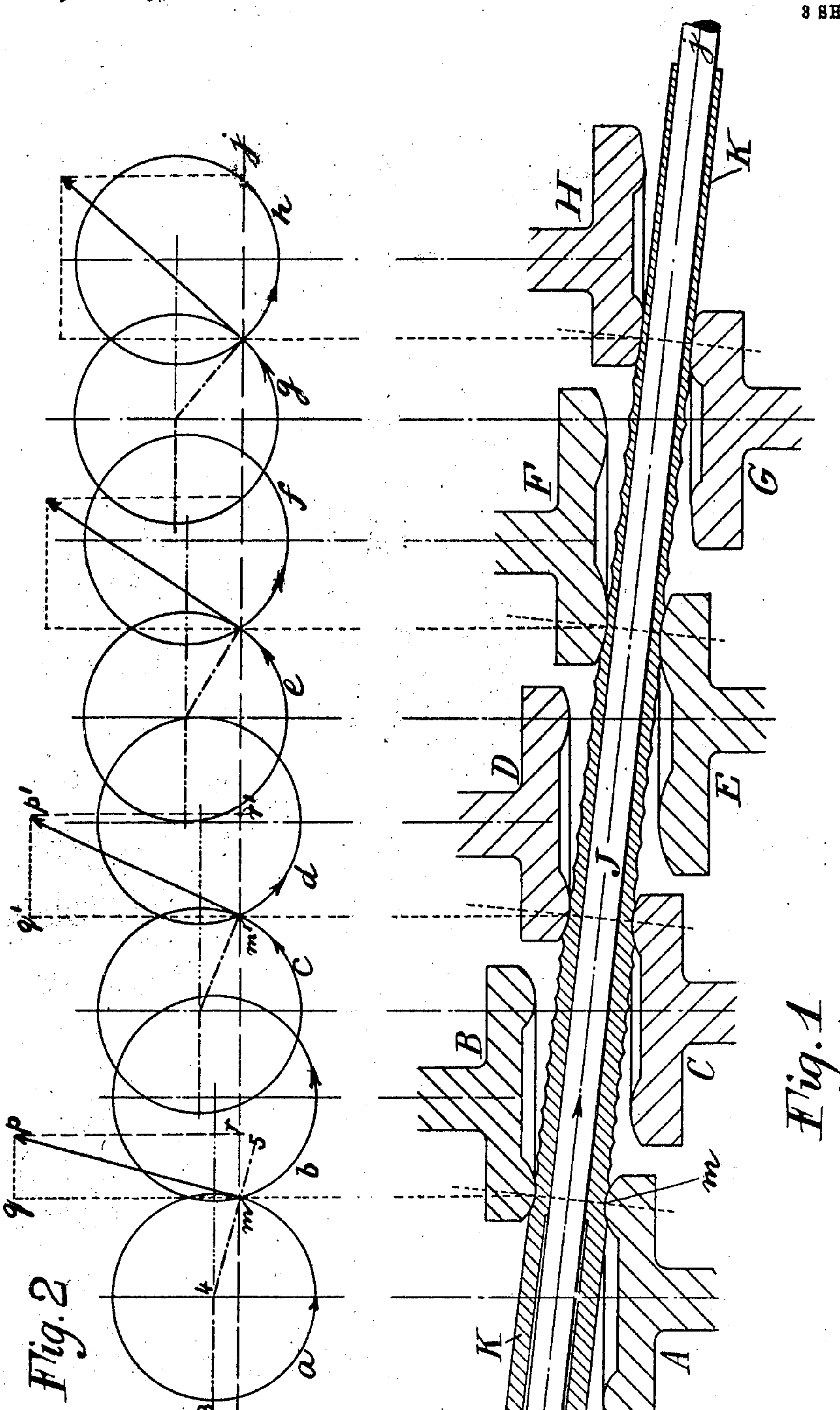
R. C. STIEFEL.

