No. 627,299. Patented June 20, 1899.

F. G. ECHOLS.

METAL WORKING MACHINE.

(Application filed June 13, 1898.)

(No Model.) 4 Sheets—Sheet 1.

Fig. 1.

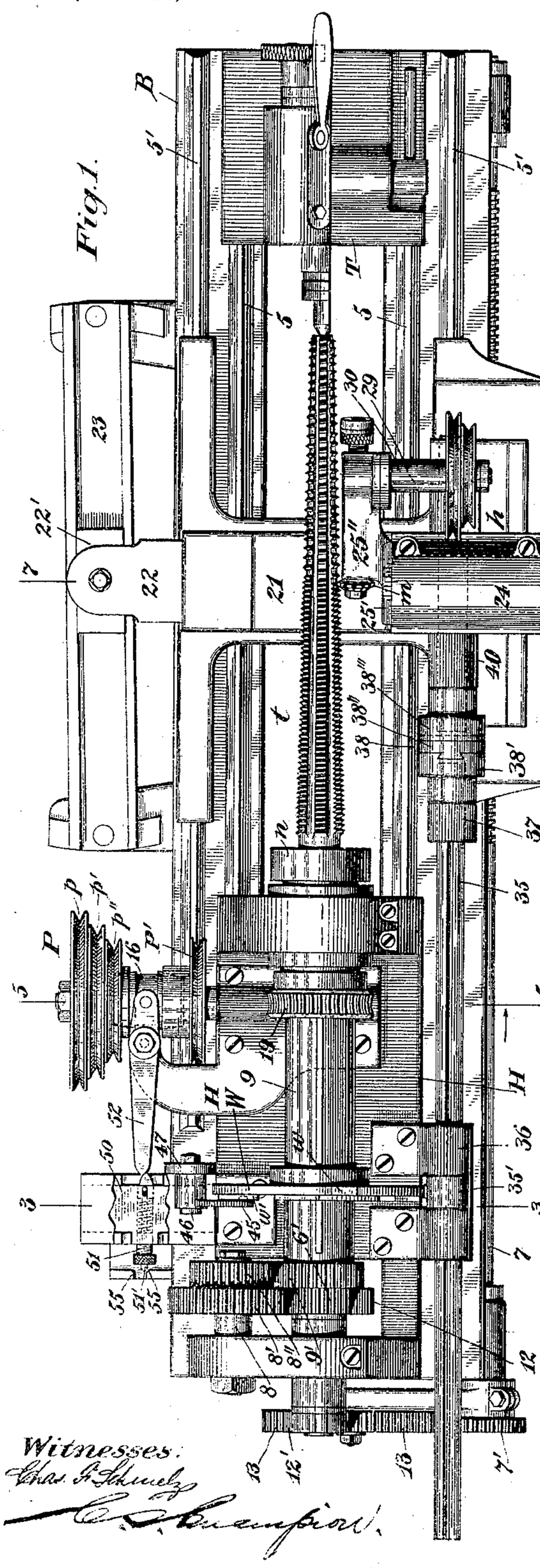
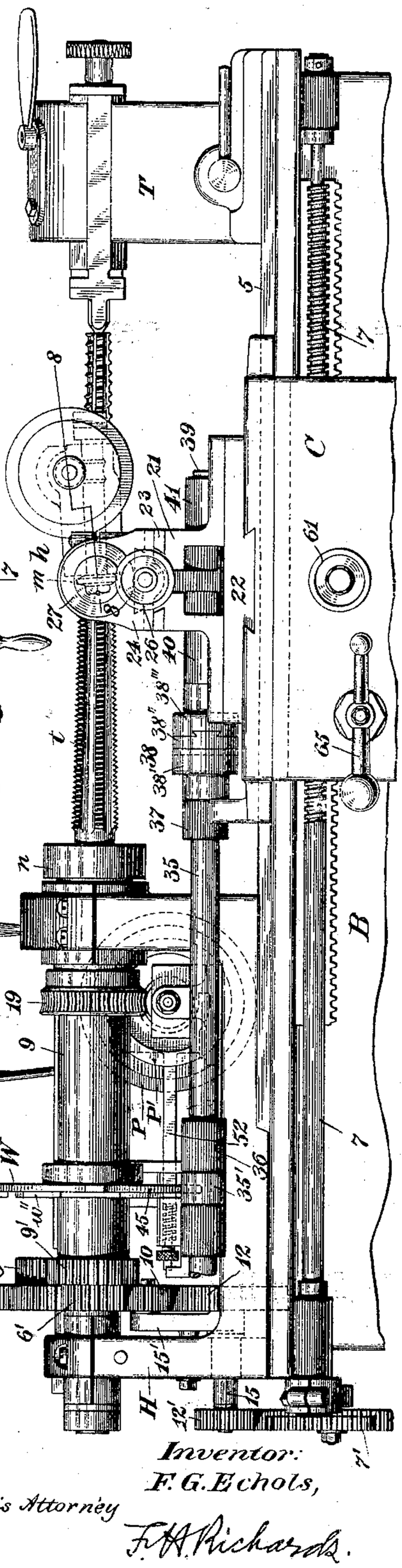


Fig. 2.



Witnesses:
Chas. F. Schmelz
C. Sumpter.

Inventor:
F. G. Echols,
By his Attorney
F. A. Richards.

No. 627,299. Patented June 20, 1899.

F. G. ECHOLS.

METAL WORKING MACHINE.

(Application filed June 13, 1898.)

(No Model.) 4 Sheets—Sheet 2.

Fig. 3.

