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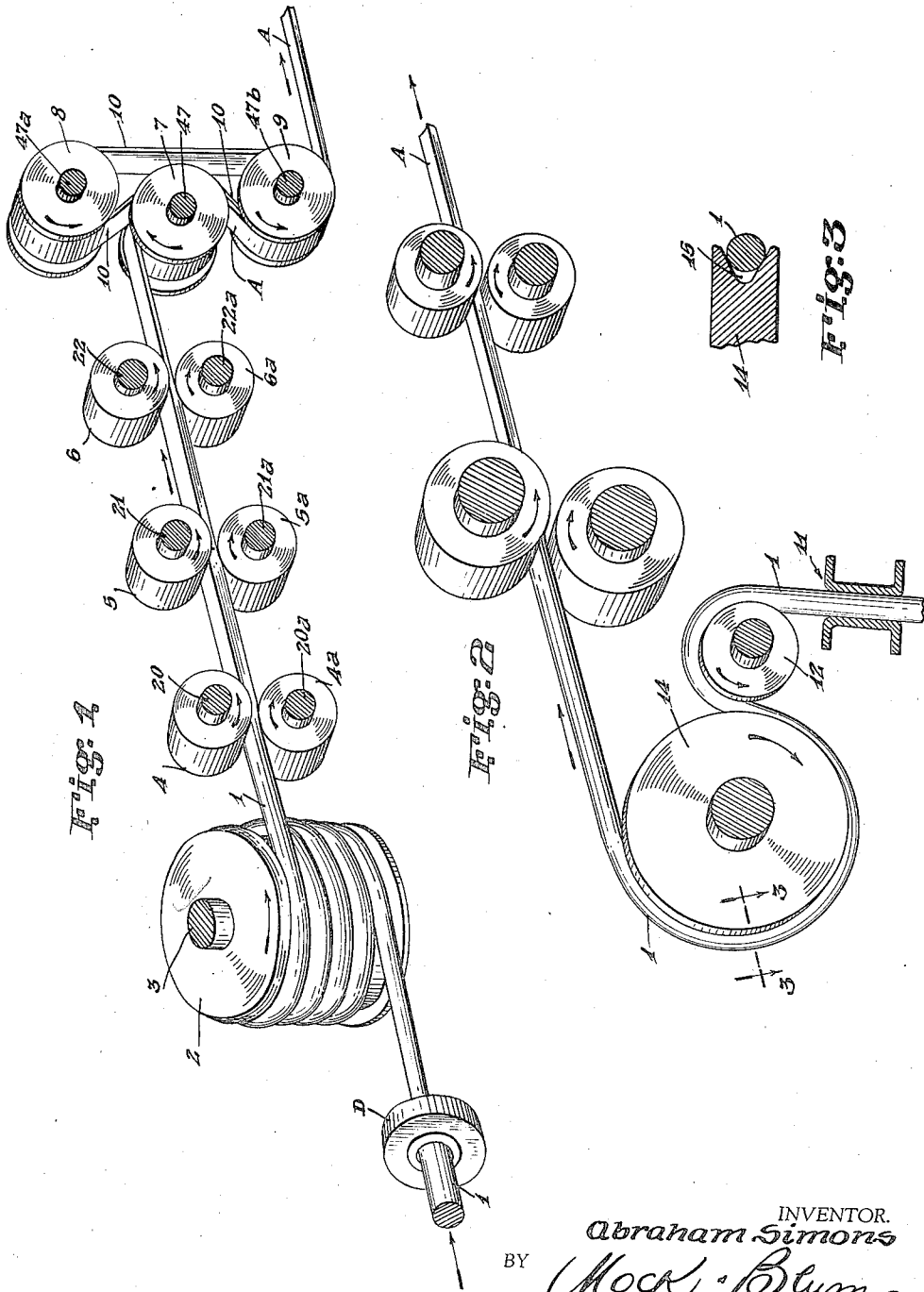
A. SIMONS

2,226,948

METHOD OF ROLLING

Filed Jan. 11, 1936

4 Sheets-Sheet 1



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Dec. 31, 1940.

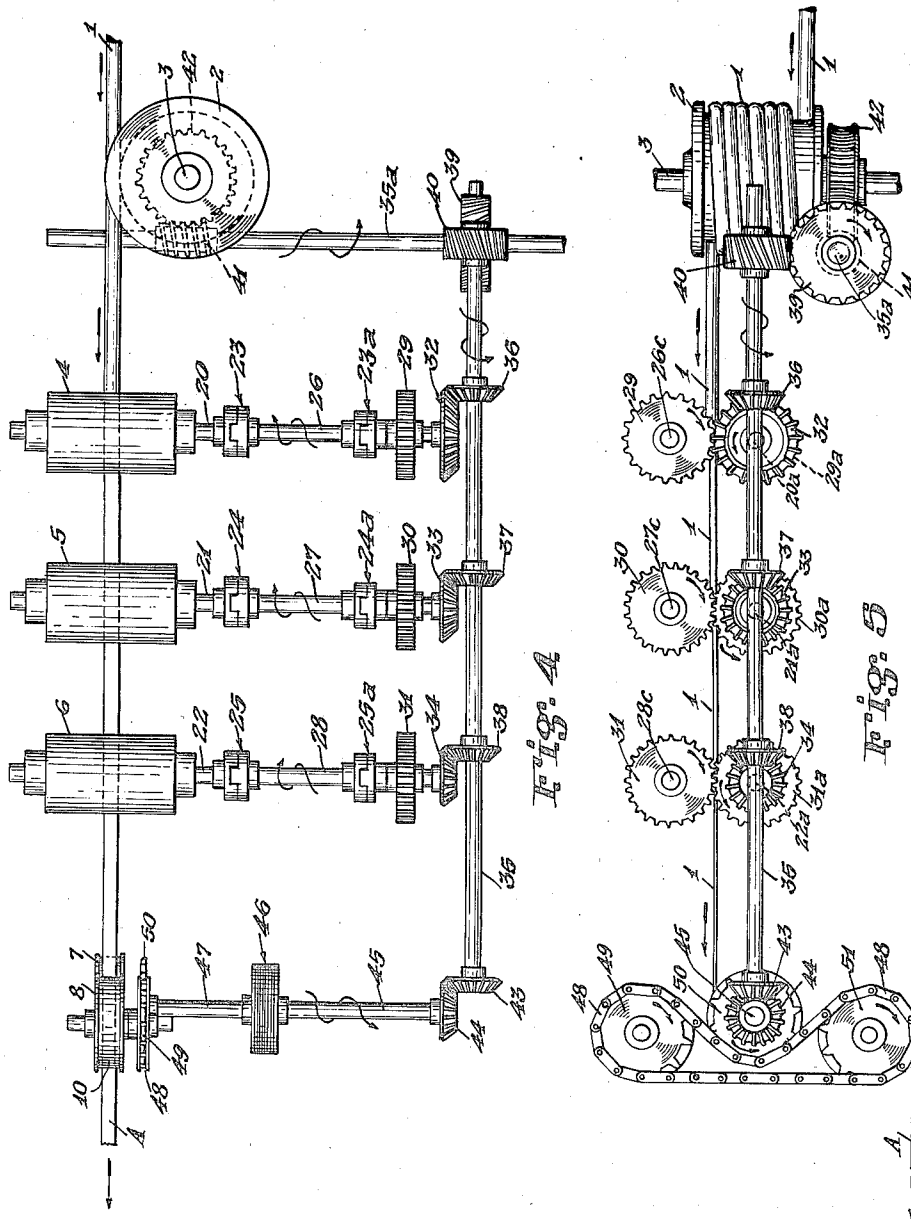
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4 Sheets-Sheet 2



