Jan. 5, 1932.

J. W. SMITH

1,840,059

ROLLING MACHINE

Filed June 28, 1928

8 Sheets-Sheet 1

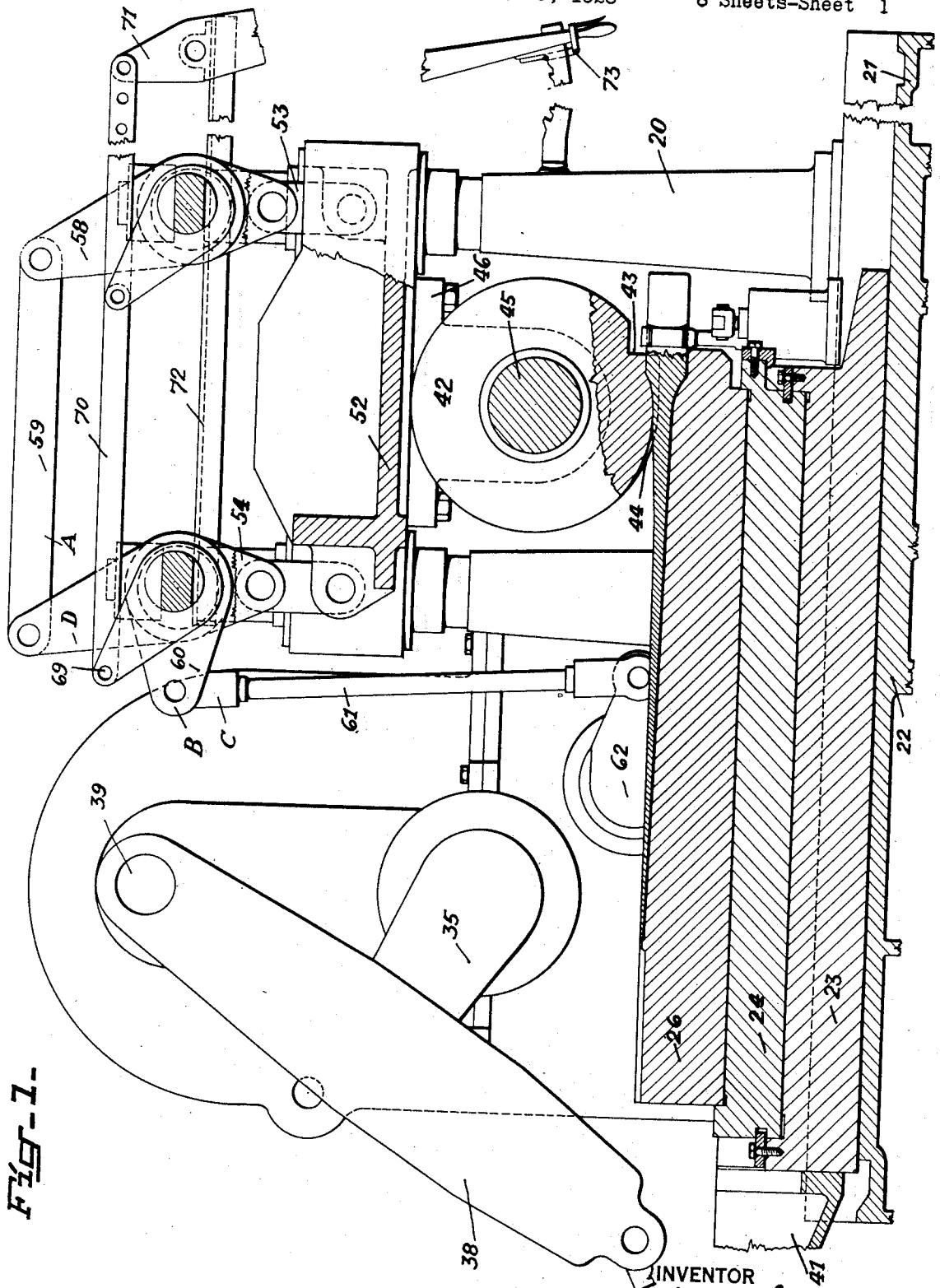


FIG. 1.

