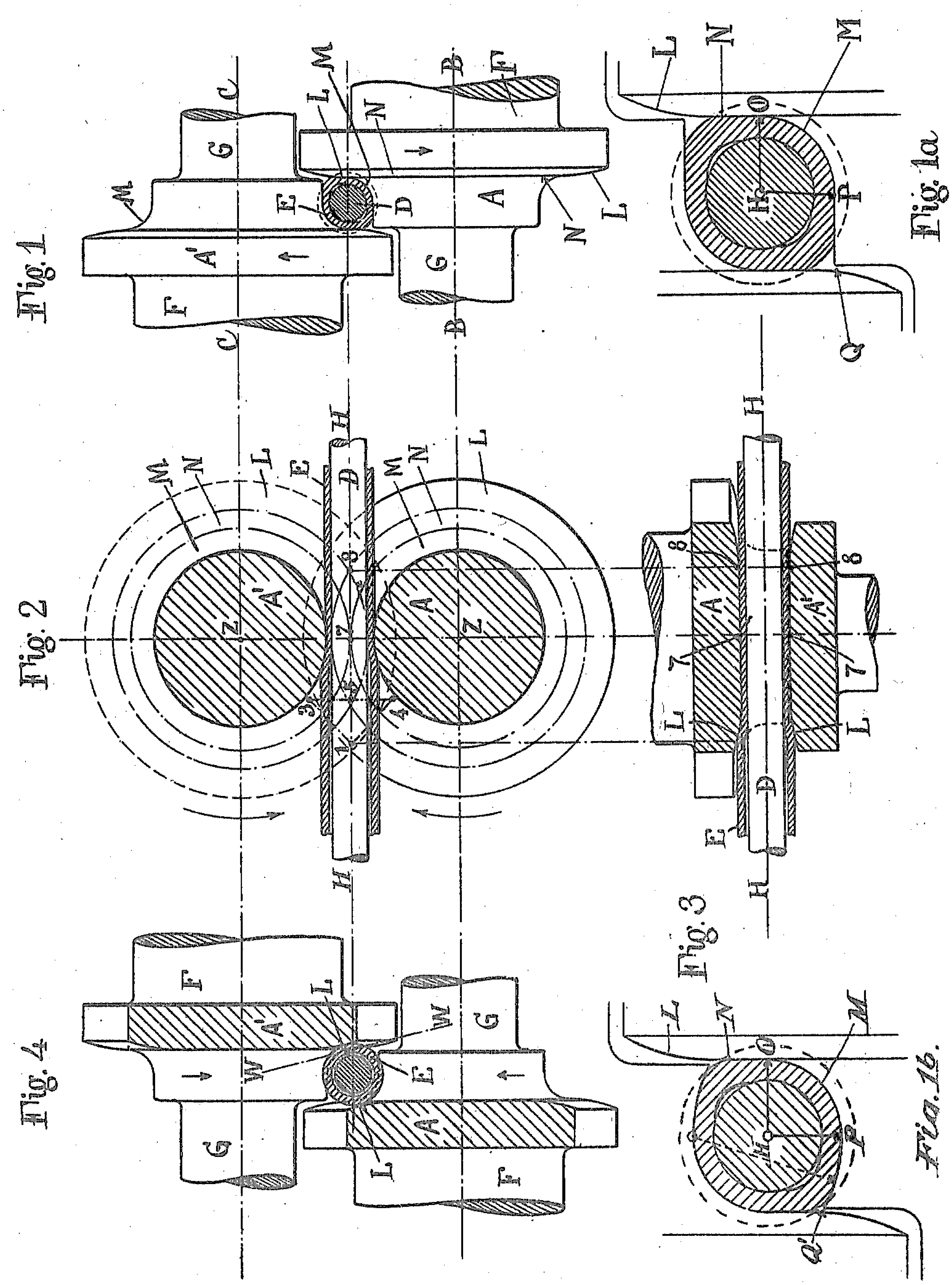
R. C. STIEFEL.

PROCESS OF AND APPARATUS FOR ROLLING TUBES, SOLID ROUND BARS, AND SIMILAR BODIES.

APPLICATION FILED MAY 26, 1908.

950,708. Patented Mar. 1, 1910.