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4 Sheets-Sheet 3

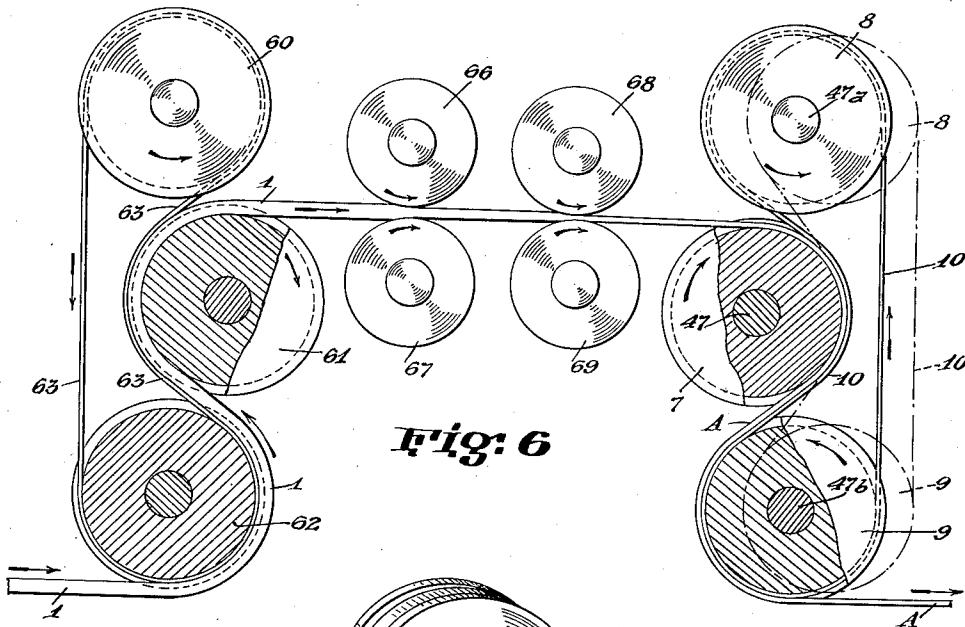


Fig: 6

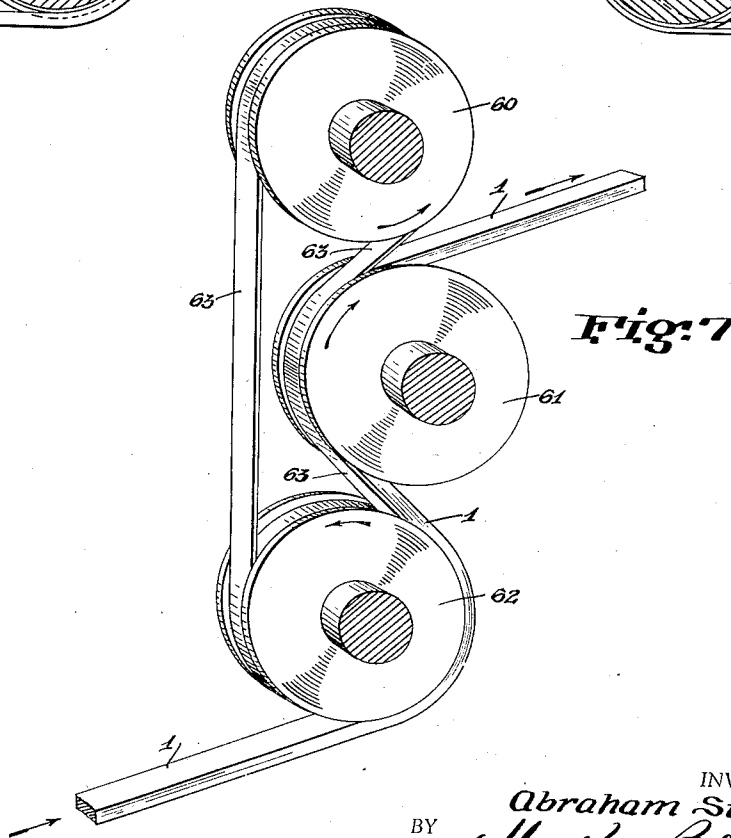


Fig: 7

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4 Sheets-Sheet 4

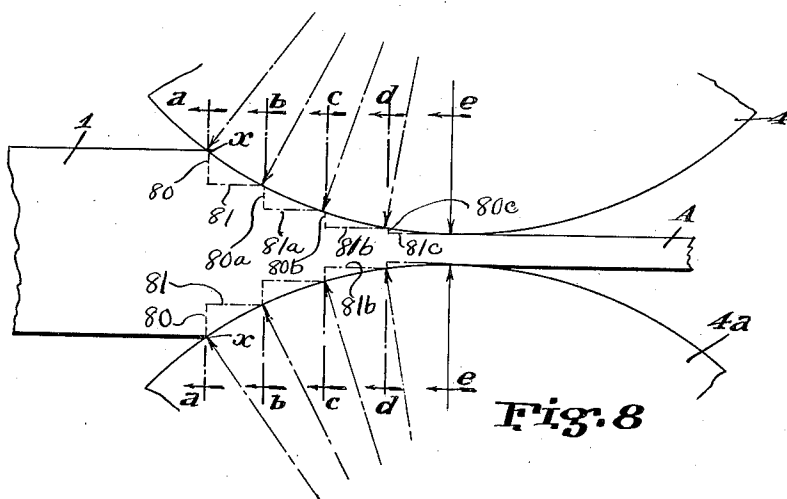


Fig. 8

Fig. 9

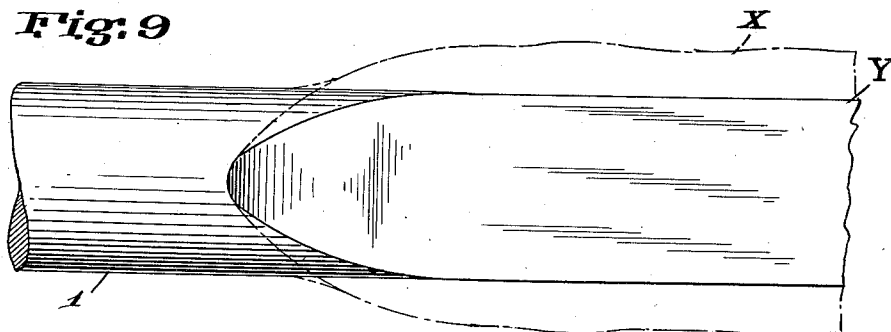


Fig. 10

Fig. 10a

Fig. 10b

Fig. 10c

Fig. 10d

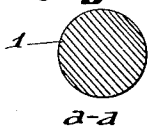
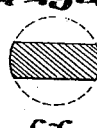
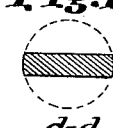
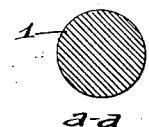
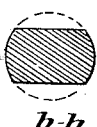
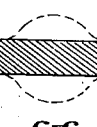
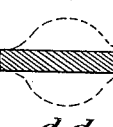
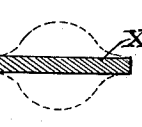


Fig. 11

Fig. 11a

Fig. 11b

Fig. 11c

Fig. 11d

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2,226,948

METHOD OF ROLLING

Abraham Simons, New York, N. Y.

Application January 11, 1936, Serial No. 58,631

2 Claims. (Cl. 80—60)

My invention relates to a new and improved method of rolling material, such as steel or other metal wire or strip, and to a new and improved rolling mechanism. It is to be understood that the improved method and mechanism applies to the rolling of any kind of material.

One of the objects of my invention is to control the width of the rolled material.

Another object is to produce rolled material having substantially planar top and bottom faces, so as to substantially eliminate the "crown" or arched formation of rolled strip.

Another object of my invention is to minimize the wear on the roll.

Another object of my invention is to provide rolled material of superior strength and properties, by controlling the width of the material, during one or more passes through the rolling mechanism.

Another object of my invention is to provide a method of, and mechanism for rolling material, whereby, if desired, the rolled material will have substantially the same width as the original stock, so that the effect of the rolling operation will be to increase the length of the original stock, without increasing the width thereof or without increasing said width to any substantial extent. While I do not wish to be limited to a method and mechanism whereby the width of the rolled material is exactly the same as the width of the original stock, this constitutes a valuable feature of my invention.

Another object of my invention is to provide positive and reliable means for controlling the feed of the stock to one or more rolling units, so as to control the increase in width of the rolled material.