INVENTOR

BY John W. Smith

Duell Dunn Anderson

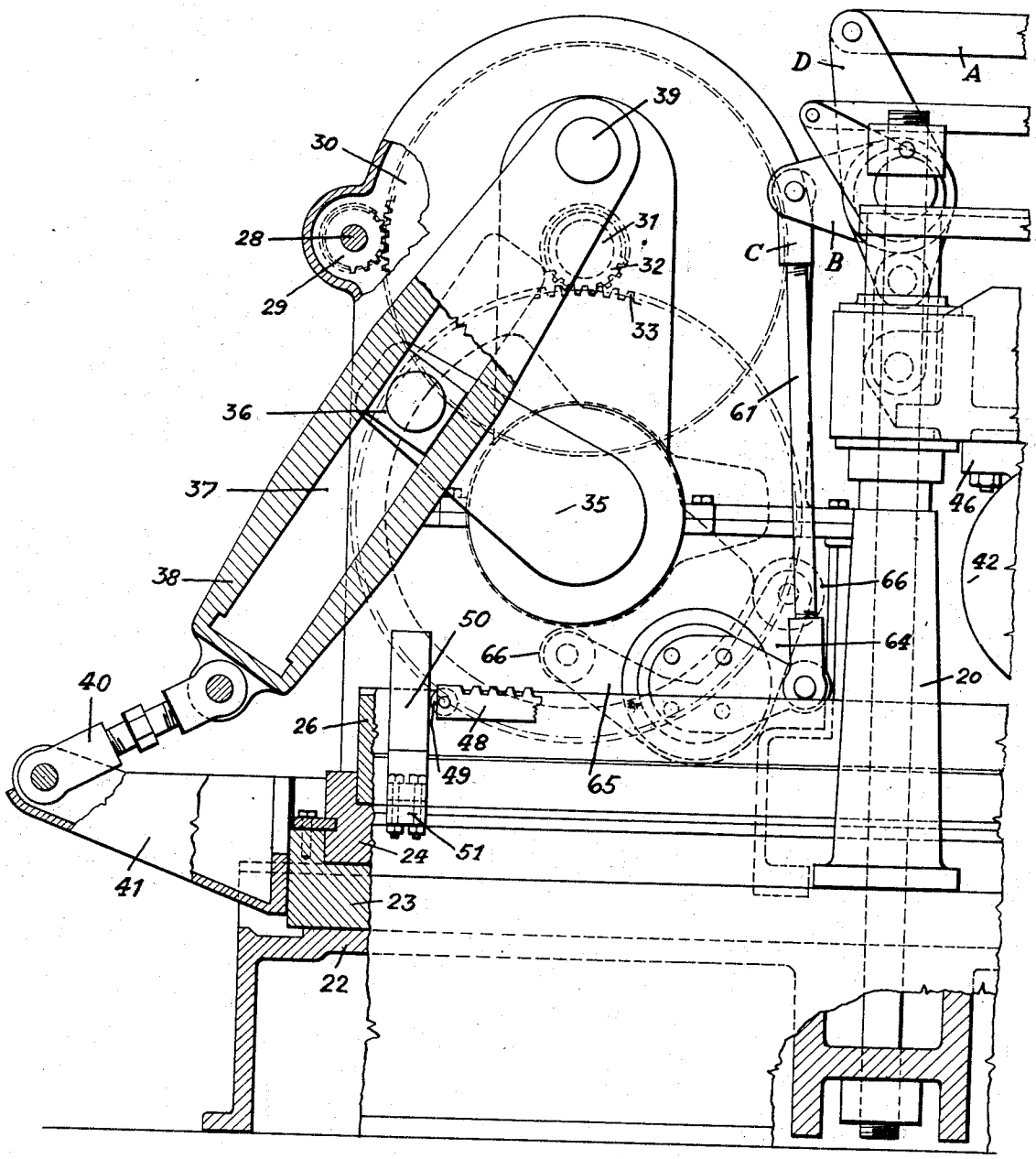
ATTORNEY

Jan. 5, 1932. J. W. SMITH 1,840,059

ROLLING MACHINE

Filed June 28, 1928 8 Sheets-Sheet 2

Fig. 2.



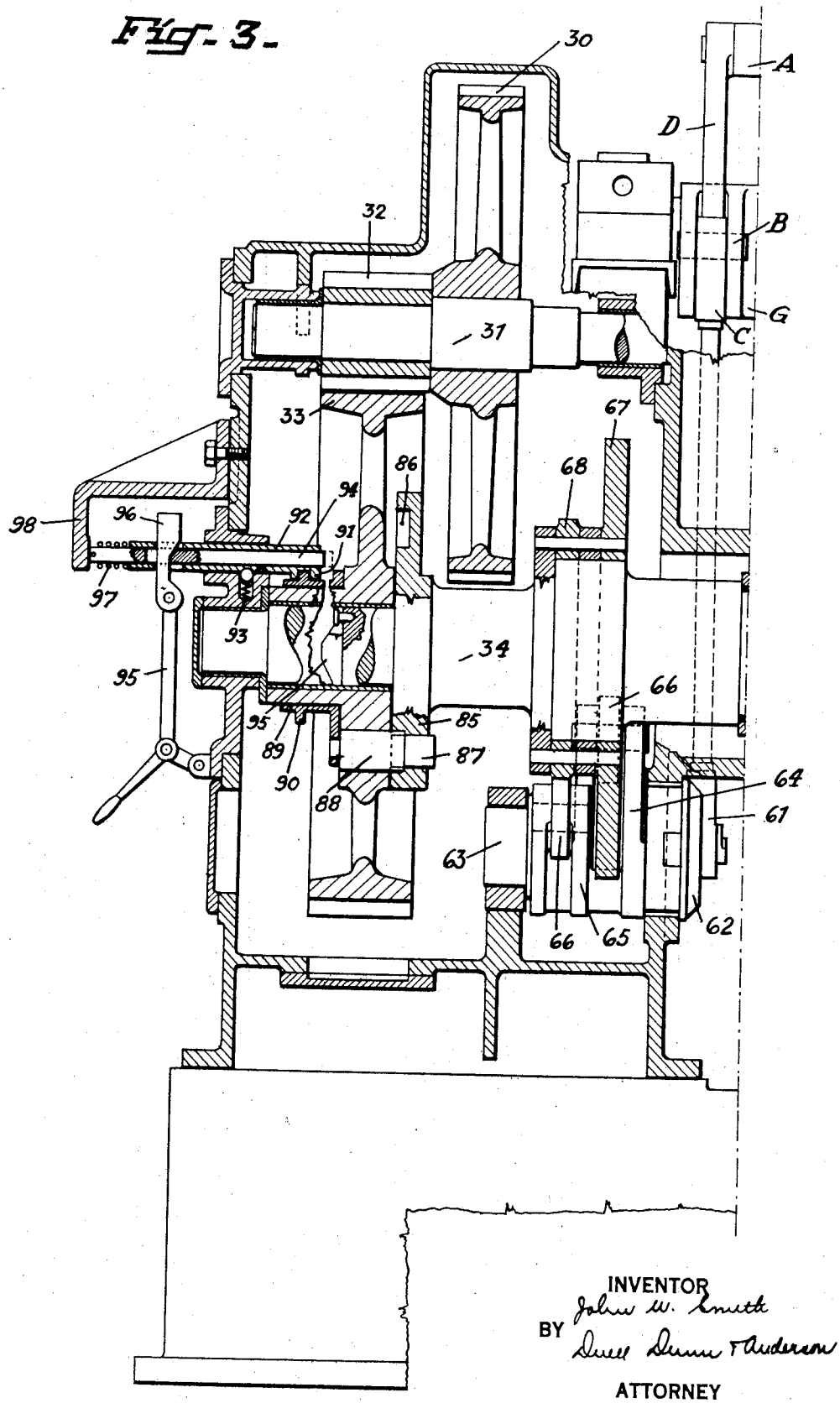
INVENTOR.
John W. Smith
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Dewey Dewey & Anderson
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Jan. 5, 1932. J. W. SMITH 1,840,059

ROLLING MACHINE

Filed June 28, 1928 8 Sheets-Sheet 3

Fig. 3.



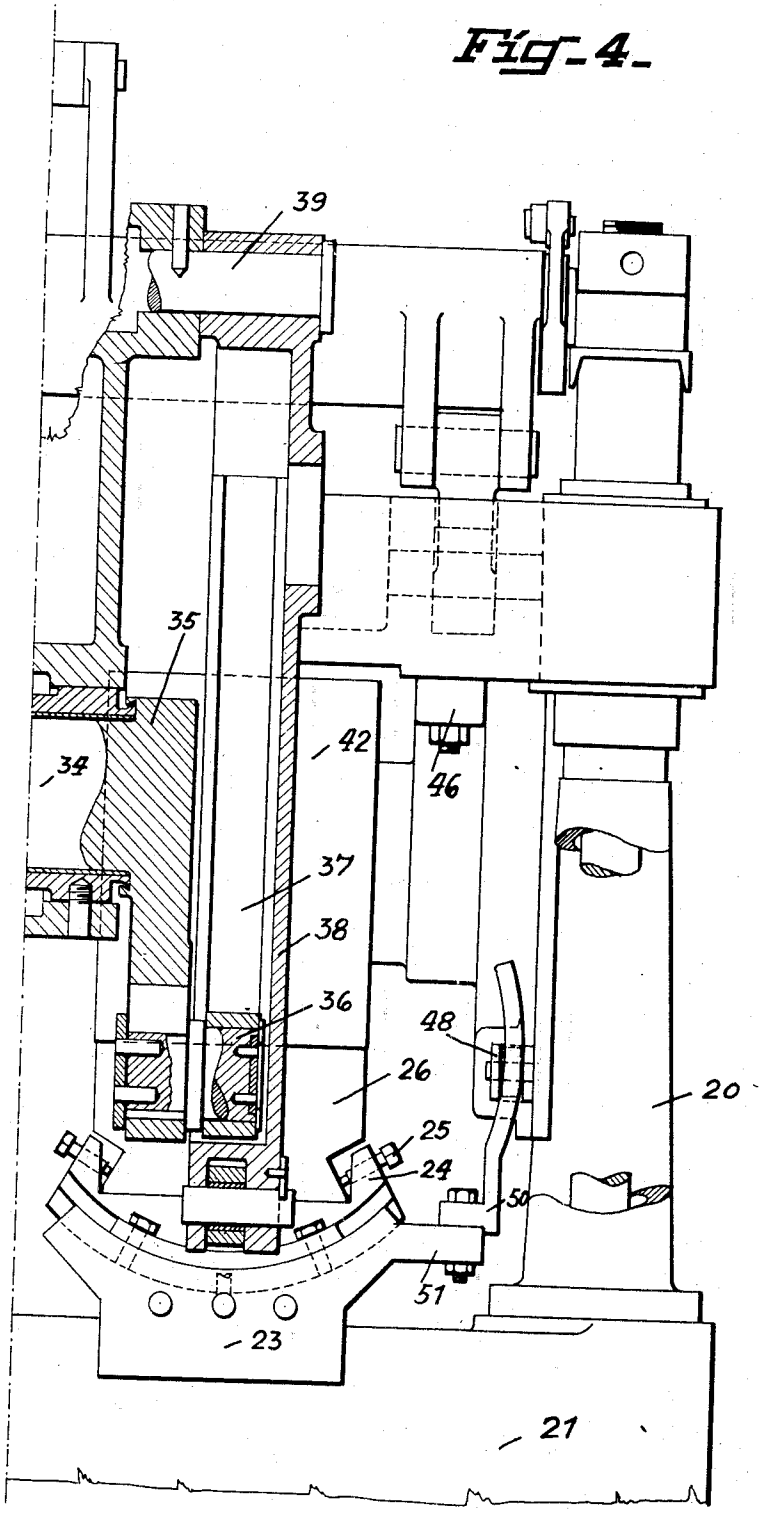
INVENTOR
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ATTORNEY