3 SHEETS—SHEET 1.



Witnesses
E. Van Zandt
Herman Meiners

Ralph Charles Stiefel Inventor.
By his Attorneys Binney & Ogden

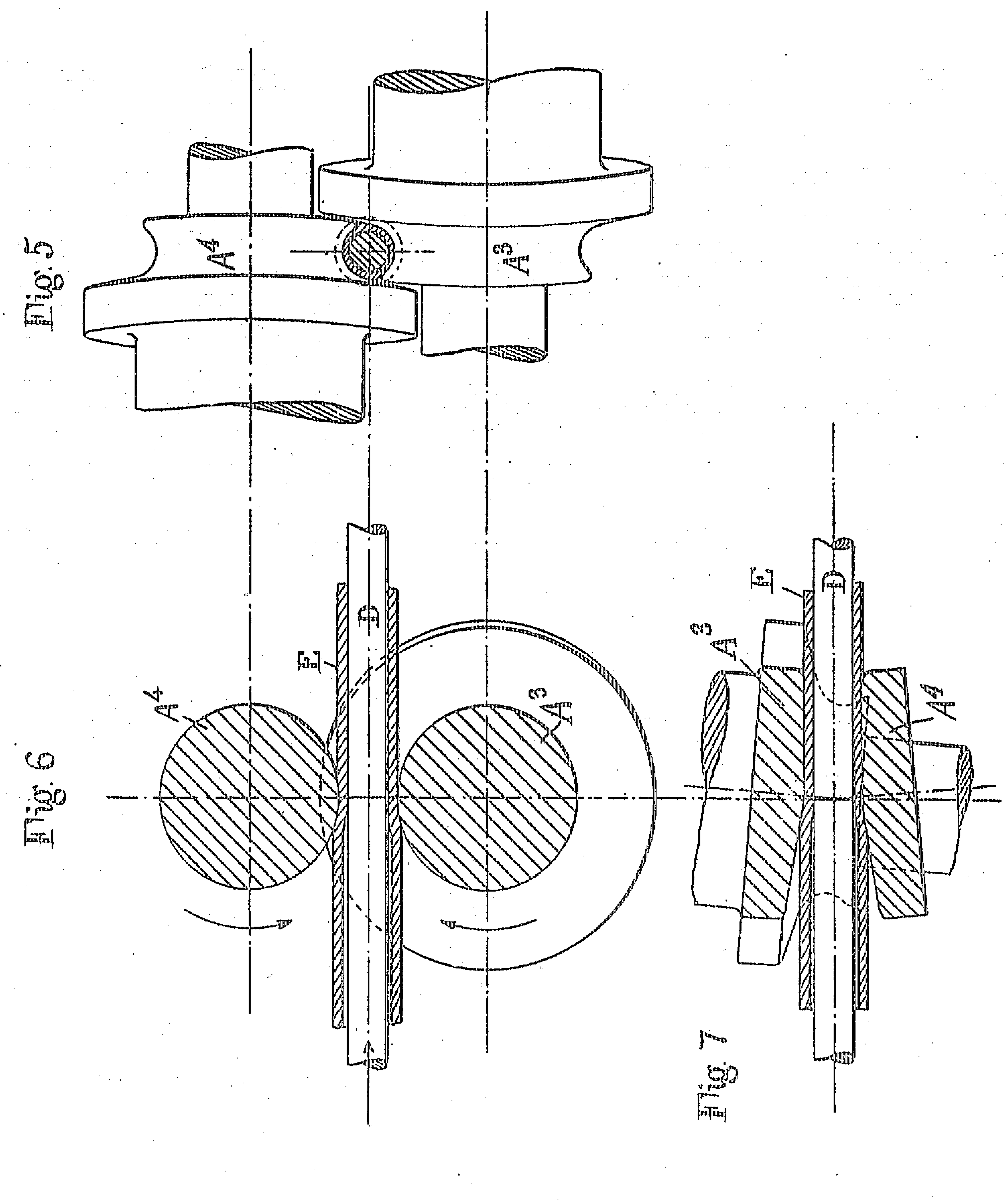
R. C. STIEFEL.

PROCESS OF AND APPARATUS FOR ROLLING TUBES, SOLID ROUND BARS, AND SIMILAR BODIES.

APPLICATION FILED MAY 26, 1908.

950,708. Patented Mar. 1, 1910.

3 SHEETS—SHEET 2.



Witnesses
E Van Zandt
Herman Meiners

Ralph Charles Stiefel Inventor
By his Attorneys Binney & Ogden

R. C. STIEFEL.

PROCESS OF AND APPARATUS FOR ROLLING TUBES, SOLID ROUND BARS, AND SIMILAR BODIES.

APPLICATION FILED MAY 26, 1908.

950,708. Patented Mar. 1, 1910.

