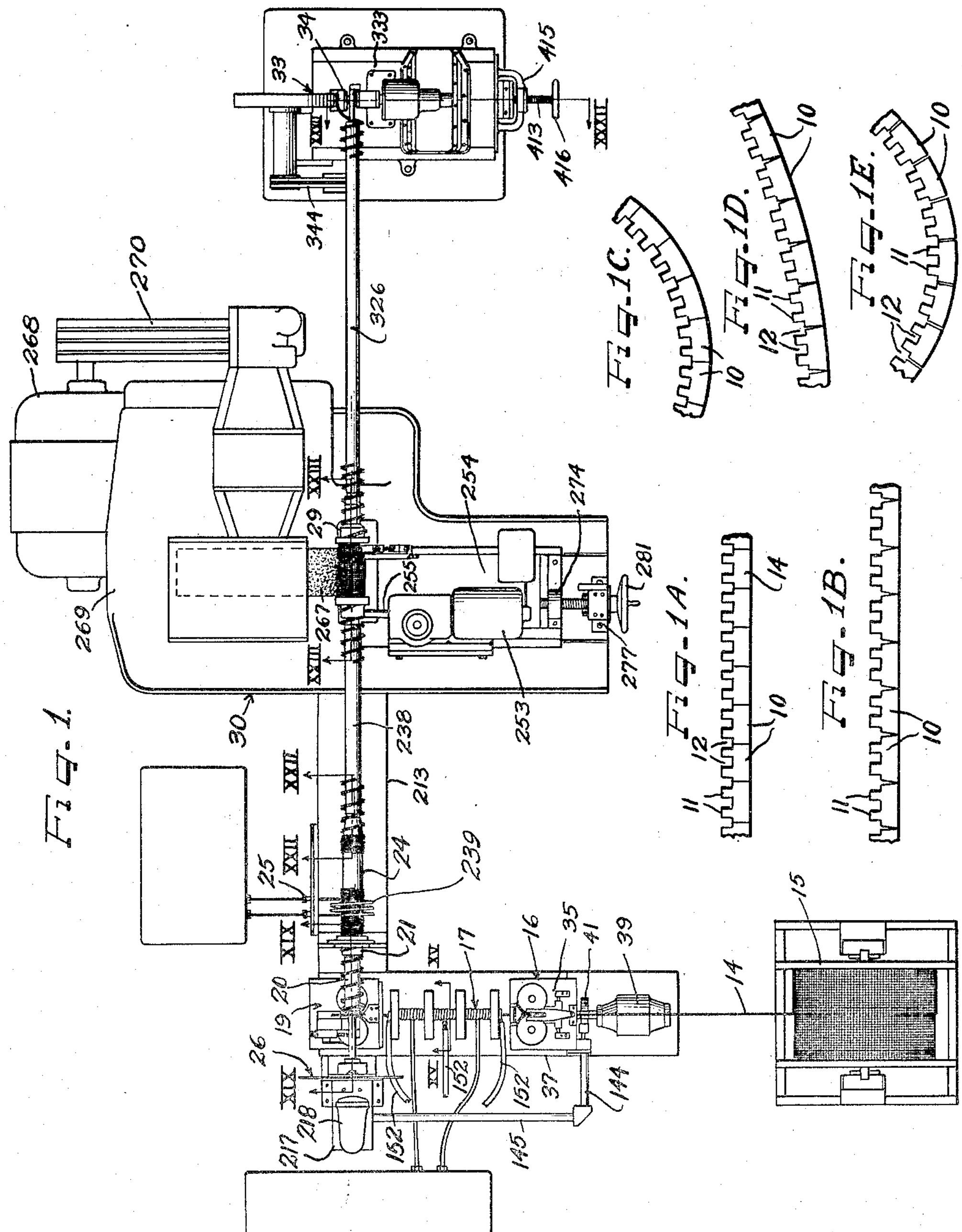
Dec. 28, 1954 S. H. NORTON 2,697,865

PISTON RING MAKING MACHINE AND PROCESS

Filed Aug. 19, 1949 21 Sheets-Sheet 1



Inventor
SAMUEL H. NORTON

by Attys.

PISTON RING MAKING MACHINE AND PROCESS

Filed Aug. 19, 1949 21 Sheets-Sheet 2

Fig. 20.

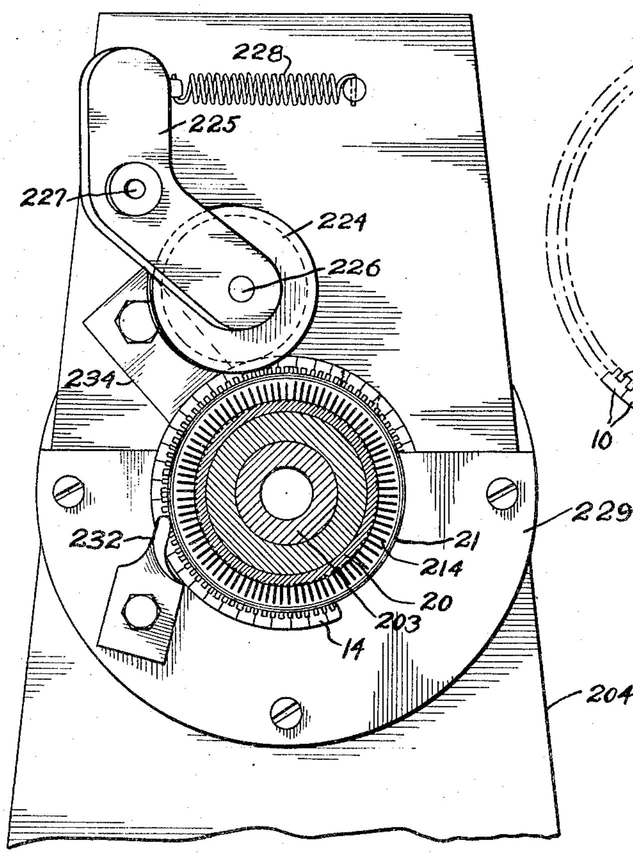


Fig. 2.

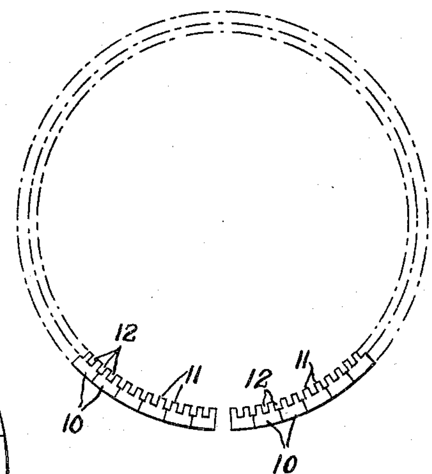


Fig. 3.

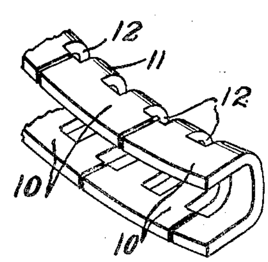
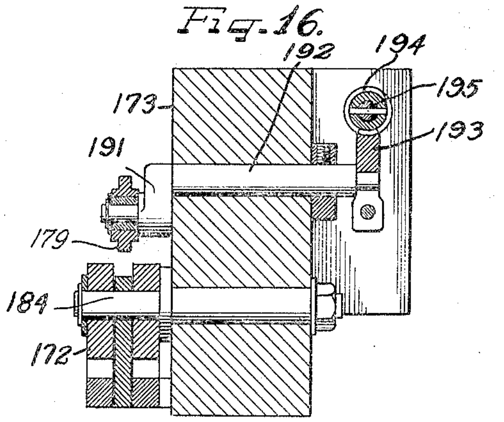


Fig. 16.



Inventor
Samuel H. Norton

by The firm of Charles W. Hills Attys.

Dec. 28, 1954 S. H. NORTON 2,697,865

PISTON RING MAKING MACHINE AND PROCESS

Filed Aug. 19, 1949 21 Sheets-Sheet 3

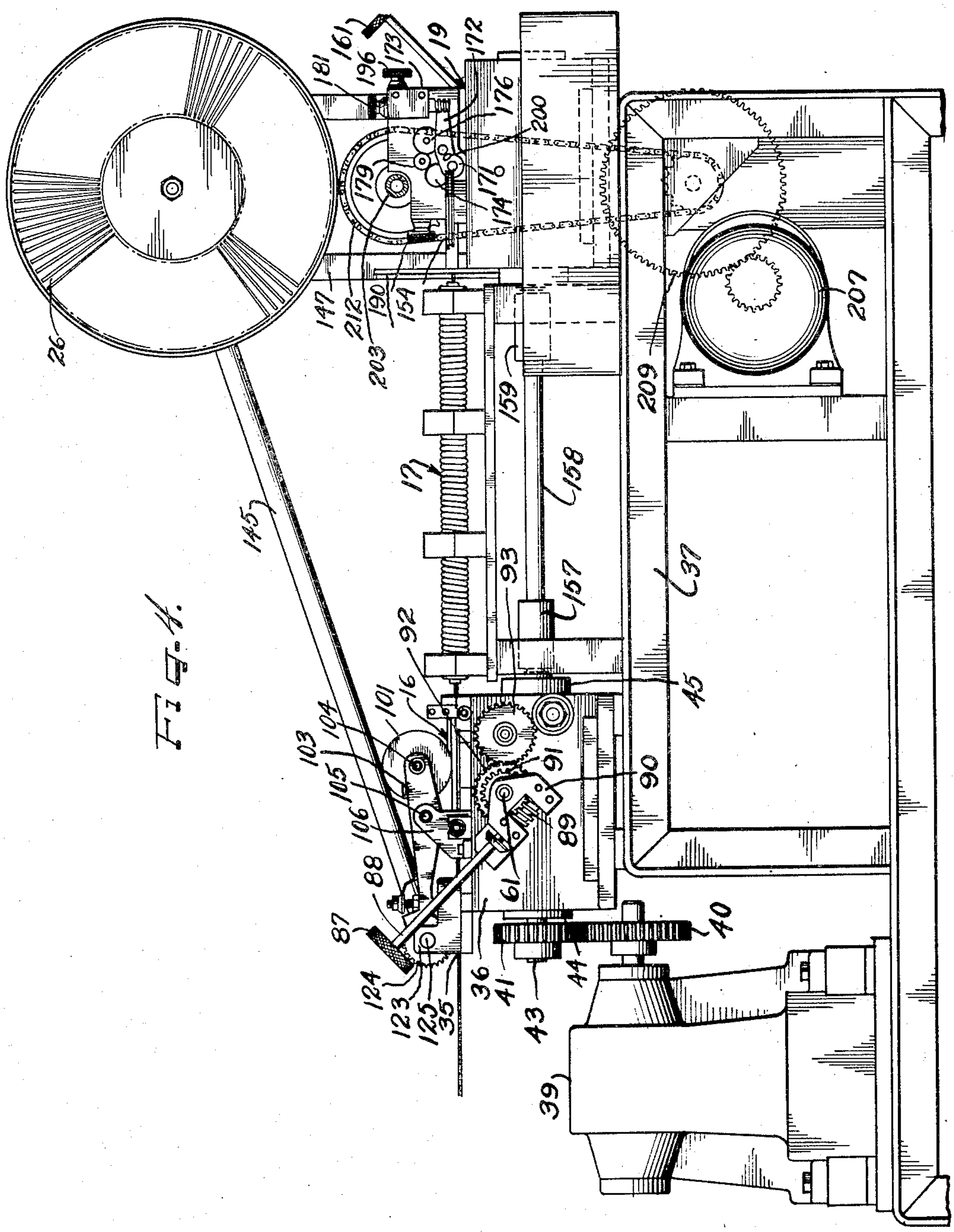


Fig. 4.

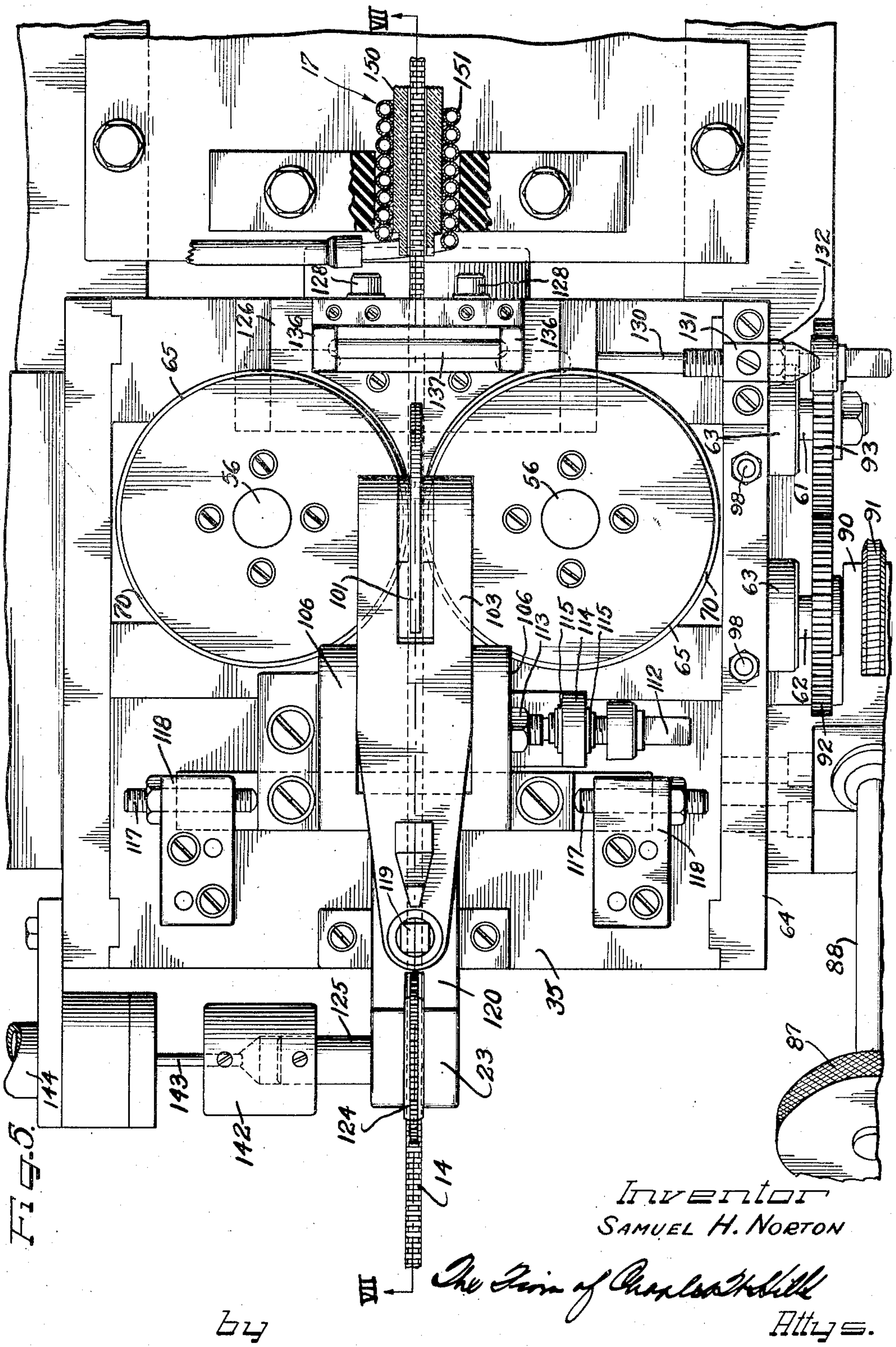
Inventor
SAMUEL H. NORTON

by The Firm of Charles W. Hills Attys.

Dec. 28, 1954 S. H. NORTON 2,697,865

PISTON RING MAKING MACHINE AND PROCESS

Filed Aug. 19, 1949 21 Sheets-Sheet 4



PISTON RING MAKING MACHINE AND PROCESS

Filed Aug. 19, 1949 21 Sheets-Sheet 5

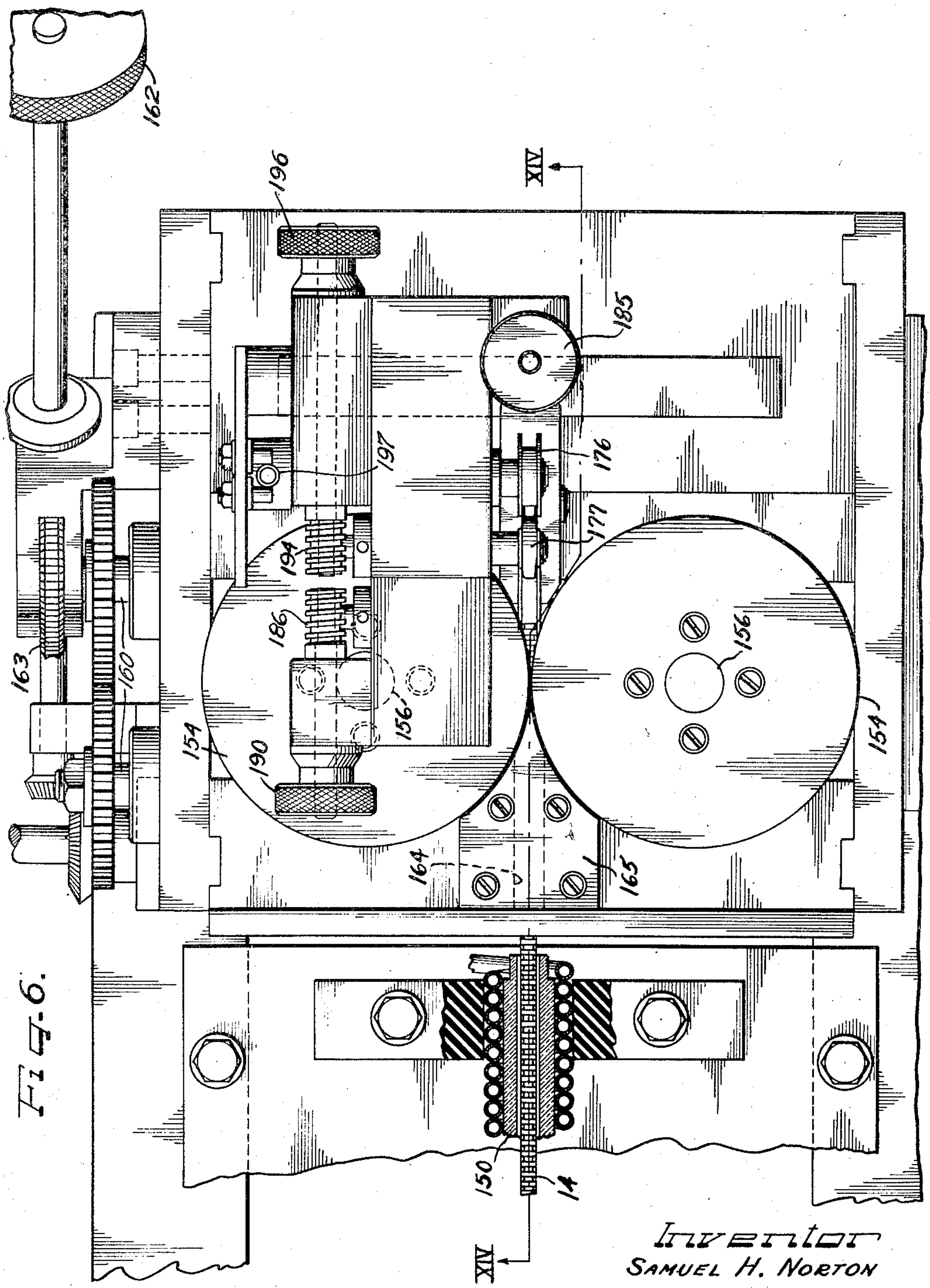


Fig-6.