CONTINUOUS TUBE ROLLING PROCESS AND APPARATUS THEREFOR.

APPLICATION FILED MAR. 13, 1912.

1,055,368. Patented Mar. 11, 1913.

3 SHEETS—SHEET 1.



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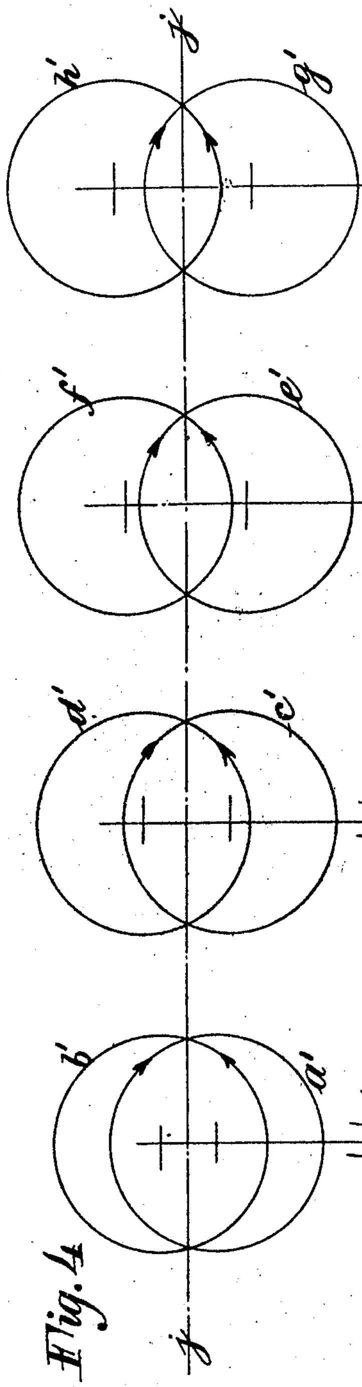