Another object of my invention is to provide mechanism for controlling the feed of the stock to the rolling unit or units, which shall be reliable and uniform, since it is not possible to produce a reliable and uniform control of the feed, by means of the ordinary friction devices which heretofore have been used.

Another object of my invention is to provide an improved method of and improved mechanism for rolling steel material, such as the steel strips which are used for making safety razor blades, springs for clocks and for other purposes, armor for armored cable, and for other purposes where it is desired to have a strip made of steel or other material which has a substantially uniform width and thickness throughout.

Other objects of my invention will be set forth

in the following description and drawings which illustrate preferred embodiments thereof, it being understood that the above general statement of the objects of my invention is intended merely to explain the same, and without limiting it in any particular.

Fig. 1 is a diagrammatic perspective view which illustrates certain essential parts of one embodiment of my invention.

Fig. 2 is a partial perspective view which illustrates the essential parts of a second embodiment of my invention.

Fig. 3 is a sectional view on the line 3—3 of Fig. 2.

Fig. 4 is a diagrammatic rear elevation illustrating the gearing or other connecting parts which can be used in connection with the embodiment which is illustrated in Fig. 1.

Fig. 5 is a front elevation of Fig. 4.

Fig. 6 is a side elevation, partially in section, illustrating a third embodiment of the invention.

Fig. 7 is a perspective view which shows in enlarged detail one of the essential parts which are illustrated in Fig. 6.

Fig. 8 is a diagrammatic view which is used for illustrating the theory of the invention.

Fig. 9 is a diagrammatic top view of the stock, showing the effect of the preferred rolling operation, and said figure illustrates the control of the width of the rolled stock.

Fig. 10 is a sectional view which illustrates the contour of the original stock, if such stock is of cylindrical shape.

Figs. 10a—10d inclusive illustrate the change in the contour of said original stock, as the result of a single rolling operation which is illustrated in Figs. 8 and 9, if said rolling operation is carried out according to the preferred embodiment of the method.