Jan. 5, 1932. J. W. SMITH 1,840,059

ROLLING MACHINE

Filed June 28, 1928 8 Sheets-Sheet 4

Fig-4-



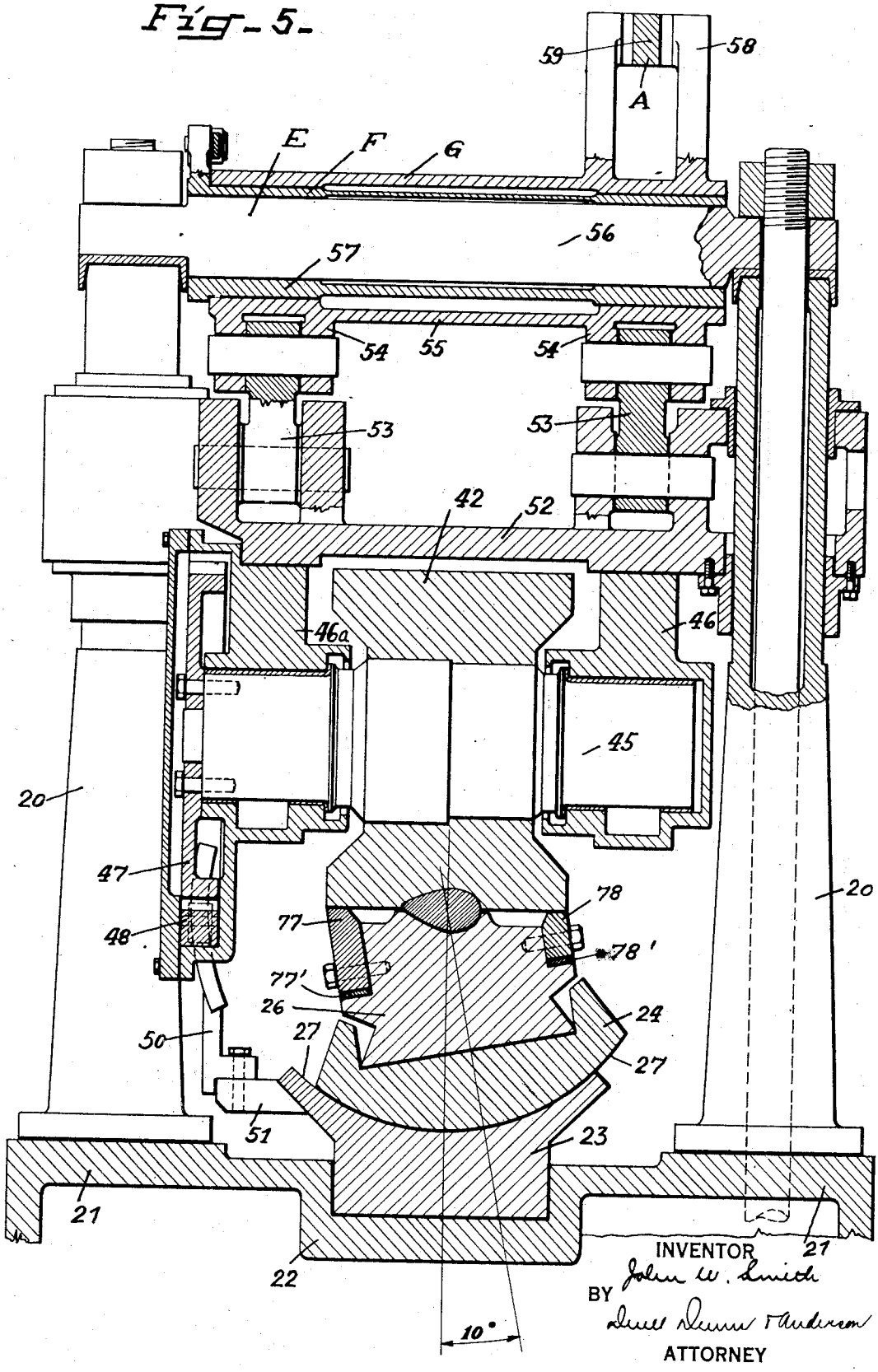
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Jan. 5, 1932. J. W. SMITH 1,840,059

ROLLING MACHINE

Filed June 28, 1928 8 Sheets-Sheet 5

Fig. 5.



