

Nov. 15, 1938.

E. S. CORNELL

2,136,491

METALWORKING MACHINE

Filed Jan. 11, 1937

7 Sheets-Sheet 1

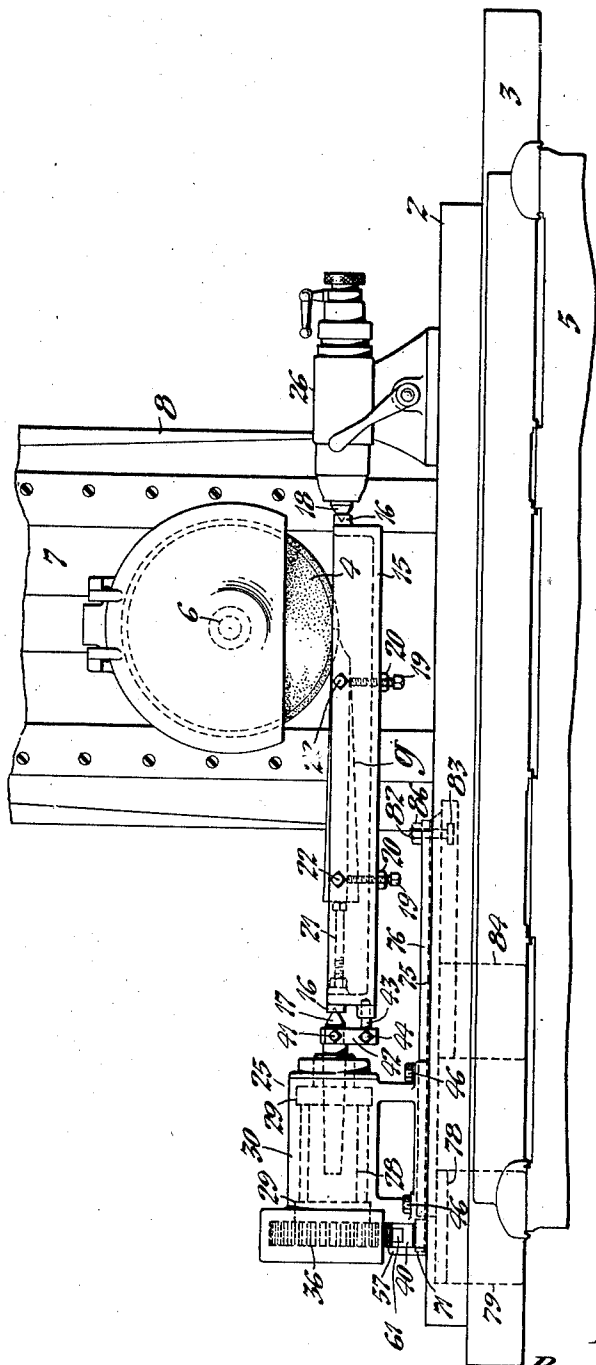


Fig. 1.

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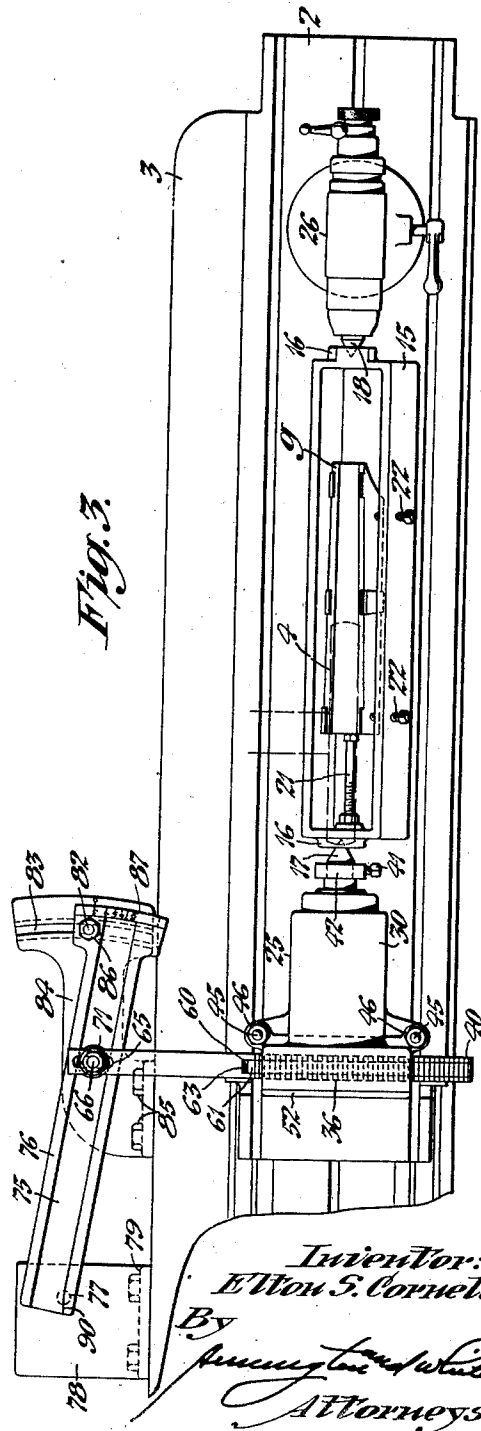
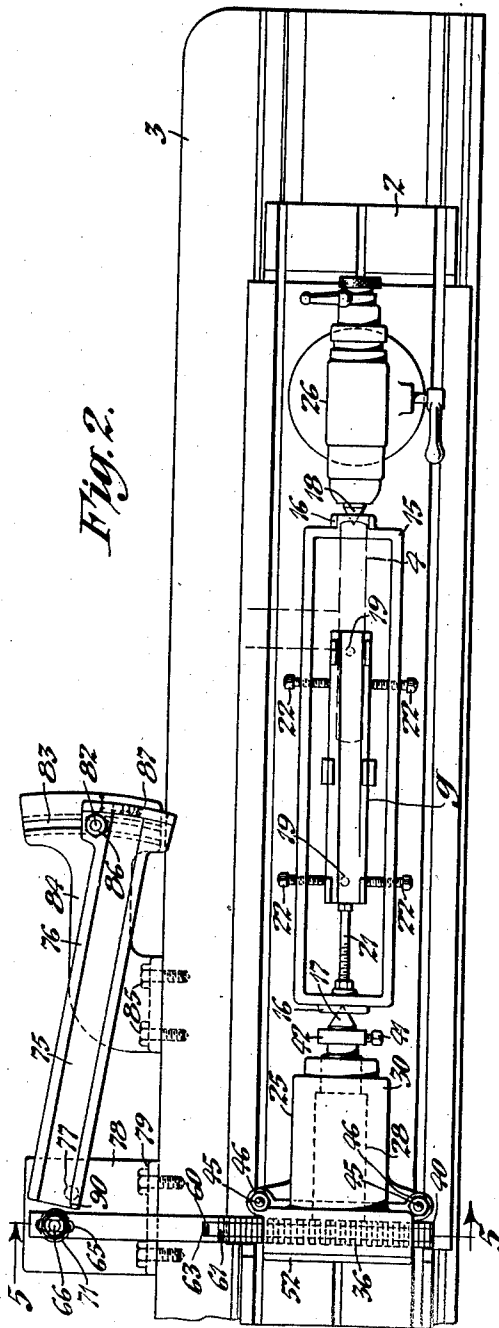
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7 Sheets-Sheet 3