Inventor
Samuel H. Norton

by The Firm of Charles Hill Attys.

Dec. 28, 1954 S. H. NORTON 2,697,865

PISTON RING MAKING MACHINE AND PROCESS

Filed Aug. 19, 1949 21 Sheets-Sheet 6

Fig. 7.

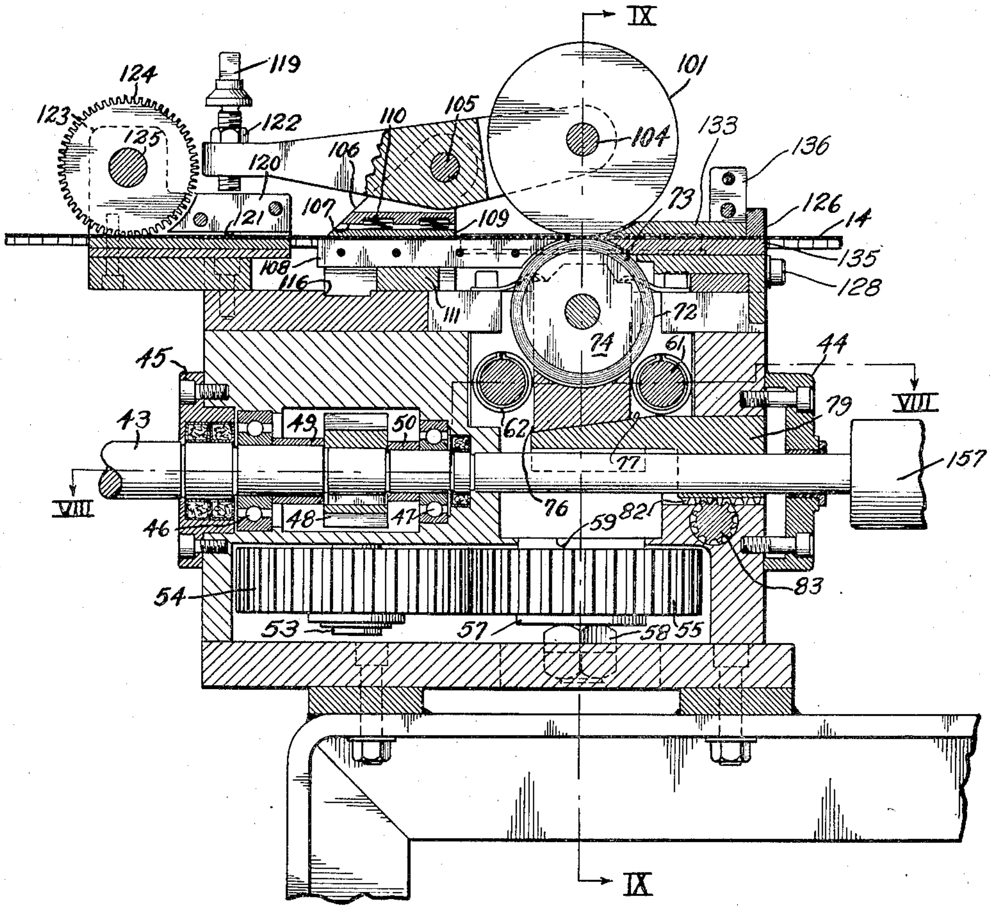
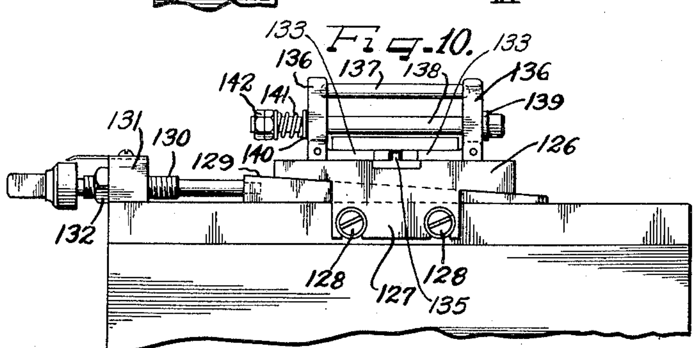


Fig. 10.



Inventor
Samuel H. Norton

by The Firm of Charles W. Hills Attys.

PISTON RING MAKING MACHINE AND PROCESS

Filed Aug. 19, 1949 21 Sheets-Sheet 7

Fig. 8.

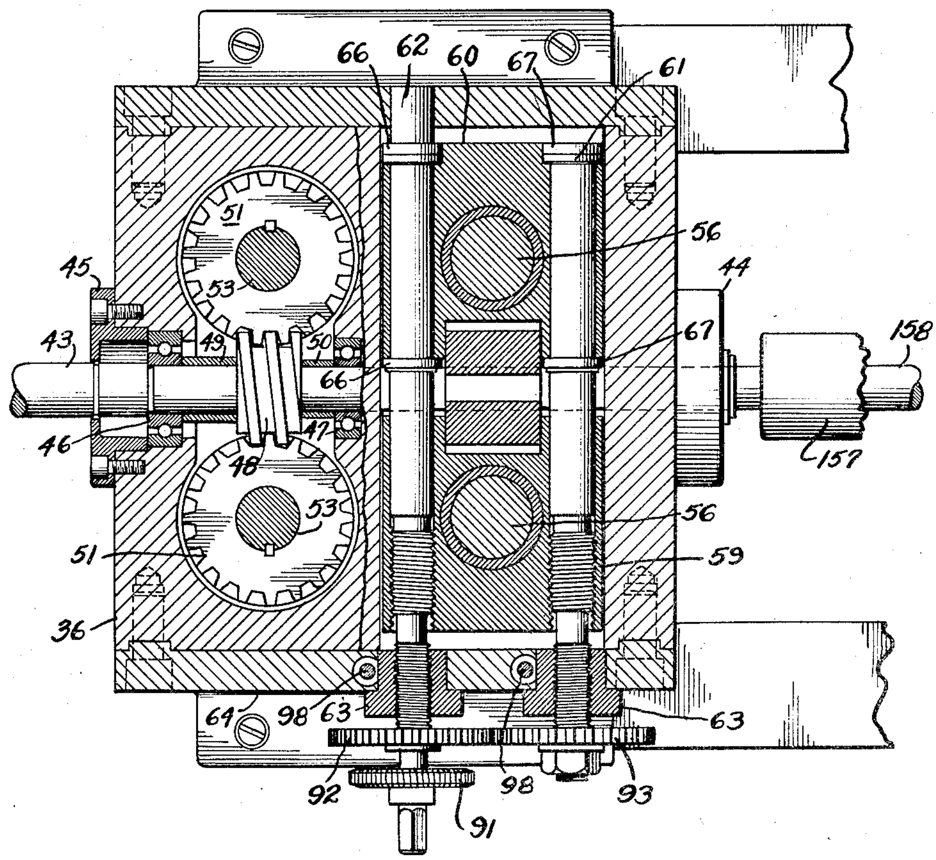


Fig. 11.

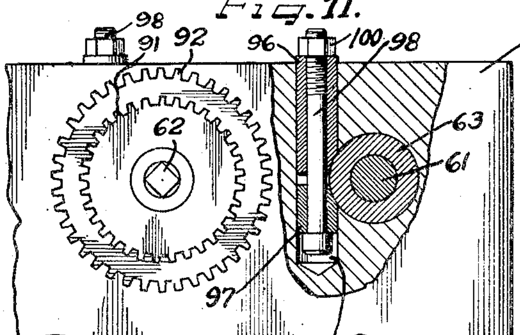
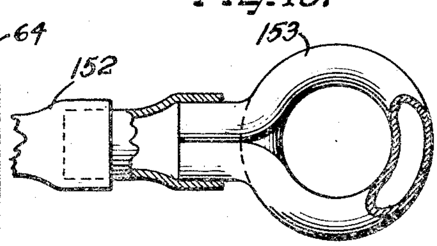


Fig. 15.



Inventor
Samuel H. Norton

by The Firm of Charles Hill Attys.

Dec. 28, 1954 S. H. NORTON 2,697,865

PISTON RING MAKING MACHINE AND PROCESS

Filed Aug. 19, 1949 21 Sheets-Sheet 8

Fig-9.

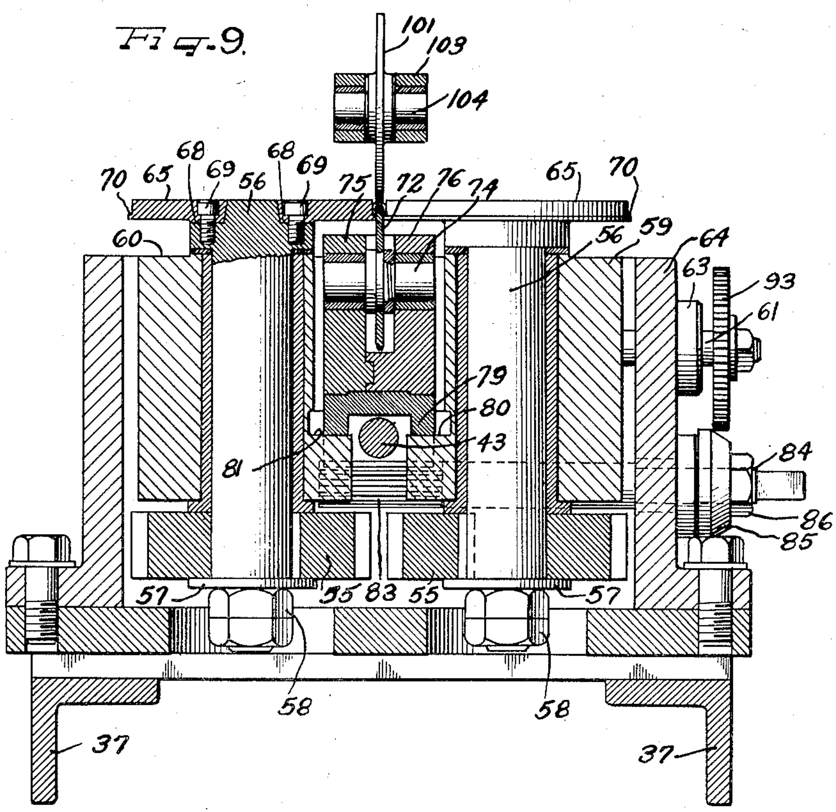


Fig-12

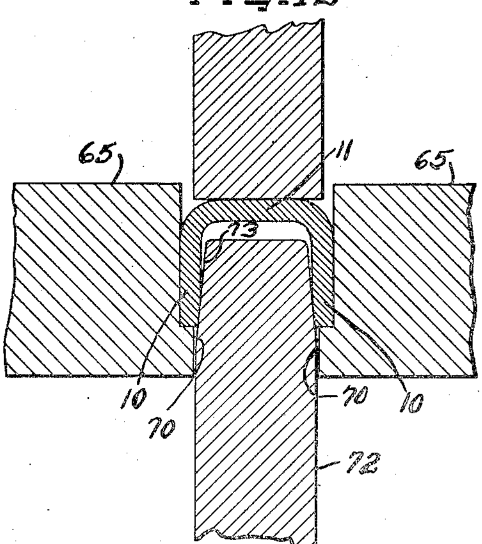
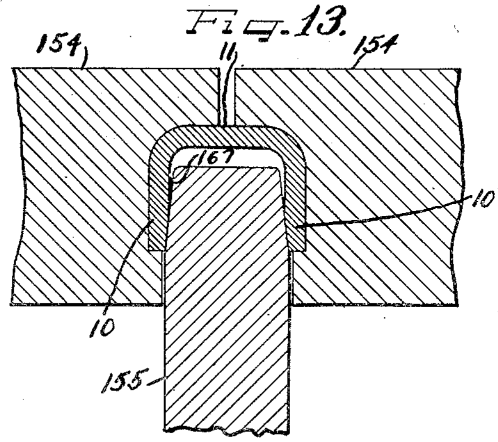


Fig-13.



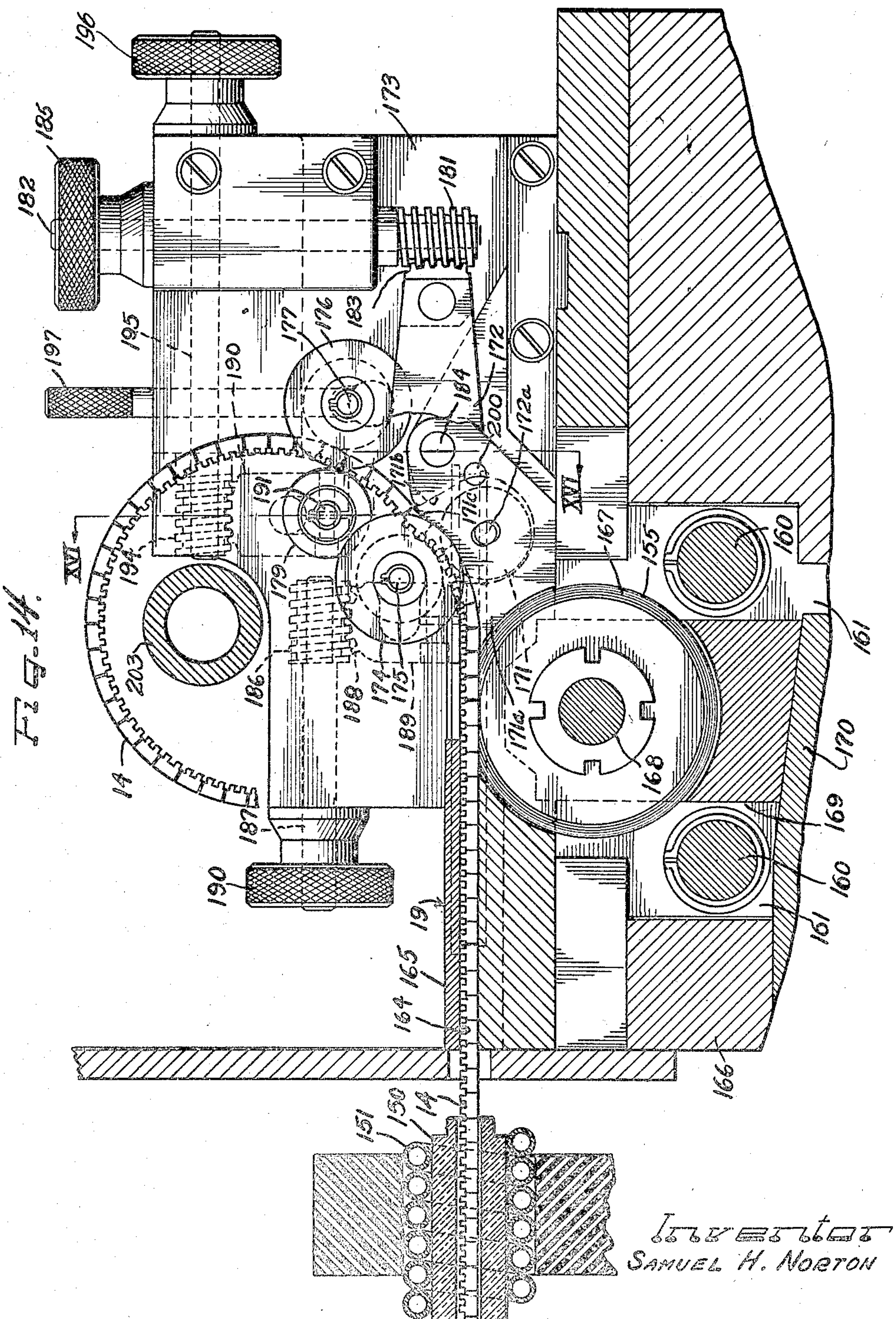
Inventor
SAMUEL H. NORTON

by [signature] Attys.