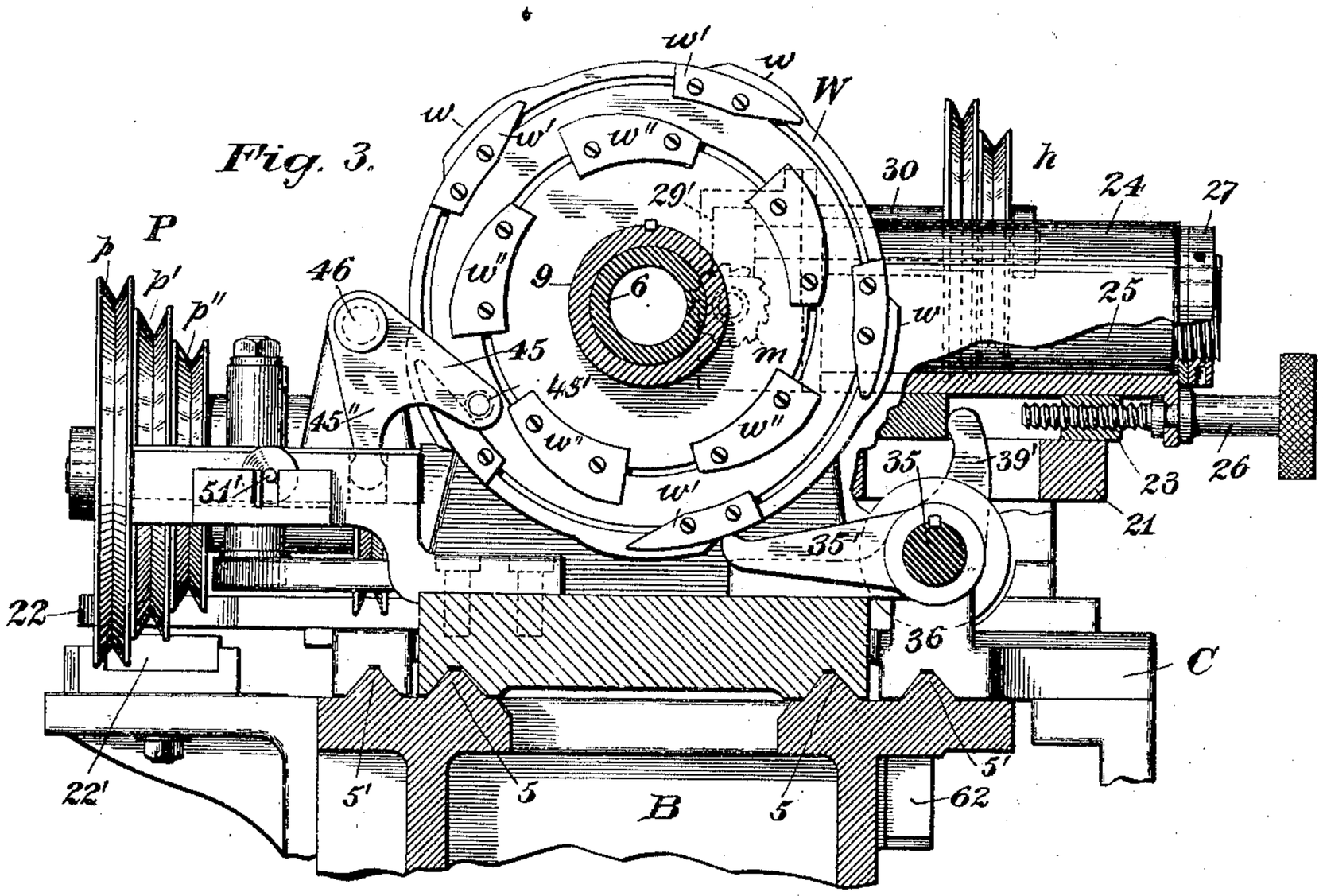
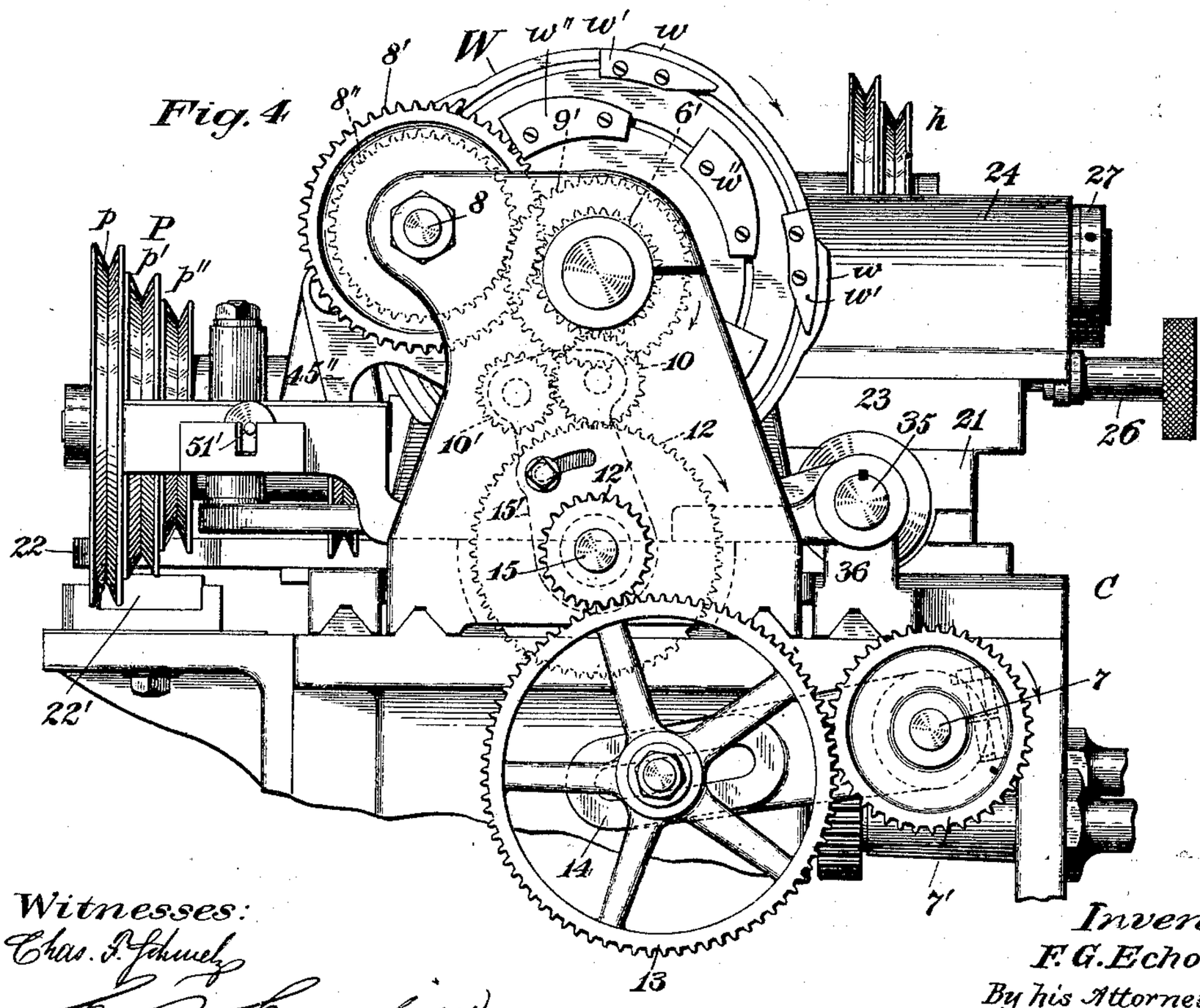


Fig. 4.



Witnesses:
Chas. F. Schmelz
C. A. Campbell.

Inventor:
F. G. Echols,
By his Attorney,
F. A. Richards.

No. 627,299. Patented June 20, 1899.

F. G. ECHOLS.

METAL WORKING MACHINE.

(Application filed June 13, 1898.)

(No Model.)

4 Sheets—Sheet 3.

Fig. 5.