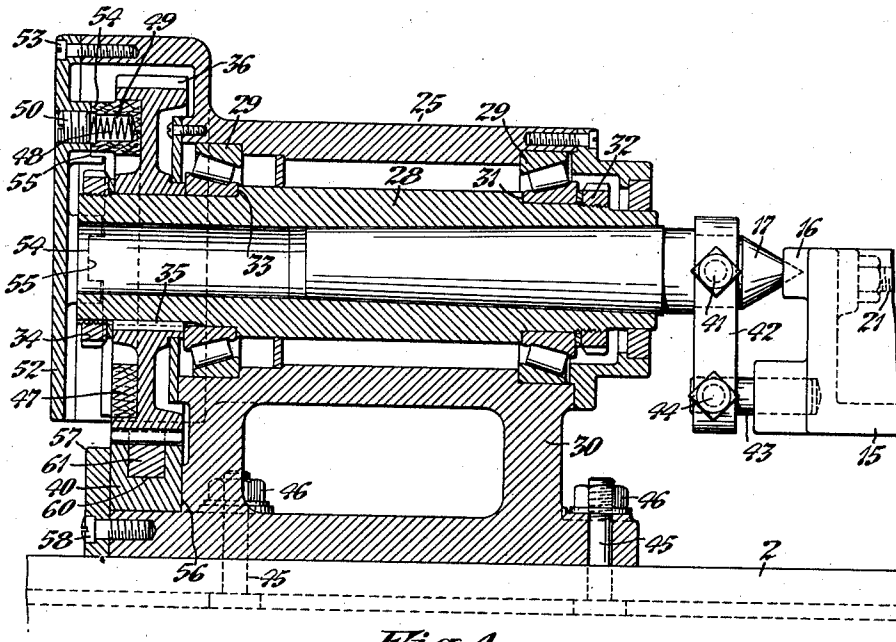


Fig. 4.

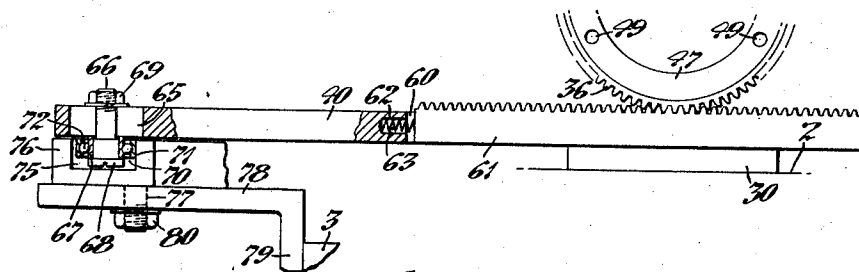


Fig. 5.

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METALWORKING MACHINE

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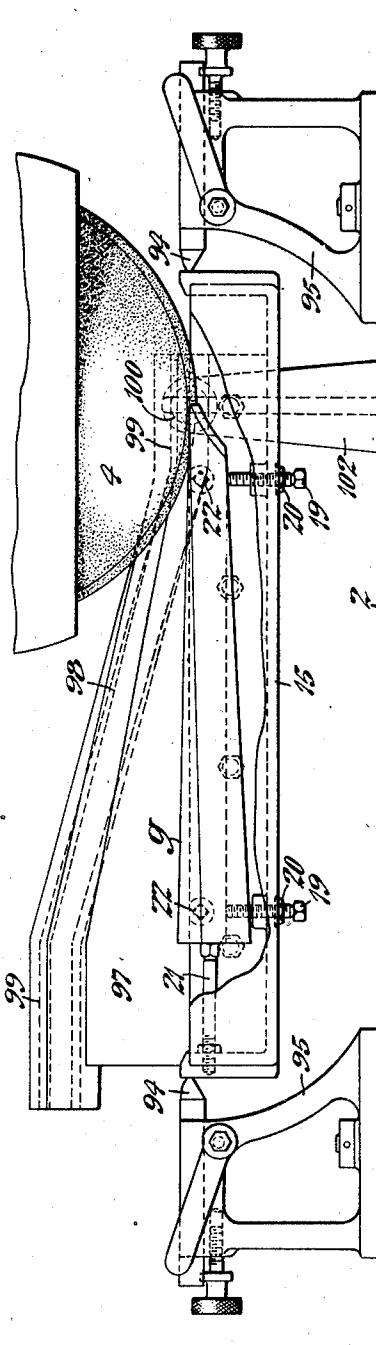


Fig. 6.

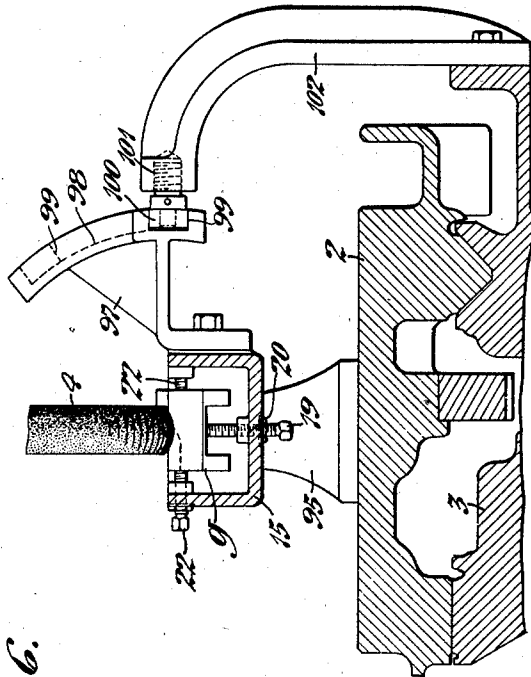


Fig. 7.

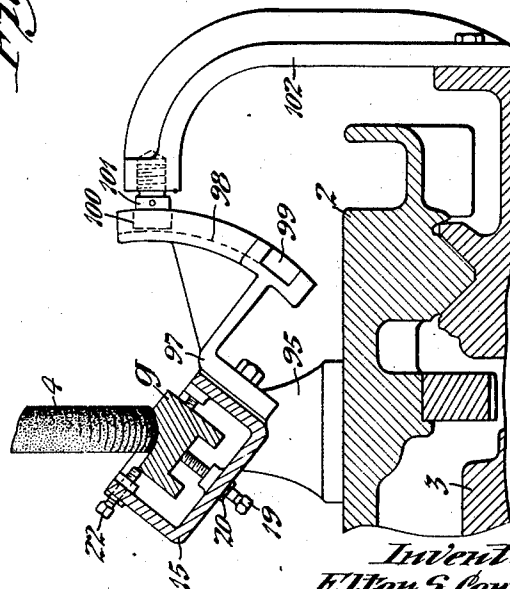


Fig. 8.