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Jan. 5, 1932. J. W. SMITH 1,840,059

ROLLING MACHINE

Filed June 28, 1928 8 Sheets-Sheet 6

Fig-8-

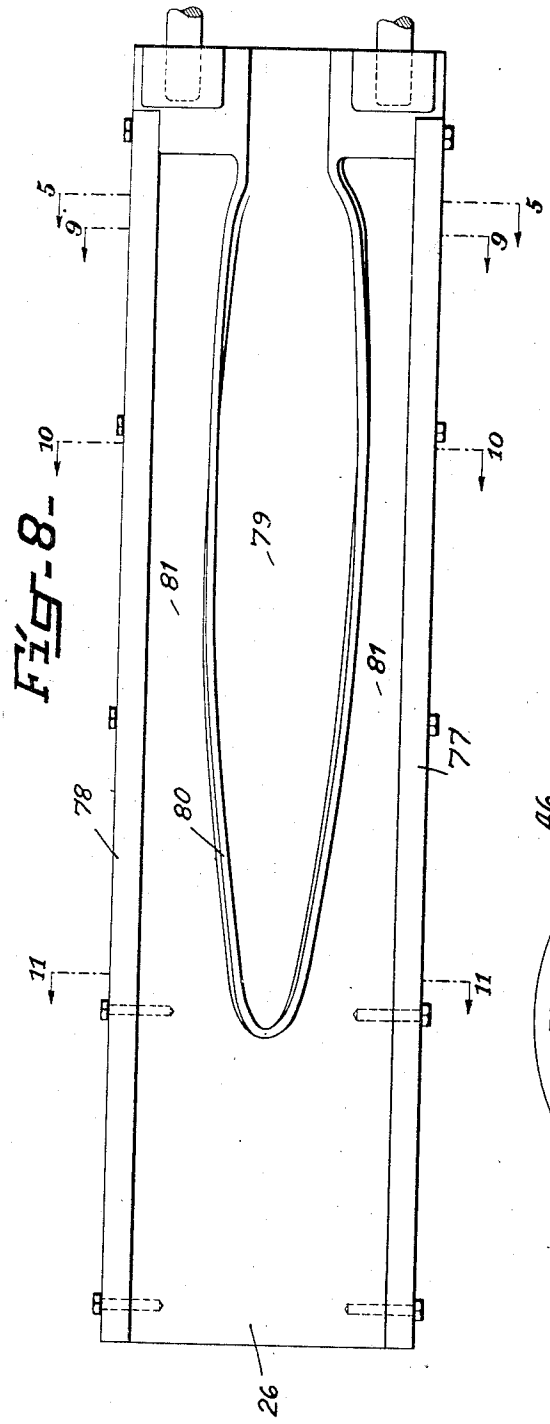


Fig-7-

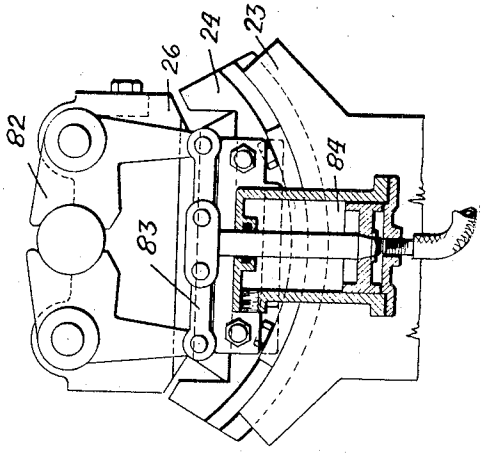
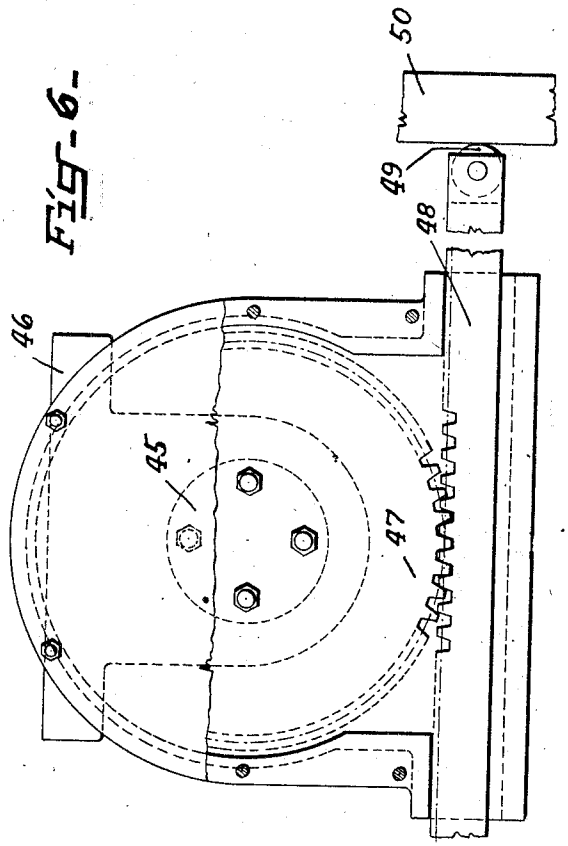


Fig-6-



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Jan. 5, 1932. J. W. SMITH 1,840,059

ROLLING MACHINE

Filed June 28, 1928 8 Sheets-Sheet 7

Fig-11.

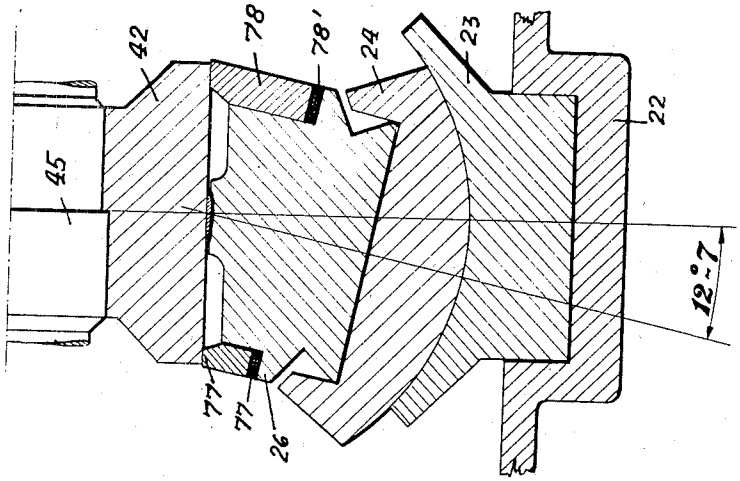


Fig-10.

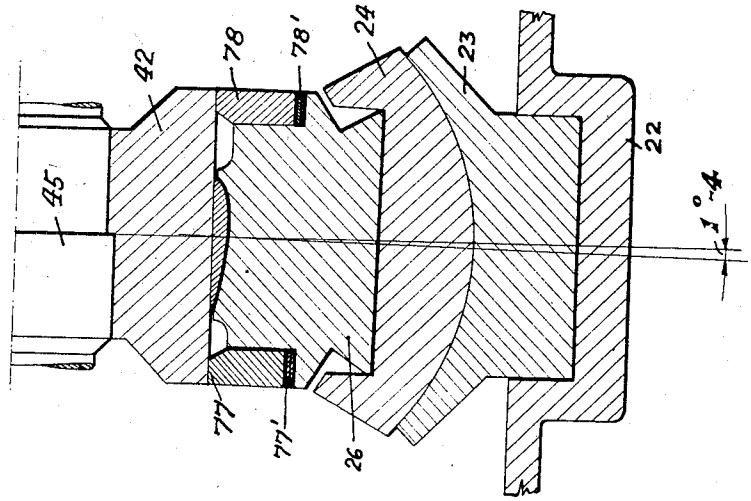
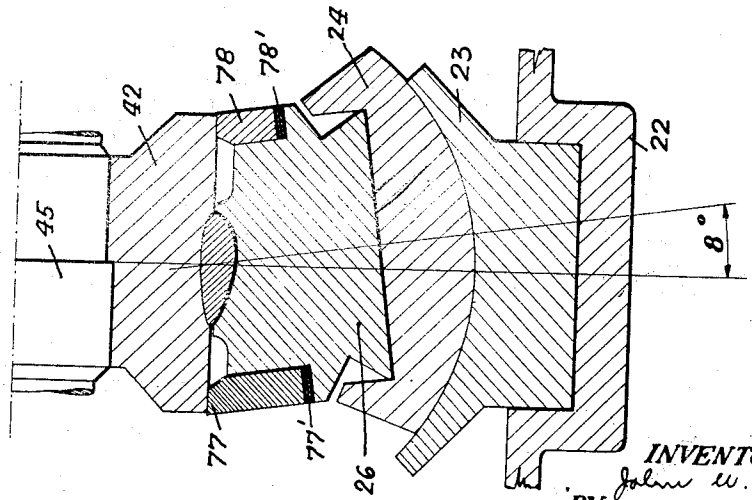


Fig-9.