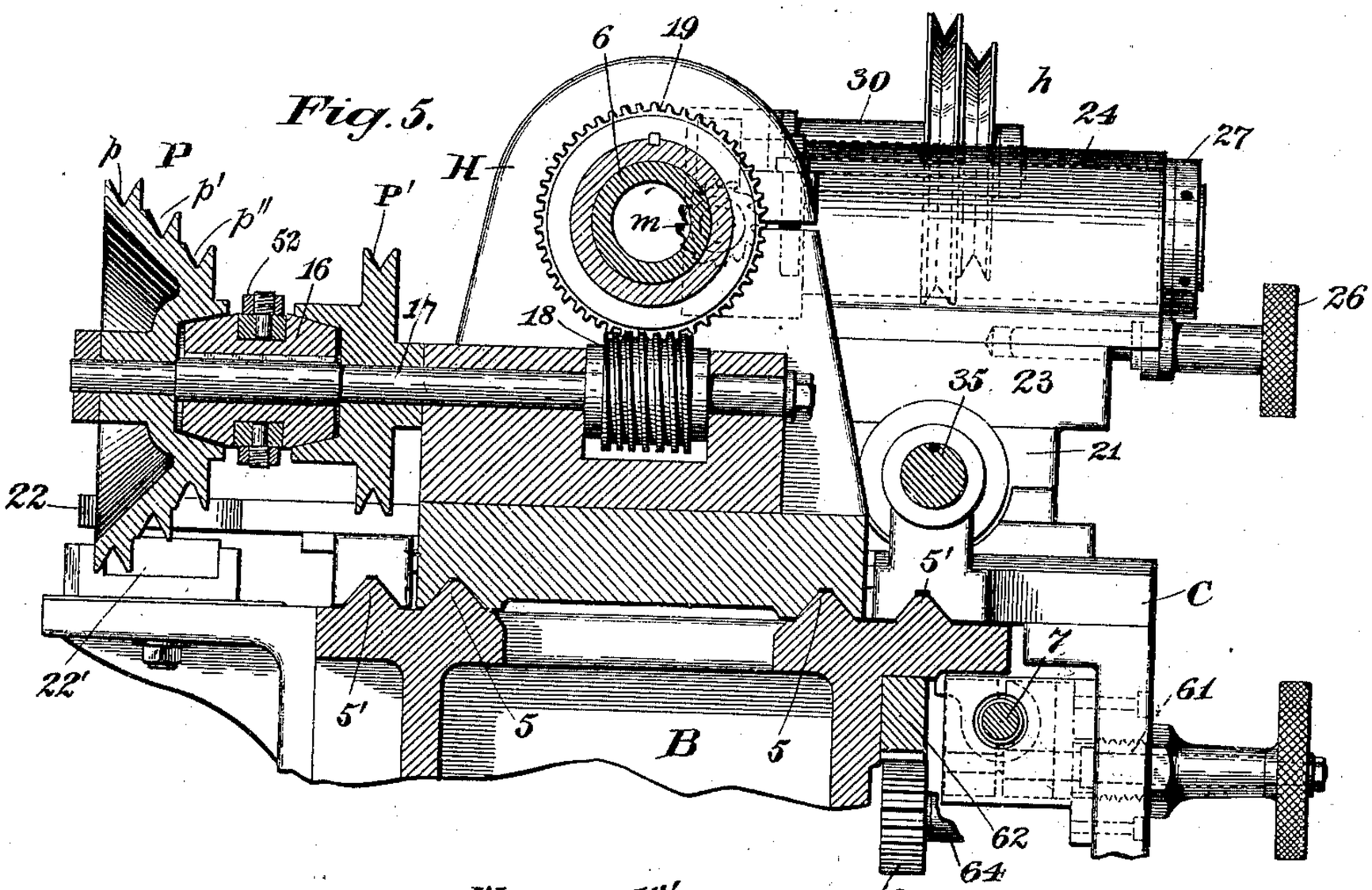
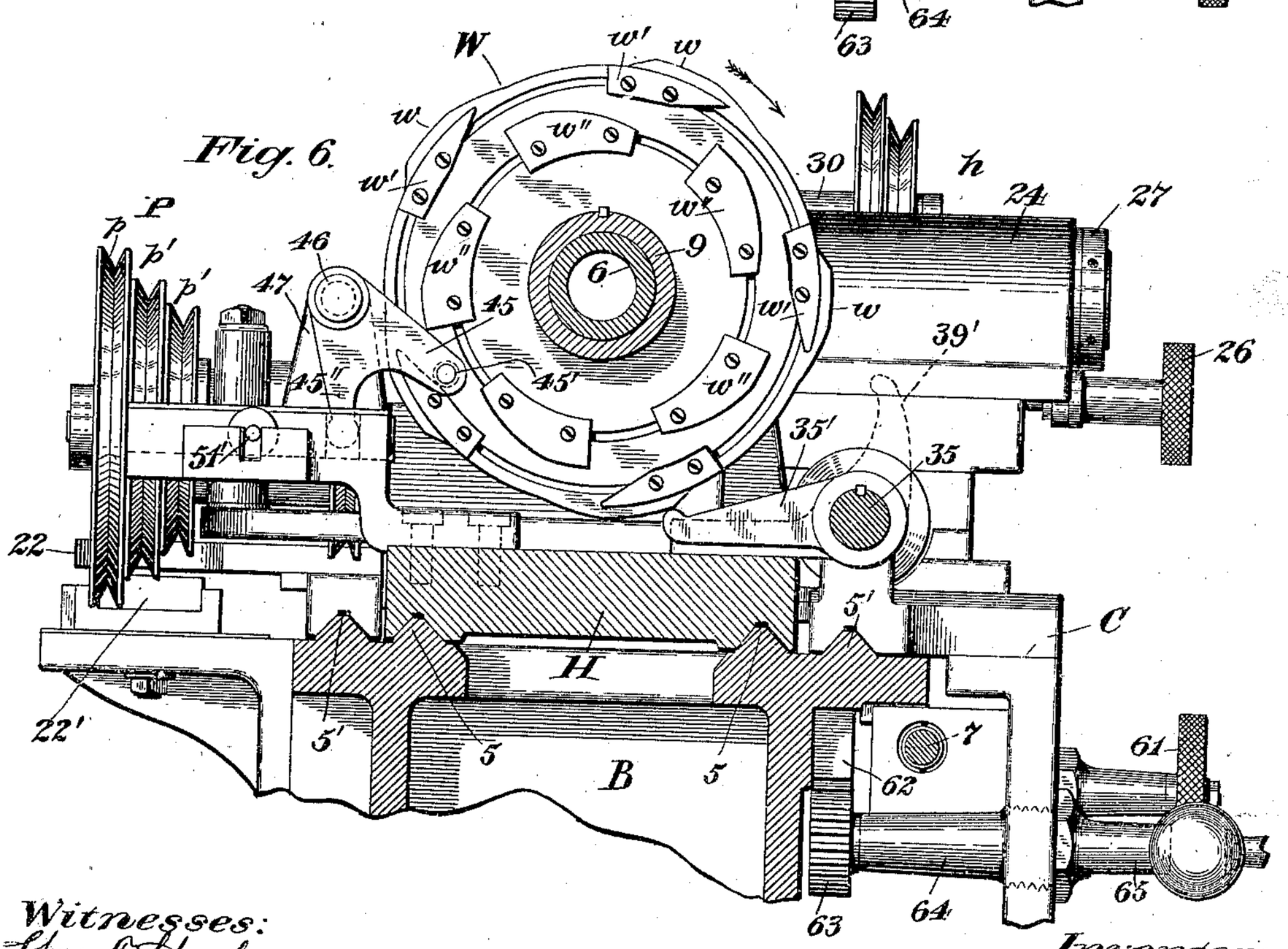


Fig. 6.



Witnesses:
Chas. F. Schuelz
C. C. Thompson

Inventor:
F. G. Echols,
By his Attorney
F. A. Richards.

No. 627,299. Patented June 20, 1899.

F. G. ECHOLS.

METAL WORKING MACHINE.

(Application filed June 13, 1898.)

(No Model.) 4 Sheets—Sheet 4.

Fig. 7.

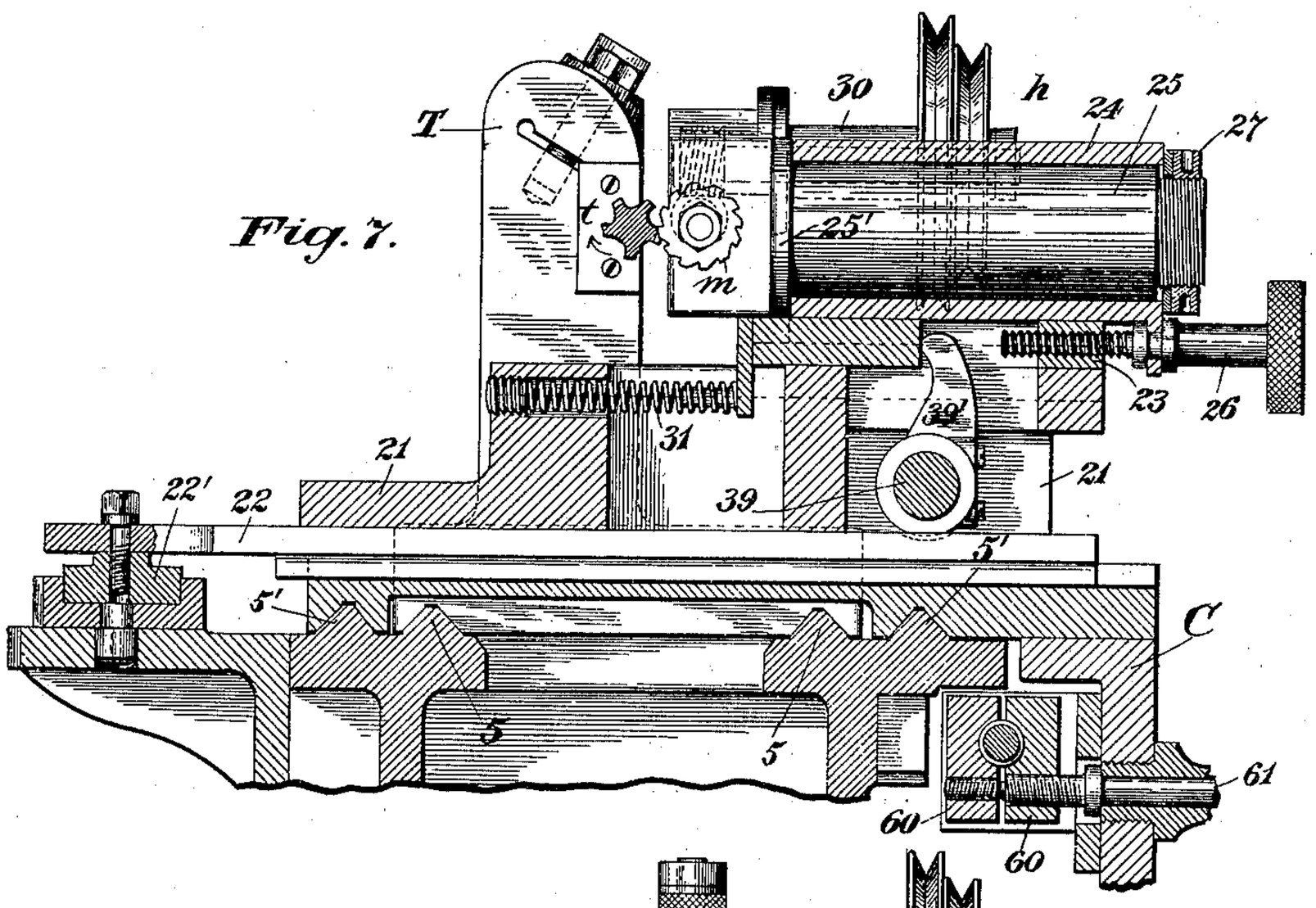


Fig. 10.