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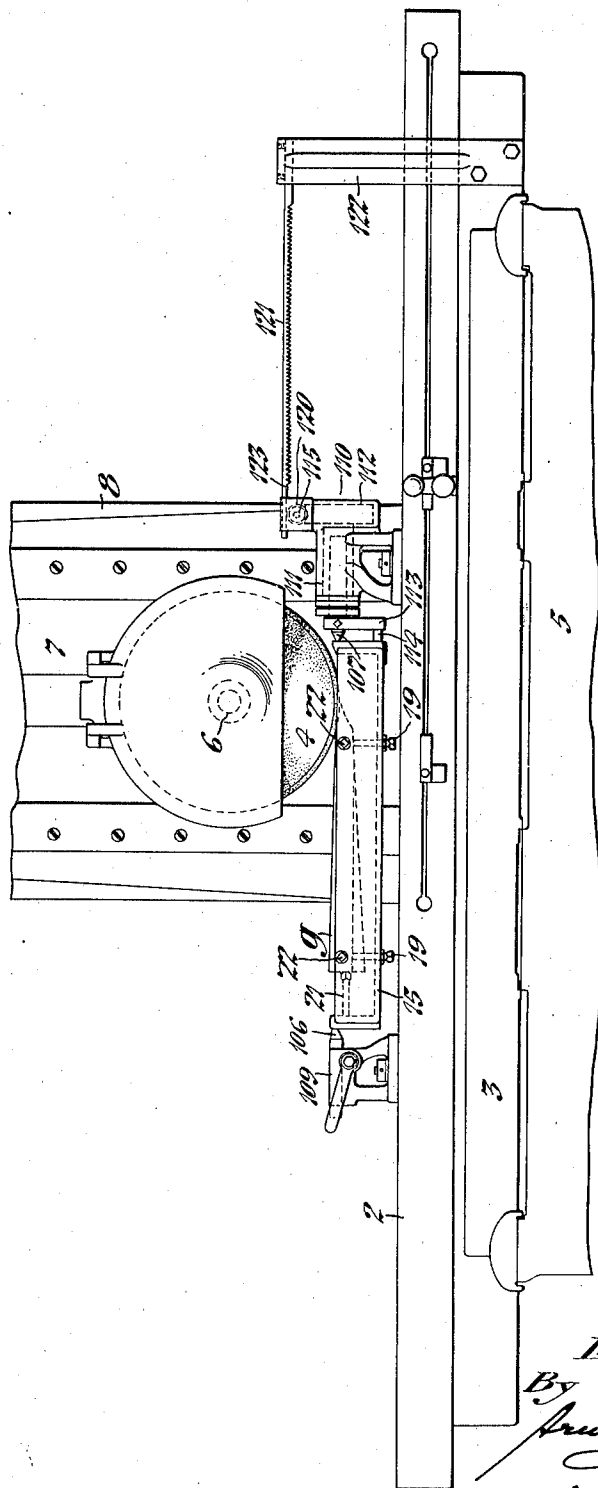


Fig. 9.

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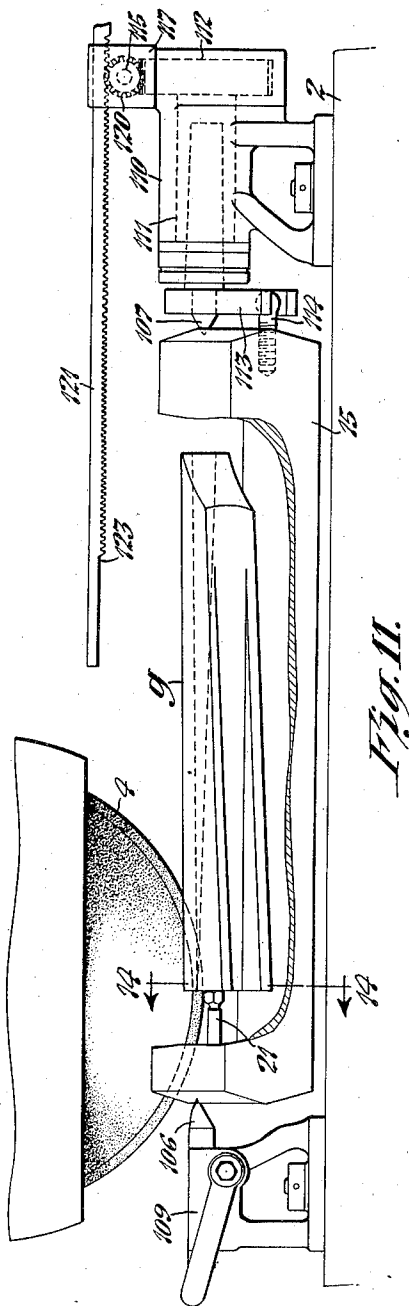
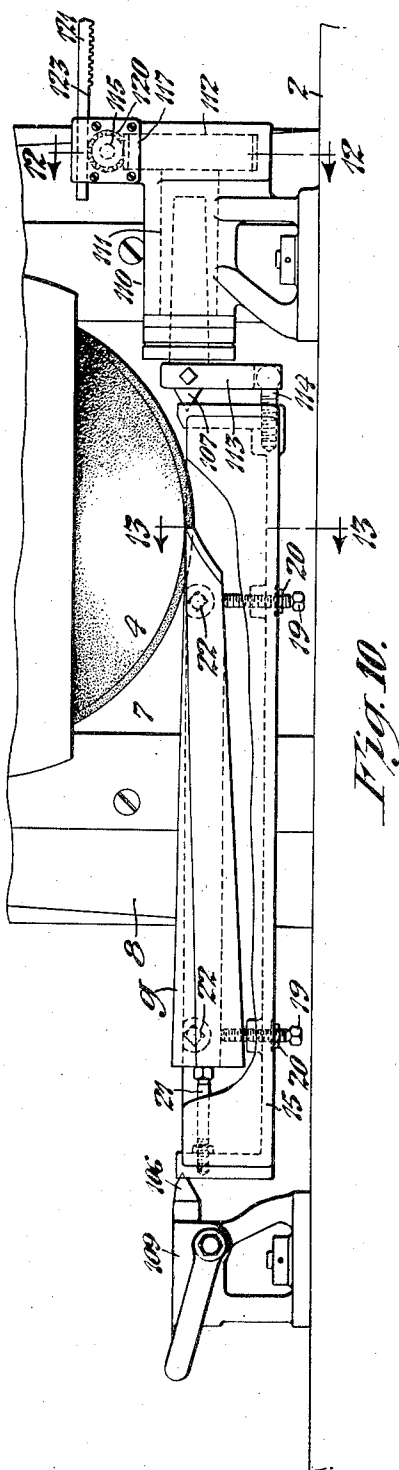
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METALWORKING MACHINE

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Filed Jan. 11, 1937

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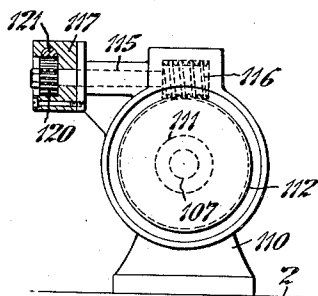


Fig. 12.