Dec. 28, 1954 S. H. NORTON 2,697,865

PISTON RING MAKING MACHINE AND PROCESS

Filed Aug. 19, 1949 21 Sheets-Sheet 9



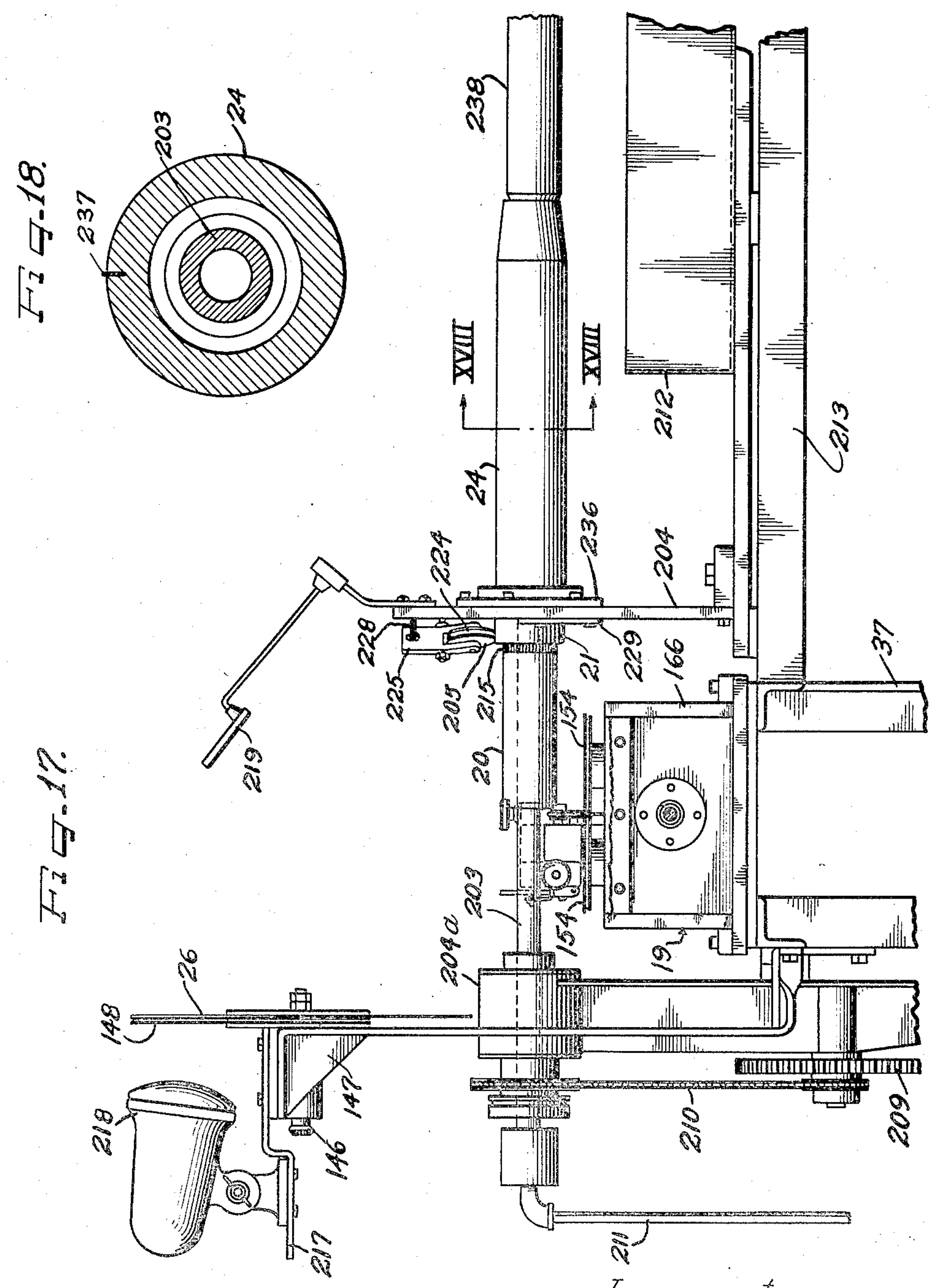
Inventor
Samuel H. Norton

by [signature] Attys.

Dec. 28, 1954 S. H. NORTON 2,697,865

PISTON RING MAKING MACHINE AND PROCESS

Filed Aug. 19, 1949 21 Sheets-Sheet 10



Inventor
Samuel H. Norton

by The Firm of Charles W. Hills Attys.

PISTON RING MAKING MACHINE AND PROCESS

Filed Aug. 19, 1949 21 Sheets-Sheet 11

Fig. 19.

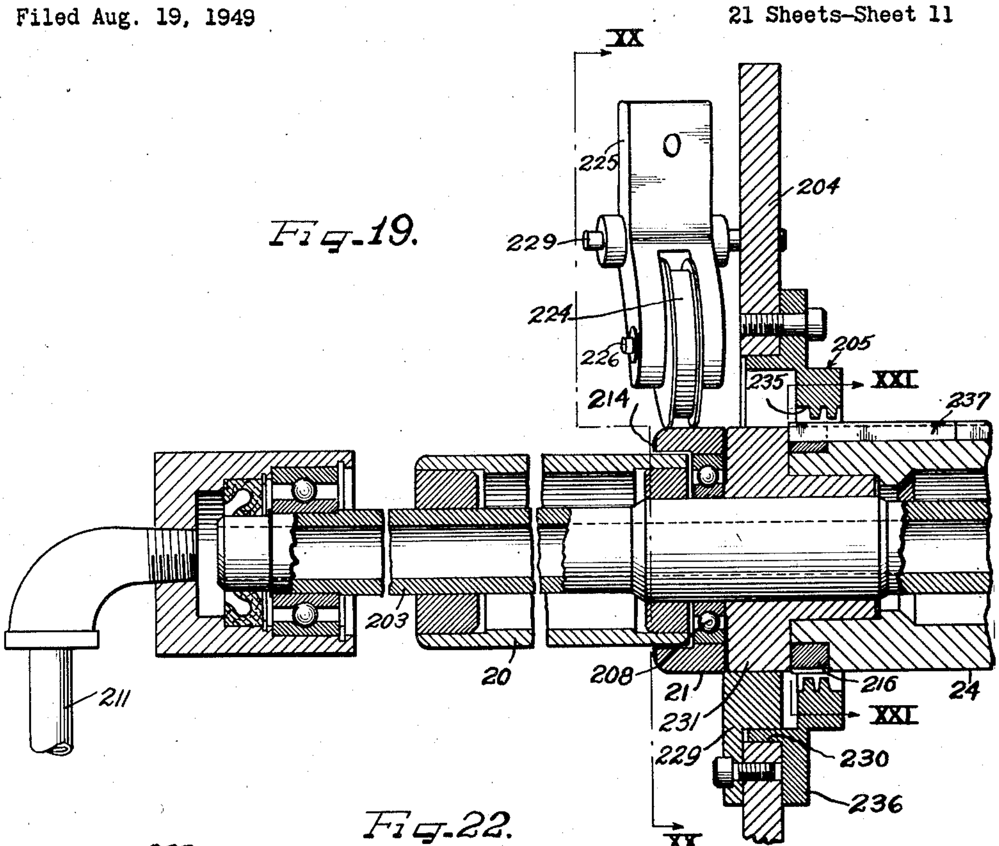


Fig. 22.

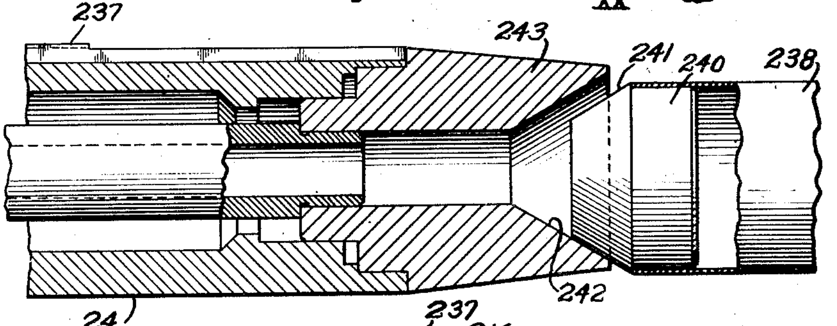
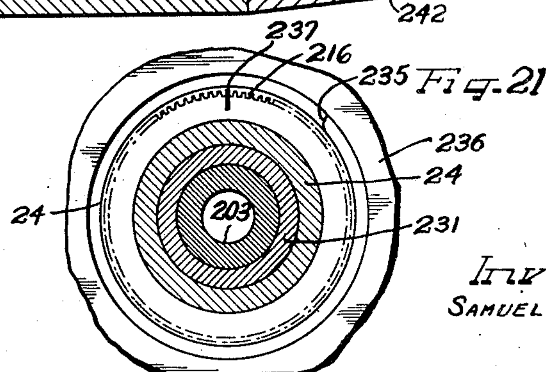


Fig. 21.



Inventor
Samuel H. Norton

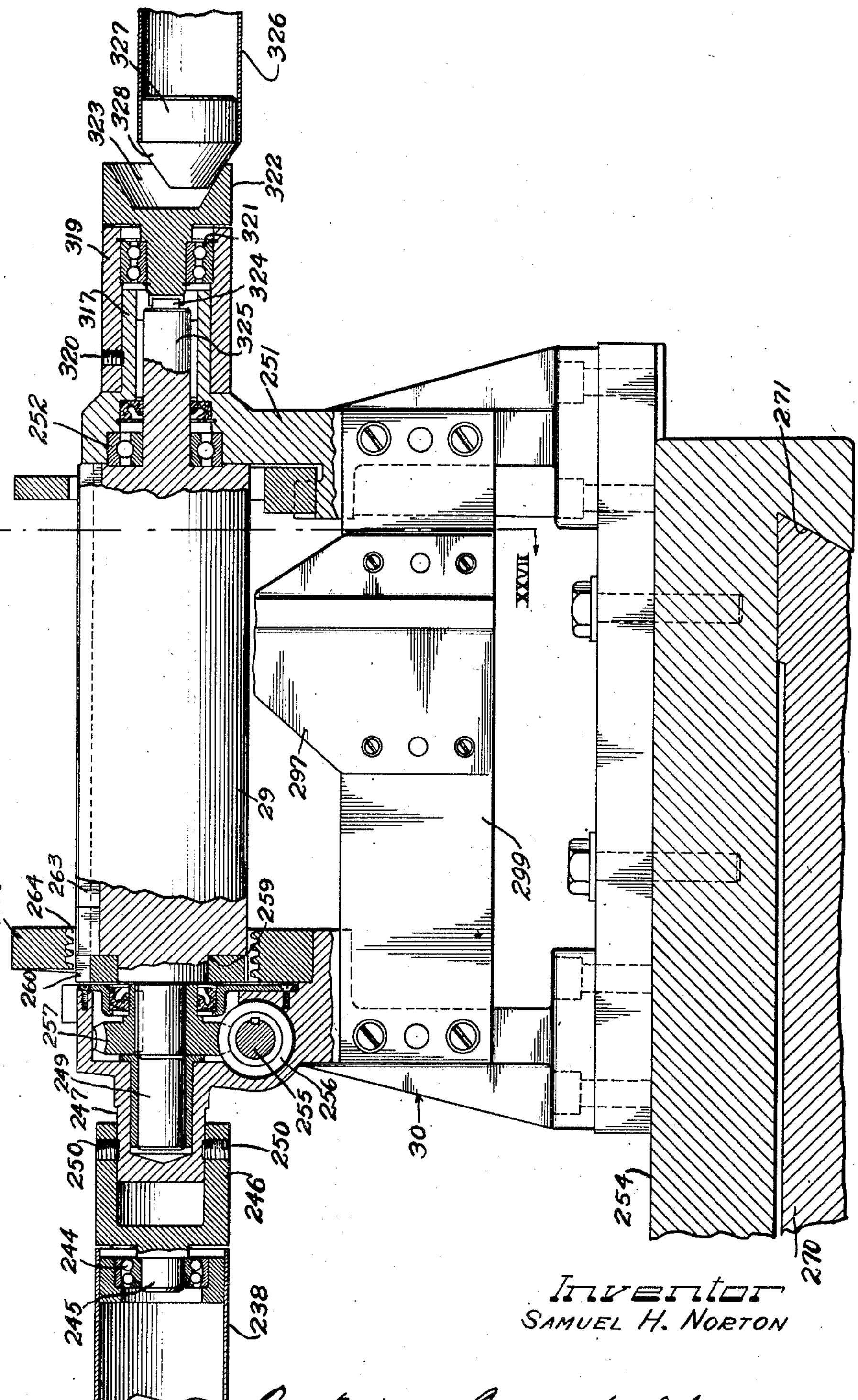
by The Firm of Chapler & Hill Attys.

Dec. 28, 1954 S. H. NORTON 2,697,865

PISTON RING MAKING MACHINE AND PROCESS

Filed Aug. 19, 1949 21 Sheets-Sheet 12

Fig. 23



Inventor
SAMUEL H. NORTON

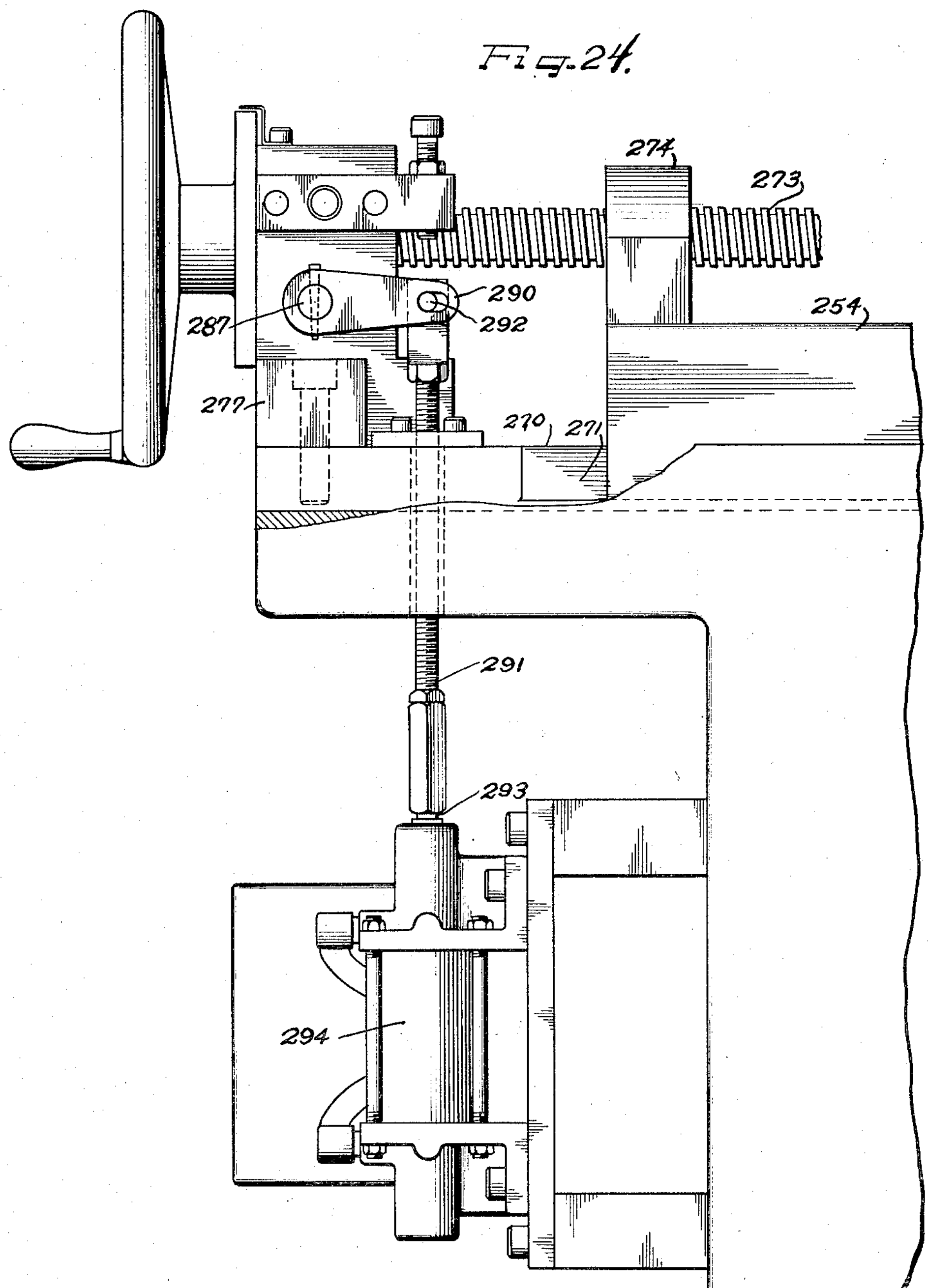
by The Firm of Charles W. Hills Attys.

Dec. 28, 1954 S. H. NORTON 2,697,865

PISTON RING MAKING MACHINE AND PROCESS

Filed Aug. 19, 1949 21 Sheets-Sheet 13

Fig. 24.



Inventor
Samuel H. Norton

by The Firm of Charles H. Hill Attys.

PISTON RING MAKING MACHINE AND PROCESS

Filed Aug. 19, 1949 21 Sheets-Sheet 14

Fig. 25.

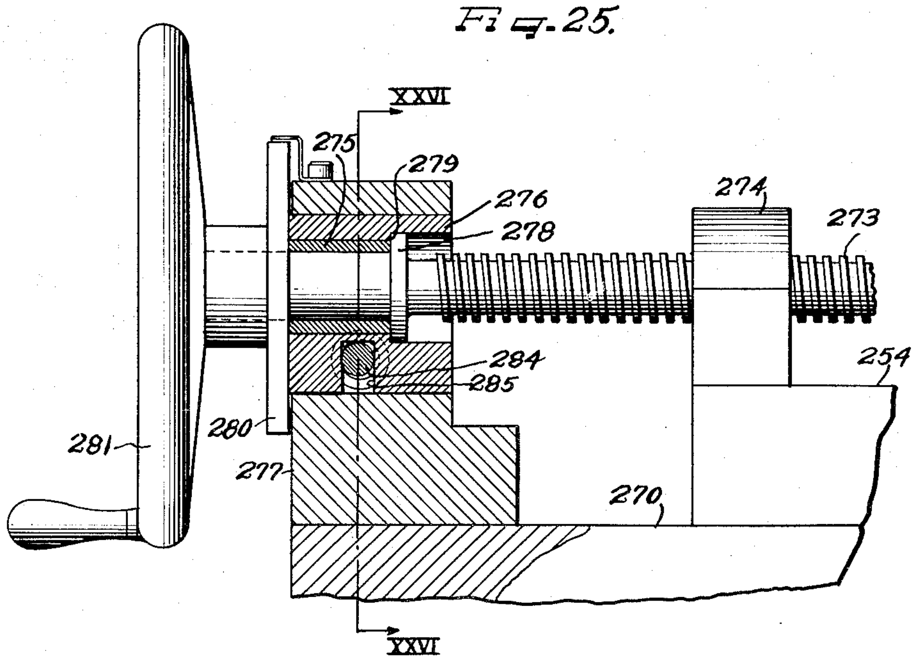


Fig. 26.