3 SHEETS—SHEET 3.

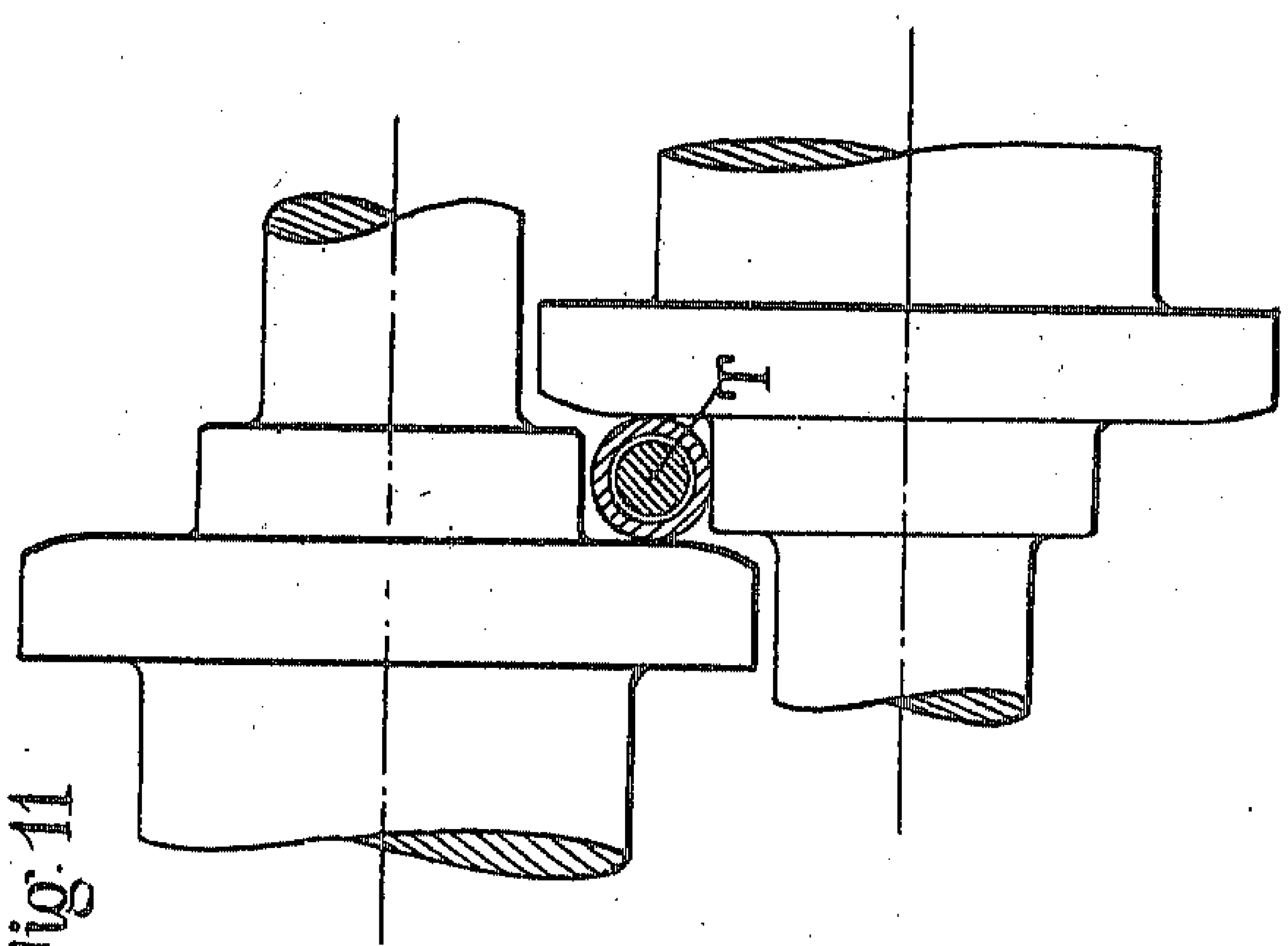


Fig. 11

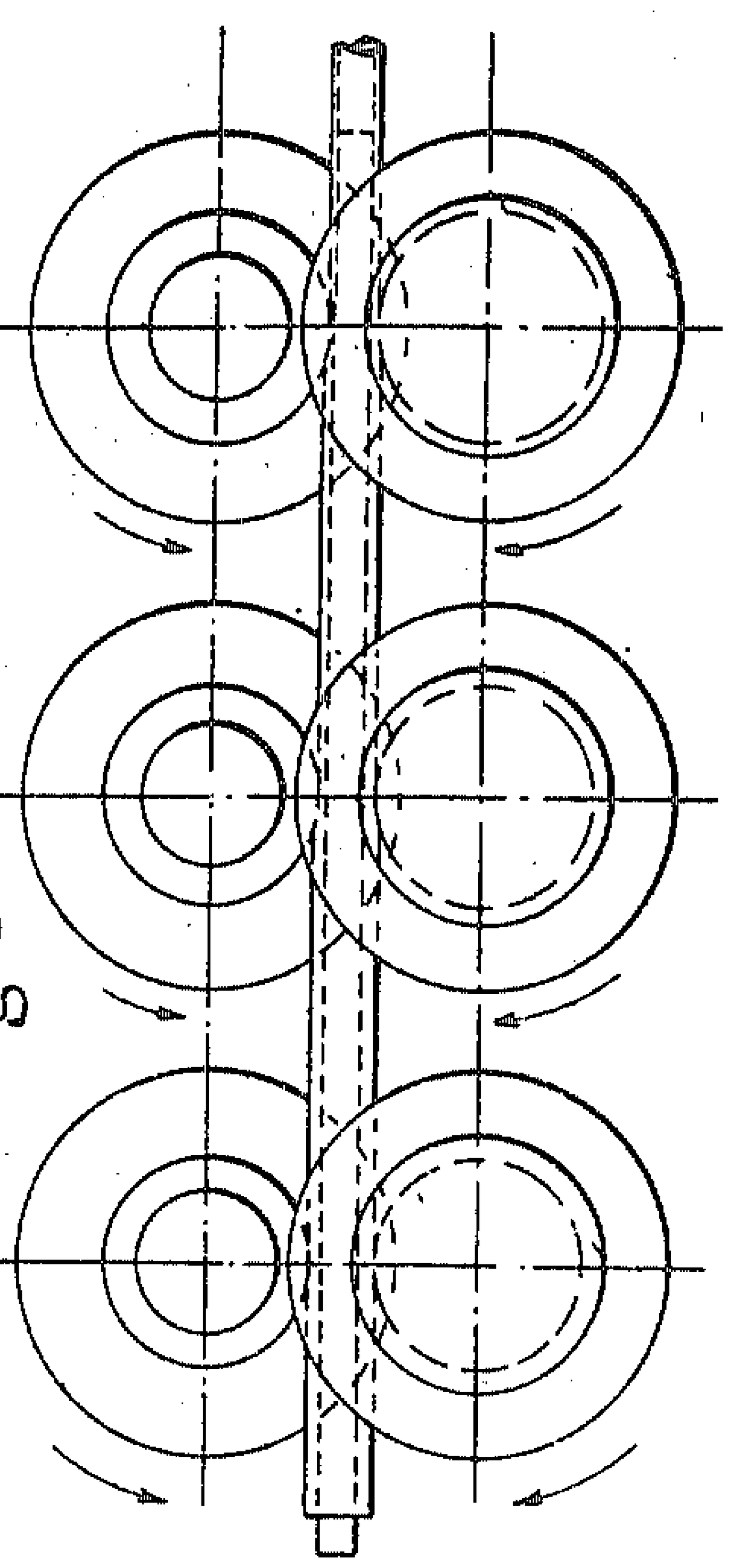


Fig. 8

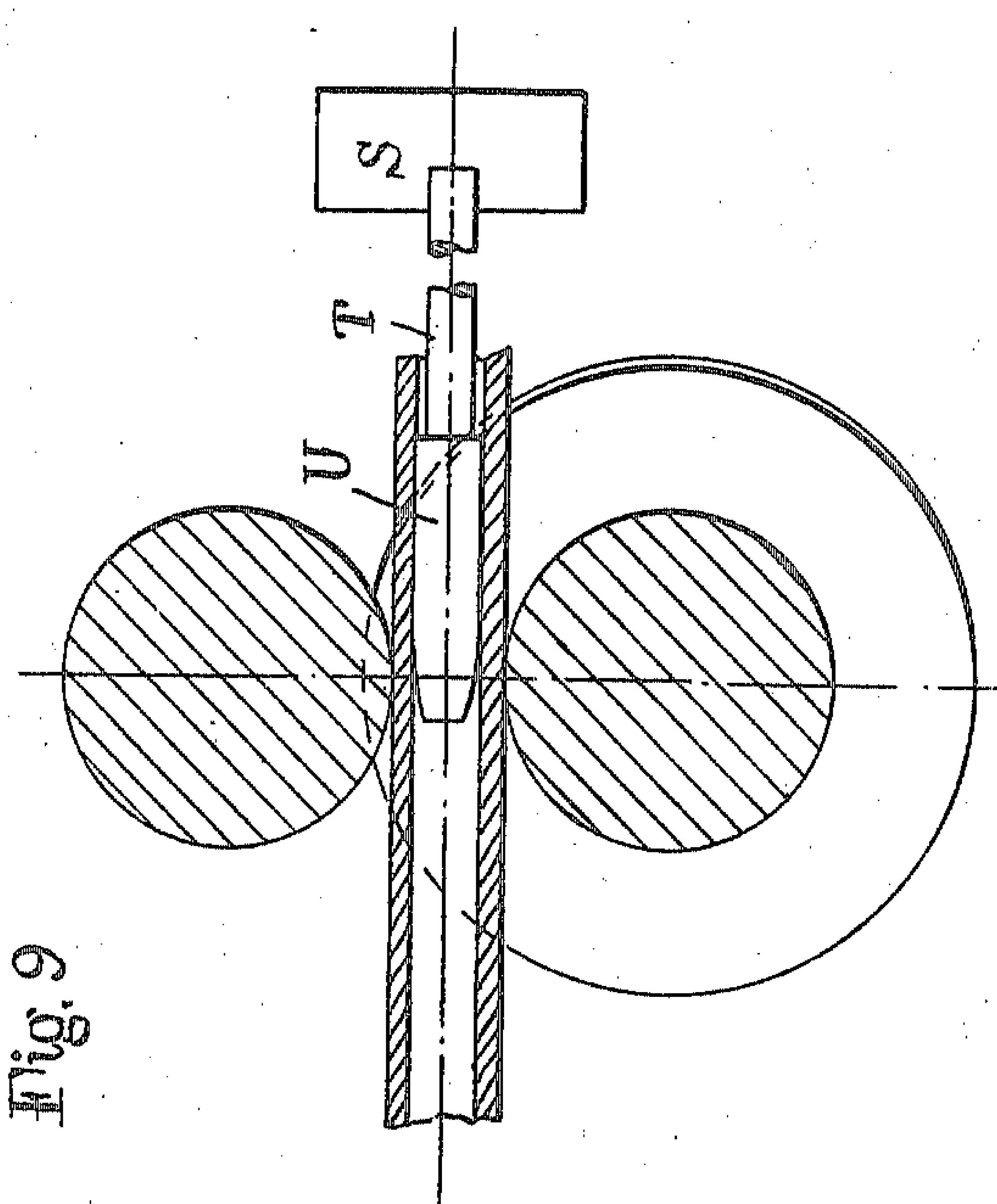


Fig. 9