Fig. 11 corresponds to Fig. 10.

Figs. 11a—11d correspond to Figs. 10a—10d, save that Figs. 11a—11d illustrate the result of a rolling operation which is carried out according to the old and well known method.

It has been well known for many years to roll steel stock, such as wire or strip, for various purposes. Experience has shown that by means of the rolling method and mechanism which has heretofore been used, it has been impossible to obtain rolled strip of uniform width or of uniform thickness. This defect was very serious, especially if it was desired to make articles such as razor blades, springs for clocks and for other purposes, and the like.

When steel strip was used for making safety razor blades, it was necessary to trim the edges of the stock, and the edge portions of the original strips were thrown away as waste, because the original rolled strip was not of the desired uniform width and thickness. Likewise the rolled strip did not have true planar faces. In making steel springs for clocks and the like, from rolled steel strip, it was also necessary to trim the edges of the rolled material, because it was not of uniform width and thickness.

Likewise, there was excessive wear on the rolls. This was due to the fact that the old method increased the width of the stock substantially, thus requiring high working pressure in order to spread or to extrude the metal laterally. This high lateral spread caused the faces of the strip to curve or "crown."

In feeding the stock to the rolls, according to the old method, it has been proposed to feed the stock through one or more friction clamps, anterior to the rolls. However, this expedient has proved to be of no practical value in controlling the width of the rolled strip.

According to my improved method I provide an absolutely uniform and reliable control of the feed of the stock to and through the rolling unit or units, so that the width and thickness of the stock can be controlled with great precision throughout the rolling operation or operations.

Referring to Fig. 1, this shows the stock 1, which is shown as being a cylindrical wire. Ordinarily, this wire 1 has a diameter of a quarter of an inch, although said diameter may be as high as three-eighths of an inch. Said wire is flexible so that it can be wound around a drum or reel.

If the stock 1 is cylindrical wire, the stock is first led through a die D, which reduces the cylindrical wire, in order to make the contour of said wire 1 more uniform, and to reduce the wire to size.

The die D also assists in producing a uniform diameter of the wire 1.

The stock 1 is then led around a reel or drum 2, which is mounted upon a shaft 3. A sufficient number of turns of the stock 1 is formed upon said drum or reel 2, so as to produce a reliable locking or gripping frictional effect, so that the stock cannot slip relative to the drum 2. The drum 2 thus frictionally and positively grips the stock 1, so that the feed of the stock is controlled absolutely by the speed of turning of the drum 2, and the drum 2 and the stock 1 move in absolute unison, or at least, in substantial unison which is sufficient for commercial purposes.

The stock is then reduced in a series of passes through suitable rolling units. In Fig. 1 I have illustrated three such rolling units, consisting of associated pairs of rolls 4 and 4a, 5 and 5a, 6 and 6a. I can use only one pair of rolls, or any number of pairs of rolls.

The rolls 4 and 4a are respectively mounted on the shafts 20 and 20a. The rolls 5 and 5a are respectively mounted on the shafts 21 and 21a. The rolls 6 and 6a are respectively mounted upon the shafts 22 and 22a.

The feed of the stock is regulated throughout the rolling operation or operations, as will be later more fully described.

After the rolling has been completed, the finally rolled stock is subjected to a pulling force away from the rolling mechanism, by means of a friction feed, which is secured by means of an endless band 10, which passes around the three pul-

leys 8, 7 and 9. These pulleys are positively driven in unison, by mechanism which will be later described. The stock is led around the pulley 7, so that said stock is located between the periphery of the pulley 7 and between the adjacent surface of the endless belt or band 10. The belt 10 and the pulley 7 therefore exert a positive frictional pull upon the rolled strip.

Referring to the embodiment shown in Figs. 2 and 3, the stock 1 is led through a friction guide 11 which creates a braking or retarding effect upon the stock. This effect may be slight. The stock is then led around an idler 12, and then around the grooved periphery of a pulley 14. The groove 15 of said pulley 14 is shown in Fig. 3. Said pulley 14 may be of the well known type, whereby a positive frictional lock or grip is produced between the grooved periphery of the pulley and the stock, so that the feed of the stock is absolutely and reliably controlled by the speed of movement of the pulley 14. Friction pulleys of this kind are well known in heavy-duty hoisting and pulling mechanism and I therefore do not show the details thereof. Pulleys of this type ordinarily have mechanism which is supplemental to the groove 15.

The stock is then led through one or through any desired number of rolling units.

The theory and operation of the improved mechanism can be explained with reference to Figs. 8 and 9, Figs. 10-10d and Figs. 11-11d.

Referring to Fig. 8, this shows a pair of rolls 4 and 4a. The left-hand side of Fig. 8 shows the stock with its original thickness, prior to the rolling operation. This may be the first rolling operation. The right-hand side of Fig. 8 shows the reduction in diameter or thickness of the stock. It is assumed that the stock first contacts with the peripheries of the rolls 4 and 4a, at the lines x. The shape of the stock is then indicated in Fig. 10, if cylindrical stock is used.

Between the lines a-a and b-b in Fig. 8, the thickness of the stock is reduced, as indicated in Fig. 10a and in Fig. 11a. As indicated by the angular dotted lines in Fig. 8, the reduction in thickness successively diminishes throughout the movement of the stock between the rolls 4 and 4a for equal angular movements of the rolls. This is also indicated by Figs. 10a-10d and by Figs. 11a-11d.

According to the method in common use, in which the feed of the stock was not controlled prior to throughout the rolling operation so as to control the width of the rolled material, the width of the stock increased during the rolling operation, in an irregular manner, as illustrated by the line X in Fig. 9. That is, the increase in width of the stock, during the rolling thereof, depends in part upon the speed with which the stock is supplied to the rolls. Unless said stock is supplied to the rolls by means of feeding mechanism which has an operative feeding speed which has a constant ratio to the speed of the rolls, the rolled stock will not be of uniform width. Likewise, unless the feed of the stock to the rolls is controlled properly, the rolling operation will result in an undesirable and excessive increase in the width of the stock, during said rolling operation.