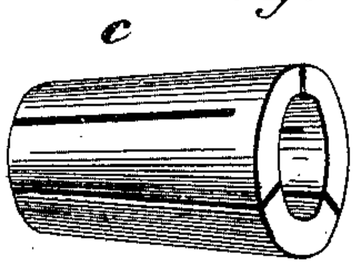


Fig. 8.

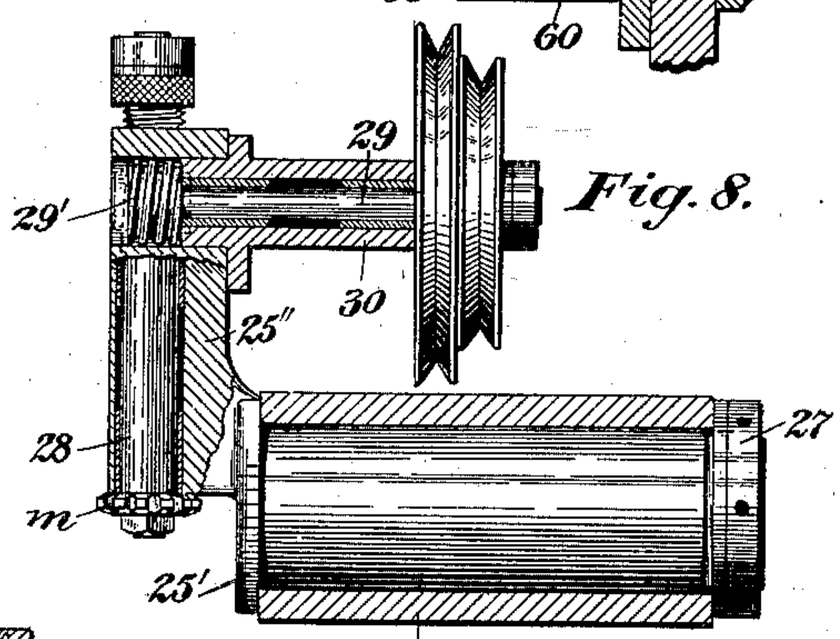
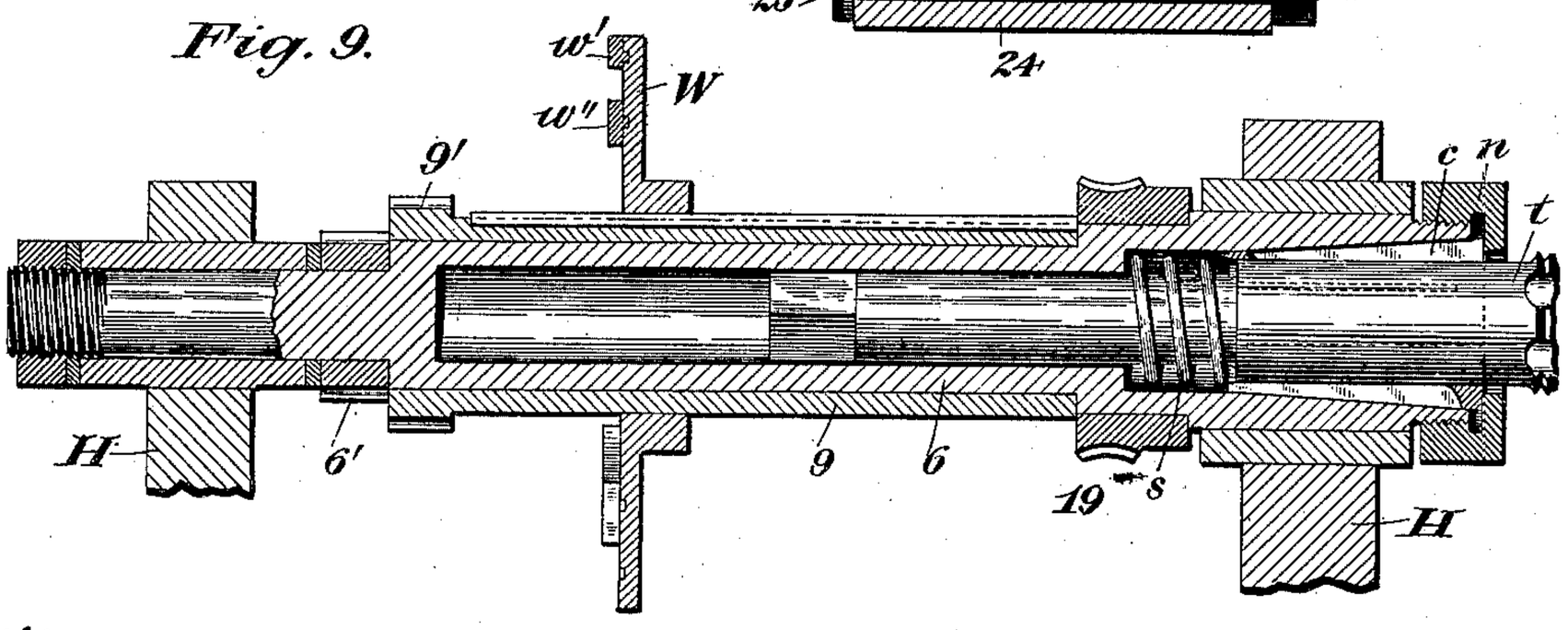


Fig. 9.



Witnesses:
Chas. P. Schmeltz
C. C. Champion.

Inventor:
F. G. Echols,
By his Attorney
F. W. Richards.

UNITED STATES PATENT OFFICE.

FRANK G. ECHOLS, OF HARTFORD, CONNECTICUT, ASSIGNOR TO THE PRATT & WHITNEY COMPANY, OF SAME PLACE.

METAL-WORKING MACHINE.

SPECIFICATION forming part of Letters Patent No. 627,299, dated June 20, 1899.

Application filed June 13, 1898. Serial No. 683,271. (No model.)

To all whom it may concern:

Be it known that I, FRANK G. ECHOLS, a citizen of the United States, residing in Hartford, in the county of Hartford and State of Connecticut, have invented certain new and useful Improvements in Machines for Removing the Teeth of Screw-Threading Tools, of which the following is a specification.

This invention relates to improvements in metal-working machines, and especially to milling-machines; and it has for its main object the provision of a machine of this character especially adapted for cutting away a portion of the teeth of an ordinary screw-cutting tap to form the improved tap described and claimed in Patent No. 588,056, granted to me August 10, 1897. In the tap described in this patent the tool has an odd number of wings, and each wing has one-half the usual number of teeth, one-half of all the teeth of the tap being entirely removed, preferably by cutting away alternate peripheral teeth, all of the teeth being located in a single spiral from end to end of the tap. A machine suitable for forming this improved tap is shown, described, and claimed in my prior patent, No. 602,062, granted April 12, 1898, which machine is intended to operate an ordinary chasing tool or cutter for removing alternate teeth from the wings of the tap. In the machine shown, described, and claimed in the present application, however, my improved tap is intended to be formed by cutting away these alternating teeth by means of a milling-cutter; and one of the main objects of my present invention is the provision, in connection with a suitable rotary work-holder or tap-holder, of a tool-holder on which is mounted a rotary milling-cutter capable of adjustment relatively to the longitudinal axis of the tap to bring the cutter into position for milling teeth of different pitch for different taps, suitable means being employed for shifting the tool-holder toward and from the work-holder a plurality of times during each rotation of a tap in order that the milling-cutter may be shifted into and out of engagement with teeth of alternate wings of the tap.

In connection with suitable means for rotating the work-holder, and hence the tap, and for advancing the milling-cutter up to and withdrawing it from the work I will also employ, ordinarily, feeding means for imparting a traveling movement to the tool-carriage on which the milling-cutter is intended to be mounted in order to permit the cutter to operate upon the teeth of the tap not only at separate points in the periphery of the work, but also at different points in the length of the latter, and follow the spiral in which the teeth of the tap are located.