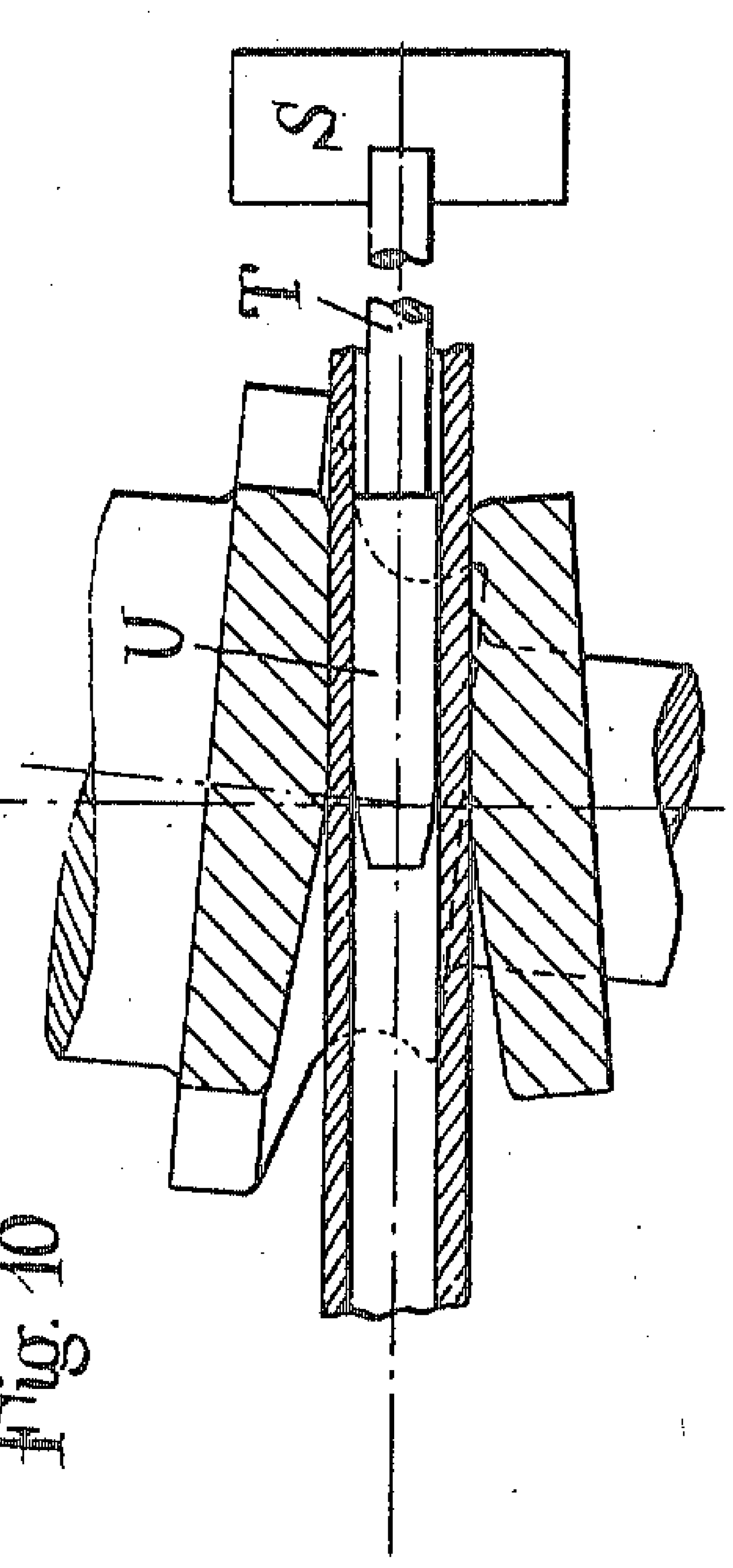


Fig. 10

Witnesses
E. Van Zandt
Francis Morris

Ralph Charles Stiefel Inventor
By his Attorneys
Binney & Ogden

UNITED STATES PATENT OFFICE.