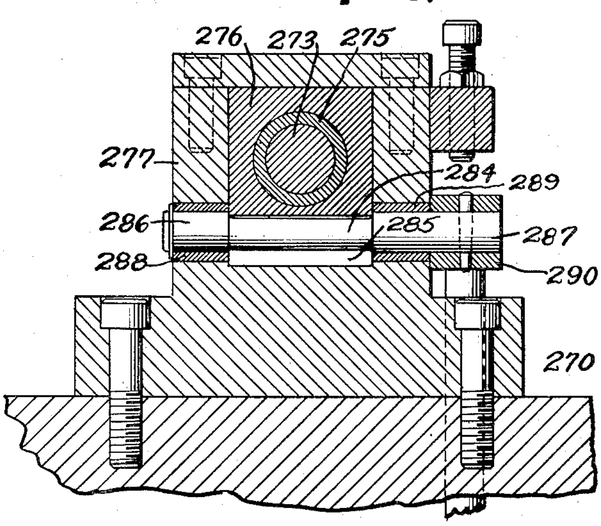
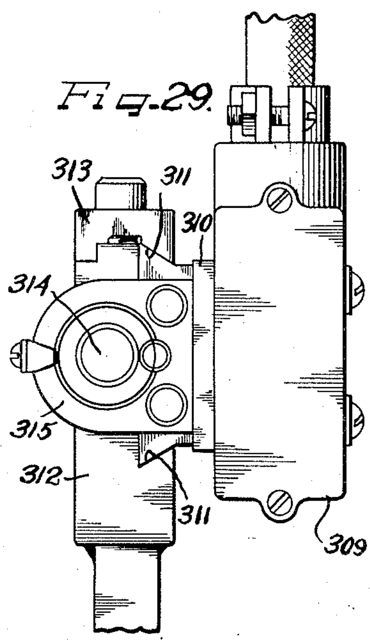


Fig. 29.



Inventor
Samuel H. Norton

by The Firm of Charles W. Hills Attys.

PISTON RING MAKING MACHINE AND PROCESS

Filed Aug. 19, 1949 21 Sheets-Sheet 15

Fig. 27.

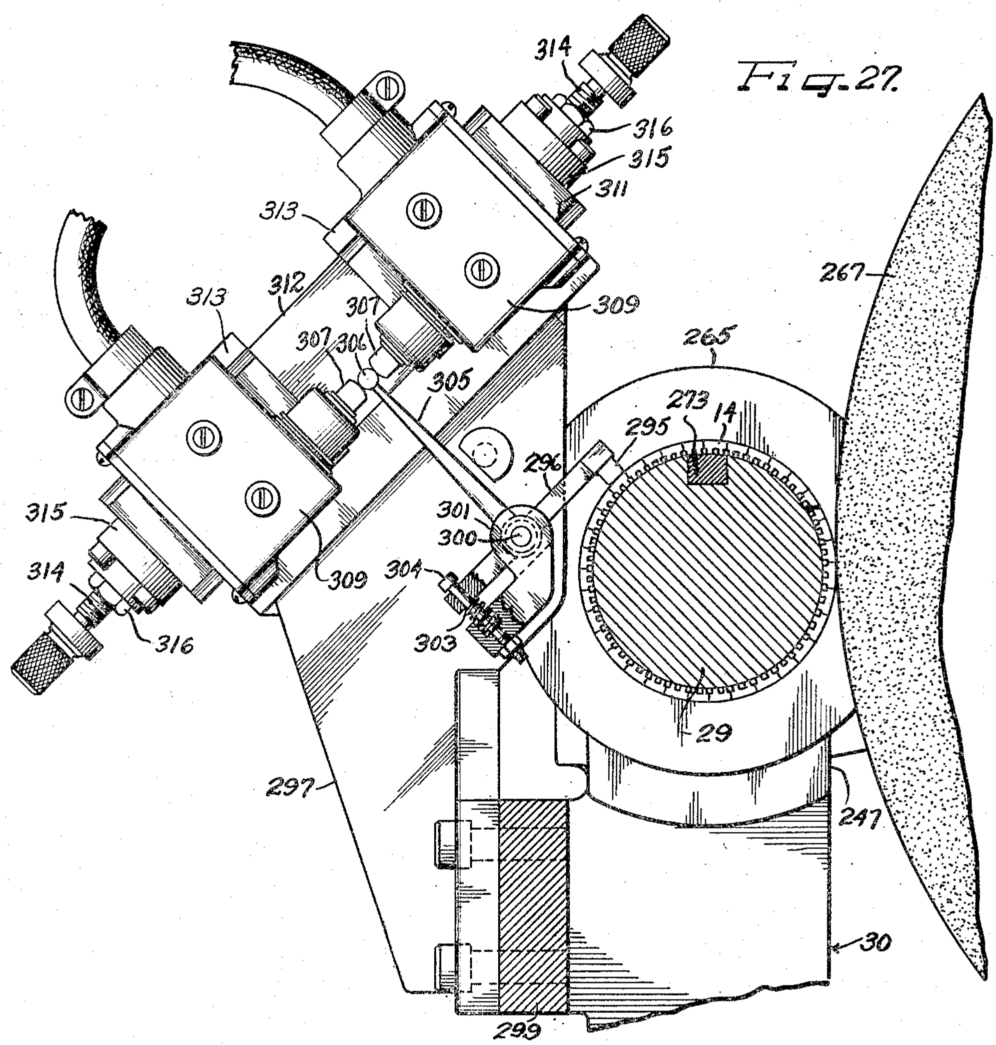
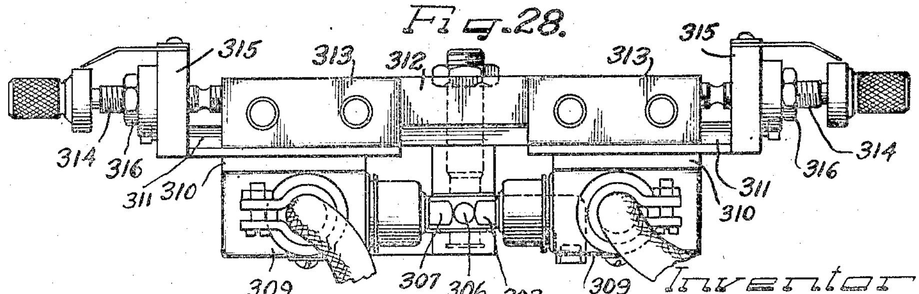


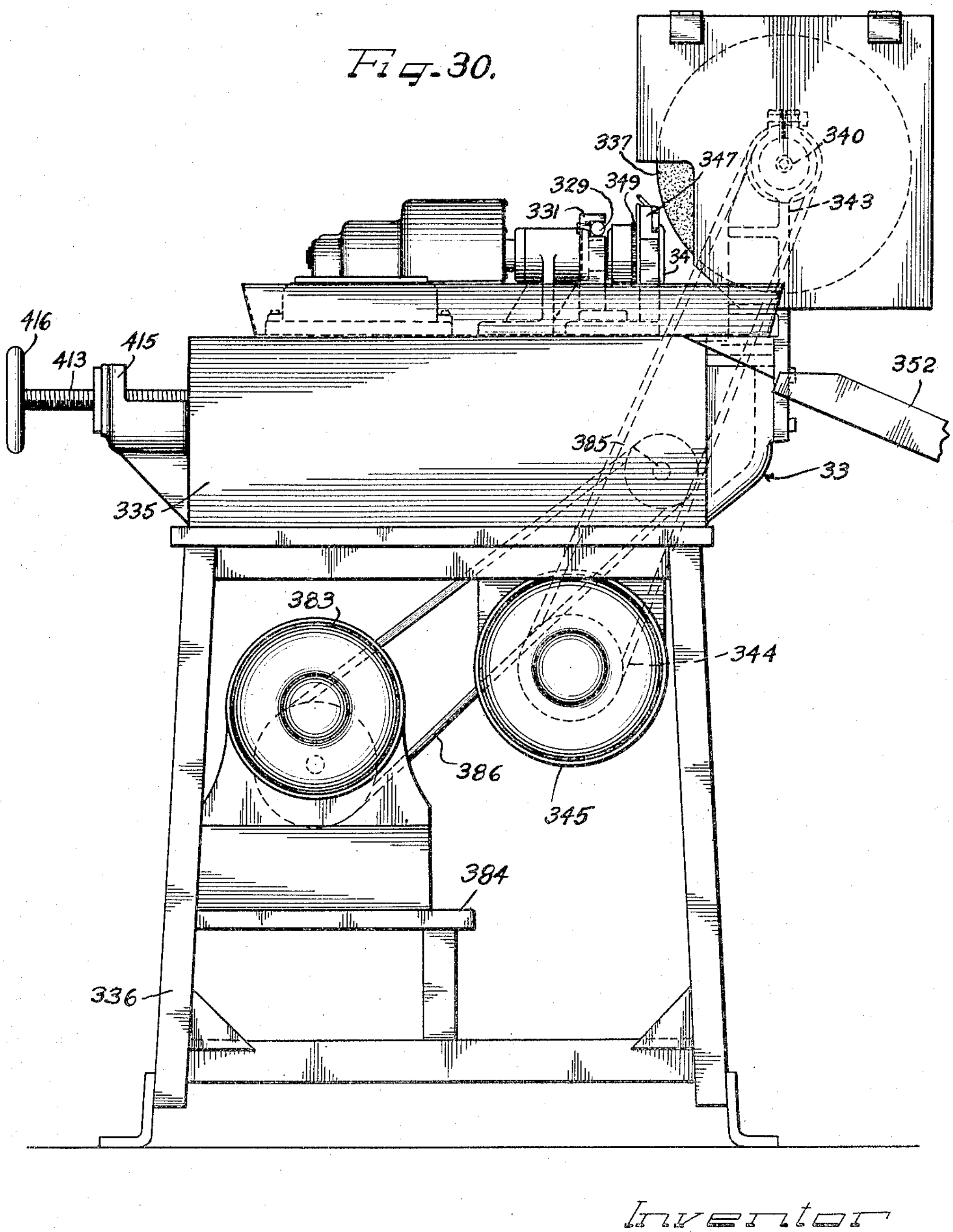
Fig. 28.



Inventor
Samuel H. Norton

by The Firm of Charles W. Hills Attys.

Fig. 30.



Inventor
Samuel H. Norton

by The Firm of Charles W. Hills Attys.

Dec. 28, 1954 S. H. NORTON 2,697,865

PISTON RING MAKING MACHINE AND PROCESS

Filed Aug. 19, 1949 21 Sheets-Sheet 17

Fig. 36.

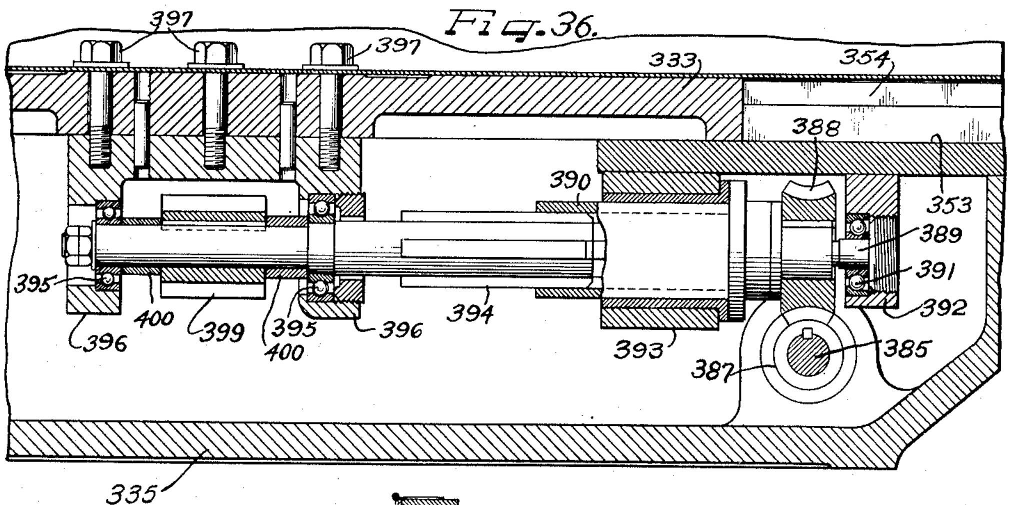
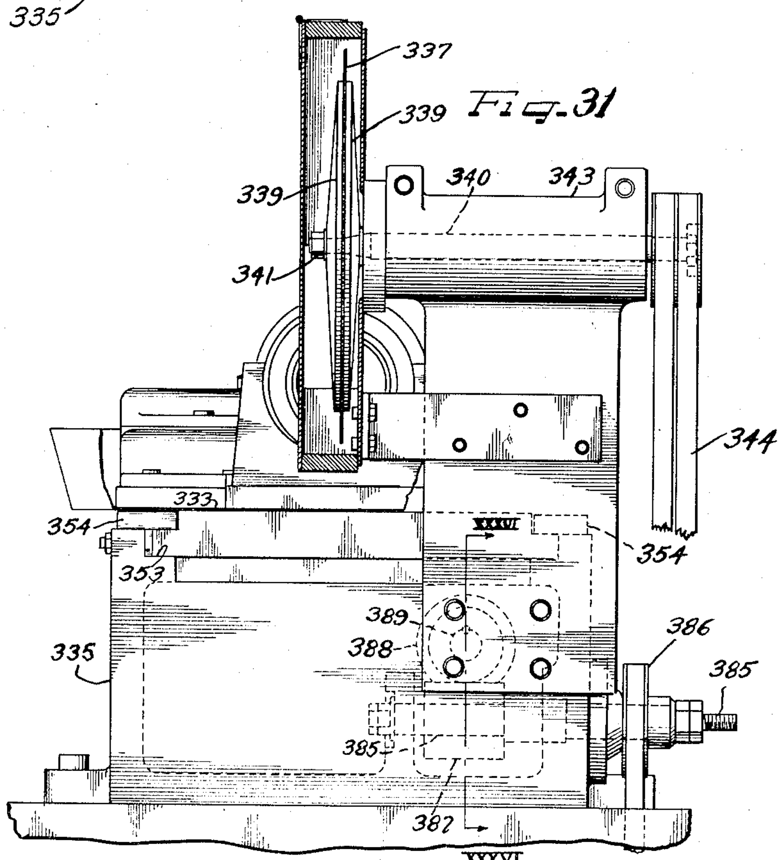


Fig. 31



Inventor
Samuel H. Norton

by The Firm of Charles H. Hill Attys.

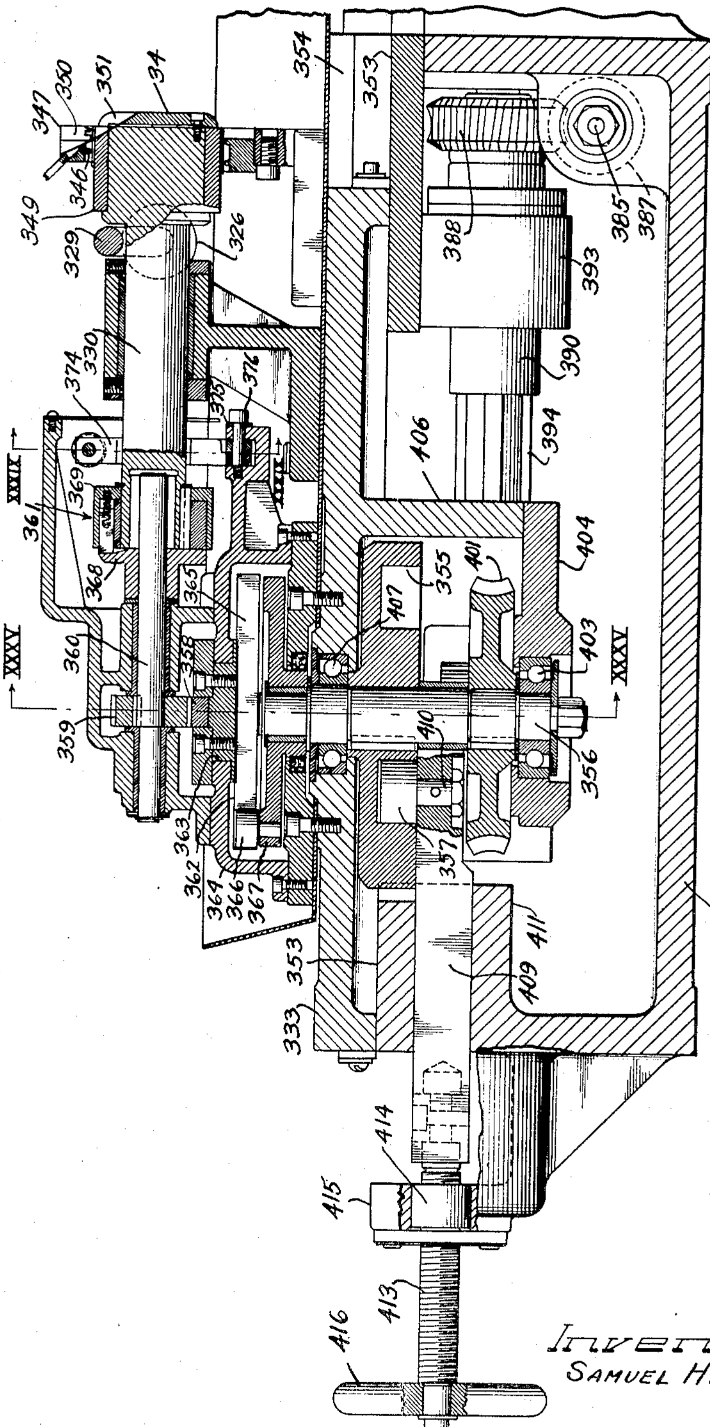
Dec. 28, 1954 S. H. NORTON 2,697,865

PISTON RING MAKING MACHINE AND PROCESS

Filed Aug. 19, 1949

21 Sheets-Sheet 18

Fig-32.