As it is customary in milling to advance the milling-cutter toward the work somewhat slowly, I prefer ordinarily to make use of a low-speed feed mechanism for imparting this advancing movement to the cutter during the milling of the work; but such a slow return movement to the idle position of the cutter is undesirable not only for the reason that time is wasted in thus retracting the cutter slowly, but also because it would be extremely difficult in milling teeth in alternate wings of the tap, as this machine is intended to do, for the cutter to clear the wing of the tap on which it does not operate and to withdraw from the work in time to prevent striking such wing, which of course would result in interfering with the proper action of the mechanism. When the milling-cutter is withdrawn from the work, however, at a higher rate of speed than that which is employed to advance it, the cutter will readily clear the intermediate uncut wing before the tap in its rotation can come into position for such intermediate wing to strike the teeth of the milling-cutter. Hence an important feature of my present improvements is the employment of differential feed mechanism for imparting somewhat slow advancing movements to the milling-tool during the cutting action and a relatively rapid return movement to such tool to prevent marring of the work, injury to the cutter, and possible damage to other parts of the mechanism. This differential feed mechanism may be of any suitable type; but I prefer to employ for operating the tool-holder upon which the milling-cutter will be mounted a pair of driving members operative alternately, the low-speed one to advance the cutter while it is in action and the high-speed one to return it after it has finished the milling of a tooth in a wing

of the tap, and in connection with this high-speed actuating means for returning the cutter to its idle position I prefer to employ also a quick-let-off device, such as a cam and an operating-spring, the cam serving to permit a quick return movement of the cutter at the proper time and the spring to retract the tool-holder, and hence the cutter, positively and quickly the moment it is released by the cam.

For the purpose of rendering the machine entirely automatic in its action I prefer to employ in connection with the differential driving members of the differential feed mechanism a clutch or coupling which may be of any suitable type, controlled in its movements by the rotation of a driven member actuated first by one and then by the other of the two driving members with which such clutch coöperates. In the preferred construction the clutch will engage the driving members alternately to the driven member, and a suitable slide operated at intervals in the rotation of the driven member will reciprocate the clutch member to its respective clutching positions. The manner in which this is accomplished will be described in detail hereinafter.

In cutting plain taps having straight sides the work-holder and tool-holder will of course maintain the same relative distances between them at the initial points of the several cutting operations; but in cutting taper-taps this interval should vary in accordance with the taper of the tool. Hence in cutting away the teeth of taper-taps I make use, in connection with the instrumentalities hereinbefore mentioned, of a guide disposed at an angle to the longitudinal axis of the work-holder, the angle of inclination of the guide corresponding, of course, to the angle of taper of the tap.

These and other important features of my improved machine not hereinbefore set forth will be hereinafter described in detail.

In the drawings accompanying and forming part of this specification, Figure 1 is a plan of a metal-working machine constructed in accordance with my present improvements. Fig. 2 is a side elevation of the same. Fig. 3 is an enlarged transverse section of the same with parts broken away, the section being taken in line 3 3, Fig. 1, this view illustrating the tool-holder retracted and the milling-cutter in its idle position. Fig. 4 is an enlarged end view of the machine as seen from the left in Fig. 1. Fig. 5 is an enlarged transverse section of the machine with parts broken away, the section being taken in line 5 5, Fig. 1. Fig. 6 is an enlarged transverse section of the machine similar to that shown in Fig. 3, but with the parts in the positions which they assume when the milling-cutter is in its advanced or working position. Fig. 7 is an enlarged section of the machine, the section being taken in line 7 7, Fig. 1. Fig. 8 is an enlarged sectional detail illustrating the tool-holder, the milling-cutter, and the driving means for the latter, the section being taken on the line 8 8, Fig. 2. Fig. 9 is an enlarged longitudinal section of the main driving-spindle or work-spindle and the parts carried thereby, and Fig. 10 is a detail of the chuck-center or collet for engaging and holding the tap in the work-spindle.

Similar characters designate like parts in all the figures of the drawings.

The several operative parts of my improved machine will be mounted ordinarily upon the usual bed B, and many of these working parts are substantially similar to those in metal-working lathes in common use. Among these may be mentioned the tail-stock T, which slides on ways 5 in the usual manner, the head-stock H, the work-spindle 6, and the lead-screw 7, supported for rotation in the bed of the machine and connected with the tool-carriage for imparting to the latter a traveling movement longitudinally of the bed of the machine. The lead-screw receives its movement in this case from the work-spindle 6 through a spur-gear 6′, which meshes also with a gear-wheel 8′, supported on a stud 8, which also carries a second gear-wheel 8″, meshing with the gear-wheel 9′, secured to a sleeve or spindle 9, journaled in this case for rotation on the work-spindle 6, and the movement of the gear 6′ is in turn transmitted through either one of a pair of pinions 10 and 10′ to a gear-wheel 12, suitably supported and driving a pinion 12′, which meshes with a large gear-wheel 13, which in turn drives a gear 7′ on one end of the lead-screw. The large gear-wheel 13 is adjustably supported in this case on an adjustable arm in the usual manner to permit of the use of change-gears, and the two pinions 10 and 10′ are also supported in a well-known manner on the end of an adjustable rock-arm 15′, projecting from a short shaft 15, on which the gear 12 and the pinion 12′ are carried. (See Figs. 2 and 4.) It will be apparent, of course, that when the pinion 10 is in mesh with the gear 6′ the lead-screw will be turned in one direction, while when the pinion 10′ is in mesh with said gear 6′ the movement of the lead-screw will be reversed. These devices just described of course constitute the feeding means for actuating the tool-carriage, and hence the tool-holder, longitudinally of the machine.

For the purpose of rotating the work-spindle 6 I prefer to make use of differential driving mechanism, and hence I have illustrated at P and P′ a pair of driving members. The former in this case may be a cone-pulley having three steps or pulleys p, p', and p'' for driving the mechanism at a low speed, an intermediate speed, or a high speed, while the pulley P′ when operating will always act as a high-speed driving member. Ordinarily either the pulley p or p' will be employed, and the pulley p'' will be used only for very light work. The two driving members or pulleys P and P′ are intended to be alternately effective and will be continuously rotated in the same direction by suitable belts,

as indicated in Fig. 2. For the purpose of engaging these driving members alternately to a suitable driven member of the machine I may make use of a clutch or coupling device such as that illustrated, for example, in Figs, 1 and 5, where I have shown a friction-clutch 16 supported on the same driven member or shaft 17 on which the pulleys P and P′ are mounted, this clutch serving to couple the pulleys alternately to the shaft 17 in a manner well understood. The driving-shaft 17 is intended to transmit its movement directly to the work-spindle 6, which carries the tap to be cut, and in this case the inner end of said shaft is supported in a long bearing in the head-stock H, (see Fig. 5,) a portion of the body of the head-stock being cut away to form cheeks for holding firmly in place a worm 18, carried by the driven member or shaft 17, which worm in turn drives a worm-gear 19, secured to the work-spindle 6.

The work or tap *t* is supported in the usual manner between the head-stock and the tail-stock, the work-spindle 6 being in this case hollow for the greater portion of its length and having a flaring inner end adapted to receive a chuck-center or collet *c*, the inner end of this work-spindle being externally screw-threaded in this case to receive a nut *n* for wedging the chuck-center in place and for loosening the same. This chuck-center may be released by means of a spring *s* and is preferably divided at both ends thereof, as shown clearly in Fig. 10, in order that it may grip the shank of the tap firmly at two widely-separated points in the length of such shank.

The tool-carriage is designated in a general way by C and is supported in the usual manner on ways 5′ for traveling movement longitudinally of the machine. This tool-carriage is made up of several parts; but the tool-carriage proper is intended to support a transversely-movable slide and also a tool-holder, which may be mounted directly on the tool-slide.

The tool-holder may be of any suitable construction, and it will be so mounted as to have a movement for shifting the milling-cutter toward and from the work-holder intermittently, the movement of said tool-holder being so timed that the tool or cutter will be shifted back and forth a plurality of times during a single rotation of the work-spindle. The movement of the tool-holder for carrying the cutter toward and from the work-holder and into and out of engagement with the work may advantageously be a reciprocatory one, the tool-holder, which is indicated herein in a general way by *h*, being mounted in this case on a tool-slide 21, secured to a slidable operating-bar 22, having at its opposite end a shoe 22′, working in a taper-guide 23 of the usual type. By means of this taper-guide and the connections to the cross-feed slide or tool-slide 21 the latter may be operated to impart the proper taper-feed movement to the cutting-tool.

While the cross-feed slide 21 serves as a means for imparting a taper-feed movement to the cutter, it does not in this case support the latter directly; but instead the cutter is carried by the tool-slide proper, *h*, which is intended to be capable of shifting quickly from its working to its idle position in order that the cutter may clear any tooth of the tap which is not to be milled.