RALPH CHARLES STIEFEL, OF ELLWOOD CITY, PENNSYLVANIA.

PROCESS OF AND APPARATUS FOR ROLLING TUBES, SOLID ROUND BARS, AND SIMILAR BODIES.

950,708. Specification of Letters Patent. Patented Mar. 1, 1910.

Application filed May 26, 1908. Serial No. 435,042.

To all whom it may concern:

Be it known that I, RALPH CHARLES STIEFEL, a citizen of the United States, residing at Ellwood City, Pennsylvania, have invented certain new and useful Improvements in Processes of and Apparatus for Rolling Tubes, Solid Round Bars, and Similar Bodies, of which the following is a specification, illustrated by drawings.

The invention is particularly useful for rolling and elongating tubes and tubular blanks of iron or steel in a heated state upon mandrels to elongate the tubes and reduce the wall thickness; or with the omission of the mandrel it is also applicable to the rolling of solid round bodies to elongate and reduce their diameters.

It is also applicable to any metal that will stand the treatment.

By a description of the invention in the preferred form as applied to the rolling of tubular bodies upon mandrels, its adaptability to solid bodies will be well understood without further explanation.

The invention contemplates the application of rolling pressure on the sides of the tube or body during its continuous passage through a pass and while in contact with rolls by which the pressure is applied.

In the preferred form of the invention the application of the acting forces is such that each successive cross section of the body is first compressed between surfaces that cross-roll it while confining the pressure within narrow limits circumferentially, allowing and causing the metal to flow circumferentially while the body is being fed forward into the pass; then, as it progresses, each section is subjected to longitudinal rolling while being confined and under pressure circumferentially through a large proportion of the circumference, causing the metal to flow longitudinally of the body and to consequently elongate and reduce the body; then, each section as it progresses farther is subjected to a smoothing cross-rolling action between parallel or approximately parallel faces, which permit or cause the metal to flow circumferentially to insure its substantially cylindrical shape as it issues from the pass.

In the drawings, Figure 1 is an elevation of two rolls for effecting the improved process, as seen from the exit end of the pass; Fig. 1ª is a diagram explanatory of Fig. 1 and Fig. 1ᵇ a similar diagram of a variation. Fig. 2 is a central longitudinal section of the same. Fig. 3 is a horizontal section through the axis of the pass. Fig. 4 is a vertical section across the inlet end of the pass at approximately the first points of contact between the tube illustrated and the rolls. Figs. 5, 6, and 7 are end view, longitudinal section, and horizontal section, of a modification, the rolls being slightly skewed. Fig. 8 shows a modification having three sets of rolls acting conjointly, in which a combined as well as separate effect upon the metal will be produced by the three sets, as hereinafter explained. Figs. 9 and 10 are central longitudinal section and horizontal section of the axis of a pass to illustrate another modification. Fig. 11 illustrates another modification.

The details of the bearings, housings, mechanical adjustments and well known flexible driving connections for the rolls are not illustrated, as such details do not concern the process of treatment given to the metal or the combination of the rolls themselves, and as connections for driving adjustable shafts with axes set as shown are well known. Tubular blanks and mandrels are shown, but the mandrels are of course omitted when treating solid bodies. Guides for guiding the work into the pass and out of it, as used in practice, are also omitted as they are not novel with or necessary to explain the new invention.

Two rolls shown in Figs. 1, 2, 3, and 4, have rolling surfaces of similar shapes and symmetrically placed in respect to each other and the axis of the pass. The axes of the rolls are parallel with each other and, as illustrated, are horizontal, lying in a common plane perpendicular to the axis of the pass.

A is the lower roll and A′ the upper roll. B, B and C, C are the axes of the roll and H H the axis of the pass; D is the mandrel; E the tubular blank or billet; F and G are the journals or shaft extension of the rolls.

Each roll has a flange presenting a plane working surface N and an outer gently beveled or curved working surface as at L (Figs. 1 and 1ª). From the plane surface N the contour of the roll at M as viewed axially along the pass has a circular curvature of a radius H O through an arc of ninety degrees to the point P and thence may continue straight as a cylinder from P to Q. The radius H O is equal to the radius to which the body is to be reduced in passing through between the rolls under the most perfect conditions, but some latitude in size by a slight approaching or separation of the rolls is of course contemplated. It will be seen that at the cross section through the pass shown in Fig. 1, which is in the plane of the two axes of the rolls, the metal is confined and radially compressed by the rolls through a large portion of its circumference by the curved surface between the point O and P of the roll A in Fig. 1 and the similar opposite surface of the roll A′. From P to Q the roll may be straight and tangential of the curve O P, being therefore truly cylindrical so as gradually to leave the body E as seen in Fig. 1. Instead of the cylindrical portion P Q a concave surface as seen in Fig. 1[b], at P Q′ may be substituted so as to somewhat further embrace, compress and confine the metal at the middle of the pass, the radius of curvature of the surface indicated by these dotted lines being much greater than H O in order that the end or edge of the rolling surface shall not cut into the body that is being rolled.