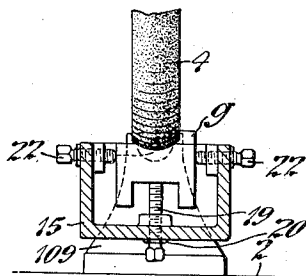


Fig. 13.

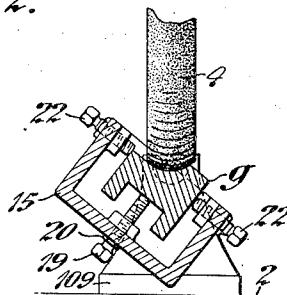


Fig. 14.

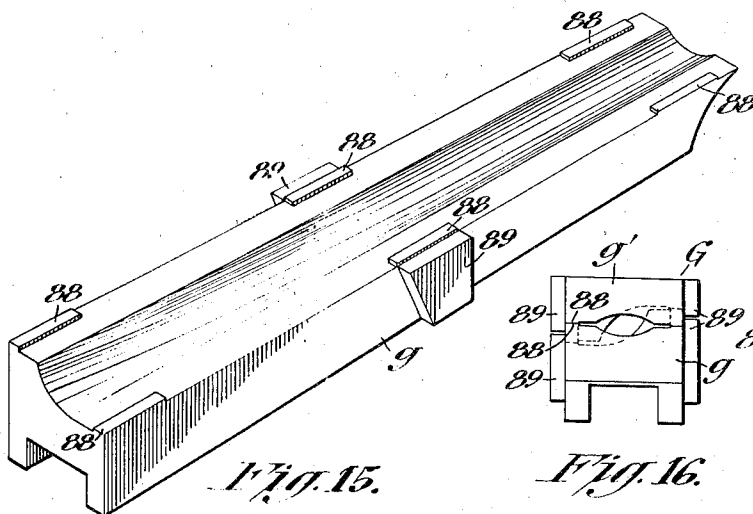


Fig. 15.

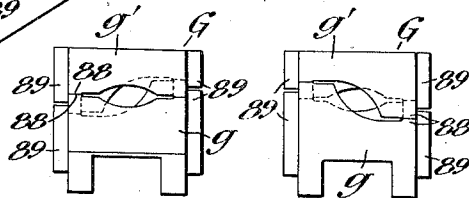


Fig. 16.

Fig. 17.

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UNITED STATES PATENT OFFICE

2,136,491

METALWORKING MACHINE

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Application January 11, 1937, Serial No. 120,124

16 Claims. (Cl. 51—94)

This invention relates to metal-working machines and particularly to means for forming and finishing the grooves of so-called "twister-guides" employed in the manufacture of wire and other attenuated material.

One object of the invention is to provide a device for forming and finishing the grooves in twister-guides to produce an extremely smooth surface without irregularities or flaws liable to scratch or abrade the surface of the wire as it is drawn therethrough during the process of manufacture.

Another object of the invention is to provide a device of the type indicated which is entirely automatic in operation and adapted to produce grooves of helical or like conformation.

Another object of the invention is to provide a device of the type indicated which is adjustable to adapt it for finishing grooves of varying twist or lead and which when once adjusted will operate to produce accurate duplication of the work.

Another object of the invention is to provide a device of the type indicated for accurately producing various forms of grooves having continuous straight and helical portions.

Further objects of the invention are set forth in the following specification which describes several forms of construction of the device, by way of example, as illustrated by the accompanying drawings. In the drawings:

Fig. 1 is a front elevation of a grinding machine incorporating the present invention for forming and finishing the grooves of twister-guides;

Fig. 2 is a plan view of the work-holding parts of the machine showing their position at the start of the grinding operation;

Fig. 3 is a similar view illustrating the parts at the completion of the grinding operation and the manner in which the twister-guide is oscillated with respect to the grinding wheel to cause the groove to be ground in a helical path;

Fig. 4 is an enlarged longitudinal sectional view through the headstock of the machine showing the means for oscillating the work-holder;

Fig. 5 is transverse sectional view through a portion of the machine on line 5—5 of Fig. 2 showing certain elements of the work-holder oscillating means;

Fig. 6 is a front elevational view of a portion of the machine showing a modified form of construction of the work-holder oscillating means;

Fig. 7 is a transverse sectional view of the oscillating means shown in Fig. 6 illustrating the posi-

tion of the elements at the start of the grinding operation;

Fig. 8 is a view similar to Fig. 7 showing the position of the parts at the completion of the grinding operation;

Fig. 9 is a front elevation of the machine showing a further modified form of construction of the work-holder oscillating means;

Fig. 10 is an enlarged front elevational view of the work-holder oscillating means shown in Fig. 9 illustrating the parts in the position assumed at the start of the grinding operation;

Fig. 11 is a view similar to Fig. 10 showing the position of the parts at the completion of the grinding operation;

Fig. 12 is a transverse sectional view of the headstock in this latter modified form of the invention taken on line 12—12 of Fig. 10;

Fig. 13 is a transverse sectional view on line 13—13 of Fig. 10 showing the position of the work-holder at the start of the grinding operation;

Fig. 14 is a transverse sectional view on line 14—14 of Fig. 11 showing the position of the work-holder at the completion of the grinding operation;

Fig. 15 is a perspective view of one of the complementary sections of a twister-guide showing the twister-groove as finished;

Fig. 16 is an end view of the two complementary parts of the twister-guide shown in assembled relationship as applied to use; and

Fig. 17 is a view of the opposite end of the same.

In the manufacture of wire and other attenuated stock the material is usually heated to a high temperature and fed through a rolling mill comprising series of rolls between which the stock draws to reduce it in size, step by step, until it finally takes the required cross-sectional shape and dimension. After feeding through one set of rolls the material is guided to the next set by means of so-called "twister-guides". It has been found in practice that in rolling material to produce stock of various shapes in cross-section better results are obtained by presenting the stock to the rolls with its longer transverse axis positioned vertically. The rolls then act to draw out the material, reducing it in size and delivering it with its major axis in horizontal position. Stated briefly, the stock leads to the rolls with its longer axis in vertical position and after being acted upon by the rolls emerges therefrom with its major axis in horizontal position to be again brought into vertical position before entering the next set of rolls; and so on throughout most of the rolls.

The stock is treated to alter the position of its major axis from horizontal to vertical position between different sets of rolls by means of the twister-guides through which it feeds, see Figs. 15, 16 and 17. Grooves of a shape and size corresponding substantially to that of the stock being worked are formed in the guides and arranged helically to provide that during the travel of the stock therethrough it will be twisted and presented to the next set of rolls in the required relationship. The twister-guides are usually constructed in two complementary sections with one-half of the groove formed in each part; the parts being clamped together to form the complete guide as shown in Figs. 16 and 17. It will be readily understood that the grooves of the twister-guides must necessarily be precisely formed, true to shape, accurate as to size and finished with a smooth, polished surface so as to avoid scraping or otherwise marring the surface of the stock drawing therethrough. For many years the grooves in twister-guides have been finished by manually feeding the latter back and forth across a grinding wheel and by scraping, filing and rubbing with abrasive material. None of these methods has proved satisfactory since it is well nigh impossible to produce a groove having its surface free from rough spots, indentations or crevices, the edges of which are liable to abrade the stock being worked. Since the stock passes through the rolling mill in a heated condition and at a rapid rate of feed it is extremely difficult to detect imperfections therein. Owing to this fact the amount of scrap or waste occurring during production has been very great, sometimes running as high as eighty percent. of the total output of the mill. To overcome this condition the mill is usually stopped periodically and the twister-guides manually refinished and reassembled in place. This requires considerable time, even though duplicate guides are provided, and thus the productive capacity of the mill is curtailed.