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Jan. 5, 1932. J. W. SMITH 1,840,059

ROLLING MACHINE

Filed June 28, 1928 8 Sheets-Sheet 8

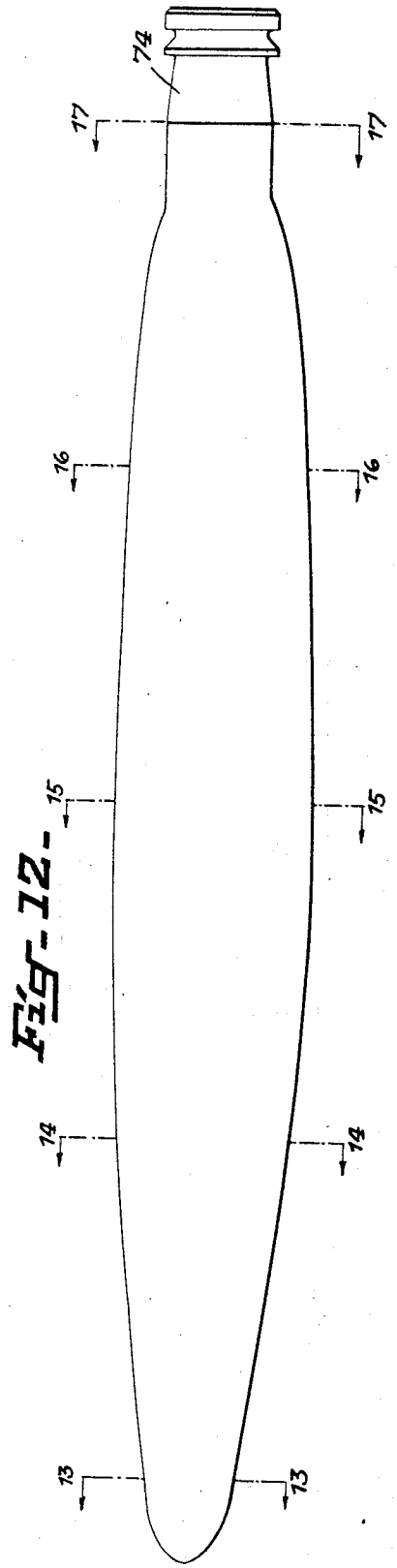


Fig. 12.

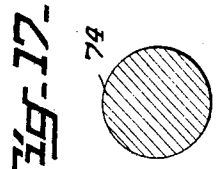


Fig. 17.

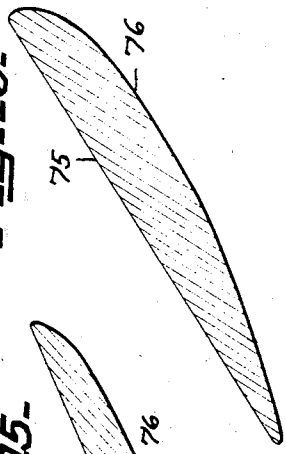


Fig. 16.

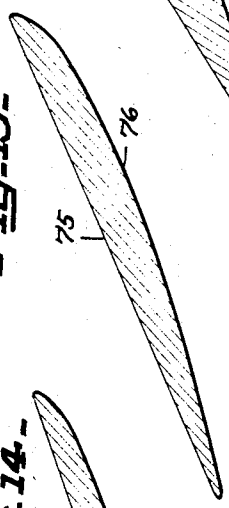


Fig. 15.

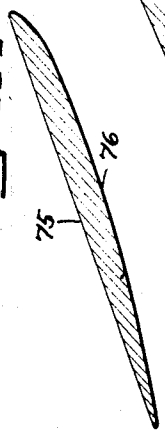


Fig. 14.



Fig. 13.

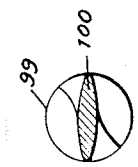


Fig. 19.

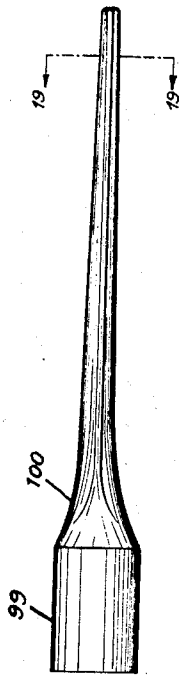


Fig. 18.

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Patented Jan. 5, 1932

1,840,059

UNITED STATES PATENT OFFICE

JOHN WILLIAM SMITH, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR TO BOHN ALUMINUM & BRASS CORPORATION, OF DETROIT, MICHIGAN, A CORPORATION OF MICHIGAN

ROLLING MACHINE

Application filed June 28, 1928. Serial No. 289,052.

This invention relates to an improved method and machine for manufacturing metallic articles. While the features of the present invention may be employed to advantage in numerous connections, they are of particular value in connection with the manufacture of propeller blades and, specifically, propeller blades for aircraft.

Therefore, while the present specification will describe the invention in connection with aircraft propeller blades for use in connection with which it is primarily intended, it will be understood that such features thereof as are adaptable for use in connection with other articles are within the province of the present invention.

It is an object of the invention to provide a method of manufacture and a machine for the practice of such method whereby metallic articles and, preferably, articles of metal having low specific gravity may be efficiently shaped and drawn.

It is a further object to work such articles and especially propeller blades according to the present invention so that the metal will be subjected to mass compression, the resultant articles embodying a consequent high degree of tensile strength and, furthermore, having a proper elastic limit.

A still further object of this invention is that of furnishing an article and, specifically, a propeller blade, which will be finally shaped and finished to gauge thickness by precision working to a unit weight measurement and in which there will be embodied the highest practicable physical properties to withstand the strain of centrifugal force and vibration.

Another object is that of providing a machine capable of commercially achieving the aforestated objects and which machine will embody, for example, either an oscillating and longitudinally reciprocable die and a cooperating non-oscillating roller or mounting therefor, which latter is capable of oscillation, and a die, these elements being capable of reciprocation longitudinally with respect to each other, whereby a draw-rolling action is achieved.