The billet or tubular blank E, if of iron, steel, or similar metal at a temperature suitable for hot rolling the metal, is placed upon the mandrel D, which is preferably cold, and is introduced through suitable guides into the inlet end of the pass. The blank being of slightly larger radius than the H O (Fig. 1[a]) will first make contact with the two rolls at two opposite points where the blank first meets the converging surfaces L of the flanges of the two rolls. The rotation of the rolls at equal speeds in the direction indicated by the arrows, will carry the blank forward and grip it strongly, compressing it laterally between these opposing points, as apparent in Fig. 4. The direction of motion of the flange of the upper roll A′ at the point 1 (Fig. 2) of first contact is forward and downward, as indicated by the line 1—4 in Fig. 2, while that of the lower roll is upward and forward, as indicated by the line 1—3. The forward feeding components of the effects of the two rolls are equal and are indicated by the line 1—5, as will be apparent. The rotating or cross rolling effect of the two rolls at the points 1 of the pass is roughly indicated by the oppositely directed components of motion 5—3 and 5—4, but being on opposite sides of the body or blank, they both tend to produce rotation in the same direction; right-handedly as seen in Fig. 4. As the cross section of the billet enters farther into the pass, this gripping and cross rolling pressure by the flanges on opposite sides of the blank increases progressively in amount and in the width of the area of contact between the blank and the opposing flanges until and after the section reaches a point where the roll surfaces M act to compress the blank horizontally, diagonally, and also vertically on opposite sides (see Fig. 2). When the given cross section reaches the transverse plane of the axes of the rolls, as at 7 in Fig. 2, the confining and rolling pressure extends circumferentially around two areas including more than half the total periphery of the blank, as seen in Fig. 1. But at this cross section the motions of all points of the rolls in contact with the billet are longitudinally forward parallel with the axis of the pass. There is no cross rolling component.

A third stage of the procedure is reached as the given cross section of the billet, passing out from the most confined cross section of the pass, emerges toward the exit end of the pass and the rolls again make contact with the billet only on narrow lines at opposite sides where the flanges of the roll still remain in contact with the blank. The last points of contact between the rolls and the blank are approximately located at the points marked 8 in Figs. 2 and 3; and at these points it will be seen that the flanges are exerting a cross rolling pressure on the surface of the blank but in the direction that tends to rotate or twist the blank in a direction reverse to the tendency at the inlet end of the pass.

The surfaces N of the roll flanges at the exit will produce a smoothing effect tending to roll out and smooth away any bunching or crowding of the metal at opposite sides of the billet produced in the previous portions of the pass, and which is shown in cross section of the blank E in Fig. 1.

Having thus followed the procedure applied to any one cross section of the blank, it will be seen that a simultaneous action is occurring at the inlet and exit ends of the pass on different sections or portions of the same blank whereby at the inlet end the metal is being cross rolled by forces applied to a limited area of the surface at opposite points, as in Fig. 4, and the metal subjected to a right-handed twisting tendency; at the exit end of the pass the metal is subjected to a reverse rotary or twisting tendency and given a smoothing action; and at an intermediate cross section longitudinal rolling compression of the metal occurs between surfaces that confine the metal circumferentially around the greater part of the periphery. At the inlet of the pass the metal will flow mostly circumferentially of the billet, as for example along the line W W of Fig. 4; while at the middle portions of the pass the metal is necessarily elongated and is prevented from materially enlarging radially. It is consequently reduced in external diameter and thickness. At the exit end of the pass, however, the cross rolling and smoothing effect produces also a loosening of the tube upon the mandrel D, which is a great practical value because it facilitates the subsequent drawing out of the mandrel from the tube. The axial or feeding components of the motions of all points of each of the rolls that lie in the horizontal plane of the pass are necessarily exactly equal if the two rolls are the same size and rotate at equal speed, and the axial feed components are approximately equal at all other points of the pass. The cross rolling component of motion of the rolls diminishes and again increases in reverse direction as the axial distance from the transverse plane Z, Z′ through the central point 7 of the pass varies.

I prefer to have the forces at work upon the blank symmetrical, that it to say balanced at diametrically opposite points of the blank as it advances through the pass; and this is the case in the application of the invention that I have just described. As the billet advances into the inlet side of the pass, it is first subjected to a cross rolling and pressure by what I may call point contact or narrow line contact between blank and roll. Subsequently it is subjected to an embracing surface contact and pressure, compelling the metal to yield longitudinally; and lastly it is subjected to cross rolling or smoothing between opposed and substantially plane parallel surfaces.

It will be seen that the action to which I subject the blank differs radically from the common procedure of rolling out bars or tubes between rolls having semi-circular or semi-elliptical grooves and that it differs equally from the well known art of piercing or expanding billets or tubes by cross rolling between rolls by which the blank is not embraced circumferentially through any considerable portion of its periphery at any one instant.

In Figs. 5, 6, and 7 rolls with axes slightly oblique to each other and to the transverse plane of the pass are shown for carrying out the process.

In Figs. 1 to 4 inclusive the blank after coming in contact with the flange portions of the rolls has to travel a considerable distance before it is embraced circumferentially to any great extent; and during this period of its progress it is subjected to torsional or twisting strain. In cases where metals having less resistance to such strains than iron and steel are to be treated; or where the thinness of the wall or other conditions make a diminished torsional strain preferable at the entrance to the pass, this can be accomplished by disposing the roll axes slightly inclined toward the rear of the pass, as shown in Figs. 5, 6, and 7, making the converging entrance of the pass more abrupt (as will be clear from Fig. 7,) as compared with the exit end of the pass and giving the working surfaces of the rolls as a consequence a slightly different shape. It will be understood that the plane surface of the flanges in Figs. 1, 2, 3, and 4 should here be replaced by slightly conical or, more exactly hyperboloidal surfaces so as to give with the appropriate cross section at the smallest section of the pass, as explained above, a shortened inlet and a relatively more prolonged straight sided exit end of the pass. The rotary or twisting effect of the exit will dominate when the reduction of diameter given to the blank is but slight.