It is the aim of the present invention to provide means for automatically forming and finishing the grooves of twister-guides in a machine capable of operating at high speed and accurate in performing the required functions. The machine is preferably provided with a rotating grinding wheel and a table carrying a work-holder for mounting the twister-guide, the wheel or the table being reciprocated, one with respect to the other. The twister-guide is clamped in a holder pivotally mounted on the table and adapted to be rocked about its longitudinal axis during the grinding operation to cause the groove to be ground with a helical pitch. The extent and rate of rocking motion of the holder is adjustable and positively controlled so that the groove may be ground true to form and dimension and with the required degree of twist. In this way the groove may be finished with a mirror-smooth surface, free from imperfections liable to damage the stock to be worked. With the use of twister-guides finished in this manner the quality of the finished stock is greatly improved and the rolling mill may be operated over longer periods of time without stopping to substitute refinished guides. The time required to produce definite lengths of wire or other stock is thus reduced to a minimum with consequent economies in the cost of manufacture.

Referring first to Figs. 1, 2 and 3 of the present drawings, the base machine as herein shown is similar in construction to standard surface-grinding machines now in use but it is to be

understood that the present invention may be embodied in machines of other types with either the table or the metal-working tool arranged for reciprocatory movement as preferred. The grinding machine comprises a carriage or table 2 mounted for reciprocatory movement in ways at the top of a bed or saddle 3 as shown in Figs. 1, 7 and 8. The saddle 3 may be stationary on the base 5 of the machine or adjustable forwardly and rearwardly thereof.

The grinding wheel 4 may be of usual form carried by a spindle or shaft 6 journaled in suitable bearings in a head or support 7 which is mounted for vertical sliding movement in guide-ways formed in the sides of a stanchion or column 8 rising from the base 5 of the machine, see Fig. 1. The grinding wheel may be driven from any suitable source of power by means of a belt passing around a driving pulley on the shaft 6 and another pulley, not herein shown, which forms one element of the table-reciprocating means. In another form of construction, the table 2 may be stationary and the head 7 together with the wheel 4 adapted to be reciprocated longitudinally of the table. The periphery of the grinding wheel 4 may be of a contour to grind grooves of any desired cross-sectional shape such as polygonal, being herein shown as of arcuate shape to adapt it to form semielliptical grooves.

The work *g* comprising one of the complementary parts of a twister-guide is carried by a rockable work-holder 15 supported between a headstock 25 and a tailstock 26 mounted for adjustment longitudinally of the reciprocating table 2. The work-holder 15 may be in the form of a box, see Figs. 2, 3 and 7, having an open top and provided at its ends with lugs 16 formed with tapered holes for receiving the tapered or pointed ends of the centers or trunnions 17 and 18 of the headstock and tailstock 25 and 26, respectively, by which the holder is pivotally suspended. Projecting upwardly through bosses on the bottom of the holder 15 are a plurality of screws or bolts 19 for supporting and positioning the work *g* in the holder; the bolts being locked in adjusted position by means of check-nuts 20 set up against the under side of the holder. The work *g* is placed in the holder 15 resting on the bolts 19 with its end engaging a suitable locating pin or bolt 21 projecting inwardly from one end of the holder, after which bolts 22 threaded through tapped holes in the opposite sides of the holder are set up against the sides of the work to secure it fixedly in place.

The tailstock 26 may be of any suitable type and is therefore not herein shown or described in detail. The headstock 25, however, is of novel construction to adapt it for the purpose of both supporting and rocking or oscillating the holder 15. Referring to Fig. 4, the tapered center 17 of the headstock 25 is fitted to the bore of a hollow spindle 28 journaled in spaced roller-bearings 29 mounted within the housing or hollow frame 30 of the headstock. The inner race of one roller-bearing 29 is held against a shoulder 31 on the spindle 28 by a nut 32 screwed onto a threaded portion of the spindle; while the inner race of the opposite bearing 29 is held against a similar shoulder 33 on the spindle by a nut 34 screwed onto the threaded end of the spindle. Keyed to the spindle 28 at 35 between the nut 34 and shoulder 33 is a spur-gear 36 which is adapted to be rotated to turn the spindle through a part of a revolution by means of a slidable rack 40 to be later described.

Secured to the reduced end of the center or trunnion 17 by means of a set-screw 41 is a depending clamp or dog 42 having a slot at its lower end for receiving a pin 43 projecting from the end of the holder 15; the pin 43 being held fast in the dog by a set-screw 44. The headstock 25 may be adjusted longitudinally of the table 2 and secured in place by T-bolts 45 and nuts 46 arranged in the usual manner, after which the set-screws 41 and 44 may be tightened. Rotary motion of the gear 36 is transmitted to the center 17 of the headstock and through means of the dog 42 the workholder 15 together with the work *g* is oscillated through a part of a revolution for a purpose to be later explained.

Means are provided for resisting the rotative movement of the work-holder 15 for a purpose as later explained. This means consists in a friction ring 47 seated in an annular recess in the side of the gear 36 and normally urged against the finished face of the gear by means of a plurality of compression springs 48. The springs 48 are held in pockets 49 in the side of the ring with their ends bearing against adjusting screws 50, see Fig. 4. The screws 50 are threaded into tapped holes in a cover-member 52 fastened to the end of the housing 30 by screws 53. The friction-ring 47 is held from rotation by projections or splines 54 on its lateral face engaging sockets or keyways 55 on the inner face of the cover-member 52.

The rack-bar 40 is slidably mounted in a guideway 56 formed by transversely-extending vertical and horizontal finished surfaces of the housing 30 and the inner face of a plate 57 attached to the end of the housing by screws 58. The forward end of the rack 40, that is, the end formed with the rack-teeth, is provided with a central slot 60 which extends the entire length of its toothed portion to receive a bar 61 formed with rack-teeth on its upper surface which substantially align with the teeth on the main rack 40. As shown in Fig. 5, the inner end of the slot 60 in the rack 40 is provided with a bore 62 for receiving a compression spring 63 which bears against the inner end of the bar 61 to urge it forwardly. Through the last-described form of construction of the rack 40 any play or backlash between the teeth of the gear 36 and the rack is taken up or compensated for by the spring-pressed bar 61, thus providing for an even and steady rocking motion of the work-holder 15 without vibration or chattering.