With these and further objects in mind reference is had to the attached sheets of drawings illustrating one practical embodiment of the invention and in which:—

Figure 1 is a vertical, longitudinal sectional view of the machine;

Fig. 2 is a fragmentary side elevation with certain of the parts broken away to disclose underlying construction;

Figs. 3 and 4 are views showing the rear end of the machine and certain of the parts being illustrated in section;

Fig. 5 is a transverse sectional view of the machine and die, the section through the latter being taken along the lines 5—5 of Figure 8;

Fig. 6 is a somewhat fragmentary side elevation of the die-moving mechanism;

Fig. 7 is an end view of the front of the die and carriage therefor with the billet-retaining mechanism applied to the former;

Fig. 8 is a plan view of the die;

Figs. 9, 10 and 11 are transverse sectional views taken along the lines 9—9, 10—10 and 11—11 respectively and in the direction of the arrows indicated in Fig. 8;

Fig. 12 is a plan view of a finished propeller blade provided by a machine and according to the method of the present invention;

Figs. 13, 14, 15, 16 and 17 are views taken along the lines 13—13, 14—14, 15—15, 16—16 and 17—17 respectively of Fig. 12;

Fig. 18 shows one form of prepared blank, and

Fig. 19 is a transverse sectional view taken along the lines 19—19 of Figure 18.

In these views, the numeral 21 indicates a base from which four standards or posts 20 extend upwardly.

The base 21 provides, as in Figures 4 and 5, a channel portion 22 within which a die bed 23 is mounted for reciprocation longitudinally of the machine base and which, in turn, mounts a die-supporting member 24 to which there is secured as, for example, by the locking bolts 25, a die block generally indicated at 26 and the detailed construction of which will be hereinafter described. At this time it will be observed that the upper face of the bed 23 and the adjacent face of the mounting member 24 are curved transversely,

as has been indicated at 27, the degree of this curvature being equal to that of an arc of a circle, having its center adjacent the center portion of the upper face of the die block 26. As a consequence, while the die bed 23 is capable of reciprocation and carries with it the block 26, the latter, together with the supporting member therefor, may be rocked transversely of the machine in a manner hereinafter brought out.

Now with a view to showing one practical form of mechanism by means of which the bed and associated structure may be reciprocated with respect to the base of the machine, attention is invited to Figure 2, in which the numeral 28 indicates a power shaft, to which a driving pinion 29 is secured, the teeth of such pinion meshing with the teeth of a gear 30 mounted on a shaft 31. This shaft in turn mounts a pinion 32 meshing with the teeth of a gear 33 mounted by a shaft 34 terminating in a crank 35 which carries at its outer end a traveler block 36 riding within the slot or groove 37 of a beam 38. The latter is mounted for rocking movement adjacent its upper end, as at 39, and carries at its lower end a link 40 secured to a bracket or extension 41 attached to the inner end of the die block.

It will thus be obvious that with the drive shaft 28 rotated, the beam 38 will be oscillated, resulting in a reciprocation of the bed 23 and, incident to this construction it will be seen that the die block and the parts mounting the same will have a slight dwell upon the completion of each outward or working stroke, i. e. the movement of the parts from right to left, as viewed in Figure 2.

Cooperating with the upper face of the die is a roller 42, as shown in Figures 1 and 5, and this roller may (although not necessarily, as shown in Figure 1) be formed with a recess 43 in its periphery, from which there extends a groove portion 44 at a tangent to the periphery of the roller and merging and extending into the remainder of the roller periphery, which is truly concentric with respect to the axis. The roller is mounted upon a shaft 45 supported by brackets 46 and 46*a* and to which shaft it is preferred that a timing gear 47 be secured. The teeth of this gear mesh with the teeth of a rack 48, the ends of which, as in Figure 6, may mount rollers 49 bearing against actuating bars or other portions 50 secured to extensions 51 of the die bed 23. It will thus be obvious that with the timing gear 47 having a diameter equal to that of the periphery of the die roller, the latter will have a peripheral speed equivalent to the speed of reciprocation of the die block and the teeth and the pinion and rack will remain in mesh irrespective of whether the shaft 45 is elevated or depressed, in a manner hereinafter brought out. However, if the diameter of the gear is increased it will be obvious that the periphery of the roller and face of the die block will not move in synchronism, and that this will result in urging the metal forward at the moment of squeeze, which, in certain instances, might be desirable with a view to facilitating and improving the working and shaping of the blank supported by the die block.

However, it will be understood that, by means of the present method the urging of the metal forward up to certain limits does not result in any material slippage of the roller since the internal molecular friction of the metal would be less than the surface friction on the roller face.

It is obvious that roller 42 may be provided with a plain concentric face and in this event the rack 48 could be readily dispensed with. The drawing or pulling process would still be made use of to a very marked degree due to the friction on the journal of shaft 45, together with the piling up of the metal which will obviously occur in front of the roller.

Now with a view to bodily shifting the roller towards and away from the die block, a mechanism may be employed which, as shown particularly in Figs. 1 and 5, includes a mounting plate 52 to which are secured the brackets 46 and 46*a* mounting the shaft 45. This plate is supported by links 53, the upper ends of which are carried by the lower ends of arms or toggle cranks 54 secured to a sleeve 55. Thus, a toggle mechanism is provided which, by an oscillation of the sleeve, will cause the plate 52 and the die roller supported thereby to be moved towards or away from the die block. Two sleeves are employed, one supported by each of the shafts 56, eccentric bushings 57 being introduced between the shafts and the sleeves for a purpose hereinafter brought out and the ends of the shafts being supported between the pairs of posts 20. Extending upwardly from each sleeve are actuating arms 58 coupled to move in synchronism by a connecting rod 59 extending therebetween. The rearmost sleeve also carries a further lever or arm 60 which, by means of a rod 61 and crank arm 62, is coupled to a shaft 63. This shaft carries as has been shown in dotted lines in Fig. 2 and in full lines in Fig. 3, two pairs of arms 64 and 65 respectively mounting at each of their outer ends and between them, cam rollers 66. Secured to the shaft 34 is a toggle pressure cam 67 and a toggle release cam 68, the former cooperating with the roller mounted between the pair of arms 64 and the latter having its periphery engaged by the roller 66 mounted between the pair of arms 65.

As a consequence of the rotation of the shaft 34 it will be obvious that the cams 67—68 will be turned and the first of these cams will serve periodically to turn the shaft 63 and actuate the crank 62 to move the rod 61 downwardly and consequently rock the

sleeves 55 and thus depress the roller 42. The cams are so timed that after the roller has been retained in this plane throughout movement of the die block the cam 68 will actuate the shaft 63 by means of the roller 66 and arm 65 to release the toggle. In other words, an upward thrust will be exerted upon the rod 61, resulting in a partial rotation of the sleeves 55 and a consequent raising of the roller.

While the foregoing represents one practical and, in certain aspects, a preferred form of mechanism for periodically moving the roller towards and away from the face of the die block, it will be understood that different forms of mechanism might be employed to achieve this result without departing from the scope of the present invention. Likewise, in connection with the mechanism which will be immediately hereinafter described, for varying the plane into which the roller is thrust by the toggle structure, it will be understood that while a somewhat manually operated mechanism has been shown for the sake of simplicity, a mechanism might be provided in which manual attention is not necessary and, furthermore, this mechanism might, in certain aspects, be modified without detriment to the effective operation of the machine.