It will be understood by those familiar with this art that my process, even in the entire absence of any cross-rolling effect at the entrance of the pass prior to the longitudinal rolling and circumferential pressure, is characterized in the preferred forms described by a continuous progression and transmission from longitudinal rolling and circumferential compression to a substantially simple cross-rolling action without circumferential compression, and all in a single pass.

In cases where very large reductions of wall thickness or external diameter are required, I prefer to accomplish the total reduction by successive repetitions of the process that I have so far described. This may be done by several sets of rolls as exemplified in Fig. 8. I prefer to place the succeeding pairs of rolls so near the preceding pairs that the blank and mandrel bar will come within the grip of the last pair of rolls before leaving the first pair, and to proportion the speeds of the succeeding pairs of rolls to compensate for the elongation of the metal which occurs in each pair of rolls, the succeeding pairs operating faster in proportion to the reduction of cross section of the blank that occurs. Obviously, however, as a mandrel bar, which is preferably in a cold state, can only assume one forward speed for all its points, its speed will be less than the feeding speed of the third or last pair of rolls and greater than the first pair of rolls. By this use of my process, therefore, I produce a longitudinal movement between the mandrel and the tubular blank. This also facilitates the removal of the tube from the mandrel bar after they leave the roll.

The process may be also utilized with a mandrel that is held stationary so far as endwise movement is concerned but is free to rotate. This is illustrated in Figs. 9 and 10, wherein a short mandrel or plug U is shown on the end of a bar T which is braced against a fixed support S, allowing the mandrel U to turn but not to move axially in the pass. This facilitates the spiral twisting of the blank by the rolls because the mandrel if it only extends through the middle and rear portions of the pass does not tend to reduce or prevent the somewhat different speed of rotation and consequent twist of the billet at the commencement of the pass where it is first gripped by the roll flanges, as heretofore explained. Incidentally the rotation of the mandrel causes it to wear more evenly on all sides, and to remain round much longer producing consequently a smoother surface on the interior of the tube than if the mandrel did not rotate.

The process may be also used to give very slight reduction in thickness of the walls of the tubes where it is only desirable to remove creases or irregularities such as are frequently produced in tubular blanks by the ordinary method of rolling a tubular blank over a stationary mandrel or plug. Similarly the method may be employed for merely rolling out rough places on the outside surfaces of the tubes, such as are frequently produced in billets that have been pierced or rolled by defective or rough rolls or mandrels or injured by scale. In utilizing the process for this purpose I prefer to minimize the pressure and reduction occurring at the middle of the pass where the metal is confined circumferentially and to rely mainly on the last step of the process where the cross rolling action mainly occurs.

If the rolls already described are drawn slightly farther apart vertically, that is perpendicularly to their axes, the circumferential confining action will be lessened or omitted while the cross rolling in reverse directions at the inlet and exit ends of the pass remains. Where it is desired to cross roll or reel a tube to compress it very slightly, so as to remove creases or rough places inside or outside the first and last stages of the process or the last stage only may be employed exclusively, the central portion of the pass acting merely as rotating guides for the tube and mandrel, holding them in alinement in the center of the pass, while the wall of the tube is compressed and rolled spirally forward between the flanged portions of the rolls. Such guides can be made to fit the tube much closer without practical inconvenience and if the tube tends to bind between the guides they at once act to roll it longitudinally forward instead of opposing it as would fixed guides or idler rollers.

In Fig. 11 the rolls are shown with the curved portion corresponding to O P in Fig. 1ª transformed into cylindrical and plane faces. Such rolls can embrace and confine the metal on four sides at the center of the pass or, when adjusted so that the horizontal dimension of the pass is less than the vertical, can only cross roll the blank between the opposed flanges.

It will be seen that in the various figures of the drawings the flanges of the respective rolls overlap the coöperating flange of the opposed roll to produce the rotatory or twisting tendency on the body being treated. It will also be seen that the rolls rotate approximately in opposite directions when their axes are inclined and exactly in opposite directions when their axes are parallel, as common in grooved rolls for longitudinal rolling.

It will be clear to those skilled in the rolling art that the dimensions of either of a pair of rolls may be increased relatively to the opposing roll and the angular speed proportionately decreased without materially altering the surface speed and equal effects of the two rolls.

Without attempting to set forth many other modifications, I claim and desire to secure by Letters Patent the following:

1. The improvement in the art of rolling tubes or round bodies, which consists in subjecting such a body to a continuous and progressive rolling and compressive pressure while moving forward in a suitable pass by pressing and cross rolling the body in the inlet end of the pass between approximately parallel rolling faces, thereby tending to rotate the body while allowing the metal to flow circumferentially, simultaneously subjecting the cross sections of the body farther within the pass to confining and rolling pressure around a large part of its periphery from surfaces moving substantially longitudinally of the pass with little or no cross rolling motion, whereby the metal flows and elongates in an axial direction and simultaneously subjecting the cross sections of the body in the exit portion of the pass to rolling pressure between approximately plane surfaces moving transversely to the pass and tending to rotate the body reversely to the inlet portions of the pass, for substantially the purposes set forth.

2. The improvement in the art of rolling tubes or round bodies, which consists in subjecting such a body to a continuous and progressive rolling and compressive pressure while moving forward in a suitable pass by subjecting the cross sections of the body to confining and rolling pressure around a large part of its periphery from surfaces moving substantially longitudinally of the pass with little or no cross rolling motion, whereby the metal flows and elongates in an axial direction and simultaneously subjecting the cross sections of the body in the exit portion of the same pass to rolling pressure between approximately plane surfaces moving transversely to the pass and tending to rotate the body, for substantially the purposes set forth.