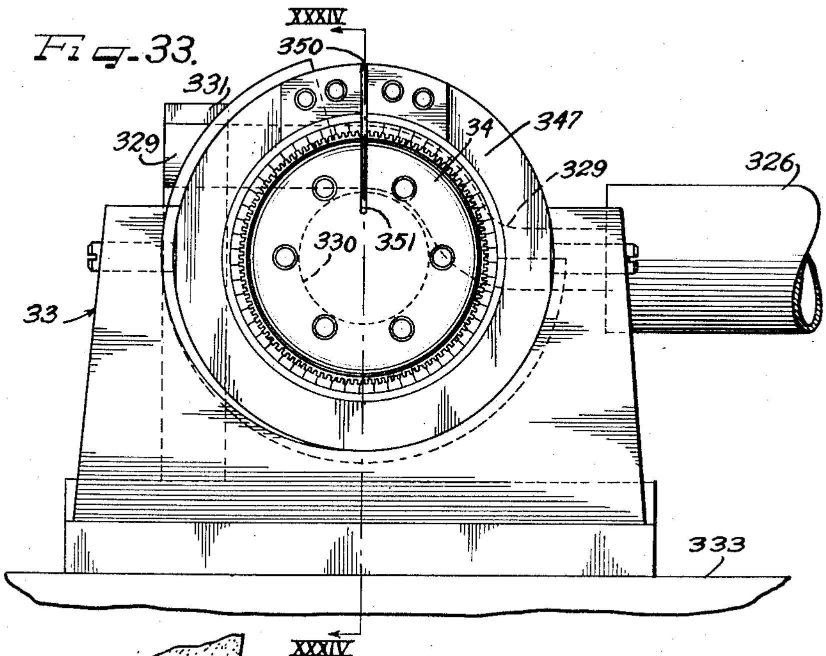
Inventor
SAMUEL H. NORTON

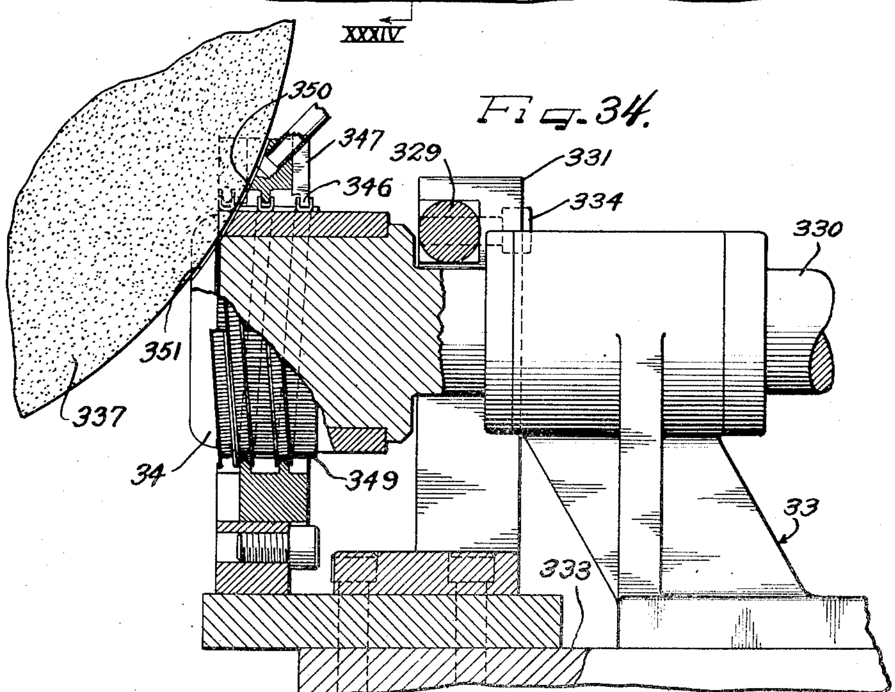
by The Firm of Wardell Ekblill Attys.

Dec. 28, 1954 S. H. NORTON 2,697,865

PISTON RING MAKING MACHINE AND PROCESS

Filed Aug. 19, 1949 21 Sheets-Sheet 19





Inventor
SAMUEL H. NORTON

by The Firm of Charles W. Hills Attys.

Dec. 28, 1954 S. H. NORTON 2,697,865

PISTON RING MAKING MACHINE AND PROCESS

Filed Aug. 19, 1949 21 Sheets-Sheet 20

Fig-35.

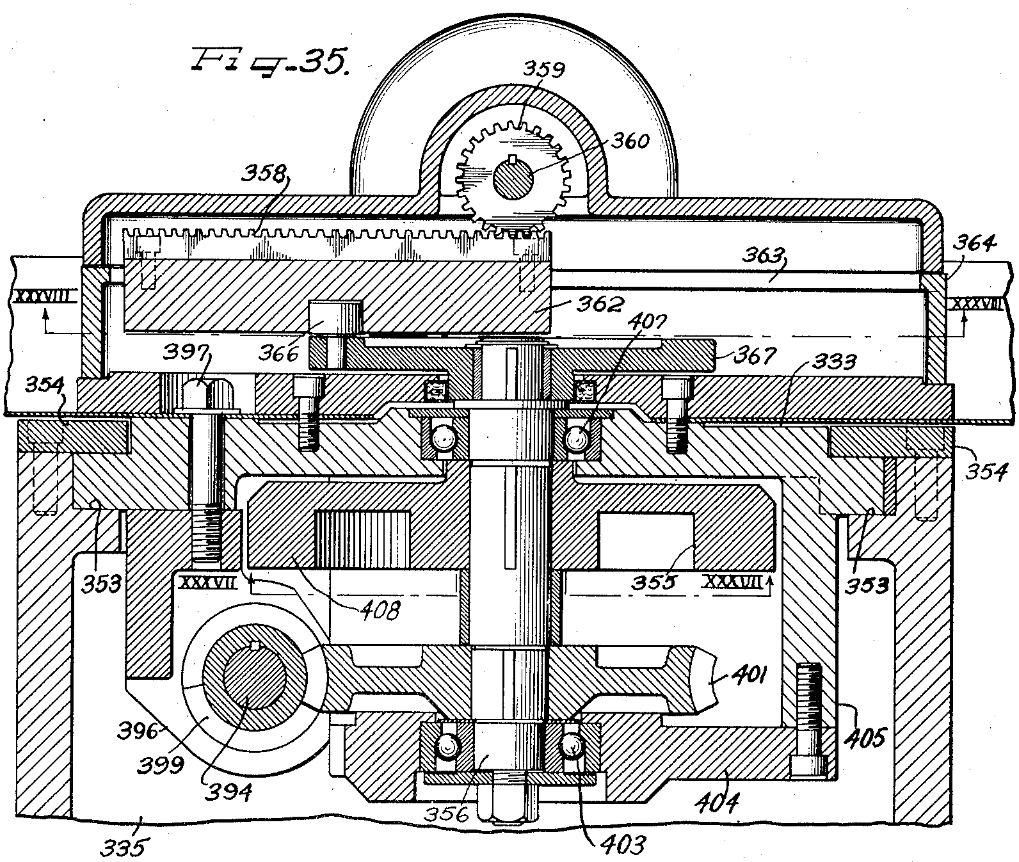


Fig-39.

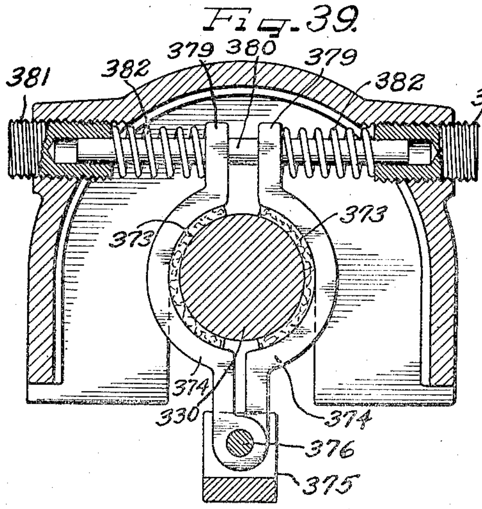
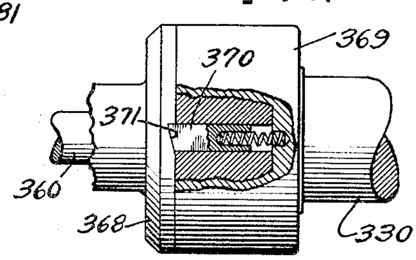


Fig-40.



Inventor
SAMUEL H. NORTON

by The Firm of Charles W. Hills Attys.

Dec. 28, 1954 S. H. NORTON 2,697,865

PISTON RING MAKING MACHINE AND PROCESS

Filed Aug. 19, 1949 21 Sheets-Sheet 21

Fig. 38.

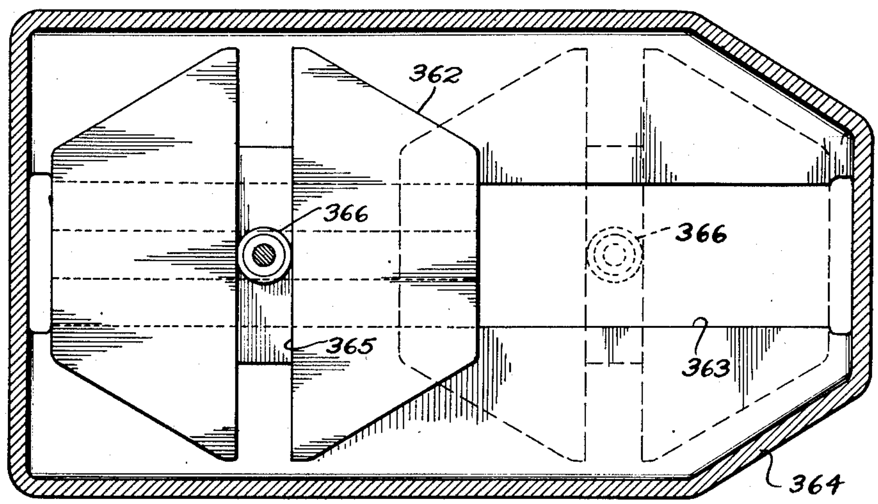
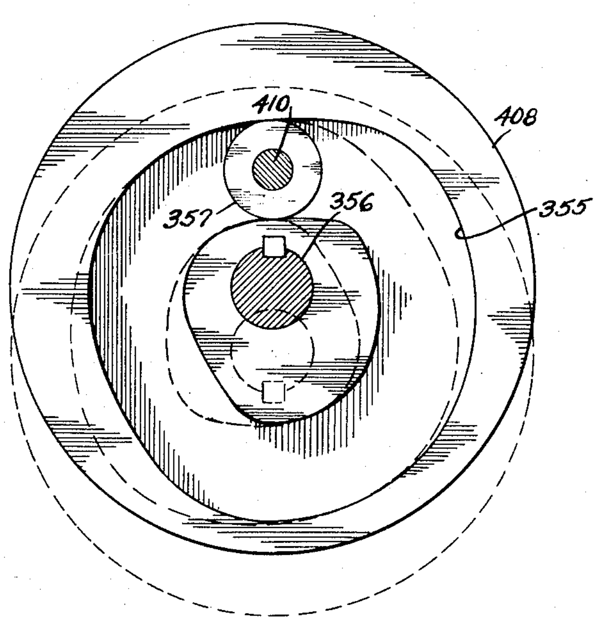


Fig. 37.



Inventor
SAMUEL H. NORTON

by The Firm of Charles W. Hills Attys.

United States Patent Office

2,697,865

Patented Dec. 28, 1954

1

2,697,865

PISTON RING MAKING MACHINE AND PROCESS

Samuel H. Norton, University Heights, Ohio, assignor to Thompson Products, Inc., Cleveland, Ohio, a corporation of Ohio

Application August 19, 1949, Serial No. 111,312

29 Claims. (Cl. 29—33)

This invention relates to methods and apparatus for making oil piston rings from continuous strip piston ring material.

The principal object of my invention is to provide an improved method and apparatus for accurately forming the crown segments of flexible piston ring material, finishing the material to the required diameter, and cutting the finished material to length in a series of continuous operations.

A more specific object of my invention is to provide a method and apparatus for producing flexible oil piston rings in a more facile manner than formerly arranged, with a view toward increasing the accuracy of the radial edges of the crown segments of the ring and overcoming variations in circumference or length of the finished ring.

A further object of the invention is to provide a novel method and apparatus to accurately and uniformly gap or space apart the adjacent edges of the crowns of strip piston ring material after the rolling operation by pushing them together to substantially cylinder size, bending them back over themselves out of round and then bending them in an opposite direction and coiling the strip to cylinder size.

A still further object of my invention is to provide a novel method and apparatus, enabling variations in circumferential spacing of the crown segments of the ring to be readily detected during manufacture of the ring.

Another object of my invention is to provide an economical and simple form of apparatus arranged to continuously and accurately produce flexible oil piston rings from flexible piston ring material in a more efficient and cheaper manner than formerly.

Still another object of my invention is to provide a means for gauging the accuracy of the formation of the crown segments of piston ring material, and the circumferential spacing thereof, by the relative movement of two parts with respect to each other about which the piston ring material is trained, one of which parts is positively driven by power and the other of which parts is rotatably driven by frictional engagement with the piston ring material while passing through the apparatus.

A still further object of my invention is to provide a simple and novel means for holding the formed piston ring material for finish grinding the outer sides of the crowns thereof to the required size while continuously advancing the material during the grinding operation and to the next succeeding operation.

A further object of my invention is to provide a novel and efficient means for holding spiral piston ring material, the segmental crowns of which have been properly formed, for finish grinding to the correct diameter while continuously advancing it to the next operation for intermittently severing the piston ring material into finished rings of the correct diameter after the grinding operation.

A further more detailed object of my invention is to provide a new and novel method and apparatus for accurately making piston rings in a contnuous operation from continuous strip piston ring material formed to have connected parallel spaced crowns extending perpendicular to the web of the ring material and along opposite sides of the strip by thinning the lower portions of the crowns by a rolling action while the strip is cold, then heating the strip, finish working the hot strip and forming the crowns into segments of a circle, gapping the strip to uniformly space the segments apart and coiling the strip in the form of a spiral coil of cylinder bore size, quenching it to harden it during the gapping operation, then measuring and feeding it along the axis of the coil and gauging the accuracy of the formation of the crown segments, then heating the strip to a drawing temperature while being so fed, and then grinding the outer periphery of the crowns and feeding it in a spiral path into position to be cut and intermittently severing it into completed rings of the correct lengths.

In carrying out my invention I utilize a flexible piston ring material which has first been slotted along the center or web of the material and then alternately cut along its edges perpendicular to the center line thereof. The strip thus formed is bent longitudinally of itself on opposite sides of the slotted web to form a substantially U-shaped strip with alternately arranged crowns on opposite sides thereof. This partially formed piston ring material may then be stored on reels from which it may be uncoiled and formed in accordance with my invention. I take this partially formed strip and feed it through a rolling mill which acts on the strip while cold and thins the lower edges of the crowns thereof to keystone the crowns or form them in the form of segments of a circle, the adjacent edges of which conform to radial lines passing through the centers of the finished rings. I then heat the strip to a hot working temperature while continuously traveling through the apparatus and finish roll the crowns while hot in a second operation. I then gap the crown segments or space them a uniform distance apart by confining the strip to a circular path and compressing it while so confined, then bending it backwardly on itself and then bending it in a reverse direction and coiling it in a spiral coil and at the same time quenching it, the strip being confined and coiled with the web and slots on the inside of the coil and the crowns forming two spaced annular flanges extending outwardly from the web thereof. This coiled strip is then fed spirally along a rotating arbor or mandrel of lesser diameter than the coil over and around a freely rotatable measuring collar journaled on said mandrel which measures the rolled strip for tempering. From said collar the strip is fed onto a coaxial mandrel forming a continuation of the first mandrel and rotatably driven thereby. At this point irregularities in the forming of the inclined sides of the crown segments and the resultant length of the strip will cause said measuring collar to lag behind or advance ahead of said first arbor, which may be observed by relative movements between the collar and small mandrel. Where the crown segments are inaccurately formed so the finished ring does not conform to the proper circumference, the rolling operation just mentioned must be adjusted to properly form the inclined sides of the keystone segments. The strip is stretched into tight engagement with this last-mentioned mandrel, heated to a drawing temperature, allowed to cool in the air, and acquires its set while coiled thereon. The strip is then stretched and coiled onto a grinding mandrel while still traveling in a spiral path, and the outer edges of the crowns are ground to the correct cylinder diameter. The strip, while being continuously fed in a spiral path, is then periodically severed into oil rings of uniform length and diameter.

These and other objects of my invention will appear from time to time as the following specification proceeds and with reference to the accompanying drawings wherein:

Figure 1 is a top plan view of a piston ring making apparatus constructed in accordance with my invention showing certain parts of the apparatus in a diagrammatic form;

Figure 1A through 1E are diagrammatic views illustrating various stages in the rolling and gapping of the ring;

Figure 2 is a fragmentary plan view of a piston ring constructed by the process of my invention;

Figure 3 is an enlarged fragmentary isometric view of the ring showing in detail the web and crown segments thereof;

Figure 4 is an enlarged view taken transversely of the apparatus and showing the stroboscopic disk for detecting inaccuracies in the formation of the crown segments of the ring and also showing the hot and cold rolling mills and the induction heating unit therebetween;

Figure 5 is an enlarged detail plan view of the cold rolling mill and also showing certain details of the advance end of the induction heating unit in horizontal section;

Figure 6 is an enlarged detail plan view of the hot rolling mill with certain parts thereof broken away and showing the discharge end of the induction heating unit in horizontal section;

Figure 7 is a vertical sectional view taken substantially along line VII—VII of Figure 5;

Figure 8 is a fragmentary horizontal sectional view taken substantially along the line VIII—VIII of Figure 7;

Figure 9 is a fragmentary transverse sectional view taken substantially along line IX—IX of Figure 7;

Figure 10 is a fragmentary end view of the cold rolling apparatus looking from the induction heating unit toward the discharge end thereof, and drawn to a reduced scale;

Figure 11 is an enlarged fragmentary detail side view of the cold rolling mill with certain parts broken away and certain other parts shown in section, and looking toward the side thereof, which in Figure 8 is the right-hand side thereof;

Figure 12 is an enlarged partial fragmentary transverse sectional view showing certain details of the cold working roller operating on the crowns of the strip piston ring material;

Figure 13 is an enlarged detail partial fragmentary transverse sectional view showing the details of the hot working rollers operating on the crowns of the strip piston ring material;

Figure 14 is a sectional view taken substantially along line XIV—XIV of Figure 6;

Figure 15 is an enlarged detail fragmentary sectional view taken substantially along line XV—XV of Figure 1 and illustrating certain details of the cooling connection to the induction coils for heating the strip to a hot working temperature;

Figure 16 is a fragmentary sectional view drawn to a reduced scale and taken substantially along line XVI—XVI of Figure 14;

Figure 17 is an enlarged fragmentary side view with certain parts broken away and shown in section in order to illustrate the means for visually detecting inaccuracies in the forming of the wedge-shaped segments and in the length of the strip or the circumference of the finished ring;

Figure 18 is a transverse sectional view taken substantially along line XVIII—XVIII of Figure 17;

Figure 19 is an enlarged fragmentary sectional view taken substantially along line XIX—XIX of Figure 1;

Figure 20 is an enlarged fragmentary transverse sectional view taken substantially along line XX—XX of Figure 19;

Figure 21 is a fragmentary sectional view taken substantially along line XXI—XXI of Figure 19;

Figure 22 is an enlarged longitudinal sectional view taken along line XXII—XXII of Figure 1 and showing certain details in the drive connection from the drawing mandrel to the conveyor shaft for conveying the coiled strip to the next operation in the process;

Figure 23 is an enlarged detail fragmentary longitudinal sectional view taken along line XXIII—XXIII of Figure 1 and showing the grinding mandrel for the spiral strip;

Figure 24 is an enlarged fragmentary side view of the control end of the grinding apparatus showing certain details of the adjusting means therefor;

Figure 25 is an enlarged fragmentary detail sectional view taken through the control means for the grinding apparatus and showing certain details thereof not shown in Figure 24;

Figure 26 is a sectional view taken substantially along line XXVI—XXVI of Figure 25;

Figure 27 is an enlarged fragmentary transverse sectional view taken substantially along line XXVII—XXVII of Figure 23 and showing certain details of the means for indicating inaccuracies in the grinding of the spiral strip;

Figure 28 is a view of the indicating mechanism for the grinding apparatus looking from the top thereof in the plane of inclination of said indicating mechanism;

Figure 29 is an end view of the indicating mechanism for the grinding apparatus and showing certain details thereof not shown in Figures 27 and 28;

Figure 30 is a side view of the mechanism for cutting off the spirally coiled piston ring material into finished rings of uniform circumference;

Figure 31 is an end view of the mechanism shown in Figure 30 with certain parts thereof broken away and with the guard for the cut-off wheel shown in section;

Figure 32 is an enlarged fragmentary sectional view taken substantially along line XXXII—XXXII of Figure 1;

Figure 33 is an enlarged detail fragmentary end view of the cut-off mechanism with the cut-off wheel broken away in order to show certain details of the cut-off gauge and mandrel;

Figure 34 is a sectional view taken substantially along line XXXIV—XXXIV of Figure 33, showing the cut-off wheel at the completion of the cut-off operation;

Figure 35 is a transverse sectional view taken substantially along line XXXV—XXXV of Figure 32;

Figure 36 is an enlarged fragmentary longitudinal sectional view taken substantially along line XXXVI—XXXVI of Figure 31 in order to show certain details of the drive for the cut-off mechanism not shown in Figures 32 and 35;

Figure 37 is an enlarged fragmentary horizontal sectional view taken substantially along line XXXVII—XXXVII of Figure 35 and showing certain details of the cam for advancing the work to the cut-off wheel;

Figure 38 is an enlarged fragmentary sectional view taken substantially along line XXXVIII—XXXVIII of Figure 35 and showing certain details of the connection for intermittently turning the cut-off mandrel and advancing the spirally coiled strip for cutting off to the required circumference;

Figure 39 is a fragmentary transverse sectional view taken substantially along line XXXIX—XXXIX of Figure 32 and showing certain details of the means for restraining rotation of the cut-off mandrel; and

Figure 40 is an enlarged detail view with parts shown in section, showing certain details of the one-way drive coupling to the cut-off mandrel.