Referring now to Figs. 2, 3 and 5 of the drawings, the rearward end of the rack-bar 40 is formed with a slot 65 for receiving the upper reduced end of a stud 66 and surrounding the main shank of the stud is the inner race 67 of a ball-bearing 70. The head 68 of the stud 66 abuts the lower end of the race 67 and a nut 69 on the upper threaded end of the stud holds the race firmly against the under side of the rack-bar 40. Surrounding the race 67 with balls 72 therebetween is an outer race 71 which serves as a bowl or roller adapted to follow a slot or groove 75 in an inclined track or guide 76 to impart a longitudinal reciprocating movement to the rack-bar 40 during the traverse of the table 2.

As shown most clearly in Figs. 2, 3 and 5, the track 76 has a depending stud 77 at one end which projects downwardly through a hole in the horizontally-extending leg 78 of an angular bracket 79 fastened to the rearward side of the bed or saddle 3. It has been explained that os-

cillatory motion is transmitted to the workholder 15 by means of the rack 40 and that the longitudinal sliding movement of the rack is effected by the travel of the roller 71 at its end in the groove 75 of the inclined track 76. The movement of the roller 71 and rack 40 may be controlled to regulate the extent of rocking movement of the work-holder 15 during a predetermined lineal movement of the table 2, this latter movement being usually equal to the length of the work *g*. As shown in Figs. 2 and 3, the track 76 has a widened portion at its end opposite from the pivot-stud 77 with a hole therein through which extends the upper threaded end of a T-bolt 82. The T-bolt 82 has its rectangular head slidably engaged in a T-slot 83 formed in the upper surface of an angular bracket 84 bolted to the rearward side of the saddle 3 at 85. The T-slot 83 is formed in an arc concentric with the axis of the stud 77 to provide that the track 76 may be swung on its pivot with the T-bolt 82 sliding in the slot. After the track 76 has been adjusted at the desired angle with respect to the direction of movement of the table 2 a nut 86 screwed onto the upper threaded end of the T-bolt 82 and set up against the top of the track fixedly secures the latter in position. The opposite end of the track 76 may be held fixed by means of a nut 80 screwed onto the lower threaded end of the pivot-stud 77 and set up against the under side of the leg 78 of the bracket 79. The upper face of the bracket 84 may be provided with an index mark adapted to register with graduations 87 scored in the beveled end of the track 76 to indicate the degree of angular adjustment of the track as it is swung on its pivot. As previously explained, the stock passing through the drawing mill must be turned or twisted ninety degrees between different sets of drawing rolls and the grooves in the twister-guides form helical guideways to impart such turning movement to the stock. The graduations 87 are so calculated and placed as to indicate the required adjustment of the track 76 to effect proper oscillation of the work during predetermined lengths of traverse thereof in accordance with the desired twist per unit of length. One preferred form of construction of the device having now been described in detail its method of operation will next be explained.

To prepare the machine for operation a suitable grinding wheel 4 is applied to the spindle 6 and the twister-guide section *g* placed in the holder 15 and secured in place by the bolts 22. The device is herein illustrated, by way of example, as adjusted to cause the twister-guide section *g* to be formed with a semielliptical groove which, if continued, would twist with its major axis turning from horizontal to vertical position within the required distance of say, three feet; this distance being governed by the relation of the guide to the set of the rolls to which it delivers. To effect the required degree of twist the track 76 is swung on its pivot until the graduation marked "3" registers with the index-mark on the bracket 84, after which the nuts 80 and 86 are tightened to fixedly secure the track in place. The machine is then ready for the operation of forming and finishing the helical groove in the twister-guide section *g*.

Referring now to Figs. 15, 16 and 17, the twister-guide *G* comprises a bottom section *g* and a top-section *g'* in the form of castings or forgings. The complementary parts *g* and *g'* are provided with raised bosses 88 which abut when

the parts are placed in juxtaposition in reverse relationship. Substantially midway of their length the members *g* and *g'* are formed with tapered lugs 89 which are gripped by suitable clamps for holding them in position when applied to use. The two members *g* and *g'* are formed with concavities at one end to adapt the assembled twister-guide *G* to be placed in close proximity to the periphery of the rolls from which the material delivers, this end receiving the material with its major axis positioned horizontally. It is a common practice to form the twister-guides with their grooves extending without twist for a short distance from the end and the present drawings illustrate the guide-section *g*, see Fig. 15, of this form. Since the length of the guide is considerably less than the distance between the pairs of rolls in the drawing mill the groove need twist only a part of the total ninety degree twist to which the material is subjected during its feed between rolls.

Referring now to Fig. 2, at the left-hand end of the track 76 the groove 75 is preferably beveled off at one side as indicated at 90 to provide that the roller 71 may properly enter into and ride out of the groove as the table 2 is reciprocated. The operation of the machine is started in the usual manner by shifting a clutch to connect the grinding wheel 4 and reciprocating means for the table 2 with the drive. As the table travels toward the right, as viewed in Fig. 2, the work-holder 15 is traversed therewith and remains nonrotative until the roller 71 enters the groove 75 in the track 76. During the first part of the stroke the abrasive wheel 4, indicated by dash lines in Fig. 2, grinds the semielliptical groove in a straight course without twist for a short distance as desired.

Upon entering the groove 75 the roller 71 is caused to move toward the front of the machine simultaneously with its traversing movement toward the right, as viewed in Fig. 3. The roller 71 thus imparts a forward sliding movement to the rack-bar 40 which causes the spur-gear 36 to be rotated to turn the hollow spindle 28 in a clockwise direction as viewed from the right-hand end of the machine. The center 17 and dog 42 being fast with the spindle 28, the turning movement of the latter rocks the work-holder 15 in the same direction to cause the groove to be ground by the wheel 4 with a helical twist; it being understood that the grinding wheel is fed downwardly in the usual manner during the operation of the machine. As the table 2 completes its travel to the right suitable tripping means operate to automatically reverse its direction of traverse while at the same time actuating the feeding means for the grinding wheel. During the return movement of the table 2 the roller 71 travels in the groove 75 to slide the rack-bar 40 rearwardly to rock the work-holder 15 back to initial position to cause the grinding wheel to follow the helical portion of the groove. As the roller 71 runs out of the groove 75 the abrasive wheel 4 acts to grind the straight portion of the twister-groove while the work-holder 15 remains stable on the centers 17 and 18. The direction of traverse of the table 2 is then reversed again and the wheel 4 fed downwardly to adapt it to continue its grinding action in the groove of the guide-section *g* in the manner as first explained.

After the groove in the guide-section *g* has been ground to the correct dimensions, shape and twist, the machine is stopped and the work re-

moved therefrom. The complementary part *g'* may then be placed in the holder 15 and the groove ground therein in the same manner. When the two guide-sections *g* and *g'* are properly finished by the grinding operation they may be clamped in position as illustrated in Figs. 16 and 17 to form the groove elliptical throughout its full length with its major axis twisting from a horizontal plane to a plane at the required inclination to the horizontal as required by the arrangement of the drawing rolls in the mill.

As previously explained, the machine may be adjusted to cause it to grind the twister-grooves with part of their length straight and part twisting. It will be understood, however, that the machine may be adjusted so that the roller 71 will remain in the groove 75 to grind the groove with a continuous helical twist. By limiting the length of the track 76 and providing a bell-mouth entrance at either end of its groove 75 the roller 71 may be caused to leave the groove at both ends thereof to grind the grooves with straight portions at both ends.