Fig. 4

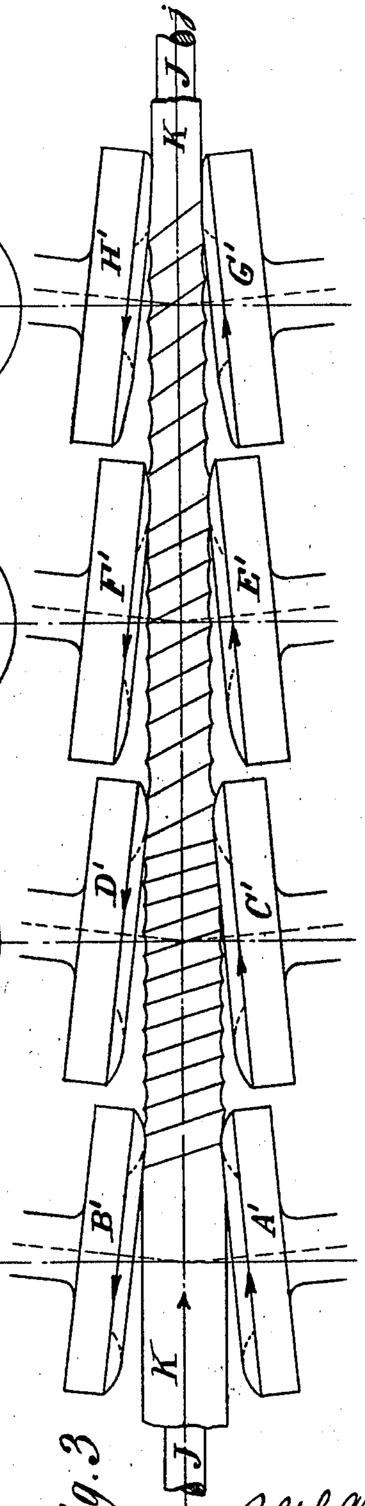

Fig. 3

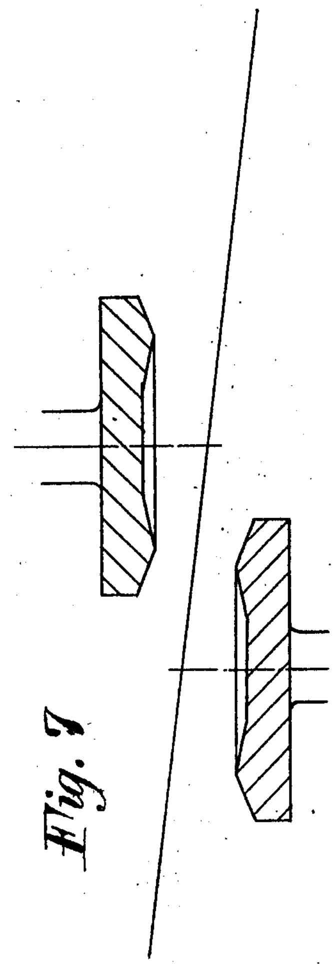

Fig. 7

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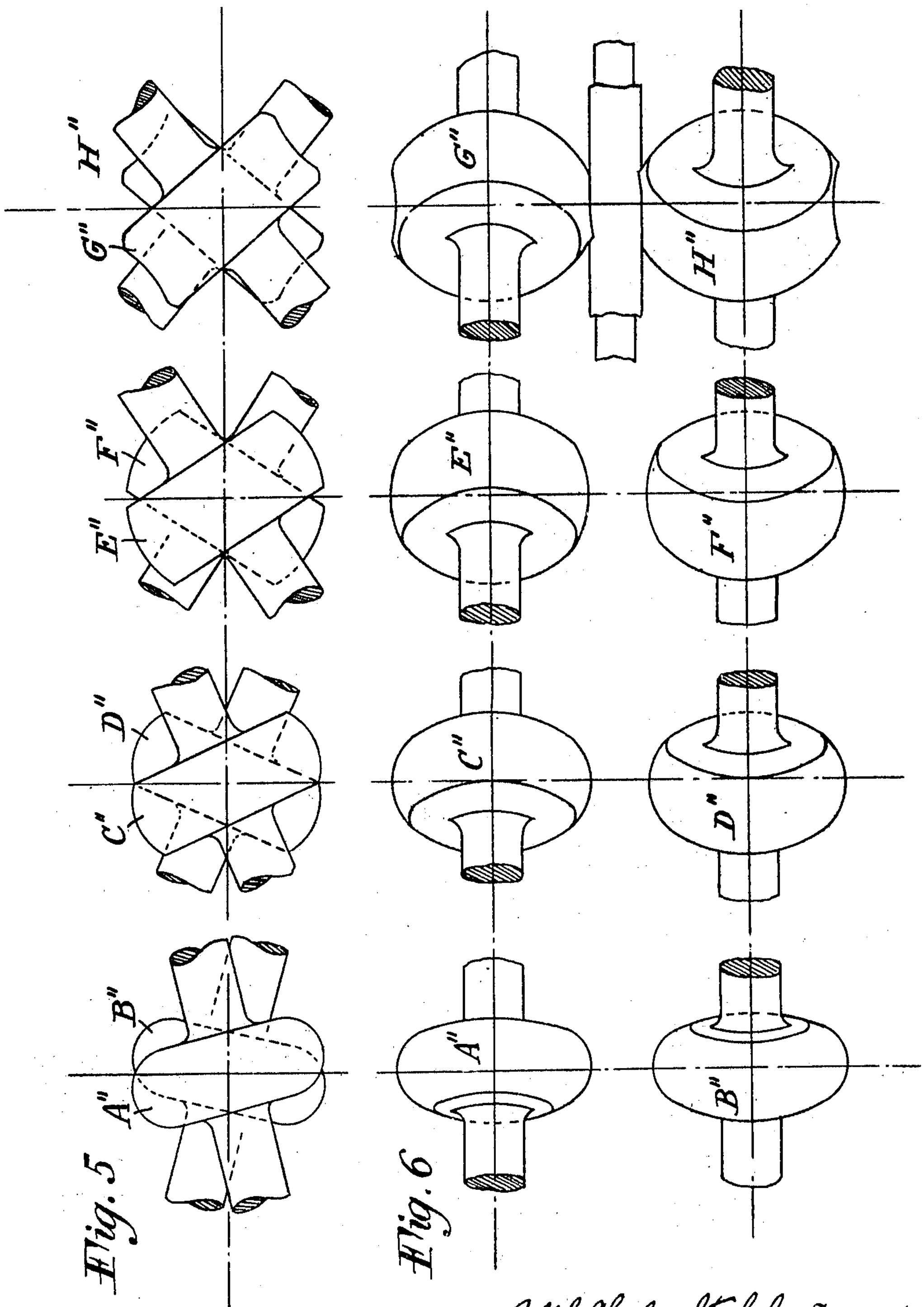