Piston ring and machine in general

The piston ring made in accordance with the process and apparatus of my invention is shown in Figures 2 and 3 as being a well known form of oil ring, such as is disclosed in Patent No. 2,345,176 which issued to E. A. Bowers March 28, 1944, and known to the trade as the "Bowers ring." This ring is formed from a tool steel which may be hardened, such as S. A. E. 1095 containing 0.95% carbon, and includes generally two axially spaced apart annular rows of crown segments **10**, **10** connected together by a web of a ladder-like form having parallel spaced cross bars **11**, **11** connecting said crown segments together and leaving transverse slots **12**, **12** between said cross bars and herein shown as opening into the spaces between adjacent ends of the crown segments. Said ring may be formed from a stamped strip of resilient piston ring material **14** coiled on a reel **15** (Figure 1). Said piston ring material as coiled on said reel and as entering the machine is transversely slotted along the web thereof and alternately slit along the crowns thereof with the slits extending into the slotted portions thereof and perpendicular to the longitudinal axis thereof, and the slit portions are bent toward each other at right angles to the web to form a resilient strip of U-shaped formation as illustrated in Figure **1A**. The mechanism for slotting, slitting and bending the slit portions of the strip to form the strip of piston ring material is no part of my present invention, so need not herein be shown or described.

The apparatus for forming the U-shaped slotted and slit strip **14** into piston rings of uniform circumference, as shown in Figure 1, includes generally a cold rolling mill **16**, rolling the strip to thin the crowns thereof, an induction heating unit **17** through which the strip passes and is heated to a temperature suitable for hot forging or hot working, such as about 1540° F. for S. A. E. 1095 steel, a hot rolling mill **19** for straightening any deformed crown segments, finish rolling the crowns thereof to the form shown in Figure 1B, and then gapping the strip or spacing the crowns thereof at uniform distances apart and quenching the strip and coiling it into a quenched brittle and hard spiral coil with the crowns thereof extending outwardly from the web thereof and spaced equal distances apart (Figure 1E).

The machine also includes a horizontal power-driven shaft or arbor 20 about which the strip is spirally coiled and extending perpendicularly to the path of travel of the strip through said cold and hot rolling mills and of a smaller diameter than the inside diameter of the finished ring.

The machine also has a freely rotatable gauging or measuring collar 21 journaled coaxially with shaft 20 at the discharge end thereof and adapted to have the formed piston ring material spirally coiled therearound and to measure the strip as it travels and is coiled and stretched onto a mandrel 24 of a draw furnace 25 where it acquires its set. The draw furnace heats the coil 600° to 650° F. while still on the mandrel to temper the steel and render it less brittle. The thus heated coil is air quenched.

The machine further includes a stroboscopic disk 26 arranged to permit the shaft or arbor 20 and the measuring collar 21 and the strip to be viewed as it passes onto the mandrel 24 to enable the speed of said shaft to be adjusted to the speed of the rolling mills 17 and 19 and to enable relative movement of the measuring collar 21 with respect to the arbor 20 to be seen by the eye as the strip is spirally coiled onto said mandrel 24 so as to enable inaccuracies in length of the crown segments 10 to be visually detected, as will hereinafter more clearly appear as this specification proceeds.

The machine also includes a conveyor forming a continuation of the mandrel 24 and serving to convey the piston ring material to a grinding mandrel 29 of a grinder 30, about which the strip is coiled and stretched, for grinding to the required outside diameter while passing along said mandrel.

The machine further has a conveyor forming a continuation of the grinding mandrel 29 and rotatably driven thereby to convey the strip to a cut-off machine 33 where it is turned at right angles to its path of travel along said conveyor and coiled around and advanced along a cut-off mandrel 34 and is then cut off at predetermined intervals while on said mandrel to form oil piston rings of uniform circumference, completely finished to the correct size and ready for use.

Feeding and crown cold rolling mechanism

The mechanism for feeding the strip and cold rolling the crowns thereof to thin and form them substantially in the shape of keystone or wedge-shaped segments includes a working table 35 having strip guiding means extending longitudinally along the upper surface thereof and along which the strip is fed during the rolling operation, as will hereinafter more clearly appear as this specification proceeds.

Said table is mounted on and extends across the top of a housing 36, herein shown as being mounted on a frame structure 37 resting on the ground, and also forming a support for the induction heating unit 17 and the hot rolling mechanism 19.

A motor 39, herein shown as being of a well known form of electric motor, is mounted on said frame structure and is provided to drive the hot and cold rolling mechanisms 16 and 19 through meshing spur gears 40 and 41 (Figure 4). The spur gear 41 is herein shown as being keyed on the forward end of a longitudinal shaft 43 journaled in the housing 36 in an end cap member 44 closing the rear end of said housing and as extending through an end cap member 45 closing the forward end of said housing. Said shaft is also journaled on ball bearings 46 and 47 on opposite sides of a worm 48 secured to and rotatably driven by said shaft (Figure 7). Sleeves 49 and 50 are interposed between opposite sides of said worm and said ball bearings to transmit end thrust to said bearings. The worm 48 meshes with and drives worm gears 51, 51 on opposite sides thereof and herein shown as being keyed to vertical shafts 53, 53 (Figure 8). Said shafts are suitably journaled in said housing and have spur gears 54, 54 secured to and driven from the lower ends thereof. Said spur gears mesh with forwardly spaced spur gears 55, 55 on the lower ends of and driving vertical shafts 56, 56 and secured thereto by means of washers 57, 57 abutting the lower ends of said spur gears and nuts 58, 58 threaded on the lower ends thereof.

The vertical shafts 56, 56 are each suitably journaled in bearing blocks 59 and 60, the bearing block 59 forming a bearing support for one of said vertical shafts 56 and the bearing block 60 forming a bearing support for the other of said vertical shafts (Figure 8). Said bearing blocks are mounted on two parallel spaced transversely extending shafts 61 and 62 threaded in the bearing block 59 and also threaded in flanged collars 63, 63 mounted in a side wall 64 of the housing 36. Said transverse shafts serve to adjustably move said vertical shafts 56, 56 toward or from each other and to adjust the spacing of horizontally extending anvil rolls 65, 65 secured to the upper ends of said vertical shafts, as will hereinafter more clearly appear as the specification proceeds (Figures 5 and 9).

The shafts 61 and 62 have spaced collars 66, 66 and 67, 67 respectively engaging opposite sides of the block 60 to rectilinearly move said block upon rotation of said shafts. Said shafts are turned to move the blocks 59 and 60 toward and from each other so as to enable the space between the anvil rolls 65, 65 to be adjusted to the proper width to receive and back up the piston ring material during the rolling operation by means of a hand wheel 87 at the advance right-hand side of the machine and mounted on the upper end of an inclined shaft 88 (Figure 4). Said shaft is journaled at its lower end on opposite sides of a worm 89 in a bearing bracket 90 secured to and projecting outwardly from the outside of the side plate 64. Said worm meshes with a worm gear 91 on the transverse shaft 62. A spur gear 92 keyed to the shaft 62 meshes with and drives a spur gear 93 keyed to the shaft 61 to drive said shaft in an opposite direction of rotation than said shaft 62.

It should here be noted that the threads on the shaft 61 are right-hand threads, while the threads on the shaft 62 are left-hand threads, to rectilinearly move the bearing block 59 upon rotation of said shafts in opposite directions. Also, the threaded portions of said shafts threaded within the collar 63, 63 are of a finer or flatter pitch than the threaded portions of said shafts threaded within the block 60. Thus, as the two shafts are turned together the block 60 will move in one direction and the shafts themselves will move in an opposite direction by reason of their threaded engagement with the collars 63, 63. This will effect movement of the block 59 in a direction opposite to the direction of movement of the block 60. The worm gear 91 may be feathered on the shaft 62 to take care of axial movement of said shaft with respect to said worm gear.

The collars 63, 63 are each held from rotation by clamping members 96 and 97 on a vertically extending bolt 98 (Figure 11). Said clamping members each has arcuately formed recessed surfaces engaging opposite sides of the respective collars and are each slidably mounted in a recessed or drilled portion 99 of said side plate. The head of each bolt 98 abuts the lower clamping member 97. A nut 100 threaded on the upper end of said bolt abuts the clamping member 96 to clamp said clamping members 96 and 97 into engagement with their respective collars to hold them from rotatable movement. Loosening of said nuts permits rotatable movement of said collars to effect adjustment of the mechanism where desired or necessary.

Each anvil roll 65 is mounted on the tapered upper end of a shaft 56 and rests on a shouldered portion 68 thereof (Figure 9). Machine screws 69, 69, recessed within said anvil roll, are threaded within the shouldered portion of said shaft to secure said roll to said shaft for rotation therewith. Each anvil roll 65 is of a flat disk-like form with a lower flanged portion 70, the upper edge of which has supporting engagement with the bottoms of the crown segments 10 of the piston ring strip 14. The outer peripheries of said rollers above said flange 70 engage opposite sides of the crown segments to feed the strip and back up the sides of the crowns during the forming operation thereof. A thinning roll 72 is mounted to extend upwardly between said feeding and anvil rolls and has opposite taper working sides 73, 73 inclined toward the transverse center thereof. Said tapered sides are adapted to have rolling engagement with the insides of the crown 10 of the strip 14 to thin said crowns toward their ends. The angles of the tapered working sides of said thinning roll are such that the rolling action thereof against the anvil rolls 65, 65 will taper and thin the insides of the crowns toward their lower edges and increase the length of the crowns circumferentially of the finished ring. This will incline opposite sides of said crowns to conform substantially to radial lines extending through the center of the finished ring when compressed.

The thinning roll 72, as best shown in Figure 9, is mounted on a transverse shaft **74** journaled on opposite sides of said thinning roll in bearing blocks **75** and **76** slidably guided in the blocks **59** and **60**, respectively, for vertical adjustment with respect thereto to adjust the depth of the thinning operation. The bottom surfaces of said blocks are herein shown as being inclined downwardly from the discharge to the advance end of the machine. Said blocks rest on a correspondingly inclined surface **77** of a support block **79** movable longitudinally of the machine (Figure 7.) Said support block is slidably guided on inwardly extending shoulders **80**, **81** formed on the insides of the blocks **59** and **60**, respectively. Said support block also extends over and downwardly along opposite sides of the longitudinal drive shaft **43** and has downwardly facing racks **82**, **82** formed integrally therewith and extending along opposite sides of and beneath said shaft **43**. Said racks mesh with a pinion **83**, herein shown as being formed integrally with the inner end of a transverse shaft **84**, journaled in the housing **36** and extending outwardly beyond the side plate **64** of said housing. The outer end of said shaft may be squared to receive a hand crank (not shown). An index plate **85**, which may indicate the position of said block **79** and the vertical elevation of the roller **72**, is secured to said shaft on the outside of said side plate **64** and is held thereto as by a nut **86** threaded on said shaft.

A hold-down roller **101** freely rotatable about a transverse axis and disposed just above the thinning roll **72** between the feeding and anvil rolls **65**, **65** is engageable with the top of the web **11** of the strip material to hold the strip down into engagement with the shoulders **70**, **70** of the anvil rolls **65**, **65** during the feeding and thinning operation. Said hold-down roller is herein shown as being mounted between the furcations of an arm **103** on transverse shaft **104** for free rotation with respect thereto (Figures 5 and 7). Said arm is pivotally mounted intermediate its ends on a rock shaft **105** mounted at its ends between laterally spaced upright sides of a trunnion support **106** mounted on the table **35**.

The trunnion support **106** has a recessed central portion **107** opening toward the ground and having a guide member **108** slidably guided therein and forming a subtantially U-shaped guide (not shown) engaging the inside of the strip and forming a slidable guide therefor. Said guide member extends well into the nips between the rollers **72** and **101** for guiding the strip into the nips between said rollers and the anvil rollers **65**, **65**. A retaining plate **109** is also mounted in said recessed central portion of said trunnion support for engagement with the top of the strip. Compression springs **110**, **110**, mounted in said recessed portion, are interposed between said recessed portion and the top of said retaining plate to yieldingly engage said plate with the top of the strip.

The guide member **108** has an inclined bottom (not shown) and rests on the inclined surface of a slidable adjusting block **111** adapted to adjust the elevation of said guide. Movement of said block is effected by means of an adjusting screw **112** threaded in the trunnion support **106** and locked in position with respect thereto by a lock nut **113**. Said block has an outer upright portion **114** through which the screw **112** extends. Collars **115**, **115** on said screw abut opposite sides of said upright portion to effect movement of said block upon rotation of said screw.

The trunnion support **106** is slidably mounted on the table **35** for transverse movement with respect thereto to afford a means for adjusting the guide member **107** and hold down roll **101** in alignment with the nips between the rolls **65**, **65**. Said trunnion support is guided in a channelled guide **116** extending across the table **35** and is moved along said guide or is held in fixed relation with respect thereto by means of adjusting screws **117**, **117** engaging opposite shouldered portions of said trunnion support and mounted in lugs **118**, **118** mounted on and extending upwardly from said plate.

The end of the arm **104** opposite from the hold-down roll **101** has an adjusting screw **119** threaded therein and engaging the top surface of a member **120** having a substantially U-shaped guide **121** extending longitudinally therealong in alignment with the guide extending along the guide member **108**. A lock nut **122** is provided to lock said adjusting screw and arm **104** in position.

The member **120** has an upwardly extending bifurcated forward end portion **123** having a gear **124** mounted between the furcations thereof on a transverse shaft **125**, journaled in said upright portion. The teeth of said gear mesh with the slots **12** formed in the web of the strip **14** to rotatably drive said gear and to drive the stroboscopic disk **26** at the speed of travel of the strip, as will hereinafter more clearly appear as this specification proceeds.

A guide member **126** in alignment with the nips between the thinning roll **72** and hold-down roll **101** is provided at the discharge end of said rolls to guide the strip as it leaves said rolls and enters the induction heating unit **18**. Said guide member is mounted at the discharge end of the table **35** and has a depending flange **127** extending downwardly along the edge of said table and retained thereon by means of retaining bolts **128**, **128** threaded within said table and extending through downwardly opening slotted portions of said flange to permit vertical adjustment of said guide with respect to said table. The bottom surface of said guide is inclined and rests on the inclined top surface of an adjusting block **129** mounted for adjustable movement across said table. Said block is moved transversely of said table or is held in fixed relation with respect thereto to adjust the elevation of the guide member **126** by means of a threaded adjusting screw **130** threaded within a lug **131** projecting upwardly from said table and locked in position on said table by a lock nut **132**.

Two plates **133**, **133** are slidably mounted on the top surface of the guide member **126** for movement toward and from a guide rib **135**, forming a slidable guide for the strip. Said plates are adapted to slidably engage the outer sides of the crown of the strip while moving along the rib **135** and are adjustably moved with respect to the strip by means of two parallel links **136**, **136** pivoted at their lower ends to the outer sides of said guide plates and engaged at their inner upper ends by a transverse reaction pin **137**. An adjusting bolt **138** extends through said links beneath said pin and has a collar **139** engaging the outside of one of said links and a washer **140** engaging the outside of the other link and held in engagement therewith by a spring **141**. Said spring is held in engagement with said washer by lock nuts **142** threaded on said bolt.

The drive to the stroboscopic disk **26** from the indexing gear **124** includes a coupling member **142** arranged to drive a transverse shaft **143** from the shaft **125**. Said transverse shaft **143** is journaled within a tube **144** and drives an upwardly inclined longitudinal shaft (not shown) within an inclined tube **145** through a miter gear drive (not shown). Another miter gear drive, including a miter gear **146** having drive connection with said disk **26**, is provided to drive said stroboscopic disk from said inclined shaft at the speed of rotation of said gear **124** (Figures 4 and 17). Said disk **26** is journaled on the upper end of a bearing support bracket **147** projecting upwardly from the frame **37**. A stationary quadrant **148** is mounted on said bearing support in advance of the disk **26**. Said quadrant has radial slits therein corresponding to the radial slits in said stroboscopic disk **26**.