By loosening the set-screw 41 and turning the dog 42 to different positions of adjustment the work-holder 15 may be turned on the pivots 17 and 18 until the upper surface of the twister-guide *g* or *g'* is inclined at different angles to the wheel 4 so that grooves having the major axis initially inclined at any desired angle to the horizontal may be produced in the machine. In grinding the straight lengths of the groove while the roller 71 is beyond the end of the track 76 the tendency of the work-holder 15 is to remain level under the action of gravity due to its pendulous mounting. When the work-holder 15 is set at an angle to the wheel 4, however, its tendency to swing back to horizontal position is resisted by the friction-ring 47 which acts in the manner of a brake-shoe to prevent rotation of the gear 36 when the roller 71 is beyond the end of the groove 75.

Figs. 6, 7 and 8 illustrate a modified form of construction of the device in which the work-holder 15 is suspended between pointed trunnions 94 carried by opposite tailstocks 95 adjustably mounted on the reciprocating table 2. Bolted to the side of the work-holder 15 is an arcuately-shaped bracket 97 formed with a helical groove 98 having straight portions 99 at its ends extending in parallel relation to the axis on which the track swings. Engaged in the groove 98 is a roller 100 carried by a stud 101 fast in the upper end of an arm 102 rising from the saddle 3 of the machine.

The method of operation of the last-described device is substantially the same as that of the first-described form of construction. As the table 2 is reciprocated the fixed roller 100 rides in the groove 98 of the bracket 97 to swing the work-holder 15 on its pivots 94. In this manner the work-holder is rocked from the horizontal position shown in Fig. 7 to the inclined position illustrated in Fig. 8 to cause the groove in the twister-guide section *g* to be ground with a straight portion which changes to a helical path as the roller first rides in the straight end 99 and then in the helical portion 98 of the groove in the bracket 97. It will be understood that different brackets 97 having various forms of grooves may be substituted for the one herein shown whereby to adapt the machine for grinding twister-grooves of varying twist or lead.

Figs. 9 to 14, inclusive, illustrate a still further modified form of construction of the means for 75

rocking the work during its travel with respect to the grinding wheel. In this latter form the work-holder 15 is pivotally supported at its ends on the pointed trunnions 106 and 107 of the tailstock 109 and headstock 110, respectively. The tailstock 109 may be of any suitable type while the headstock 110 is of novel construction as next described. A spindle 111 rotatably mounted in the headstock 110 carries the trunnion 107 at one end and a worm-wheel 112 at its opposite end. On the projecting end of the trunnion 107 is adjustably mounted a clamp or dog 113 having its lower end slotted to receive the spherical end of a stud 114 projecting from the end of the work-holder 15. Referring now to Fig. 12, the headstock housing is bored to receive a transversely-extending shaft 115 formed at its inner end with a worm 116 which meshes with the worm-wheel 112. On the opposite end of the shaft 115 is fixed a spur-gear 120, this end of the shaft being journaled in a bearing block 117 fastened to the side of the headstock housing. Mounted to slide in the bearing block 117 above the gear 120 is one end of a relatively long bar 121 having rack-teeth on its under side which mesh with the teeth of the gear. As shown in Fig. 9 the opposite end of the rack-bar 121 is fixedly secured to the end of an angular arm 122 fastened to the side of the saddle 3 of the machine.

As the table 2 is reciprocated with respect to the grinding wheel 4 the shift 115 is rotated by the gear 120 as the latter travels along the rack-bar 121 in mesh with the teeth thereof. Rotary motion is transmitted from the shaft 115 to the spindle 111 and trunnion 107 of the headstock 110 through the worm 116 and wheel 112. As the trunnion 107 is turned it acts through the dog 113 and stud 114 to oscillate the work-holder 15 and the work *g* carried thereby. In this manner the work is swung first in one direction and then in the opposite direction during the traversing motion of the table 2 to cause the groove to be ground in with a helical twist. To provide for grinding the twister-groove with a straight portion the inner end of the bar 121 is formed without rack-teeth as indicated at 123 so that during the initial part of the traversing stroke of the table 2 the gearing remains inoperative.

It will be observed from the foregoing that the present invention provides a machine for forming and finishing twister-guide grooves with varying lengths of straight and helical portions as required. The machine is automatic in operation and adjustable to adapt it for grinding twister-grooves of various forms; when once adjusted being capable of duplicating the work to produce twister-guides of accurate form and dimensions.

With the use of the present improved machine the guides may be ground very rapidly with their grooves finished without flaws so that they may be employed continuously for longer periods of time without refinishing. Due to the fact that the twister-grooves are formed automatically and mechanically without requiring subsequent hand-finishing operations, the guides may be constructed from relatively hard metal of dense and flawless structure, capable of withstanding high temperatures and durable over long periods of use.

While the machine is herein shown and described as embodied in several preferred forms of construction, it is to be understood that various other modifications may be made in the structure and arrangement of the parts thereof without departing from the spirit or scope of the inven-

tion. Therefore, without limiting myself in this respect, I claim:

1. In a machine of the type indicated, a rotating tool, a table reciprocable with respect to the tool, a work-holder rockably mounted on the table, a gear operatively connected to the work-holder, a slidable rack having teeth meshing with the gear, a relatively fixed inclined track, a follower on the rack slidable on the track during the movement of the table, and means for preventing back-lash between the rack and gear comprising a toothed bar slidable longitudinally of the rack with its teeth meshing with the gear, and resilient means acting between the rack and toothed bar to normally urge the latter longitudinally of the rack to compensate for play between the rack and gear.

2. In a metal-working machine, a tool, a table, means for relatively reciprocating said tool and table, a work-holder, means for rockably mounting the work-holder for pendulous oscillation on the table, and automatically-operated means for rocking said work-holder during the relative reciprocation of the tool and table to oscillate the surface of the work about an axis located above the working face of the tool, said last-named means being operative in timed relation to the relative reciprocation of the tool and table to rock the work-holder in one direction as the tool traverses the work during one stroke and to rock the work-holder in the opposite direction as the tool traverses the work during a reverse stroke.

3. In a machine for forming helical grooves in twister-guides, a rotating tool, a table, means for relatively traversing the tool and table, a work-holder, means for mounting the work-holder on the table to adapt it to oscillate the work about an axis at right-angles to the axis of the rotating tool and to contact the tool with the work at a greater distance from the axis of rotation of the tool than from the axis of oscillation of the work-holder, and automatically-operated means for oscillating the work-holder during the relative traverse of the tool and work.

4. In a machine for forming helical grooves in twister-guides, a rotating tool, a table, means for relatively traversing the tool and table, a work-holder beneath the tool, means for pendulously mounting the work-holder on the table to adapt it to oscillate the work about an axis at right-angles to the axis of the rotating tool and to contact the tool with the work below the axis of oscillation of the work-holder, and means automatically operative in timed relation to the relative traverse of the tool and table to rock the work-holder in one direction as the tool traverses the work during one stroke and to rock the work-holder in the opposite direction as the tool traverses the work during a reverse stroke.