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UNITED STATES PATENT OFFICE.

RALPH CHARLES STIEFEL, OF ELLWOOD CITY, PENNSYLVANIA.

CONTINUOUS TUBE-ROLLING PROCESS AND APPARATUS THEREFOR.

1,055,368. Specification of Letters Patent. **Patented Mar. 11, 1913.**

Application filed March 13, 1912. Serial No. 683,540.

To all whom it may concern:

Be it known that I, RALPH CHARLES STIEFEL, a citizen of the United States, and resident of Ellwood City, Pennsylvania, have invented certain new and useful Improvements in Continuous Tube-Rolling Processes and Apparatus Therefor, of which the following is a specification, accompanied by drawings.

The invention relates primarily to the cross rolling of steel and other tubes and tubular billets in a heated state in the manufacture of seamless tubes.

The objects of the invention in its most complete and preferred embodiment are to accomplish by cross rolling rapidly and easily the elongation of the tube or billet and the reduction of its wall thickness, doing this in such a manner that the process shall be independent of specially designed apparatus or grooved rolls for each considerable difference in size of tube to be made, and in such a manner that the friction and wear and tear on the mandrel bar and rolls shall be slight as compared with longitudinal rolling processes employing grooved rolls which circumferentially embrace the tube.

It has heretofore been a common practice in the rolling of seamless tubes in continuous rolling mills to roll the tubes longitudinally between a plurality of successive sets of grooved rolls having grooves which form a circular or elliptical pass and embrace the billet or tube circumferentially for the greater portion of its circumference and which roll the billet or tube longitudinally on the mandrel bar, elongating and stretching the metal, causing it to grip the mandrel bar so tightly that special devices are frequently necessary for loosening the billet upon the mandrel bar before it is stripped therefrom. If the roll axes of such grooved rolls are perpendicular to the axis of the pass, neighboring pairs of rolls are usually placed at right angles, so as to act at ninety degrees or a quarter turn on the billet and not all to act along the same sides of the billet, but in lieu of this the pairs of rolls are sometimes slightly inclined or skewed, so as to give a quarter turn to the billet itself in passing between neighboring pairs of rolls and allow the roll pairs to be all conveniently placed in like positions relatively to the pass, the quarter turning of the billet or tube causing the successive rolls in effect to act ninety degrees apart in respect to the metal of the billet or tube. Even with these provisions, in such processes the flow of the metal and the rolling action is necessarily different at different points in the circumference of the billet, whereas in the cross rolling process such is obviously not the case. Moreover the process of longitudinal rolling in grooved rolls necessitates different sets of rolls with different sizes of grooves for every considerable difference in the diameter of the tubes rolled with consequent loss of time and increase of expense in changing the rolls.