Thus, as has been stated, the bushings 57 are preferably eccentric and the ends thereof, as clearly shown in Figure 5, extend beyond the ends of the sleeves and at these points are provided with upstanding levers or arms 69 connected to move in synchronism by a rod 70, the end of which is coupled to a hand lever 71 pivotally mounted upon a supporting member 72 and having any desired locking expedient 73. It is obvious that as the lever is rocked from left to right the periphery of the roller will be caused to extend into an increasingly lower plane and the contrary is true if the lever is rocked in an opposite direction. At this time it will be noted that, if desired, any convenient form of automatic or semi-automatic mechanism might be substituted for the manually controlled means just described and which would serve efficiently to progressively decrease the distance between the die block and roller.

Now with regard to the die block, which has heretofore been referred to generally in connection with reference numeral 26, it will be understood that, as aforestated, the present machine is primarily adapted and intended for the forming of aircraft propeller blades. These blades, as in Figure 12, include a body usually having, as an integral part, a hub portion 74 adjacent which the plate is circular in cross-section, as in Figure 17. Beyond this point the blade is developed to provide effective air-foil surfaces which in the embodiment under consideration take the form of a flat inner face 75 and a convexed outer face 76. In order to provide a blade of maximum efficiency these surfaces present angularly varying faces and the area of the blade decreases toward the tip thereof, as does also the thickness of the blade body, attention being invited in this connection to Figs. 13 to 17. With this in mind and according to the present invention, the surface of the die block is developed as in Figs. 8 to 11 to assure the varying angularity or, in other words, the proper pitch of the blade and the die block, as shown, includes rail portions 77 and 78 extending longitudinally of its upper side edges and a central recessed portion 79 for the reception of a prepared blank, the area of this central cavity being defined by a rib or flange 80 upstanding from the upper face of the block 26 and spaced from the rail 78 to provide flash recesses 81. Furthermore, the flange 80 terminates in a plane short of the plane into which the rails 77—78 extend, the latter being adapted to be engaged by the periphery of the roller 42 and the flange being thus spaced to provide a flash-gap between the roller periphery and its upper edge.

Obviously, the flange 80 defines a space exactly equal to the area of the blade and the base of the recess 79 is concaved to just exactly the extent necessary to provide for the proper formation of the air-foil surface thereof. It will be noted that in the present exemplification both the rails 77 and 78 have been shown as removable, these rails controlling the gage thickness and unit weight of the finished blade. Incidentally, at the time of manufacturing the dies the rails are preferably made of a height proper for cold finishing the blade to the required thickness. When used for hot rolling they would be raised to the proper distance by inserting suitable shims 77′ and 78′ so that the blade would be hot rolled to a point where it was slightly over weight, thus leaving sufficient material to cold roll the blade to the subsequently required finished weight. In other words, the recess 81 provides a space accommodating the surplus metal forced over the edge of the flange 80 in the form of flash which is afterwards trimmed in any desired manner. Thus the blade which is initially of an excess weight, is reduced to exactly the proper weight and size.

With a view to holding the blank within the cavity 79 any desired mechanism may be employed which, for example as shown in Figure 7, may include a pair of pivotally mounted jaws 82 gripping between them the hub of the blank and these jaws having bell crank extensions, the arms of which are interconnected by a toggle mechanism 83 actuated by, for example, a cylinder and piston 84 connected with a suitable source of fluid under pressure. This assemblage is mounted conveniently, in the manner shown in Fig-

ure 1, in which the supporting member 24 carries the same.

A desired form of blank has been shown in Figure 18, in which the numeral 99 indicates the hub portion and 100 the blade body of the blank, the former being gripped by the means provided for retaining it in operative association with the die and the latter being engaged by the roller. This blank is preferably formed by extrusion.

With the blank properly disposed within the cavity 79 and its end gripped by the clamping means, the operator shifts the lever 71 so that the roller will be depressed to a minimum extent. With the billet is somewhat heated condition and the pinion shaft 28 rotating, the toggle mechanism will now act to bring the roller towards the die block, the parts being so timed that the "dwell" incident to the provision of the link 40 and the fact that the crank 35 is on dead center, will assure against any movement on the part of the die block or roller. Subsequently, the block will be moved outwardly and the roller bearing against the upper face of the blank will decrease the thickness of the latter and draw the same to tend to fill out the entire space 79. Coincident with this stroke it will be observed, as has been particularly shown in Figs. 9 to 11, that the die block will rock transversely of the bed of the machine, thus assuring a proper initial contouring of the blade being formed. Upon the completion of the stroke the toggle mechanism will release to raise the roller out of contact with the billet, but the roller and block will continue to move in unison incident to the provision of the rack and pinions 47—48. An operator may now shift the lever 71 or the roller-adjusting mechanism may otherwise be shifted in any desirable manner. During the first stroke or pass it will be apparent that the excess material of the billet will move through the flash gap extant between the upper edge of the rib 80 and the periphery of the roller 42. With the latter now brought into even closer proximity to the die block and having in mind the fact that on this or a succeeding stroke the roller will have its periphery in engagement with the contact rails 77—78, the blade will have been rolled to the required gage thickness and unit weight, the surplus metal being forced into the flash cavity. The flash may now be trimmed and the blade may be heat-treated. Thereupon the blade is prepared for the final cold rolling finish, which may be accomplished in the die previously used for the hot rolling step by removing the shims from under the rails 77—78.

By making use of a longitudinal drawing action simultaneously with the squeezing action of the roller which is urging the metal in a longitudinal direction at the moment of squeezing, a longitudinal fiber structure will be furnished which will improve the physical properties of the metal.

In the drawing process which is used as the final stage in fabricating propeller blades the metal is drawn or pulled at the moment of squeeze, while in the extruding process herein referred to the metal is shoved together or compressed at the moment of squeeze. Thus the drawing process for the final stage is the reverse of the extruding step of the first stage.

Thus, by means of the present invention it will be understood that a metallic article will be fabricated by a working operation which results in a combined shaping and drawing action. Furthermore, this article, as a result of such working, will embody the desired degree of tensile strength and be capable of being subjected to predetermined elastic stresses. As a consequence the article will possess the highest physical properties and withstand all strains for which it is designed. By mean of the draw-rolling operation taught by the present invention the article and, specifically the blade, as it emerges from the machine, will require no further machining or hand working to meet the specifications for the finished blade, which will have the required twist or pitch angle, together with the required cross- section area and airfoil. The blade will furthermore be finished to a gage thickness by the precision draw-rolling to a unit weight measurement. Finally, it will be obvious that any desirable degree of draw may be achieved during the rolling period by increasing the diameter of the timing gear engaging the rack.

While the embodiment of the machine herewith described is preferably to be adhered to in practice, it will be understood that the construction thereof might be varied in numerous particulars. All mechanical details have not been specifically described but will be obvious to those skilled in the art. It might, however, be well to refer to the automatic trip mechanism shown particularly in Figure 3, in which it will be noted that the gear 33 is rotatable with respect to the shaft 34, but moves in synchronism therewith, and is normally clutched thereto by means of a disk portion 85 having a groove 86 within which a dog 87 is disposed. A clutch pin 88 carried by the gear 33 may be moved transversely with respect thereto and into the groove to engage the dog 87 by employing a collar 89 slidably mounted upon the hub of the gear 33. This collar is provided with an annular rib 90 straddled by the arms of a fork 91 forming a part of a tube 92. Means are provided for holding the tube projected or retracted as, for example, a spring-pressed ball 93 riding within depressions formed in the tube body and a rod 94 is slidably disposed within the tube and projectable beyond the same to the position indicated in dotted lines.