It should here be noted that the teeth of the gear **124** meshing with the slots **12** of the strip **14** are spaced apart to uniformly mesh with said slots and be driven thereby at the lineal speed of the strip and correspond in number to the slots in the finished ring. The stroboscopic disk **26** is driven by said gear **124** and has the same number of radial slits therein as there are teeth on said gear. The function of said stroboscopic disk is to enable variations in speed between the draw mandrel **24** and said gear to be readily detected and corrected and to enable variations in length of the strip and travel of the freely rotatable measuring collar **21** to be readily detected when viewing the strip through said quadrant **148** and disk **26**. It should also be understood that variations in length of the strip and rotatable travel of the measuring collar **21** indicate that the crown segments **10**, **10** have been rolled either too much or too little, increasing or decreasing the length of the ring, as will more clearly appear as this specification proceeds.

Induction heating unit

The strip is pushed from the cold rolling mill by the anvil rollers **65**, **65** through a quartz tube **150** of an induction heating unit **17** where it is heated for hardening and hot finish working (Figures 4 and 5). Said induction heating unit may be of any form well known in the art and is no part of my present invention except insofar as it forms a means for heating the cold formed piston ring material for further treatment and includes generally the quartz tube 150 in alignment with the path of travel of the strip piston ring material as it leaves the anvil rolls 65, 65 and having induction coils of copper tubing wound therearound and indicated by reference character 151 through which high frequency alternating currents are sent to induce a current in the traveling piston ring material and heat it to the required temperature for hot finish rolling, coiling and hardening. The copper tubing 151 may be cooled by water flowing therethrough and conducted thereto for circulation therethrough as by pipes 152 connected to adapter coils 153 spaced at intervals along said tubing as shown in Figures 1 and 15. The strip when leaving the tube 150 passes between a pair of spaced anvil rolls 154, 154 of the hot rolling, coiling and quenching apparatus 19, which anvil rolls operate in cooperation with a thinning roll 155 engaging the inside of the crowns of the strip to pull the strip through the tube 150 for finish forming and further treatment.

Hot rolling apparatus

The hot working apparatus includes the anvil rolls 154, 154 rotatably driven by laterally spaced vertical shafts 156, 156 and mounted on the upper ends of said shafts. Said vertical shafts are both driven from the longitudinal shaft 43 of the cold rolling apparatus 16 through a coupling 157, longitudinal shaft 158, coupling 159, and a geared reduction drive like the geared reduction drives from the shaft 43 to the anvil rolls 65, 65 of the cold rolling apparatus, so not herein shown or described in detail. Said anvil rolls 154, 154 are also moved toward and from each other by means of threaded shafts 160, 160 having operative engagement with bearing blocks 161, 161 like the bearing blocks 59 and 60, and moving said bearing blocks 161, 161 toward and from each other in the same manner the bearing blocks 59 and 60 are moved toward and from each other (Figure 4). A hand wheel 162 is provided to effect adjustment of said anvil rolls through a geared reduction drive indicated generally by reference character 163 and similar to the drive for adjusting the anvil rolls 65, 65 toward and from each other, so is not herein shown or described (Figure 6).

A substantially U-shaped guide 164, closed at its top by a plate 165 and extending along the top of a housing 166 for the drive mechanism for said anvil rolls, is aligned with the center of the tube 150 and serves to guide the hot piston ring material from said tube between the anvil rolls 154, 154 into engagement with the thinning roll 155. It should be noted with reference to Figure 13 that the anvil rolls 154, 154 are shown as extending over the web of the strip material to hold it down while passing over the thinning roll 155 and are also recessed to substantially conform to the outer surfaces of the crowns and web of the piston ring material and to have supporting engagement with the bottoms of the crowns thereof.

The thinning roll 155 has opposite inclined working sides 167, 167 like the inclined working sides of the thinning roll 72 of the cold rolling apparatus and is mounted on a transverse shaft 168 journaled at its ends in blocks 169, 169 having inclined bottom surfaces resting on the inclined surface of an adjusting block 170 which may be rectilinearly moved to effect vertical adjustment of said thinning roll 155 in the same manner as said adjusting block 79, so the means for adjustably moving said block need not herein be shown or described in detail.

Gapping, coiling and quenching apparatus

From the anvil rolls 154, 154 and the thinning roll 155 the strip is gapped and formed into a spiral coil with the web thereof on the inside of the coil, and is at the same time quenched.

The anvil rolls 154, 154 push the strip onto a shoe 171ª having an entering end coming into close proximity to the thinning roll 155 and tangent to the path of travel of the outer edges of the crown segments of the strip as they leave said thinning roll. This shoe curves about a radius of curvature substantially equal to the cylinder bore and guides the strip in a curved upward path on the edges of the crowns. A roll 171 is mounted in a recessed portion 171ᵇ of said shoe 171ª and engages the inside of the crowns of the strip as the outer edges of the crowns are held in engagement with the curved surface of said guide shoe by an upper grooved roll 174. Said roll 174 engages the outside of the web of the strip and holds it in engagement with the curved guide shoe 171ª causing the crown segments to be pushed together by the feeding and anvil rolls 154, 154 to the position shown in Figure 1*c*, and also extends along the outsides of the crowns.

The lower roll 171 extends with a recessed portion 171ᵇ of the guide shoe 171ª, and the guide surfaces of said shoe extend along opposite sides of said roll beneath the periphery thereof. Said lower roll is journaled between the furcations of a bifuracted support arm 172 on a shaft 172ª. Said support arm extends along opposite sides of said shoe and is pivoted intermediate its ends to a carriage 173 mounted on and extending upwardly from the top of the housing 166. The arm 172 serves to adjustably move the roll 171 with respect to the shoe 171ª. Said shoe is slotted and the shaft 172ª passes through the slotted portions thereof and moves along said slotted portions during adjustment of the roll 171. The roll 171 serves to flatten the sides of the crown segments against the walls of the groove of the roll 174 and to eliminate saw-tooth edges on the sides of the crowns.

The grooved roll 174 is mounted above the lower roll 171 but closer to the feeding and anvil rolls 154, 154 than said roll 171 on a transverse shaft 175. The roll 174 engages the outside of the web of the ring and positively engages the thin outer edges of the crown segments with the curved surface of the shoe 171ª and forms a reaction means therefor, causing said crown segments to conform to said shoe and to be pushed together by the feeding rolls 154, 154 to substantially the form the ring will assume when in a cylinder, as shown on Figure 1*c*. The guide surface of the shoe at the discharge end of the roll 171 is rounded to curve outwardly and to provide a rounded end 171ᶜ over which the strip is bent backwardly to deform or open the slots between cross bars of the web. Rolls 176 and 179 are spaced to bend the strip back over said rounded end of said shoe to the form shown in Figures 14 and 1*d* and also to bend it back onto itself and coil it to cylinder size with uniform gaps between adjacent ends of said crown segments as shown in Figure 1*e*.

The roll 176 is journaled on a transverse shaft 177 mounted on the carriage 173 above and behind the rolls 171 and 174 for adjustable movement with respect thereto and engages the outer edges of the crowns of the strip and extends along opposite sides thereof. The cooperating roll 179 is likewise adjustably mounted on the carriage 173 above and behind the rolls 171 and 174 but in advance of the roll 176 and engages the outside of the web of the strip as the strip passes by the roll 176 in cooperation with said roll 176 in such a manner as to bend the strip back to cylinder size, leaving the proper gaps between the crown segments thereof, as shown in Figure 1*e*.

The rolls 176 and 179, in bending the strip to cylinder size, after bending it backwardly over itself, spirally coil the strip about the shaft or arbor 20, in substantially the form the finished ring will assume when free, with uniformly spaced gaps between the adjacent edges of each crown segment. Said shaft 20 extends transversely of the path of travel of the strip through the cold and hot rolling apparatus and serves to convey the strip in the direction of the axis of the coil for further treatment.

Adjustment of the roll 171 is effected by a worm 181 on the lower end of a vertical shaft 182, journaled in said carriage. Said worm meshes with a worm segment 183 on the opposite end of the arm 172 from the roll 171. Said arm 172 is transversely pivoted on the carriage 173 intermediate its ends on a rock shaft 184. The worm shaft 182 may be turned by the operator by means of a hand wheel 185 on the upper end of said shaft.

In a like manner adjustment of the guide roll 174 toward and from the roll 171, to vary the pressure of the edges of the crown segments against the curved surface of the shoe 171ª, is effected by means of a worm 186 on the end of a longitudinal shaft 187. Said worm meshes with a worm gear segment 188 on the upper end of a pivoted arm 189 having the shaft 175 mounted thereon. A hand wheel 190 on the outer end of said shaft is provided to turn said worm. The guide roll 179 is journaled on a crank 191 pivotally mounted in the carriage 173 on a shaft 192 for adjustable movement toward and from the roll 176 (Figure 14). A worm gear segment 193 is secured to the opposite end of said shaft from said crank and is meshed with a worm 194 on a horizontal shaft 195 journaled in said carriage. A hand wheel 196 on the outer end of said shaft is provided to turn said worm and effect adjustment of said roll.

The roll 176 on the shaft 177 may be adjustably moved toward and from the guide roll 179 in a similar manner by turning the knurled upper end of a vertical shaft 197.

The strip may be quenched by water, oil or any other suitable medium to harden it as it leaves the rolls 171 and 174 and is being bent back on itself over the rounded end 171^c. As herein shown, a passageway 200 is provided in the arm 172 for this purpose. The passageway 200 leads to the recessed portion 171^b in which the roll 171 is mounted, to quench the strip as it passes beyond said roll. Suitable piping for the quenching medium may be connected to the passageway 200 to spray and quench the strip during the gapping operation.

Gauging apparatus

The gauging apparatus includes the shaft or arbor about which the strip is coiled by the rolls 171, 174, 176 and 179 during the gapping operation. Said shaft is hollow and is mounted on and extends from a hollow shaft 203 journaled in a bearing support member 204^a extending upwardly from the frame structure 37 (Figures 17 and 19). Said hollow shaft 203, besides having the shaft 20 mounted thereon, likewise has the mandrel 24 of the draw furnace 25 mounted thereon and rotatably driven thereby. A vertically extending support plate 204 mounted on and projecting upwardly from the frame structure 37 at the discharge end of the shaft 20 and the receiving end of the draw furnace affords a support for said shaft 203 intermediate its ends and for the discharge end of the shaft 20 and receiving end of the mandrel 24. Said plate also forms a mounting for a stationary guide means 205 for guiding the spirally coiled piston ring material from the shaft 20 to the mandrel 24 of the draw furnace (Figures 17 and 19).

The hollow shaft 203 is driven from a motor 207 mounted on the frame structure 37 beneath the hot rolling apparatus 19 and herein shown as being a well known form of electric motor (Figure 4), the speed of which may be varied to adjust the speed of the draw furnace mandrel 24 to the speed of the rolling mill. The drive from said motor to said hollow shaft includes a spur geared reduction drive 209 and a chain and sprocket drive 210 driven therefrom and connected to rotatably drive said hollow shaft. Cooling fluid such as water may be supplied from a pipe 211 through the hollow center of said shaft 203 to maintain the temperature of said draw furnace mandrel 24 to the required temperature (Figure 19). This cooling fluid may drain from the end of said shaft 203 and mandrel 24 into a pan 212 beneath the end of said mandrel and supported on and extending along a frame structure 213 at right angles to the frame structure 37 and forming a right angled continuation thereof (Figure 17).

Variations in travel of the measuring collar 21 and in speed of shaft 20 may be detected by viewing said collar and shaft through the quadrant 148 and stroboscopic disk 26 rotating at the speed of the gear 124. As shown in Figure 17, a bracket 217 extends rearwardly from the support 147 and quadrant 148 and has a light 218 mounted thereon and arranged to project a beam of light through the slits in said quadrant 148 and rotating disk 26 to a mirror 219 mounted on and disposed above and in advance of the plate 204. Said mirror is so positioned as to direct or project the beam of light from said light 218 to indicating marks 215 on the shaft 20 and 214 on the measuring collar 21 to enable variations in travel between said shaft and the gear 124 and also between said shaft and the measuring collar 21 to be readily detected by the naked eye.

The shaft 20 is provided with a plurality of equally spaced indicating marks 215 therearound and extending parallel to the axis thereof and the same in number as the slots in the stroboscopic disk 26. This is to determine the speed of the shaft 20 with respect to the gear 124 and the cold and hot rolling mills 16 and 19. Since the flashes of light projected on the marks 215 are at the same frequency as the meshing of the teeth of the gear 124 with the slots of the web 12, the speed of said shaft 20 will be at the speed of the gear 124 if the marks 215 appear to stand still. If they appear to advance, the draw mandrel is turning faster than said gear; and if they appear to back up, said mandrel is turning slower than said gear. The speed of said mandrel may be adjusted by adjusting the speed of the motor 207 driving said mandrel.

The indicating collar 21 is journaled on the shaft 203 at the discharge end of the shaft 20 on a ball-bearing 208 on the hollow shaft 203. Said indicating collar extends partially over the discharge end of the shaft 20 and has the marks 214 spaced at equal intervals on the vertical face thereof. The outside diameter of said indicating collar is slightly smaller than the outside diameter of the draw mandrel 24 and is such that it will measure out the correct amount of strip during each revolution to make one ring less the width of one cross bar of the web of the strip, which is the amount the ring is stretched on the draw mandrel 24, plus the thickness of the cut-off wheel of the cut-off device 33.

The draw arbor 24 is smaller in diameter than the diameter of the finished ring, causing the ends of the ring to overlap when cut off on a slightly larger arbor. Also, in order to insure that the draw mandrel be touched by each cross bar of the web to short out into the mandrel any induced current set up in the ring and to avoid soft sections in any portion of the ring which might not touch said mandrel, the spiral ring material is stretched on said mandrel. This slightly widens the gaps between the segments and requires that part of the gaps be put in the ring at the gapper and that the balance be put in when the material is coiled on the draw mandrel.

The spiral piston ring material is trained from the shaft 20 around the measuring collar 21 through the guide means 205, as will hereinafter more clearly appear. The slots 12 of the strip are meshed with and the cross bars thereof engage the teeth of a gear 216 mounted at the entering or receiving end of the mandrel 24. The indicating marks on said collar and mandrel are the same in number as there are teeth on the indexing gear 124 and radial slits on the stroboscopic disk 26, and the second function of said disk is to indicate if the metal is being properly rolled to length. The gear 216 also has the same number of teeth as the indexing gear 124 and the teeth thereof are tapered to pick up and mesh with the slots 12 of the piston ring material, and where the slots of the web are not spaced regularly will either spread the web and spaces between the crown segments or close them up. This is possible because the ring material is so slotted and slit that it is a spring in construction and is not so hard after quenching but what it will spring a certain amount, thus assuring that there is no piling up or failure of the gear 216 to mesh with the slots 12, 12. Thus, if the crown segments 10 are properly thinned to give the correct angle of inclination to the edges thereof, the slots 12 will uniformly mesh with the teeth of the gear 216 and the collar 21 will rotate at the speed of the shaft 20. If, however, the edges of said crown segments are not at the proper angle of inclination, the spaces between the crown segments will either be opened or closed as cross bars engage the teeth of the gear 216, causing the measuring collar 21 to increase or decrease its speed of rotation and indicating improper formation of the crown segments 10, 10.

The guide means 205 for guiding the strip around the measuring collar 21 and into mesh with the spur gear 216 and onto and along the draw mandrel 24 and coiling and stretching it thereon in the form of a spiral coil and feeding it therealong by rotation of said mandrel, includes a grooved guide roller 224 directed at the helix angle of the strip as it travels along the collar 21. Said guide roller is mounted on the lower end of an arm 225 on a shaft 226. Said arm 225 is pivotally mounted intermediate its ends on the advance side of the plate 204 above said collar on a rock shaft 227 mounted in and extending from said plate in the same axial direction as the shaft 20. A tension spring 228 is connected between said plate and the upper end of said arm 225 to urge said guide roller 224 into engagement with said collar 21. A segmental plate 229 is mounted on the advance side of the plate 204 and extends partially around and within an apertured portion 230 of said plate 204 at the entering end of said plate and has a bearing member 231 mounted therein and supporting the shaft 203 and the receiving end of the mandrel 24 on said plate 204. A guide member 232 is secured to the advance face of said segmental plate and extends outwardly therefrom to a position adjacent the collar 21 beneath a horizontal line extending through the center thereof to initially guide the strip onto and around said collar and into the groove of said roller 224. From thence the strip passes entirely around said measuring collar 21 in a spiral path and inside of a guide 234 on its next time around said collar. Said guide is secured to the advance face of said plate 204 adjacent but spaced closer to said plate than the roller 224, a distance determined by the angle of the spiral of said strip as it travels about said collar 21. The free end of said guide 234 terminates adjacent said collar for guiding the strip therearound and across the bearing member 231 into an inwardly opening grooved spiral guide 235 encircling the gear 216 and the advance end of the mandrel 24.

The spiral guide 235 serves to guide the slots 12 in the web of the piston ring material into mesh with the teeth of the gear 216 and onto the mandrel 24. Said spiral guide is formed on the inner periphery of an annular guide member 236 secured to the opposite side of the plate 204 from the segmental plate 229 and extending within the open portion of said plate 204.

A key 237 is mounted in and extends along the drawing mandrel 24 in alignment with one of the teeth of the spur gear 216 and projects from the face of said mandrel a distance equal to the distance the teeth of said gear 216 extend from the face of said mandrel. Said key is adapted to engage certain of the slots 12 in the web 11 of the spirally wound piston ring material to have driving engagement therewith for its entire length of travel along said mandrel and to maintain the strip in tight engagement with said mandrel and feed it onto an aligned conveyor shaft 238 extending from said mandrel to the receiving end of the grinding mandrel 29.

When starting the apparatus, after the leading end of the piston ring material has been gapped and coiled around the shaft or arbor 20 by the rolls 171, 174, 176 and 179, the strip may be trained by hand around the measuring collar 21, past the guide 232 under the roller 224 and past the guide 234 across the plate 204 and into the spiral guide 235 into mesh with the teeth of the gear 216, it being understood that once the piston ring material is trained into mesh with the teeth of the gear 216 it will continue to be fed onto and along the mandrel 24 as long as the apparatus is in operation and until the tailing end of the strip passes through said spiral guide.

It should be noted that the length of a piston ring measured on its periphery may vary because of two things. One is due to variations in the width of the gaps between the crown segments. The second is due to variations in the amount the crown segments are thinned, giving them a greater or lesser length.