Under the present improvement, the billet is subjected to cross rolling action between successive pairs of cross rolling bodies, which treat the billet alike upon all sides; and preferably I also simultaneously subject the metal to a longitudinal tension while so cross rolling it, and I do the rolling between rolling faces which are preferably short and convex longitudinally of the pass and cause the metal to yield and flow out beneath them longitudinally, and preferably at or toward the rear end of the series of rolls, I subject the billet to cross rolling between rolls which have rolling faces which are flat in the longitudinal direction and are approximately parallel with the pass and which smooth the billet or tube and also slightly enlarge it upon the mandrel bar.

In the drawings, Figure 1 is a diagrammatic longitudinal sectional view of one preferred arrangement of rolling bodies for carrying out the present invention, Fig. 2 is a diagram of the same arrangement of rolling bodies in elevation, showing the circles corresponding to the central lines or mean diameters of the rolling contact surfaces of the rolls and showing the directions and speeds of the rolling motion and the transverse and longitudinal speed components of the same, Fig. 3 shows in plan view a modified arrangement of rolls for carrying out the invention, Fig. 4 is a corresponding diagram of the mean diameter circles thereof in elevation, Fig. 5 shows an elevation of another type and arrangement of the rolls for operating the process, Fig. 6 shows in plan view, four of the roll pairs of Fig. 5, and Fig. 7 is a section through a pair of disk rolls, presenting angular convex faces, instead of curved convex faces, to the pass.

The roll bearings, housings, guides for

the billet, driving connections and other parts not necessary to the understanding of the invention are omitted for clearness from the drawings.

In Figs. 1 and 2, the rolling bodies are four pairs of overlapped disk-shaped rolls, having horizontal axes raised above the plane of the axis of the pass, so as to give a feeding effect in addition to the cross rolling action, as well understood. The axes of each pair are parallel and the faces of the rolls overlapped. The rolls are slightly but sufficiently inclined to the axis of the pass in order to allow clearance for the billet or tube. The rear portion of roll A acts opposite the forward portion of roll B, and the other pairs of rolls C, D and E, F and G, H are overlapped to act similarly.

For convenience in explaining the process, the section for each roll in Fig. 1 is taken, as follows: The roll A is sectioned horizontally from its axis toward the lefthand side in the plane of the axis 3—4, Fig. 2. On the active side, or righthand side, of the axis the section plane runs from the axis through the central point of the surface of contact at the instant between the roll and the billet, as shown by the section line 4—5 in Fig. 2. Similarly, the other rolls are each sectioned, one half horizontally, and the other half through the inclined plane passing through the axis and the central point of the surface in contact with the billet. This gives the slightly one-sided appearance to the sections which may be noticed in Fig. 1. Circles *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h* in Fig. 2 are paths of the motion of revolution of those points in the faces of the respective rolls which pass through the centers of the surface in contact with the billet. Consequently, the speed and direction of motion and the approximate longitudinal and cross effect of the roll upon the billet may be graphically determined from these circles, which correspond to the mean working diameters of the working or contact surfaces. The correction for the slight obliquity of the roll axes may be neglected. The arrows on these circles show the direction of rotation. The axial line through the pass is marked *j*—*j*. A portion of the mandrel bar is shown at J, and the billet or tube at K. The first pair of disk rolls, A, B, give the least feeding effect, because their axes are least raised above the axis of the pass, as shown by the height of the line 3—4 in Fig. 2 above the axis of the pass. Let the tangent *mp* be drawn through the center of contact *m* of the disk on the billet and of length and direction corresponding to the speed of the roll surface at that point. Let lines *mq* and *mr* be drawn to represent the components of cross rolling motion and longitudinal feeding motion at the point *m*, by means of the familiar parallelogram of forces and motions, as shown. The ratio of the feeding effect to the cross rolling, determined by the degree of raising the axis of the roll, should be small, as is shown. The contact surfaces of the rolls should be convex and short longitudinally of the pass, so that they roll transverse and slightly oblique spirally overlapping depressions or shallow grooves in the surface of the heated billet, and facilitate the spreading and flow of the metal longitudinally from beneath the rolling surfaces, so as to elongate the billet upon the mandrel bar and reduce its wall thickness. The succeeding pair of rolls, C, D, which act progressively and simultaneously with the rolls A, B, upon the billet during the greater portion of its length, may be of the same shape, but with preferably slightly less convexity, so as to span and not fit the previously made spiral grooves. The cross rolling component of motion of the rolls C, D, may be made less than that of the preceding rolls by an amount proportional to the differing diameters of the billet under the respective rolls in order that the rolls may elongate the metal without twisting it. Twist, however, may be imparted in making tubes for special uses, by varying the cross rolling components.