The tool-holder *h* may consist of several main parts, although it is only essential for the purpose of adjusting the milling-cutter at any desired angle to cut teeth of different pitch that it should be slidable toward and from the work and should also be so mounted as to permit it to tip in the direction of the axis of the tap; but in the present case the tool-holder preferably consists of a main supporting-slide, such as 23, mounted on the tool-slide 21, an adjusting tubular slide, such as 24, supported on the slide 23 and movable back and forth to enable the operator to adjust the cutter up to and away from the work, and a tool-holding cylinder, such as 25, mounted to turn in said tubular slide. Hence although the tubular slide 24 has an adjustment on the supporting-slide 23, yet it is not essential that more than one part be so used for obtaining a reciprocating or back-and-forth movement of the tool-holder with respect to the work, and therefore said tool-holder may be considered as a duplex one, consisting, essentially, of a slide shiftable on the tool-slide or cross-feed slide 21 and a tool-holding member adjustable in an arc of a circle. The adjustment of the tubular slide 24 on the supporting-slide 23 may be effected in any desired manner, as by means of the adjusting-screw 26. (Shown in Figs. 3 and 7.)

Any suitable means may be employed for holding the cylinder 25 in its adjusted position; but I prefer that the cylinder have a shoulder or flange at its forward side, as indicated at 25′, which shoulder abuts against the forward end of the sleeve 24, while at the rear end of the cylinder the latter may be screw-threaded and carry a nut 27 and a washer for gripping the rear face of the tubular slide.

The shoulder 25′ of the cylinder 25 may have an index thereon, as indicated in Fig. 8, cooperating with a pointer or mark on the tubular slide 24 for enabling the operator to set the cutter at any desired angle to correspond to the pitch of the teeth of the tap to be milled.

The milling-cutter, which is indicated in a general way by *m*, may be mounted in a long bearing in a bracket 25″, projecting from the cylinder 25, this bearing being bushed at its opposite ends.

The spindle on which the milling-cutter is carried is indicated by 28 and may be held in place firmly by means of suitable check-nuts,

said spindle having thereon in this case a worm-wheel meshing with a worm 29′, secured to a driving-spindle 29, journaled in a bearing 30, projecting from the bracket 25″, said driving pulley or pulleys being carried by the spindle 29 and rotated from any proper source.

In order to impart to the tool-holder the quick return movement hereinbefore referred to, I prefer to introduce between the supporting-slide 23 and a fixed portion of the tool-slide or cross-feed slide 21 a strong spring, such as 31, which will force the tool-holder quickly away from the work, as when said tool-holder is released by the cam-actuator controlled by the driving mechanism. In the preferred form thereof this cam-actuator is a cam-wheel preferably of the type shown at W, and in this case it will be secured to the driven member or sleeve 9, which is mounted on the work-spindle 6, and hence said cam-wheel, as well as its supporting sleeve or shaft, will be rotated by the driving mechanism through the medium of the gear-train hereinbefore described at a different rate of speed from that of the work-spindle. In the construction shown a two-to-one gear-train is interposed between the work-spindle and the sleeve 9, and hence the former will be rotated twice as fast as the sleeve, and therefore twice as fast as the cam-wheel. The purpose of this is to enable the tap to be rotated through an arc twice as great as that through which the cam-wheel rotates at each operation in order that every other wing of the tap may be skipped by the cutter and the teeth of the tap cut away only on every wing of the tap as the latter rotates. In the construction shown the cam-wheel has several sets of cams, and the cams of each set are equidistant from one another; but at present it is only necessary to refer to the cams of the outer set, as these are the ones by means of which the tool-carrier is shifted intermittently toward the work. The cams of this outer set are indicated in a general way by *w* and in the construction illustrated coact with a rock-arm 35′, secured to a rock-shaft 35, journaled in bearings at 36 and 37, the former being carried by the head-stock H and the latter by the tool-carriage C. Between the bearing 37 and the tool-holder the shaft 35 is connected by means of a universal coupling, such as 38, with a short shaft 39, supported in bearings 40 and 41, carried by the tool-slide or cross-feed slide 21. Owing to the fact that the cross-feed slide has a taper-feed movement crosswise of the machine, it will be apparent that provision must be made for the eccentric movement of the shaft 39 with respect to the shaft 35. Hence the universal coupling 38 is not one of the ordinary kind, but instead embodies three members, which, as will be obvious by reference to Figs. 1 and 2, are capable of movement with respect to one another in two directions at right angles to one another, the coupling member 38′, secured to the shaft 35, having in this case a dovetailed connection with a central member 38″, which dovetailed connection stands in one direction transverse to the axis of the shaft 35, while the coupling member 38‴, secured to the shaft 39, has a dovetailed connection with the central member 38″, which stands at right angles to the line of the connection between the parts 38′ and 38″. This construction permits all three of these parts to move freely relatively to one another and enables the shaft 39 to be rocked readily by the shaft 35 regardless of the transverse position of the cross-feed slide. The movement of the shaft 39 may be transmitted to the tool-holder in any suitable manner—as, for instance, by a rock-arm 39′, secured to the rock-shaft 39 and working in contact with a suitable fixed part of the supporting-slide 23. When the rock-arm 35′ is in the position shown in Fig. 6, of course the arm 39′ will take a corresponding position and will hold the cutter in engagement with the work-holder. When the rock-arm 35′ is released by the quick-let-off face of the cam *w*, the spring 31 will become effective to shift the tool-holder back quickly to carry the cutter to its idle position and clear the next wing of the tap. It will be noticed that the shaft 35 has a long keyway therein and that the rock-arm 35′ is splined on the shaft in such a manner as to permit the latter to move freely as the tool-carriage travels on the bed. Two other sets of cams may be carried by the cam-wheel W for the purpose of controlling the clutch by which the driving-pulleys P and P′ are thrown into action alternately. The cams of these two sets are designated, respectively, by *w′* and *w″*, and they may be cam-segments detachably secured in concentric grooves in one face of the cam-wheel. The cams *w′* control the clutch when the pulley P′ is to be thrown into action, while the cams *w″* determine the operation of any of the pulleys of the high-speed cone-pulley P. In the construction illustrated the cam-faces of these two sets of cams face in opposite directions, and between them is intended to work a clutch-controlling member, which may be a pin, such as 45′, carried by an arm 45, secured to a short sleeve journaled on a stud 46, projecting from a short post 47, rising from the head H of the machine. This arm 45 has a movement-transmitting member or finger, such as 45″, controlling the movement of a slide, such as 50, supported for reciprocation in a slideway disposed transversely to the axis of the cam shaft or sleeve, this slide carrying a member which controls directly the movements of the clutch 16. In the present case this member or clutch-actuator which is carried by the slide may advantageously be a spring-pressed bolt or similar part, such as 51, having a substantially arrow-shaped or cam-faced point coöperating with another member connected with the clutch, which member may be the usual shifting lever 52, pivoted on the head H. In the

present case this lever and the spring-pressed bolt or pin 51 are disposed substantially in alinement with each other when in their working positions, the bolt being disposed transversely to the slide 50 and mounted in a suitable opening or aperture therein.

The spring which operates the pin or bolt 51 is preferably a strong helical one which will resist the tendency of the lever 52 to push back the bolt when the clutch is to be released from engagement with one of the pulleys P and P', but which of course will yield at the end of the stroke of the lever 52 when the parts are clutched and the lever becomes a fixed abutment, this yielding of the spring permitting the bolt to withdraw and pass by one side face of the lever 52 and engage the opposite side, the working end of this lever being also preferably pointed or substantially arrow-shaped. When the bolt is thus forced back while the shifting lever is a fixed abutment and the bolt moves—for example, from the position shown in Fig. 1 to the opposite side of the lever 52—the latter will be shifted at once, owing to the power of the spring, to the opposite position and will uncouple the clutch 16 from the pulley P' and shift said clutch into working engagement with the low-speed driving member or pulley P. This operation is entirely automatic and takes place on both movements of the bolt 51, thereby resulting in the shifting of the lever 52 in opposite directions alternately to couple and uncouple the said driving members also alternately. Ordinarily the bolt 51 should work properly to shift the lever 52; but as it is liable to stick occasionally I prefer to employ in connection with this clutch-actuator secondary actuating means, which may be one or more fixed bearing-faces, such as 55, on a suitable part of the head H of the machine and adjacent, preferably, to the head of the bolt 51, these faces being disposed substantially at the ends of the range of movement of the bolt with the slide 50. It will be evident that these faces are slightly rounded, as is also, preferably, a projecting head or other part 51' of the bolt 51. When the head 51' comes into engagement with said bearing-face, even if the bolt should stick it will be released immediately by the positive cam action exerted on the head of the bolt by one of the faces 55', which action will result in positively operating such bolt to shift the lever 52 at the proper time.