3. The improvement in the art of rolling tubes or round bodies, which consists in subjecting such a body to a continuous and progressive rolling and compressive pressure

while moving forward in a suitable pass, by subjecting the cross sections of the body to circumferential confining and longitudinal rolling pressure around a large part of its periphery from surfaces moving substantially longitudinally of the pass with little or no cross rolling motion, whereby the metal flows and elongates in an axial direction and simultaneously subjecting the cross sections of the body in the exit portion of the same pass to rolling pressure between approximately plane surfaces moving transversely to the pass and tending to rotate the body, the said metal being supported internally upon a substantially hard mandrel for substantially the purposes set forth.

4. The improvement in the art of rolling tubes or round bodies, which consists in subjecting such body to a continuous and progressive rolling and compressive pressure while moving forward in a suitable pass, by subjecting the cross sections of the body to circumferential confining and longitudinal rolling pressure around a large part of its periphery from surfaces moving substantially longitudinally of the pass with little or no cross rolling motion, whereby the metal flows and elongates in an axial direction and simultaneously subjecting the cross sections of the body in the exit portion of the same pass to rolling pressure between approximately plane surfaces moving transversely to the pass and tending to rotate the body.

5. The improvement in the art of rolling tubes or round bodies, which consists in subjecting such a body to a continuous and progressive rolling and compressive pressure while moving forward in a suitable pass, by subjecting the cross sections of the body to circumferential confining and longitudinal rolling pressure around a large part of its periphery from surfaces moving substantially longitudinally of the pass with little or no cross rolling motion, whereby the metal flows and elongates in an axial direction and simultaneously subjecting the cross sections of the body in the exit portion of the same pass to rolling pressure between approximately plane surfaces moving transversely to the pass and tending to rotate the body, and supporting the body internally during the latter action upon a mandrel that is held against axial motion as the metal moves over it.

6. The improvement in the art of longitudinally rolling tubes or round bodies, characterized by subjecting each advancing cross section to longitudinal rolling and circumferential compression throughout a large portion of the periphery, and then rolling the body by pressure between opposing cross rolling surfaces having relatively narrow limits of contact with the body, the said successive treatments occurring progressively and in continuity upon the body, for substantially the purposes set forth.

7. The improvement in the art of longitudinally rolling tubes or round bodies, characterized by first cross rolling the body between surfaces having narrow lines or areas of contact with the body and rotating the body, then subjecting each advancing cross section to longitudinal rolling and circumferential compression throughout a large portion of the periphery, and then rolling the body by pressure between opposing cross rolling surfaces having relatively narrow limits of contact with the body, the said successive treatments occuring progressively and in continuity upon the body, for substantially the purposes set forth.

8. The improvement in the art of longitudinally rolling tubes or round bodies, characterized by first cross rolling the body between surfaces both tending to twist or rotate in a like direction, then rolling it longitudinally, and then cross rolling it between surfaces tending to twist or rotate it in a like direction to each other but reverse to the first said direction, for substantially the purposes set forth.

9. The improvement in the art of rolling tubes or round bodies, characterized by first cross rolling the body between rolls having surfaces tending to twist or rotate it in a like direction and then in the same pass between the same rolls cross rolling its advanced portions between surfaces tending to twist or rotate in a direction reverse to the first said direction, while continuing the first cross rolling on other portions, for substantially the purposes set forth.

10. Machine for reducing metal comprising a set of rotary members arranged to form a single pass, at least one of said members having a central portion and an outer flange portion, said central portion being constructed and arranged to grip the billet circumferentially to elongate it and roll it substantially longitudinally, and said flange portion being inclined to the axis of the pass to operate transversely upon and cross roll the blank as it passes from the central portion, for substantially the purposes set forth.

11. Rolls forming a pass and having surfaces for longitudinally rolling and circumferentially confining the body being rolled and having opposed surfaces in the same pass for cross rolling the body, the acting surfaces of the rolls being convergent at the mouth of the pass.

12. Rolls forming a pass and having surfaces for longitudinally rolling and circumferentially confining the body being rolled, and having opposed surfaces for cross-rolling the body, the acting surfaces of the rolls

being convergent at the mouth of the pass, in combination with a mandrel for internally supporting the body at the points of longitudinal and of cross rolling.

13. Rolls forming a pass and having surfaces for longitudinally rolling while circumferentially confining the body being rolled and opposed surfaces for cross-rolling the body, the acting surfaces of the rolls being convergent at the mouth of the pass, in combination with a mandrel supported to rotate without traveling in respect to the rolls.

14. Rolling mechanism comprising rolls forming a pass and having inclined axes for imparting endwise and rotary motions to a blank while gripped thereby longitudinally and circumferentially, each of the said rolls having a concave central portion for circumferentially confining and longitudinally rolling the body, and a flange for cross rolling the body, and imparting rotation, for substantially the purposes set forth.

15. Rolling mechanism comprising rotary rolls forming a pass, for imparting endwise and rotary motions to a blank while gripped thereby longitudinally and circumferentially, each of the said rolls having a concave central portion for circumferentially confining and longitudinally rolling the body, and a flange for cross rolling the body and imparting rotation, the flanges of the rolls converging at the mouth of the pass.

16. In combination, a plurality of pairs of coacting rolls for longitudinally rolling a body or blank forming a plurality of passes in line, one or all of the said pairs having flanges for rotating or cross rolling the said body or blank and a coöperating mandrel of length to extend simultaneously into a plurality of the passes, at least one of which has such cross rolling flanges.

17. In combination, a pair of rolls forming a pass, the axis of each roll being perpendicular or nearly so to the pass axis, the rolls rotating in opposite directions and having opposed overlapped flanges making contact with the work piece along longitudinally disposed lines at the exit end of the pass, for producing cross rolling in like directions, the opposing faces of the flanges of the rolls converging at the entrance end of the pass, substantially as set forth.

18. Rolling members forming a pass and having axes inclined to each other and each having a circumferentially confining and longitudinally rolling surface portion and a cross rolling flange portion that makes acting contact against the work piece on lines disposed along the pass.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses, May 21, 1908.

RALPH CHARLES STIEFEL.

Witnesses:
R. T. Brown,
Leslie H. Mann.