The longitudinal component *m′ r′* is increased preferably by an amount sufficiently in excess of that corresponding to the elongation of the tube by these rolls to produce a longitudinal tension upon the billet between these rolls and the preceding pair. This tension or pulling on the billet not only lessens the tendency of the billet to be expanded or enlarged upon the mandrel by the cross rolling, but also assists the preceding pair of rolls in elongating the billet. It will be understood that the longitudinal or feed component of the speed depends on both the roll speed and the angle corresponding with *p′ m′ q′* and that an increase of either the roll speed or the angle will give an increase of the feed component. Similarly, several succeeding pairs of rolls may be used, with the same or varying cross rolling speed and with increasing longitudinal feed component, and preferably with increasing length and decreasing curvature of the convex rolling surface, and, of course, diminishing width of pass corresponding to the desired reduction of thickness and diameter of the tube.

It will be seen, as shown in Fig. 1, that a pair of shallow spiral depressions or grooves are rolled in the billet or tube by each of the succeeding roll pairs except by the last. The last pair, G, H, have the greater portions of their working faces substantially flat and parallel with the pass, as viewed in cross section along the pass. Between these last rolls therefore, the metal is subjected to cross rolling with but little opportunity and tendency to flow longitudinally from beneath the flat and relatively wide faces, the wavy or grooved surface is rolled out to a smooth cylindrical surface and the tube is loosened from the mandrel bar if it were tight thereon and can be readily drawn therefrom. It will now readily be seen that for rolling widely different diameters of billets the same process may be followed, merely separating the rolls to change the width of the pass by adjusting the rolls along their respective axes, instead of requiring, as in the case of grooved rolls, a change of the rolls themselves. It will also be seen that by successively diminishing the convexity of the rolling surfaces, the tendency of the rolls to fit into the spiral groove made by the previous rolls is lessened. Instead of curved convex working faces, substantially straight line components, forming a V-shaped section, as illustrated in Fig. 7, and giving an angular form of convexity, may be used, and I use the term convex to include angular forms. In either form the pass between the two rolls of the pair is rapidly convergent and then rapidly divergent in order to aid in forcing the metal to flow endwise.

Although it is preferable to effect the cross rolling by means of rolling surfaces which are both convex and short longitudinally of the pass and which give progressively greater feeding action and produce the pulling or tension in the billet, nevertheless it is possible, for example, to use convex faces of very considerable length along the pass or to use faces that are narrow or short in the direction of the pass with very little or no degree of convexity, but in such cases the tendency to expand the tube is relatively greater and the elongating effect of the rolls even with great pulling action due to increasing feeds is lessened. The successive roll pairs are placed as close to each other as convenient, in order that they may act simultaneously on the billet for a longer portion of its length than if they were farther apart. Manifestly, a greater or less number of roll pairs than that shown may be employed, but I prefer to use at least three or more pairs besides the last, or smoothing rolls, making at least four pairs, as shown.

In the process just described, it will be seen that the tubular billet while in the heated state upon a mandrel bar is subjected simultaneously to cross rolling pressure in a manner to spread out the metal endwise from beneath the convex rolling surface, and to a simultaneous pulling or tensile stress longitudinally. Where the pulling or tensile stress is not employed, the cross rolling tends to loosen and to enlarge the tube upon the mandrel, but by combining the cross rolling and the pulling with a moderate reduction of wall thickness between each roll pair, the tube may be kept substantially circular and just loose enough upon the mandrel bar to facilitate its elongation thereupon. In addition to the other advantages, the wear and tear upon the mandrel bar is greatly reduced by this process as compared, for example, with longitudinal rolling where the bar is very tightly embraced by the tube and therefore heats more rapidly.