I have illustrated in the present case a somewhat different connection between the lead-screw 7 and the tool-carriage from that shown in the machine illustrated in my prior patent hereinbefore mentioned. In this case the carriage C supports a divided nut, (indicated herein in a general way by 60,) and the two halves of this nut may be closed upon or disengaged from the lead-screw by a suitable device, such as the right and left end thumb-screw shown at 61, the operation of which will be obvious. When the nut is released from the lead-screw, of course the tool-carriage may be shifted quickly from one position on the bed to another. For the purpose of effecting this movement when the lead-screw is out of engagement with the nut I prefer to make use of a rack and pinion, the rack being carried by the bed of the machine, as indicated at 62, while the pinion (designated by 63) is secured to a short spindle journaled in a bearing 64 on the tool-carriage and preferably operated by means of the usual ball-lever 65. When the split nut is released from the lead-screw and this lever 65 is turned, the tool-carriage and its various parts may be shifted rapidly along the bed.

The operation of a machine constructed in accordance with my present improvements as shown herein is as follows: A tap of ordinary construction which is to be changed into a tap of the type shown in my patent first hereinbefore mentioned should be clamped in place in the usual manner between the head-stock and the tail-stock. It being understood that the tool-carriage is at the beginning of its range of travel—that is, at the extreme right-hand end of the machine shown in Fig. 1—the milling-cutter is then adjusted at the proper angle and clamped in place by the holding-nut 27, after which the cutter is adjusted to the proper position relatively to the tap by the adjusting-screw 26. The machine being started then by the rotation of the pulleys P and P' and the milling-cutter of course being rotated by its pulley, movement will be transmitted to the work-spindle and the other operating parts by the pulley P, which at this time is clutched to the shaft 17. Through the connections from this shaft 17 the lead-screw 7 is rotated preferably at a relatively low speed by the pulley P, and the slow traveling movement of the carriage C begins. As the cam-wheel W rotates the rock-arm 35' is gradually shifted away from the axis of the cam-wheel by riding up the ascent of one of the cams *w*, and thereupon the shafts 35 and 39 and the rock-arm 39' are oscillated correspondingly and the tool-holder *h* is positively advanced toward the tap to enable the cutter *m* to begin the cutting operation on said tap, which at this time is also turning slowly in the same direction as the cutter. When this cutting operation has been finished, the proper cam, which has been shifting the slide 50 toward the axis of the work-holder, will carry such slide through the last part of such movement, and thereby move the clutch-actuator 51 with it and enable such actuator to shift the lever 52 to uncouple the pulley P and clutch the high-speed pulley P' to the shaft 17. Thereupon, of course, the sleeve 9 and the work-holder 6 will be rotated at a more rapid rate of speed, and this will result in turning the tap to bring the second succeeding wing thereof into position to be operated upon by the milling-cutter, which during such movement of the tap will be returned quickly to its normal idle position, first, by reason of the fact that the arm

35′ will ride down the let-off face of the proper cam *w*, and, second, because the released reactive spring 31 will then become effective to return the tool-holder quickly. Shortly after the shifting of the clutch in the manner just described one of the cams *w″* comes into contact with the pin 45′ on the arm 45 and begins to shift such arm and the slide 50 in the opposite direction to that just described—that is, the clutch-actuator 50 is shifted toward the lever 52, as shown in Fig. 1, and at the proper time will ride past the point of said lever and reverse the same to uncouple the pulley P and reclutch the pulley P′ to the shaft 17, whereupon the work-holder 6 and the sleeve 9 will be again rotated at the slow rate of speed and the milling-cutter *m* will be advanced toward the work to mill out another tooth of the tap. This action just described will be repeated and a cut taken for every other tooth of the tap until the end of the spiral in which the teeth are located is reached, it being apparent that as the tool-carriage is fed along gradually by the lead-screw the milling-cutter will be shifted alternately into and out of engagement with the teeth of the tap, it operating to cut alternate teeth in alternate wings and to skip the intermediate teeth in the other wings. Moreover, as the carriage moves the tool-holder will gradually recede from the longitudinal axis of the tap to an extent determined by the taper of the tap and the angular position of the taper-guide 23. The machine will continue to operate automatically to advance and retract the milling-cutter until every other tooth in the tap is entirely cut away and the tap presents throughout the appearance shown at the right hand in Figs. 1 and 2, whereupon the split nut 60 may be released from the lead-screw by turning the right and left hand screw 61, and the ball-lever 65 may then be brought into use to return the tool-carriage to its initial position for operating upon another tap.

Having described my invention, I claim—

1. In a machine of the class specified, the combination, with a tap-holder and with mechanism for rotating the same, of a tool-holder; a rotary milling-cutter carried by said tool-holder; means for adjusting said cutter relatively to the tap to correspond to the pitch of the teeth of the latter; and tool-holder-actuating means for shifting the tool-holder toward and from the tap-holder a plurality of times during each complete rotation of the latter, and for carrying the milling-cutter into and out of engagement with alternate wings of the tap.

2. In a machine of the class specified, the combination, with a tap-holder and with automatically-operative mechanism for rotating the same, of a tool-carriage; means for imparting a feed movement to said carriage; a tool-holder on said carriage; a rotary milling-cutter carried by said tool-holder; means for adjusting said cutter relatively to the tap to correspond to the pitch of the teeth of the latter; and tool-holder-actuating means for shifting the tool-holder toward and from the tap-holder a plurality of times during each complete rotation of the latter, and for carrying the milling-cutter into and out of engagement with alternate wings of the tap.

3. In a machine of the class specified, the combination, with a tap-holder and with automatically-operative mechanism for rotating the same, of a tool-carriage; means for imparting a feed movement to said carriage; a tool-holder on said carriage; a tool-holder guide disposed at an acute angle to the longitudinal axis of the tap-holder; a rotary milling-cutter carried by said tool-holder; means for adjusting said cutter relatively to the tap to correspond to the pitch of the teeth of the latter; and tool-holder-actuating means for shifting the tool-holder toward and from the tap-holder a plurality of times during each complete rotation of the latter, and for carrying the milling-cutter into and out of engagement with alternate wings of the tap.

4. In a machine of the class specified, the combination, with a tap-holder and with automatically-operative mechanism for rotating the same, of a tool-holder; a rotary milling-cutter carried by said tool-holder; means for rotating the milling-cutter in operative relation with, and in the same direction as the tap while the latter is rotating; means for adjusting said cutter relatively to the tap to correspond to the pitch of the teeth thereof; and tool-holder-actuating means for shifting the tool-holder toward and from the tap-holder a plurality of times during each complete rotation of the latter, and for carrying the milling-cutter into and out of engagement with alternate wings of the tap.

5. In a machine of the class specified, the combination, with a rotary tap-holder, of a tool-holder; a rotary milling-cutter carried by said tool-holder; and differential-feed tool-holder-actuating means for shifting the tool-holder toward the tap-holder at one rate of speed a plurality of times during each complete rotation of the latter, and for carrying the milling-cutter into engagement with the wings of the tap, and for returning the tool-holder and the cutter at a higher rate of speed.

6. In a machine of the class specified, the combination, with a rotary tap-holder, of a tool-holder; a rotary milling-cutter carried by said tool-holder; differential driving mechanism for rotating the tap-holder at different rates of speed alternately; and tool-holder-actuating means controlled by said driving mechanism and operative for shifting the tool-holder toward and from the tap-holder a plurality of times during each complete rotation of the latter, and for carrying the milling-cutter into and out of engagement with the wings of the tap.

7. In a machine of the class specified, the combination, with a rotary tap-holder, of a tool-holder; a rotary milling-cutter carried by

said tool-holder; a driven member operatively connected with the tap-holder for rotating the latter; a pair of differential driving members; a clutch coöperative with said driving members alternately and controlled by the rotation of the tap-holder; and tool-holder-actuating means also controlled by said tap-holder and operative for shifting the tool-holder toward and from the tap-holder a plurality of times during each complete rotation of the latter, and for carrying the milling-cutter into and out of engagement with the wings of the tap.