According to my improved method, as illustrated in Figs. 10-10d inclusive, the feed of the stock towards and between the rolls is controlled with great uniformity and precision, so that the width of the stock can be maintained uniform

throughout the entire rolling operation, and said rolling operation can result only in the reduction of the thickness of the stock, if desired, so that the final width of the rolled stock can be made equal to the diameter of the cylindrical original stock, if this is desired. I do not wish to be limited to a method of rolling whereby the stock maintains its original width throughout the rolling operation. The width of the rolled stock can exceed the width or diameter of the original material, to a controlled degree. The original stock can have a rectangular cross-section or any desired cross-section. The width of the stock is indicated in Fig. 9 by the line Y, if the width of the stock is maintained uniform throughout the rolling operation, and said width is equal to the diameter or width of the original stock. If the original stock has a rectangular cross-section, the width of the rolled stock can be maintained equal to the width of the original stock. According to my improved method the width of the rolled stock may be between the lines X and Y in Fig. 9. I prefer that the width of the stock should be less than that which is represented by the line X in Fig. 9, since said line represents the increase in the width of the stock which is produced by an uncontrolled or ordinary friction-retarded feed of the stock to the rolls. The width of the stock can be maintained uniform, in all the passes, or said width can be increased in successive passes.

In fact, by suitably feeding the stock to the rolls at a relatively low speed, the rolling operation can be used for producing a rolled stock whose width is even less than that of the original stock. However, it is ordinarily not desirable to diminish the width of the stock during the rolling operation, as this weakens the final rolled stock. However, by maintaining the width of the stock uniform or substantially uniform, and equal to the width of the original stock throughout the entire rolling operation, in one or more passes, a superior and very strong rolled material is secured.

Referring to Figs. 4 and 5, the upper shafts 20, 21 and 22 of the upper rolls 4, 5, and 6, are connected by means of flexible couplings (of the universal joint type) 23, 24 and 25, to shafts 26, 27 and 28 respectively. Said shafts 26, 27, and 28 are respectively connected by couplings 23a, 24a and 25a to supplemental shafts 26c, 27c, and 28c, on which spur gears 29, 30 and 31 are mounted. The couplings 23a, 24a and 25a are of the same type as the couplings 23, 24 and 25.

The gear 31 meshes with a lower gear 31a, and the gear 30 meshes with a lower gear 30a. The gear 29 also meshes with a lower gear 29a. Said lower gears 31a, 30a, and 29a are respectively mounted upon the shafts 22a, 21a, and 20a of the lower rolls 6a and 5a and 4a.

Said lower shafts 22a and 21a and 20a are respectively provided with bevel gears 34 and 33 and 32. The diameter of the bevel gear 32 in this particular embodiment is the same as the diameter of the lower spur gear 29a, so that said gear 29a is not shown in full lines in Fig. 5.

The gears 34 and 33 and 32 respectively mesh with driving gears 38 and 37 and 36, which are located upon a drive shaft 35, which is driven by means of any suitable motor.

Said drive shaft 35 is provided with a helical gear 40, which drives a gear 39 which is mounted upon and which drives the jack-shaft 35a. Said shaft 35a carries a worm 41, which drives a gear 42, which is mounted upon the shaft 3 of the reel or drum 2.

The driving shaft 35 also has a gear 43, which drives the gear 44 of a shaft 45. Said shaft 45 is frictionally connected, by means of a friction clutch 46, to a shaft 47 on which the central pulley 7 which is illustrated in Fig. 1 is mounted. The shafts 47a and 47b of the pulleys 8 and 9 are provided with sprockets 49 and 51, and a suitable driving chain 48 passes around said sprockets 49 and 51, and said chain 48 also passes partially around and is driven by a sprocket 50 which is mounted on the shaft 47. Hence the pulley unit shown at the right-hand side of Fig. 1, and comprising the pulleys 8, 7, and 9, has all the members thereof driven uniformly and positively at the same turning speed. The method of operation and the respective driving speeds of the respective parts of the apparatus, are as follows:

The reel 2 is turned at a much lower speed than the shaft 35. If desired, the members 40 and 39 could provide a speed reduction, or their ratio may be one to one. However, the worm 41 provides a substantial speed reduction of the drive of the drum 2, compared to the turning speed of jack-shaft 35a and of the main drive shaft 35.

Hence the feed of the stock or strip 1 to the first pair of rolls 4 and 4a is regulated, so as to feed enough stock to make it possible to secure the results illustrated in Figs. 10-10d inclusive, so that the width of the stock is maintained substantially constant throughout the entire rolling operation. By increasing the rate of feed of the stock to the rolls, the width of the stock may be increased, so that said width may be between the widths indicated by lines X and Y in Fig. 9. Likewise, and as previously explained, by making the feed of the stock sufficiently slow, the width of the stock can even be reduced during the rolling operation, if this is ever desired for any reason.

Likewise, and as shown in Figs. 4 and 5, the gear-ratios for operating the respective rolling units are adjusted, so that the rolls 5 and 5a have a higher peripheral speed than the rolls 4 and 4a, and the rolls 6 and 6a have a higher peripheral speed than the rolls 5 and 5a, in the direction of feed of the material which is being rolled. The gear-ratios and the general design of the parts illustrated in Figs. 4 and 5, are not according to scale. It is to be understood that the increase in speed of the consecutive rolling units may be adjusted so as to control the width of the strips in the second pass, and in succeeding passes. In each successive pass, the width of the material may be equal to the original width or diameter of the original stock, or said width may be increased or even decreased. After the first pass, the material is elongated according to the best embodiment of my method, due to the reduction in thickness of the material which has not been compensated by a corresponding increase in width. Hence, in order to maintain the width of the strip constant, throughout the rolling operation, if more than one pair of rolls are used the successive rolling units must be driven at an increasing higher peripheral speed, if it is desired to maintain the width of the stock constant.