The process is in no wise limited to the arrangement of apparatus shown in Fig. 1. Thus, in Figs. 3 and 4, there are illustrated opposed pairs of disk-shaped rolls, the rolls of each revolving in opposite directions and placed opposite each other, as shown, instead of being overlapped, as in Fig. 1. As will be understood, the feeding effect in this case is produced between such disk rolls by raising of one and lowering of the opposite roll, as plainly shown in Fig. 4, where the circles corresponding to the mean diameters of the working faces of the respective rolls are shown. In Figs. 1 and 2, the smaller diameter of one roll is opposed to the larger diameter of the opposite roll. In Figs. 3 and 4, the larger diameters of each roll pair are opposed to each other, which consequently produces a tendency to twist the metal of the billet while between a pair of rolls. In Figs. 1 and 2, the rolls all revolve in like direction and feed by reason of their axial elevation above the axis of the pass. Obviously all or any pair could be below the axis and revolve in the opposite direction. In Figs. 5 and 6, barrel-shaped rolls with crossed axes are illustrated, arranged to give approximately the same cross rolling and feed components as in Fig. 1. The first rolls, A″, B″, have the greatest degree of convexity, as before. The intermediate rolls are of decreasing convexity, while the smoothing and loosening rolls, G″, H″, in order to give a substantially flat contact surface in the longitudinal direction, have a slightly concave hyperboloidal curve. In cases where it is not necessary that the tube be made substantially smooth and even by the last rolls, the convex-faced rolls may be the last rolls used.

It will be seen that the improved process will not be materially interfered with by even a considerable wearing away of the rolling surfaces of the disks or rolls employed in carrying it out, although corresponding wear upon grooved rolls for a longitudinal rolling process would be prohibitive of their further use. So there are many other incidental advantages that arise, directly or indirectly, from the improved process in addition to its prime advantage and importance in giving a more uniform and better treatment to the tube or billet.

I employ the terms billet and tube interchangeably to include the tubular billet or tube at any part of its manufacture.

What I claim is:

1. In a process of rolling tubes the improvement which comprises subjecting a tubular billet to cross rolling action on a mandrel bar simultaneously and progressively between a plurality of pairs of cross rolling bodies and at the same time subjecting the billet to progressively increasing feeding components of movement of the rolling surfaces, the length of contact of the cross rolling bodies being so restricted that the metal flows mainly longitudinally, elongating the tube upon the mandrel, and subjecting the metal to a stretching action while so being cross rolled by increasing the difference between the feeding components in excess of that corresponding to the elongation of the billet.

2. In a process of rolling tubes the improvement which comprises subjecting a tubular billet to cross rolling action on a mandrel bar simultaneously and progressively between a plurality of pairs of cross rolling bodies and at the same time subjecting the billet to progressively increasing feeding components of movement of the rolling surfaces, the length of contact of the cross rolling bodies being so restricted that the metal flows mainly longitudinally, elongating the tube upon the mandrel, and toward the exit end of the pass subjecting the billet to cross rolling pressure between bodies having relatively long and substantially flat faces longitudinally and thereby smoothing the billet.

3. In a process of rolling tubes the improvement which comprises subjecting a tubular billet to cross rolling action on a mandrel bar simultaneously and progressively between a plurality of pairs of cross-rolling bodies and at the same time subjecting the billet to progressively increasing feeding components of movement of the rolling surfaces, the length of contact of the cross rolling bodies being so restricted that the metal flows mainly longitudinally, elongating the tube upon the mandrel.