In this latter position it strikes against the cam or throw-out surface 95 carried by or forming a part of the gear 33 as a consequence of which this rod, together with the tube, will be forced rearwardly, carrying with it the collar 89 and consequently disengaging the clutch and stopping the operation of the machine. A finished form of mechanism for effecting a projection and retraction of the tube and the rod is, for example, a lever 95 carrying at its outer end a wedge member 96 riding within slots formed through the rod and the tube, and at this time it will be observed that a spring 97 is interposed between the ends of these two members in order to force the same normally outwardly with respect to each other, such movement on the part of a rod, however, being limited by a bracket 98. Thus, with the parts in the position shown in full lines in Fig. 3, the machine will operate continuously. If, however, the lever 95 is actuated the rod will obviously be projected against the tendency of the spring and to the position indicated in dotted lines. In such position the throw-out surface 95 will, as aforestated, retract both the tube and rod bodily to a point at which the former bears against the bracket 98 and the shaft 34 will consequently cease to rotate, it being obvious that a return of the clutch pin to operative position will be prevented by the fact that the tube will remain in position. If now, the lever 95 is returned to the position shown the tube, under the urging of the spring 97, will shift to correspondingly move the collar 89 and again engage the clutch parts, resulting in a driving of the shaft 34.

In conclusion it will be appreciated that the construction of the machine might be changed in numerous respects and that the steps of the method might also be varied in many particulars without departing from the spirit of the invention as defined by the claims.

Having described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. A machine of the character described including, in combination, a die formed with a blank-receiving cavity, a roller, means for reciprocating said elements with respect to each other and rails associated with one of said elements and cooperating with the other of the same for rocking the latter transversely with respect to said first named element and during the relative reciprocation of both of said elements.

2. A machine for fabricating propeller blades and the like from a metal blank, comprising in combination a rotatable annular die, a longitudinal reciprocating die, means for maintaining registration between said dies, means for forcing said dies with required pressure into the blank located between them and maintaining said pressure during the longitudinal rolling of the blank, and means for longitudinally reciprocating said dies relatively to each other to effect longitudinal rolling of the blank and to return the annular die and the reciprocating die after each rolling pass to their initial forging position, one of the dies being supported for transverse oscillation under control of the other die for producing blade pitch twist.

3. A machine for fabricating propeller blades and the like from a metal blank, comprising in combination a rotatable annular die, a longitudinal reciprocating die, means for maintaining registration between said dies, means for forcing said dies with required pressure into the blank located between them and maintaining said pressure during the longitudinal rolling of the blank, means for longitudinally reciprocating said dies relatively to each other to effect longitudinal rolling of the blank and to return the annular die and the reciprocating die after each rolling pass to their initial forging position, and means for gripping the blank and holding it in proper relation to the dies for forging, rolling and twisting.

4. A machine for fabricating propeller blades and the like from a metal blank, comprising in combination a rotatable annular die, a longitudinally reciprocating die, means for maintaining registration between said dies, means for forcing said dies with required pressure into the blank located between them and maintaining said pressure during the longitudinal rolling of the blank, means for longitudinally reciprocating said dies relatively to each other to effect longitudinal rolling of the blank and return the annular die and the reciprocating die after each rolling pass to their initial position for another deeper forging operation, means for setting said dies closer together to increase the depth of the forging operation for successive rolling passes, and means supporting one of the dies for transverse oscillation under control of the other die to produce blade pitch twist.

5. A machine for forming an article from a metal blank, which comprises two dies having co-operating die cavities shaped to give the article the desired cross-sectional form, means for holding the blank, means for automatically moving the dies relative to each other to produce a succession of rolling passes, automatic means for moving the dies toward each other at the beginning of each pass to make a forging stroke and for moving the dies apart at the end of each pass.

6. A machine for forming a propeller blade from a metal blank, which comprises a flat die and a roller die, the dies having co-operating die cavities shaped to give the blade the desired cross-sectional form, means for holding the blank, means for automati-

cally moving the roller die longitudinally of the flat die to produce a succession of rolling passes, automatic means for moving the dies toward each other at the beginning of each pass to make a forging stroke and for moving the dies apart at the end of each pass.

7. A machine for forming an article from a metal blank, which comprises two dies having co-operating die cavities shaped to give the article the desired cross-sectional form, means for holding the blank, means for automatically moving the dies relative to each other to produce a succession of rolling passes, automatic means for moving the dies toward each other at the beginning of each pass to make a forging stroke and for moving the dies apart at the end of each pass, and means operable to increase the depth of the forging stroke.

8. A machine for forming a propeller blade from a metal blank, which comprises a flat die and a roller die, the dies having co-operating die cavities shaped to give the blade the desired cross-sectional form, means for holding the blank, means or automatically moving the roller die longitudinally of the flat die to produce a succession of rolling passes, automatic means for moving the dies toward each other at the beginning of each pass to make a forging stroke and for moving the dies apart at the end of each pass, and means operable to increase the depth of the forging stroke.

9. A machine for forming a propeller blade from a metal blank, which comprises two dies having co-operating die cavities shaped to give the blade the desired cross-sectonal form, means for holding the blank, means for automatically moving the dies relative to each other to produce a succession of rolling passes, means for moving the dies toward each other at the beginning of each pass to make a forging stroke and for moving the dies apart at the end of each pass, and means for tilting one die transveresly with respect to the other die to give the blade the desired twist.

10. A machine for forming a propeller blade from a metal blank, which comprises a flat die and a roller die, the dies having co-operating die cavities shaped to give the blade the desired cross-sectional form, means for holding the blank, means for automatically moving the roller die longitudinally of the flat die to produce a succession of rolling passes, automatic means for moving the dies toward each other at the beginning of each pass to make a forging stroke and for moving the dies apart at the end of each pass, and means for tilting the flat die transversely with respect to the roller die to give the blade the desired twist.

11. A machine for forming an article from a metal blank, which comprises two dies having co-pending die cavities shaped to give the article the desired cross-sectional form, means for holding the blank, means for automatically moving the dies relative to each other to produce a succession of rolling passes, and cam-operated means for moving the dies toward each other at the beginning of each pass to make a forging stroke and for moving the dies apart at the end of each pass.

12. A machine for forming a propeller blade from a metal blank, which comprises a flat die and a roller die, the dies having co-operating die cavities shaped to give the blade the desired cross-sectional form, means for holding the blank, means for automatically moving the roller die longitudinally of the flat die to produce a succession of rolling passes, cam-operated means for moving the dies toward each other at the beginning of each pass to make a forging stroke and for moving the dies apart at the end of each pass.

In testimony whereof I affix my signature.

JOHN WILLIAM SMITH.