The gear-ratios will depend to some extent upon the kind of material which is being rolled. A relatively soft material, such as copper, will tend to spread out or to increase in width, more than a relatively hard material such as steel under the same working conditions. The reel 2 shown in Fig. 1, the pulley 14 shown in Fig. 3,

and the corresponding means shown in Figs. 6 and 7 herein, constitute feed means which grip the stock. The material is passed from said feed means to the mill rolls, and there may be one or more pairs of said mill rolls. The material to be reduced is fed between said feed means and the mill rolls at substantially constant controlled speed which is less than the peripheral speed of said mill rolls, so that tension is applied to the material between the feed means and the mill rolls and in advance of the mill rolls.

The difference in speed between the material which is fed to the mill rolls and the peripheral speed of said mill rolls must be sufficiently great so as to produce a tension which is proportionate to the characteristics of the material in spreading laterally when the material is reduced by the mill rolls.

As previously pointed out if a relatively hard material such as steel and a relatively soft material such as copper, are rolled in the same mechanism and under the same working conditions, the relatively soft material will tend to spread laterally much more than the relatively hard material. This increase in width must be controlled by having a sufficiently great difference between the speed of the stock towards the first pair of mill rolls, so as to control the increase in width of the stock, since an excessive increase in width results in the irregular contour which is illustrated by the line X in Fig. 9.

I therefore do not wish to be limited to any particular gear-ratios, and a commercial mechanism may involve gear boxes, or other means for varying the gear-ratios.

I prefer that the linear speed of movement of the band 10, should be substantially equal to the linear speed of movement of the finally rolled stock. The friction clutch 46 permits a certain slip between the shafts 47 and 45, so that the shaft 45 is driven at a greater speed than the shaft 47. This causes the band 10 to exert a positive pulling effect upon the stock, and to subject the stock to a certain tension, after the stock leaves the final rolls 6 and 6a. However, since all the rolls, including the rolls 6 and 6a grip the stock with substantial frictional force, the pull of band 10 merely serves to feed the stock away from the rolls 6 and 6a, as fast as the rolls 6 and 6a deliver said stock. By pulling the stock out of the last rolling unit with sufficient tension, the rolled stock is prevented from assuming a wavy and irregular contour. The pull which is imposed upon the rolled stock depends upon the nature of the material which is being rolled and the friction clutch 46 may be of any well known adjustable type, so as to regulate the pull which is imposed upon the finally rolled stock.

The finally rolled stock is represented by the reference letter "A" in Fig. 1.

In Figs. 6 and 7 I have indicated other means for regulating the control of the feed of the stock towards and through the rolling mechanism. In Fig. 6 two pairs of rolls are illustrated, namely, a first pair 66 and 67, and a second pair 68 and 69. The mechanism at the right-hand side of Fig. 6 for subjecting the rolled stock to tension, is the same as that which is illustrated at the right hand side of Fig. 1.

Figs. 6 and 7 show pulleys 60 and 61 and 62. An endless belt or band 63 is passed around the pulleys 60 and 62. The stock 1, which is now of rectangular cross-section, is led between the periphery of the pulley 61, and the corresponding portion of the endless friction member 63. The

pulley 61 is made of sufficiently large diameter, so that the stock 1 cannot slip relative to the belt or band 63. This secures a reliable feed of the stock towards the rolling unit, if the stock is of rectangular cross-section. Any suitable means can be utilized for providing a positive grip between the member 63 and the stock, so that the members 61 and 63 will regulate the feed of the stock with great precision and uniformity.

Referring to Figs. 1, 2, 6 and 7, when turnable means are used for controlling the feed of the stock, the rolling means or the like, said stock passes around the turnable means such as the members 2 and 14, in the form of a single layer. Likewise the stock passes around the control means which are shown in Fig. 7 in the form of a single layer.

The said pulleys 60 and 61 and 62 can have their shafts provided with sprockets, and said sprockets can be provided with chains, and one of said sprockets can be positively driven, as illustrated at the left-hand side of Fig. 5.

The belts 10 and 63 may be made of steel if desired. The right-hand side of Fig. 6 illustrates how one of the pulley units there shown may be shifted, so as to tighten or loosen the band or belt 10. The pulley 7 remains in fixed position, but the bearings of the shafts of the pulleys 8 and 9 can be adjustable, so that said pulleys can be shifted to the dotted-line positions illustrated in Fig. 6. In said dotted-line positions, the band or belt 10 is relatively loose, so that the rolled strip may be readily passed around the periphery of the pulley 7, and between said periphery and the belt 10. The shafts of the pulleys 8 and 9 can then be shifted to the full-line position which is illustrated in Fig. 6, thus imposing the desired frictional force. The pulley unit which is shown in Fig. 7 and at the left-hand side of Fig. 6, may likewise have the shafts of the pulleys 60 and 62 shiftably mounted, for said purpose.

It is to be understood that I do not wish to be limited to any particular type of mechanism for securing the coordinated movements of the various parts thereof, and in these respects, the illustration herein is entirely diagrammatic.

For example, in order to drive the pairs of rolls of each respective unit, I may utilize the driving mechanism which is illustrated and described in my application Serial No. 58,647 filed January 11, 1936, in the United States Patent Office.

One of the particular advantages of the improved method and mechanism, is that it facilitates and lowers the cost of manufacture of that type of wire which is known as "tinsel," and which is used extensively in the manufacture of telephone cables and the like. Said "tinsel" has a thickness which is as low as one thousandth of an inch and it has a width of about eighteen thousandths of an inch.

At the present time, and in order to make such extremely thin "tinsel," it is necessary to start with cylindrical wire having a very small diameter, which ordinarily does not exceed .0035 inch. The use of this extremely thin wire causes pitting of the rolls, due to the enormous pressure which is required. According to my invention, I can use a cylindrical stock having an initial diameter of 0.010 to 0.012 inch. In making said "tinsel" wire, I can use a single pass, namely a single pair of rolls.