4. Improvement in processes for rolling tubes which comprises cross rolling and elongating a tubular billet on a mandrel bar simultaneously between a plurality of pairs of cross rolling bodies acting obliquely on the billet and thereby rotating and advancing the billet and mandrel, and simultaneously subjecting the billet to a longitudinal tension in the interval between two succeeding roll pairs.

5. Improvement in processes for rolling tubes which comprises cross rolling and elongating a tubular billet on a mandrel bar simultaneously between a plurality of pairs of cross rolling bodies acting obliquely on the billet and thereby rotating and advancing the billet and mandrel, and progressively increasing the longitudinal feeding action of succeeding pairs of bodies without the increase of crosswise action.

6. Improvement in processes for rolling tubes which comprises cross rolling and elongating a tubular billet on a mandrel bar simultaneously between a plurality of roll pairs, and restricting the expanding effect of one or more of the roll pairs by increasing the feeding effect of the succeeding pair in excess of that corresponding to the elongation of the billet, thereby producing a longitudinal stress in the billet.

7. Improvement in processes for rolling tubes which comprises cross rolling and elongating a tubular billet on a mandrel bar simultaneously between a plurality of roll pairs, and restricting the expanding effect of one or more of the roll pairs by increasing the feeding effect of the succeeding pair in excess of that corresponding to the elongation of the billet, thereby producing a longitudinal stress in the billet, and later in the progress smoothing the tube between substantially parallel cross rolling surfaces.

8. Improvement in the art of rolling and elongating tubes which comprises subjecting a tubular billet to cross rolling on a mandrel bar between a plurality of pairs of oblique-acting cross rolling surfaces which are convex but are progressively flatter and longer longitudinally of the pass.

9. Improvement in the art of rolling tubes, which comprises subjecting a tubular billet to cross rolling action on a mandrel bar simultaneously and progressively between a plurality of pairs of cross rolling bodies, the length of contact of the cross rolling bodies upon the billet being so restricted in longitudinal direction that the metal flows or is forced out mainly longitudinally, elongating the tube upon the mandrel, and toward the exit end of the pass further subjecting the billet to cross rolling pressure on contact areas that are relatively long and substantially flat longitudinally of the billet, thereby smoothing the billet.

10. Improvement in the art of rolling tubes which comprises cross rolling a tubular billet on a mandrel bar progressively and simultaneously at a plurality of different portions of its length between a plurality of pairs of rolling bodies and causing longitudinal flow and relatively great elongation of the billet in the earlier roll pairs by rolling surfaces making contact areas relatively narrow and convex longitudinally, one of the later roll pairs making contact areas relatively flat longitudinally, forming an approximately parallel-sided pass.

11. Improvement in continuous mills for rolling tubes comprising a plurality of coacting pairs of cross rolling rolls, one or more of the earlier roll pairs having rolling

surfaces convex and relatively short in the longitudinal direction of the pass, and one of the succeeding roll pairs having rolling surfaces relatively long and substantially flat in the longitudinal direction of the pass.

12. Improvement in apparatus for elongating tubes and billets by cross rolling, comprising a plurality of separate successive pairs of cross rolling rolls having convex rolling faces, the directions of the rolling motion of successive pairs at their points of contact with the billet being progressively and substantially more inclined to a plane perpendicular to the axis of the pass, and the endwise or feeding components of the motion being progressively increased, whereby the endwise components of the rolling motion and also the ratio of the endwise components to the crosswise components of the motion are increased progressively in the successive roll pairs.

13. Improvement in apparatus for elongating tubes and billets by cross rolling, comprising a plurality of separate successive pairs of cross rolling rolls, said rolls being disk-shaped rolls set with their axes substantially crosswise to the axis of the pass with progressively increasing eccentricities of the rolls, that is to say, increasing distances between the axes of the rolls and the axis of the pass where they cross.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses this 8th day of March, 1912.

RALPH CHARLES STIEFEL.

Witnesses:

HAROLD BINNEY,

AUGUSTA PSCHIERER.