5. In a machine for forming helical grooves in twister-guides, a grooving tool, a table, means for relatively traversing the tool and table, a work-holder beneath the tool, means for pendulously mounting the work-holder on the table to adapt it to oscillate the work to contact the tool therewith below the axis of oscillation of the work-holder, and means operative in timed relation to the relative traverse of tool and table to rock the work-holder in one direction as the tool traverses the work during one stroke and to rock the work-holder in the opposite direction as the tool traverses the work during a reverse stroke comprising a gear, a rack for rotating the gear, and means for reciprocating the rack during the relative traverse of the tool and work.

6. In a machine for forming helical grooves in twister-guides, a grooving tool, a table reciprocable with respect to the tool, a work-holder beneath the tool, means for pendulously mounting the work-holder on the table to adapt it to oscillate the work to contact the tool therewith below the axis of oscillation of the work-holder, and means operative in timed relation to the reciprocation of the table to rock the work-holder in one direction as the tool traverses the work during one stroke and to rock the work-holder in the opposite direction as the tool traverses the work during a reverse stroke comprising a track inclined to the direction of traverse of the table, a rack carried by and slidable laterally of the table, a follower on the rack slidable on the track, and a gear rotated by the rack and connected to rock the work-holder.
7. In a machine for forming helical grooves in twister-guides, a grooving tool, a table reciprocable with respect to the tool, a work-holder, means for pendulously mounting the work-holder on the table to adapt it to oscillate the work to contact the tool therewith below the axis of oscillation of the work-holder, and means for oscillating the work-holder during the reciprocating movement of the table comprising a gear connected to the work-holder, a rack for rotating the gear, a track inclined to the direction of traverse of the table for actuating the rack, and means for adjusting the inclination of the track to regulate the degree of oscillation of the holder.
8. In a machine for forming grooves in twister-guides, a grooving tool, a table, means for relatively traversing the tool and table, a work-holder, means for pendulously mounting the work-holder on the table to adapt it to oscillate the work to contact the tool therewith below the axis of oscillation of the work-holder, and means for oscillating the work-holder during the traverse of the tool on the work comprising a gear connected to the work-holder, a rack slidable transversely of the table for rotating the gear, a follower on the rack, and a relatively fixed guideway having straight and inclined portions, said follower being slidable in the guideway to actuate the rack and rock the work-holder to cause the work to be grooved in both straight and helical paths.
9. In a machine of the type indicated, a rotating groove-forming tool, a table reciprocable with respect to the tool, a work-holder, means for pendulously mounting the work-holder on the table to adapt it to oscillate the work to contact the tool therewith below the axis of oscillation of the work-holder, a gear connected to oscillate the work-holder, a rack having its teeth in mesh with the gear, a follower on the rack, a track on which the follower travels during the reciprocatory movement of the table to cause it to oscillate the work-holder, and friction means for resisting turning movement of the holder during a portion of the movement of the table.
10. In a machine for forming helical grooves in twister-guides, a grooving tool, a table, means for traversing the table with respect to the tool, a work-holder, means for pendulously mounting the work-holder on the table to adapt it to oscillate the work to contact the tool therewith below the axis of oscillation of the work-holder, automatically-operated means for oscillating the work-holder during the relative traverse of the work and tool comprising an inclined guideway on the holder, and stationary means engageable with the guideway to cause it to oscillate the work-holder during the reciprocation of the table.
11. In a machine for forming grooves in twister-guides, a grooving tool, a table, means for reciprocating the table with respect to the tool, a work-holder, means for pendulously mounting the work-holder on the table to adapt it to oscillate the work to contact the tool therewith below the axis of oscillation of the work-holder, a guideway on the work-holder having inclined and straight portions, and a relatively stationary follower engaging the guideway to oscillate the work-holder during portions of the reciprocating stroke of the table without oscillation thereof during other portions of the stroke.
12. In a machine for forming helical grooves in twister-guides, a grooving tool, a table reciprocable with respect to the tool, a headstock and tailstock on the table, a work-holder pendulously mounted between the centers of the headstock and tailstock to adapt it to oscillate the work to contact the tool therewith below the axis of oscillation of the work-holder, means to rotatively connect the headstock center and work-holder, a gear on said center, and a fixed rack extending longitudinally of the table and connected to rotate the gear in timed relation to the relative reciprocation of the tool and table to rock the work-holder in one direction as the tool traverses the work during one stroke and to rock the work-holder in the opposite direction as the tool traverses the work during a reverse stroke.
13. In a machine for forming helical grooves in twister-guides, a grooving tool, a table, means for relatively traversing the tool and table, a work-holder beneath the tool, means for pendulously mounting the work-holder on the table to adapt it to oscillate the work to contact the tool therewith below the axis of oscillation of the work-holder, and means operative in timed relation to the relative traverse of the tool and table to rock the work-holder in one direction as the tool traverses the work during one stroke and to rock the work-holder in the opposite direction as the tool traverses the work during a reverse stroke comprising a worm-wheel operatively connected to the work-holder, a worm meshing with the wheel and carrying a gear, and a fixed rack engaging the gear to rotate the latter first in one direction and then in the opposite direction during the reciprocation of the table.
14. In a machine for forming helical grooves in twister-guides, a grooving tool, a work-holder beneath the tool, means for relatively traversing the tool and work-holder, means for pendulously mounting the work-holder to adapt it to oscillate the work about a fixed axis extending in the direction of said traverse, said axis of oscillation for the work-holder being coincident with the axis of the groove to be formed in the work, and means automatically operative in timed relation to the relative traverse of the tool and work-holder to rock the work-holder in one direction as the tool traverses the work during one stroke and to rock the work-holder in the opposite direction as the tool traverses the work during a reverse stroke.
15. In a machine of the type indicated, a rotating groove-forming tool, a table reciprocable with respect to the tool, a headstock and tailstock on the table, a work-holder pendulously mounted between the centers of the headstock and tailstock to adapt it to oscillate the work to contact the tool therewith below the axis of oscillation of the work-holder, means to rotatively connect the headstock center and work-holder, a gear on said

center, a rack slidable transversely of the table with its teeth in mesh with the gear, means for sliding the rack during a portion of the stroke of the table, and means operative to hold the gear
5 against rotation during other portions of the stroke whereby the work will be grooved both straight and helically.

16. In a machine for forming helical grooves in twister guides, a grooving tool, a work-holder
10 beneath the tool, means for relatively traversing the tool and work-holder, means for pendulously mounting the work-holder to adapt it to oscillate the work about a fixed axis extending in the direction of said traverse, said axis of oscillation

for the work-holder being coincident with the axis of the groove to be formed in the work, means automatically-operative in timed relation to the relative traverse of the tool and work-holder to rock the work-holder in one direction
5 as the tool traverses the work during a portion of one stroke and to rock the work-holder in the opposite direction as the tool traverses the work during the same portion of a reverse stroke, and means operative to hold the work-holder from
10 oscillation during other portions of said strokes whereby the work will be grooved both straight and helically.

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