8. In a machine of the class specified, the combination, with a tap-holder and with automatically-operative mechanism for rotating the same, of a tool-holder; a rotary milling-cutter carried by said tool-holder; a rotary tool-holder-actuating cam-shaft having a plurality of cams operative for shifting the tool-holder toward the tap a plurality of times during each complete rotation of the latter, and for carrying the milling-cutter into engagement with the wings of the tap, each of said cams having a quick-let-off face; and an independent tool-holder-actuating spring for imparting a quick-return movement to the tool-holder on the release of the latter, and for withdrawing the cutter from engagement with the wings of the tap.

9. In a machine of the class specified, the combination, with a tap-holder and with automatically-operative mechanism for rotating the same, of a tool-holder; a tool-carriage; mechanism for imparting a feed movement to the tool-carriage; a cross-feed slide supported on said carriage; a reactive slidable tool-holder supported on said cross-feed slide; a rotary milling-cutter carried by said tool-holder; and means for automatically shifting the tool-holder toward the tap-holder a plurality of times during each complete rotation of the latter, and for carrying the milling-cutter into engagement with the wings of the tap.

10. In a machine of the class specified, the combination, with a tap-holder and with automatically-operative mechanism for rotating the same, of a tool-holder; a tool-carriage; mechanism for imparting a feed movement to the tool-carriage; a reactive tool-slide supported by said carriage; a tool-holder adjustable on said tool-slide; a rotary milling-cutter carried by said tool-holder; and means for automatically shifting the tool-holder toward the tap-holder a plurality of times during each complete rotation of the latter, and for carrying the milling-cutter into engagement with the wings of the tap.

11. In a machine of the class specified, the combination, with a tap-holder and with automatically-operative mechanism for rotating the same, of a tool-holder; a tool-carriage; mechanism for imparting a feed movement to the tool-carriage; a reactive tool-slide supported by the said carriage; a tool-holder adjustable on said tool-slide in different directions; a rotary milling-cutter carried by said tool-holder; and means for automatically shifting the tool-holder toward the tap-holder a plurality of times during each complete rotation of the latter, and for carrying the milling-cutter into engagement with the wings of the tap.

12. In a machine of the class specified, the combination, with a tap-holder and with automatically-operative mechanism for rotating the same, of a tool-holder; a tool-carriage; mechanism for imparting a feed movement to the tool-carriage; a reactive tool-slide supported by said carriage; a duplex tool-holder one of the members of which is adjustable longitudinally of said slide and the other in an arc of a circle; a rotary milling-cutter carried by said tool-holder; and means for automatically shifting the tool-holder toward the tap-holder a plurality of times during each complete rotation of the latter, and for carrying the milling-cutter into engagement with the wings of the tap.

13. In a machine of the class specified, the combination, with a tap-holder and with automatically-operative mechanism for rotating the same, of a tool-holder; a tool-carriage; mechanism for imparting a feed movement to the tool-carriage; a reactive tool-slide supported by said carriage; a tubular slide adjustable longitudinally of said tool-slide; a tool-holding cylinder mounted to turn in said tubular slide; holding means for securing said cylinder in its adjusted position; a rotary milling-cutter carried by said cylinder; and means for automatically shifting the tubular slide toward the tap-holder a plurality of times during each complete rotation of the latter, and for carrying the milling-cutter into engagement with the wings of the tap.

14. The combination, with a rotary driven member having two sets of cams, of a pair of alternately-operative driving members controlling the rotation of the driven member; a clutch coöperative with said driving members alternately; and a clutch-operating slide shiftable in opposite directions alternately by said cams.

15. The combination, with a rotary driven member having a plurality of cams, of a pair of alternately-operative driving members controlling the rotation of the driven member; a clutch coöperative with said driving members alternately; a clutch-operating slide operative by said cams; and a clutch-shifting lever connected with said clutch and operative by said slide.

16. The combination, with a rotary driven member having a plurality of cams, of a pair of alternately-operative driving members controlling the rotation of the driven member; a clutch coöperative with said driving members alternately; a clutch-operating slide operative by said cams; and a spring-pressed clutch-actuator carried by said slide.

17. The combination, with a rotary driven member having a plurality of cams, of a pair of alternately-operative driving members con-

trolling the rotation of the driven member; a clutch coöperative with said driving members alternately; a clutch-operating slide operative by said cams; a spring-pressed clutch-actuator carried by said slide; and a clutch-shifting lever substantially in alinement with and operative by said actuator.

18. The combination, with a rotary driven member having a plurality of cams, of a pair of alternately-operative driving members controlling the rotation of the driven member; a clutch coöperative with said driving members alternately; a clutch-operating slide operative by said cams; a spring-pressed clutch-actuator carried by said slide; and secondary clutch-actuating means for positively operating said clutch-actuator.

19. The combination, with a rotary driven member having a plurality of cams, of a pair of alternately-operative driving members controlling the rotation of the driven member; a clutch coöperative with said driving members alternately; a clutch-operative slide operative by said cams; a spring-pressed clutch-actuator carried by said slide; and an operating-face in the path of movement of said clutch-actuator for positively shifting the latter.

20. The combination, with a rotary driven member having two sets of cams, of a pair of alternately-operative driving members controlling the rotation of the driven member; a clutch coöperative with said driving members alternately; a clutch-operating slide shiftable in opposite directions alternately by said cams; and a spring-pressed clutch-actuator carried by said slide and operative in a direction transverse to the path of movement of the slide for shifting the clutch in opposite directions alternately.

21. The combination, with a rotary driven member having two sets of cams, of a pair of alternately-operative driving members controlling the rotation of the driven member; a clutch coöperative with said driving members alternately; a clutch-operating slide shiftable in opposite directions alternately by said cams; a spring-pressed clutch-actuator carried by said slide and operative in a direction transverse to the path of movement of the slide for shifting the clutch in opposite directions alternately; and a pair of operating-faces at opposite ends of the normal path of movement of the clutch-actuator and operative alternately for shifting the latter.

22. The combination, with a driven member, of a tool-holder; a pair of alternately-operative driving members controlling the rotation of the driven member; a clutch coöperative with said driving members alternately and controlled by the rotation of the driven member; and tool-holder-actuating means also controlled by said driven member and operative for shifting the tool-holder into and out of working position a plurality of times during each complete rotation of the driven member.

23. The combination, with a driven member having three sets of cams, of a tool-holder; a pair of alternately-operative driving members controlling the rotation of the driven member; a clutch coöperative with said driving members alternately and operative in opposite directions alternately by two of said sets of cams; and tool-holder-actuating means controlled by the third set of cams and operative for shifting the tool-holder into working position a plurality of times during each complete rotation of the driven member.

24. The combination, with a driven member having three sets of equidistant cams, of a tool-holder; a pair of alternately-operative driving members controlling the rotation of the driven member; a clutch coöperative with said driving members alternately and operative in opposite directions alternately by two of said sets of cams; and tool-holder-actuating means controlled by the third set of cams and operative for shifting the tool-holder into working position a plurality of times during each complete rotation of the driven member.

25. The combination, with a driven member having three sets of cams, of a tool-holder; a pair of alternately-operative high-speed and low-speed driving-pulleys controlling the rotation of the driven member; a clutch coöperative with said pulleys alternately and operative in opposite directions alternately by two of said sets of cams; and tool-holder-actuating means controlled by the third set of cams and operative for shifting the tool-holder into working position a plurality of times during each complete rotation of the driven member.

26. The combination, with a driven member having three sets of cams, of a tool-holder; a pair of alternately-operative driving members controlling the rotation of the driven member; a clutch coöperative with said driving members alternately and operative in opposite directions alternately by two of said sets of cams; tool-holder-actuating means controlled by the third set of cams and operative for shifting the tool-holder into working position a plurality of times at one rate of speed during each complete rotation of the driven member; and means for returning the tool-holder to its idle position at a higher rate of speed.

27. The combination, with a driving member, of a tap-carrying work-spindle; a rotary driven member having a circuit of cams; a two-to-one gear-train between said work-spindle and said driven member; a tool-holder; a rotary milling-cutter carried by said tool-holder; and tool-holder-actuating means controlled by said cams and operative for shifting the tool-holder toward the work-spindle a plurality of times during each complete rotation of the latter, and for carrying the cutter into engagement with alternate wings of the tap.

FRANK G. ECHOLS.

Witnesses:
FRANCIS H. RICHARDS,
GEORGE A. HOFFMAN.