Since according to my improved method I can control the width of the rolled stock, I can regulate said width so that upon using a cylindrical

stock having a diameter of .010 inch, the rolled stock will have the dimensions above mentioned, namely, a thickness of .001 inch and a width of .018 inch. In this case, I therefore permit the width of the stock to increase slightly during the rolling operation, which may be carried out in one or more passes. This makes it possible to use a much smaller pressure between the rolls than has heretofore been used, thus greatly increasing the life of the rolls. For example, I need not use a pressure which is greater than one hundred thousand pounds per square inch, and I may use even lower pressure. If said original stock, having an original diameter of .010 inch, was rolled according to the old method so as to produce said extremely thin "tinsel," in one pass or in a plurality of passes, the width of the stock would be as great as twice or three times the required width, and it would be necessary to use very high pressures and the life of the rolls would be greatly shortened.

That is, according to my method, I can either eliminate or substantially limit the lateral extrusion and flow of the metal during the pass or passes of the rolling operation, thus making it possible to use a lower pressure and to increase the life of the rolls.

The theory of operation of the mechanism and the theory of the method set forth herein is as follows:

Referring to Fig. 8 and to Fig. 9, if the stock is moved between the rolls 4 and 4a, without any retarding or braking effect or controlled feed of any kind, the stock will be elongated during the rolling operation, to an extent which depends upon the hardness and type of the material. For example, if brass or copper is rolled, its width is more than doubled if round wire is used as the original stock, and the elongation of the stock is comparatively small. If steel is rolled, there is a greater elongation, and a smaller increase in width. The material is thus compelled to spread or extrude laterally during the pass, and this lateral spread is usually under very high pressure, since the rolls exert considerable pressure upon the stock. Since the stock is compelled to spread laterally under high pressure, the effect is to wear the adjacent surfaces of the rolls, thus pitting the rolls, and forming what is known as a "track." After the rolls have been used for a certain period of time, it is necessary to lead the stock between another portion of the rolls, since the first portion has been pitted too much, to make it possible to accomplish efficient rolling.

If the lateral spread of the stock is eliminated or minimized, the pitting or tracking is correspondingly eliminated or minimized and less pressure is required. This results in much greater life of the rolls.

It has been suggested to pass the stock through friction-clamps before the stock entered the rolls. However, a substantial braking or retarding effect could not be secured. The braking effect varied violently due to differences in the hardness and size of the material, and because of the use of lubricants, so that the only function of the friction clamps was to hold the stock straight in front of the rolls. The use of such friction clamps therefore could not produce a controlled speed which was uniform. Such clamps did not exert any substantial frictional force or any substantial influence on the shape or quality of the rolled stock.

According to my improved method, the stock

is fed towards the rolls at a uniform and controlled speed. The rolls exert a tension pulling or elongation effect upon the stock, as well as a squeezing effect. Since the material which is located between the rolls and which is being deformed by the rolls, must spread, the material can be subjected to considerable pull which causes said material to be elongated, without breaking the stock which is located anterior to the lines of contact of the stock with the rolls. Said initial lines of contact are indicated by *x* in Fig. 8. Hence, by properly coordinating the various factors, the stock can be elongated while it is kept constant, or while the increase in width is much less than according to the old practice, without breaking the stock which is anterior these initial lines of contact.

The apparatus is utilized by leading the stock between a pair of rolls or between the successive pairs of rolls and a continuous condition can be established and maintained, whereby each pair of rolls exerts the necessary pulling effect and tension, so as to elongate the stock by tension, thus maintaining the width of the stock uniform, or controlling the width of the stock so as to secure a uniform increase in width, at each pass.

Referring to Fig. 8, the direction of movement of the peripheries of the rolls, can be indicated by tangent planes to each said periphery. Said tangent planes are substantially parallel to the direction of feed, at the line of dead-centre, at which the distance between the adjacent portions of the peripheries of the rolls is a minimum. The lines which are indicated by the reference numerals 80, 80a, 80b and 80c indicate the diminution of the thickness of the stock, during the pass. The lines 81, 81a, 81b and 81c are of equal length. The movement of the periphery of each roll has its greatest component, in the direction of the feed of the stock, at the line of dead-centre. The pulling and elongation effect is therefore greatest adjacent said line of dead-centre.

If the feed of the stock towards the rolls is not retarded or controlled properly, the compression of the stock distorts it along curved lines which are inclined rearwardly to the direction of feed of the stock. This weakens the rolled material. By controlling the feed of the stock, this undesirable effect can be eliminated or diminished.

By maintaining the feed of the stock sufficiently slow relative to the peripheral speed of the rolls, said stock is shaped by the action of the rolls, so as to compress and elongate the material so that the material moves at the same speed as the peripheries of the rolls at the line of dead-centre or a little before this line of dead-centre.

The improved method and mechanism can be used in connection with hot-rolling and cold-rolling.

Likewise while I have illustrated the improved method in connection with rolls, the invention is not necessarily limited to any particular type of mechanism for elongating and compressing the stock.

In one aspect of the invention, it may be considered that it embodies means for regulating the turning speed of the drum 2 or of the member 14, so as to regulate the speed of the stock towards the rolls, so as to maintain a fixed ratio between the speed of feed of the stock towards the rolls, and the speed of the rolls. The ordinary device is not effective because the fric-

tional pull of the stock on the rolls varies, depending upon the hardness and variation in thickness of the stock. However, I do not wish to exclude the use of braking means which may be sufficiently delicate and uniform and reliable, so as to cause the stock to be fed towards the rolls, at the desired controlled speed.

Referring to the right-hand side of Fig. 1, it is noted that the rolled stock is subjected to a constant pull, subsequent to the rolling, and before the stock is wound up upon the ordinary reel or reels.

Likewise, while it would be possible to supply the material directly to the rolls from a suitable drum or drums, and to drive said drum, or to retard the speed of said drum, so as to cause the stock to be fed at a speed which has a uniform ratio relative to the rolls, I prefer to use devices such as the members 2 and 14 which operate upon the stock after the stock is unwound from any suitable and ordinary supply drum or the like. Said supply drum is not shown, as it is well known per se.

It is not necessary that the stock be maintained straight between the feeding device and the rolls. Likewise, any desired auxiliary apparatus may be located between the feed device and the rolls, such as an auxiliary die or the like.

