying an injury as to leave the dies in operative condition. This advantage of the new dies is present in the greatest degree in the form shown in Figs. 6 and 11, wherein the straight teeth extend entirely across the operative end surface, the spaces between the teeth being open at both ends, so that the oilstone can be moved between the teeth and entirely through them. This advantage is not present in as great a degree in the form shown in Fig. 8, wherein the teeth do not extend entirely across the operative end surface. The form shown in Fig. 6 is therefore the better practical form. The form shown in Fig. 8, however, is included within the scope of the invention, even although the teeth do not extend entirely across the operative end surface.

The method of making the new dies is illustrated in Figs. 13, 14, 15, and 16. The methods hitherto employed for cutting the teeth in the operative end surface of the old dies have consisted in either tapping them or rotating across the end of a die-blank a tool having a single cutting edge or else imparting relative movement toward each other to a die-blank and hob. The new method for cutting the teeth on the ends of the new die consists, broadly, in imparting relative parallel movement to the die-blank and the cutting-tool as distinguished from relative to-and-fro movement. As is shown in Fig. 13, the die-blank, suitably held in proper position, is moved bodily in the position shown—say to the right—while the hob A is rotated, or the die-blank may be held fixed in the position shown and the hob moved bodily to the left while rotating. The teeth of the hob A are not arranged around the hob in the form of a worm, but, as shown in Fig. 14, are arranged in series, each series forming a complete circle—that is, the teeth of the hob are parallel to each other. Instead of a hob, such as the rotating cutter A, a non-rotating cutter may be employed, being moved bodily parallel to the die-blank to effect the cut, or the die-blank may be removed bodily in a parallel direction with respect to such non-rotating cutter, and such an operation is included within the broad method. In any case the cutter may, if desired, consist of an assembly of separate tools, one or more teeth for each tool. Likewise the dies themselves might, if desired, consist of an assembly of parts. The method is, however, executed more specifically in order to produce dies of the exact novel construction described herein.

In order to produce the clearance-angle shown in Fig. 3 and other figures, the die-blank is, as shown in Fig. 13, held at an angle to the cutter A by any suitable means, the degree of the angle varying with the angle of clearance which it is desired to obtain. Thus the same hob may be used to make dies adapted to cut threads of any desired diameter, because if it is desired to have different clearance-angles for dies adapted to cut stock of widely-different diameter all that is required is to change the angle of the blank with respect to the hob. In the example shown the blank is already formed, Fig. 12, with its end surface at an angle to the body of the blank in order that a minimum amount of metal need be removed in cutting the teeth. If, however, the surface of the end of the blank were at a right angle to the body instead of the clearance-angle, the blank would still be held at the same angle to the hob shown in Fig. 13, the only difference being that a greater quantity of material would be required to be removed from the blank in order to cut the teeth across the end thereof.

In order to obtain the angle of the teeth shown in Fig. 1, which angle determines the lead of the die and the pitch and direction of the thread to be cut by the die, the die-blank is held by any suitable means at the angle shown in Figs. 14 and 15 with respect to the hob A. This angle is measured by the degree of anti-clockwise rotation of the die-blank about a center which is its vertical axis in the position shown in Fig. 14. This angle may be varied in degree for dies adapted to cut threads of different diameters, and hence the same hob may be used to make any such dies. This angle may conveniently be called the "lead-angle" position of the die, as resulting in the formation of the teeth at the pitch-determining angle, whereas the angle of the die-blank with respect to the hob which is shown in Fig. 13 may be called the "clearance-angle" position of the die, as resulting in the formation of the teeth at the clearance-angle. In making the second die of a complete set of dies adapted to cut a desired thread the blank is held, Fig. 14, at a distance to the left or right of the position shown, which distance is equal to

that fraction of the thickness of a hob-tooth which corresponds with the number of dies in the set. This is to produce a set of dies the teeth of each die of which shall be offset with respect to the teeth of the other dies of the set. For example, when the set is to comprise four dies, Fig. 9, the second die is held at a distance to the left or right of the position shown in Fig. 14, which distance is equal to one-fourth the thickness of a hob-tooth. The third and fourth die-blanks are held at correspondingly greater distances from the positions shown in Fig. 14.

In order to obtain a die of the above construction, but adapted to cut taper threads, the die-blank is held in such position as to lie at a third angle with respect to the hob A as shown in Fig. 15, in addition to the clearance and lead angular positions. This angle is measured by the degree of clockwise rotation of the die-blank about a horizontal axis in the position shown in Fig. 16. This angle may conveniently be called the "taper-angle" position of the die-blank with respect to the hob. By the execution of the method in this specific manner there is produced a die having the plane of the outer edges 1 of the teeth at an angle additional to the clearance-angle shown in Figs. 3 and 5, which additional angle may be called the "taper-angle." By this construction the dies are adapted to cut tapered threads when held in an ordinary die-head.

The die shown in Fig. 8 is made by exactly the same method as the dies shown in Figs. 6 and 11—that is to say, by the method shown in Figs. 13, 14, and 15. The reason for the peculiar appearance in Fig. 8 of those parts of the teeth which lie nearer the heel of the die is that the teeth have not been cut entirely across the surface of the operative end of the blank. In other words, the relative parallel movement, Fig. 13, of the blank and hob was stopped before the hob-teeth had cut entirely across theblank. The result is that the intermediate portions of the outer edges 1 of the teeth are slightly curvilinear. This form embodies the invention, however, exactly as the teeth in the forms shown in Figs. 6 and 11. The curvilinear portions of the teeth, Fig. 8, being in rear of the straight forward parts of the teeth do not affect the operation of the die in any way; but this form does possess the disadvantage, as stated above, that for purposes of repair the oilstone cannot be so readily employed as in the case of the forms shown in Figs. 6 and 11.

I believe that I am the first and only inventor of the matters described herein, and therefore intend the following claims to include and cover the same in the broadest aspect.

I am aware of United States Letters Patent to Hamer, No. 483,112, which, however, does not disclose or suggest the invention herein described and claimed.

I claim—

1. A suitable die head or holder which is provided with suitable means for adjustment of its dies toward the work; and a suitable number of threading-dies associated with the die-head in the ordinary manner so as to be adjustable therein with respect to the work; and that end surface of each die, which lies substantially transverse to the direction of adjustment of the die, being provided with straight parallel teeth.

2. A suitable die head or holder which is provided with suitable means for adjustment of its dies with respect to the work; and a suitable number of substantially oblong threading-dies associated with the die-head in the customary manner, said oblong dies being adjustable by said adjusting means, in the direction of the greater dimension of the respective dies; and that end surface of each die, which surface lies substantially transverse to the direction of the greater dimension of the die and substantially transverse to the adjusting movement of the die, being provided with straight parallel teeth.

3. A threading-die of a generally oblong shape, and having an opening substantially transverse to its greater dimension to enable the die to be adjusted to the work in the direction of the greater dimension of the die; that end surface of the die which lies substantially transverse to the greater dimension and to the direction of adjustment of the die, being provided with straight parallel teeth.

4. A threading-die of a generally oblong shape, and constructed to be adjustable in its holder toward the work in the direction of the greater dimension of the die; that end surface of the die being provided with straight parallel teeth, which surface lies substantially transverse to the greater dimension of the die; *i. e.*, that surface which is adjusted broadside on, toward and away from the work.

New Haven, Connecticut, April 23, 1904.

WILBUR A. LEONARD.

Witnesses:
H. E. ADT,
C. C. CHATFIELD.