While I do not wish to be bound by or to be limited to the details of any working example, since actual practice will depend upon the kind of material which is being rolled, and other factors, the following will serve as a guide to a man skilled in the art:

In rolling steel wire of the kind which is used for making reeds for looms, I have used two main pairs of steel rolls, each main roll having a diameter of $5\frac{3}{4}$ inches. The second pair of main rolls was turned fifty percent faster than the first pair of main rolls, so that the second main pair turned three revolutions while the first main pair turned two revolutions. The first main pair are represented by rolls 5 and 5a in Fig. 1, and the second main pair are represented by rolls 6 and 6a. The wire was fed towards the first main pair of rolls by a pair of feed rolls whose diameter was about six inches. In this model, the feed rolls may be represented by rolls 4 and 4a, which operated to feed the stock at controlled uniform speed. If the mill has more than one stand, the first pair of rolls which substantially reduce the stock to an extent sufficient to cause crowning or irregular edges under ordinary working conditions, may be designated as the first rolling means. One of the important features of the invention is to retard the feed of the stock towards said first rolling means so that the feed of the stock is less than the operative speed of the first rolling means. The operative speed of said first rolling means is equivalent to the peripheral speed of the rolls, assuming that said rolls are of equal diameter and that they are driven at equal speeds. This pair of feed rolls turned one revolution while the first pair of main rolls turned two revolutions.

The first pair of rolls reduced the wire about twenty-five percent in order to flatten the wire and to grip the wire. The second pair of rolls diminished the thickness of the flattened stock which was fed thereto, by fifty percent. This was the main pass since the feed rolls merely flattened the wire somewhat. The third pair of rolls diminished the thickness of the reduced stock which was fed thereto by $33\frac{1}{3}$ percent. The second pair of rolls may be considered as

forming the initial or first reducing zone, since they reduce the thickness of the stock more than about twenty-five per cent.

In order to define the invention, it may be stated that the first or initial zone of rolling is that zone where the material is reduced sufficiently to produce either crowning or irregular width, unless the improvement specified herein is utilized.

The stock could thus be rolled without increasing its width substantially.

The reduction in width produced by the feeding rolls flattened the stock somewhat and increased its width.

The first pair of main rolls reduced the thickness to one-half of the thickness of the stock delivered by the feed rolls, and since the peripheral speed of the first main rolls was about twice the peripheral speed of the feed rolls, the reduction in thickness was taken up almost entirely by the elongation of the material. There was a small increase in width.

Likewise, the thickness of the material was again reduced thirty three and one-third percent by the second main rolls, and since the ratio of the peripheral speed is as three to two, there was very little or no increase in width in the stock during the second pass.

By setting the second main rolls closer to each other, a greater reduction in thickness was secured, and since the peripheral speeds of the first main pair and of the second main pair remained the same, the final pass increased the width of the material.

Hence the effect can be varied either by changing the ratios between the peripheral speeds of the rolls or by changing the percentage of reduction in thickness, during successive passes.

For example, in operating said model mill, I used steel wire stock having a diameter of 0.062 inch.

The feed rolls flattened the wire to a thickness of 0.038 inch.

The first pass between the first main rolls reduced the thickness to 0.018 inch.

The last pass between the second main rolls reduced the thickness to 0.010 inch. This material had a width of 0.112 inch. Hence the final increase in width of the rolled stock was sufficiently small so as to maintain the width of the final rolled stock substantially uniform, so as to eliminate the necessity of trimming the stock. Of course if the original stock is substantially thicker than in the specific example above given, the percentage of increase in width is preferably less than when the original stock has a relatively small diameter.

By feeding the same wire to the first main pair of rolls without any retarding action, the final width was 0.160 inch, showing a much greater increase in width, and a much smaller elongation.

I prefer to control the speed by means of a member like 2 or 14, instead of using feed rolls for said purpose.

Different results are secured with different materials. If a steel wire is annealed for example, it will tend to spread more in width than a hard steel wire, which has the same composition in the old method.

Since it is impossible to anneal wire uniformly, the old method resulted in metal strip of uneven width, since non-ferrous metals are also annealed.

By suitable control, I can secure metal strip of

substantially uniform width and thickness, so that a trimming operation is unnecessary.

Likewise by controlling the increase in width, I can eliminate or minimize "crowning," namely, the rounding of the wide surfaces of the strip.

When the stock is fed freely to the rolls, or when the stock is fed through frictional clamp devices which do not uniformly control the speed of the stock, the speed of movement of the stock may be defined as the speed of "free feeding." The controlled speed which I secure is less than said free-feeding speed.

The mechanism for actuating the movable feeding member 2 or 14 may be mounted and driven independently of the mechanism for operating the rolls. Likewise the rolls and other parts may be driven independently.

I have shown preferred embodiments of my invention but it is clear that numerous changes and omissions can be made without departing from its spirit.

I claim:

1. The method of elongating and reducing material which includes passing the material from feed means which grip the stock to mill rolls, said material being sufficiently narrow so that the width thereof is increased when the thickness of the material is reduced between the mill rolls, and feeding the material between said feed

means and the mill rolls at substantially constant controlled speed which is less than the peripheral speed of said mill rolls, so as to apply a tension to the material between the feed means and the mill rolls and in advance of the mill rolls, said tension being proportionate to the characteristics of the material in spreading laterally when said material is reduced by said mill rolls, so that the reduced and elongated material is of substantially uniform width.

2. The method of elongating and reducing material which includes passing the material from feed means which grip the stock to mill rolls, said material being sufficiently narrow so that the width thereof is increased when the thickness of the material is reduced between the mill rolls, and feeding the material between said feed means and the mill rolls at substantially constant controlled speed which is less than the peripheral speed of said mill rolls, so as to apply a tension to the material between the feed means and the mill rolls and in advance of the mill rolls, said tension being proportionate to the characteristics of the material in spreading laterally when said material is reduced by said mill rolls, so that the reduced and elongated material has substantially straight lateral-surface-elements.

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