It is important that the gaps between the adjacent edges of the crown segments be the same since the gaps are the same as the spaces between the coils of a compression spring. To maintain a uniform wall pressure in the cylinder, the gaps must be uniform and held to a close limit. This is attained by the gapper and coiling apparatus consisting of the shoe 171ᵃ and the rolls 171, 174, 176 and 179 previously described.

Therefore, if the gap be held constant, it is only necessary to change the amount each ring is rolled or thinned to change the length of the ring. This is attained by adjustment of the thinning roll 155 while the machine is in operation.

As the thinned piston ring material is trained around and turns the measuring collar 21, said collar measures out the exact amount of material to be coiled on the draw mandrel 24 for one complete ring less one cross bar of the web, which is the amount the ring is stretched on said mandrel, plus the thickness of the cut-off wheel of the cut-off device 33. In this amount of material there should be the same number of cross bars or slots 12 as teeth in the gear 216, indicating marks on the collar 21, and teeth in the gear 124. When this is the case, the indicating marks 214 will appear to stand still, indicating that the rings are being made to the right length with the right amount of stock in the crown segments and with uniformly spaced gaps between said crown segments. If the marks 214 appear to move forward, the indication will be that too much material is passing over the collar 21 to make the ring the right length. As the gaps between the segments are constant, this increase in length can only be caused by the metal being rolled too thin, stretching the space between the cross bars by amounts equal to the increased lengths of the segments. It is understood that the gaps between the segments are made uniform in the gapping and coiling apparatus and that the increase in length is caused by springing of the ring and lengthening of the spaces between the cross bars thereof as they are engaged by the teeth of the gear 216. If the ring is not rolled enough, the marks 214 will move backward and the collar 20 will not make one complete turn by the time the same number of cross bars between the slots 12 have passed over it.

Draw furnace

The draw furnace 25 may be a well known form of induction furnace and is only shown diagrammatically in Figure 1 since it is no part of my present invention except insofar as it serves to perform a step in the manufacture of the piston ring. Said draw furnace, as herein shown, includes an induction coil 239 encircling a portion of the length of the mandrel 24. Said coil may be copper tubing through which water may be circulated to prevent the coil from heating. Very high frequency alternating currents are sent through said coil and induce sufficient current in the coiled strip stretched on and traveling along the draw mandrel 24 so that each cross bar thereof is in engagement with said mandrel to short out into said mandrel any induced current set up in the ring material by the high frequency current in the induction coil 229. This induced current is so great that if it builds up through two sections whose cross-overs are not touching the arbor, it will draw these two sections soft. This high frequency current heats the strip to such a temperature that it will be tempered when cooled in air as it travels along said mandrel, said temperature generally being from 600° to 680° F. The mandrel 24 of the draw furnace may be made from a heat-resistant material or may have a layer of Stellite or some other such material deposited thereon to enable said mandrel to withstand the temperature of the drawing operation.

The piston ring material stretched into tight engagement with the draw mandrel 24 of slightly smaller diameter than the finished ring acquires its set during the drawing or tempering operation and sets to the diameter of said mandrel. This will cause the ends of the ring to overlap when cut off on a slightly larger arbor or gear, and the overlapping ends thereof when butted together in a piston and cylinder of an engine cause the ring to conform to the walls of the cylinder.

Conveyor

The conveyor for transferring the strip from the draw furnace 25 to the grinder 30 comprises the conveyor shaft 238 resting on and driven by the mandrel 24 and extending therefrom in the same general direction as said mandrel (Figures 17 and 22). Said conveyor shaft is herein shown as being a tube closed at its advance end by a plug 240 having a frusto-conical engaging surface 241 projecting therefrom and resting on and driven from a corresponding recessed surface 242 of a tapered drive member 243 mounted in the end of said mandrel 24 and extending therefrom.

Said members 243 and 240 and their companion frusto-conical engaging surfaces 242 and 241, respectively, thus form a friction drive from the mandrel 24 to the conveyor shaft 238, the speed of rotation of which conveyor shaft may be varied by varying the location of the frusto-conical surface of said plug 240 with respect to the recessed drive surface 242. This arrangement forms a simple variable speed drive for driving two aligned members at variable speeds and is particularly adapted to drive a driven member of considerably smaller diameter than the driving member from the driving member at the peripheral speed of the driving member. In the form of my invention shown herein it is preferable that the peripheral speed of the conveyor shaft 238 be substantially the speed of rotation of the mandrel 24 so the spiral piston ring material may be progressed along said conveyor shaft at a substantially uniform speed.

The opposite end of the conveyor shaft 238 from the drive member 243 is rotatably mounted on a ball-bearing 244 mounted on a stub shaft 245, herein shown as being formed integrally with and projecting from the end of a coupling member 246 (Figure 23). The races of said ball-bearing are of an arcuate form, the arc of which is herein shown as being struck from the longitudinal center of the stub shaft to permit pivotal movement of said conveyor shaft 238 about said stub shaft and about an axis extending transversely to the axis of rotation of said conveyor shaft. This allows the conveyor shaft 238 to rest on and be driven from the drive surface 242 of the drive member 243 when in various positions therealong. This also permits relative movement of the coupling member 246 with respect to the mandrel 24 in a direction transversely of the axis of said conveyor shaft. The coupling member 246 is herein shown as mounted on a boss 247, the inside of which forms a bearing support for a shaft 249 projecting from the arbor 29 of the grinding mechanism 30. Said coupling member 246 may be held in position on said boss 247 by means of set screws 250 threaded thereon and engaging said boss, and may be moved along said boss and secured thereto at various positions therealong to vary the speed of said conveyor shaft 238 and enable it to be driven from said mandrel 24 at the desired speed.

Grinding fixture

The grinding fixture includes the grinding mandrel 29 supported at one of its ends in the boss and bearing suport 247 and journaled at its opposite end in a bearing support member 251 on a ball-bearing 252. Said mandrel is herein shown as being driven from a motor 253 mounted on a table 254 of the grinder 30, as shown in Figure 1. The drive from said motor to said arbor includes suitable reduction gearing (not shown) and a shaft 255 driven therefrom and extending transversely of the axis of said mandrel. A worm 256 is keyed on said shaft and meshes with a worm gear 257 keyed on the stub shaft 249.

The end of the mandrel 29 adjacent the shaft 249 and worm gear 257 is shouldered as indicated by reference character 259. A spur gear 260 similar to the spur gear 216 and having fewer teeth than said spur gear 216 is mounted on and secured to said shouldered portion 259 of said mandrel for rotation therewith. The pitch circle of the teeth of said spur gear 260 is substantially equal to the outside diameter of said mandrel 29, and the teeth thereof are adapted to engage and mesh with the slots 12, 12 of the piston ring material and progress and stretch it onto said mandrel in a spiral path in much the same manner that the gear 216 progresses and stretches the material onto the draw mandrel 24.

The mandrel 29 has an outside diameter equal to the inside diameter of the piston ring ground to cylinder bore size. The number of teeth in the gear 260 is determined by the number of teeth required to mesh with the slots 12 in the web of the piston ring material to stretch the coil so it will tightly cling to said mandred and counteract the tendency of the grinding wheel to pull it off the mandrel, and are fewer in number than the teeth of the gear 216. This spaces the teeth of the gear 260 further apart, causing the ring to stretch as the slots 12, 12 come into mesh therewith. A key 263 extends along said mandrel 29 in alignment with one of the teeth of said gear 260 and, like the key 237, is adapted to engage certain of the slots of the piston ring material and hold it in tight engagement with said mandrel and rotatably drive said piston ring material. A stationary spiral grooved guide 264, like the spiral guide 235 and formed on the inside of an annular guide member 265, encircles a portion of the gear 260 and the entering end of the mandrel 29 for guiding the strip piston ring material into mesh with said gear and causing it to progress along said mandrel 29 by relative movement of said arbor and gear with respect to said guide.

In initially starting operation of the grinder 30 the strip traveling along the conveyor shaft 238 is trained from said shaft over the coupling 246 in a spiral path and into the entering end of the spiral guide 264 to mesh with the teeth of the gear 260. The mandrel 29 may then be rotatably driven to progress the entering end of the strip through said spiral guide and into mesh with the key 263 and stretch and spirally coil it around said mandrel in tight engagement therewith. Since the teeth of the gear 260 meshing with the slots 12 of the strip piston ring material are fewer in number than the teeth of the gears 124 and 216 and thus are spaced further apart, the strip piston ring material will be stretched when meshing therewith and when engaged with the key 26 and will be fed along the grinding mandrel 29 in tight engagement therewith. The piston ring material thus advances along said grinding mandrel at the circumference it will assume in the piston and is ground to the bore of the cylinder by means of a grinding wheel indicated generally by reference character 267 (Figures 1 and 27).

It should here be noted that the ring stretched on the mandrel 29 does not change its diameter because the stretch is taken up by the slots or spaces between the cross bars, and the crown segments of the ring do not change. Therefore, the peripheral diameters of all segments of the ring are the same, whether the ring is stretched or compressed, and since each segment is ground to cylinder size, the ring will bear against the cylinder wall with a perfect fit when the segments are shoved together in a cylinder. The spring temper in the rings causes them to retract after coming off the arbor and to assume their original diameter with the gaps properly spaced.

Grinder

The grinder 30 may be of any form well known to those skilled in the art and is herein shown as being a centerless grinder of a well known manufacture, so need only be shown and described herein in sufficient detail as is necessary to make my present invention readily understandable. The grinding wheel 267 is rotatable about a fixed axis of rotation and driven by a motor 268 mounted on a base 269 of the grinder by means of a V-belt drive indicated generally by reference character 270. The boss and bearing support 247 and the bearing support 251 for the mandrel 29 are mounted on and extend upwardly from the table 254 which is slidably guided on a base plate 270 for adjustable movement toward and from the grinding wheel 267. Said table is herein shown as being guided on said base plate by dovetail guides 271 formed on opposite sides of said base plate and opposite engaging depending portions of said table to permit the work to be moved into or out of engagement with said grinding wheel 267, as is well known to those skilled in the art.

Adjustment of the table 254 along the base plate 270 is effected by means of a threaded shaft 273 threaded in a lug 274 projecting upwardly from the top of the table 254. Said shaft is journaled in a bearing sleeve 275 (Figures 24 and 25) and said bearing sleeve is mounted in a block 276 which in turn is slidably mounted in a support member 277 secured to and projecting upwardly from the top of the base plate 270. A collar 278 on said shaft extends within and abuts a shouldered inner portion 279 of said block and also abuts one end of the bearing sleeve 274 (Figure 25). A flange 280 on the hub of a hand wheel 281, secured to the outer end of said shaft 273, abuts the outer end of said block and sleeve.

A quick retracting means is provided to move the work and mandrel 29 away from the grinding wheel 267, the instant the machine is stopped. This means includes an eccentric shaft 284 extending through a transverse slot 285 formed in the block 276 and having opposite enlarged coaxial ends 286 and 287 eccentric of the center of said shaft and journaled in bearing sleeves 288—289, respectively, mounted in the support member 277 (Figure 26). A lever arm 290 is secured to the end 287 of said shaft and has the upper end of a link 291 pivotally and slidably connected thereto by means of a pivotable pin 292. The lower end of said link is secured to the upper end of a piston rod 293 extensible from a fluid pressure cylinder 294. When the grinder stops for any reason, fluid under pressure is admitted to the head end of the cylinder 294 to extend the piston rod 293 therefrom and rock the lever arm 290. This will move the block 276 in a direction which in Figures 21 and 22 is shown as being to the left and will also move the table 254 and grinding arbor 29 in the same direction to move the work out of engagement with a grinding wheel 267. The control means for admitting fluid under pressure to and releasing it from the head end of the cylinder 294 may be of any well known form and is not herein shown and described since it is no part of my present invention.

Figures 27, 28 and 29 show a gauging means for gauging the accuracy of the grinding operation and to enable the operator to readily determine when the spiral ring material is being accurately ground to size. The gauging mechanism as herein shown includes a contact member 295 on one end of a pivoted arm 296 and having sliding contact with the outer periphery of the spirally coiled strip material 14. Said gauging member and arm may be mounted on an upright support member 297 secured to and extending upwardly from a cross bar 299 connecting the bearing support members 247 and 251 together. Said support member 297 is positioned near the discharge end of the mandrel 29 so as to mount the arm 296 and contactor member 295 to slidably engage the piston ring material after it has been ground. Said arm 296 is pivotally mounted intermediate its ends on a rock shaft 300 mounted at one of its ends in a bracket 301 secured to and extending to one side of said support member 297. A compression spring 303 encircling a bolt 304 having the end of said arm opposite from said contact member 295 slidably mounted thereon is interposed between said bracket member and arm to yieldably engage the contact member 295 with the spirally moving piston ring material. An indicating arm 305 extends at right angles to the arm 296 from a point adjacent the pivotal axis thereof and is herein shown as being formed integrally therewith. Said indicating arm has a rounded or substantially ball-shaped outer end 306 having slidable engagement with the adjacent, arcuately formed outer ends of plungers 307, 307. Said plungers may be slidably mounted in casings 309, 309 for micro switches (not shown) for operating said switches. The casings 309, 309 are each mounted on a plate 310 having a dovetail guide 311 formed integrally therewith. Said guide is guided within a corresponding guide formed in an inclined plate 312 and retaining guides 313, 313 secured thereto. Said inclined plate 312 forms an upper continuation of the support 297. Adjusting screws 314, 314 are rotatably connected to opposite ends of said plate 312 and are threaded in lugs 315, 315 projecting outwardly from the plates 310, 310 in an opposite direction from the casings 309, 309. Lock nuts 316, 316 threaded on said adjusting screws are provided to hold said casings in the desired position of adjustment with respect to the indicating arm 305. The micro switches in the casings 309, 309, operated by the plungers 307, 307 and indicating arm 305, may be connected in electric circuits to turn on lights of different colors which indicate when the ring is being ground to size or when it is being ground under-size or over-size. For instance, a white light may light when the ring is being ground to size, a green light may light when the ring is being ground over-size and a red light may light when the ring is being ground under-size. Said micro switches and the circuits therefrom are no part of my present invention, so need not herein be shown or described in detail.

The bearing support 251 supporting the discharge end of the mandrel 29 is shown in Figure 23 as having an integrally formed sleeve portion 317 projecting therefrom on which is mounted a sleeve 319 (Figure 23). Said sleeve 319 extends beyond the end of said sleeve portion 317 and may be secured to said sleeve portion 317 by means of a set screw 320. A ball-bearing 321 mounted within said sleeve 319 forms a bearing support for a recessed drive member 322 having a recessed frusto-conical supporting surface 323 having driving engagement with and being driven from the squared end 324 of a stub shaft 325, herein shown as being formed integrally with and projecting from the mandrel 29.

A conveyor shaft 326, herein shown as being of a tubular form like the conveyor shaft 238, is closed at its end adjacent the drive member 322 by a plug 327 having a frusto-conical engaging surface 328 supported on and driven from the recessed surface 323 of said drive member 322 (Figure 23). Said conveyor shaft 326 may be driven from the drive member 322 at the peripheral speed of the mandrel 29 and is supported and journaled at its discharge end on a supporting member 329 of the cut-off mechanism 33 in much the same manner the discharge end of the conveyor shaft 238 is supported on the boss 247 of the grinder 30 to permit lateral movement of said conveyor shaft with respect to said drive member 323 and to permit adjustment of said shaft along its axis to vary the speed thereof (Figure 33). Said supporting member is herein shown as being of a goose-neck formation and is curved upwardly and over a drive shaft 330 for the mandrel 34 of said cut-off mechanism 33, herein shown as extending at right angles to said conveyor shaft 326. The free end of said supporting member is mounted in an up-

right bracket member 331 extending upwardly from a table 333 of said cut-off mechanism 33 and is secured thereto as by a machine screw 334 extending through said bracket and threaded in said support member. Said support member, besides supporting the discharge end of the conveyor shaft, also serves as a transferring guide for the spirally coiled traveling strip as it travels from the conveyor shaft 325 onto the arbor 34 of the cut-off mechanism extending at right angles to said conveyor shaft, as will hereinafter more clearly appear as this specification proceeds.

Cut-off mechanism

The cut-off mechanism as shown in Figures 30 to 40 includes generally a casing 335 mounted on legs 336 forming a part of the frame structure 213. A cut-off wheel 337, herein shown as being a thin disk of abrasive material, supported between two circular retaining and back-up plates 339, 339 and rotatable about an axis perpendicular to the axis of the cut-off mandrel is provided to periodically cut the spiral piston ring material into rings of uniform length. Said retaining plates 339, 339 are mounted on the tapered end of a shaft 340 and are secured thereto by a nut 341 threaded on the end of said shaft and abutting the outer of said back-up plates 339, 339. Said shaft 340 is suitably journaled in a bearing bracket 343 secured to and extending upwardly from the casing 335. The drive to said shaft and cut-off wheel is herein shown as being a V-belt drive 344 connected with and driven from a motor 345 mounted on and depending from the bottom of the casing 335 (Figures 30 and 31).

When initially setting up the machine for cutting the finished strip piston ring material into rings of uniform length the leading end of the strip is trained from the underside of the conveyor shaft 326 to the underside of the cut-off mandrel 34 extending at right angles to said conveyor shaft and into engagement with a spiral guide rib 346 extending inwardly from an annular guide member 347. Said rib is adapted to engage the space between the crowns of the strip and guide the strip along the teeth of a gear 349 forming a part of said mandrel and extending therealong to the discharge end thereof (Figure 34).

The gear 349 is like the gears 124, 216 and 260 and has one more tooth than the gears 124 and 216. The diameter of said gear is thus increased by the amount of the pitch of one tooth to cut the strip to such a circumference as will compensate for the portion cut by the cut-off wheel 337, with a slight overlap between the ends of the ring when free, so the severed ring will be a closed ring conforming to the bore of the cylinder when in the piston and cylinder of an internal combustion engine.

It should be understood that the strip piston ring material is originally trained into engagement with the spiral rib 346 of the annular guide member 347 and into mesh with the teeth of the gear 349 by hand, and that thereafter the strip travels along said spiral rib of its own accord upon relative movement of said gear with respect to said guide. The mandrel 34 and gear 349 are intermittently driven by the shaft 330 through arcs of substantially 360° to advance the expanded spiral strip to be cut into rings of uniform length ready for use as oil rings in internal combustion engines, as will hereinafter more clearly appear.

After each cut-off operation the table 333 moves away from the cut-off wheel 337. It is at this time that the shaft 330 and mandrel 34 and gear 349 rotatably move to feed the strip for cutting off the next successive oil ring. Said table is then fed toward the cut-off wheel 337 to cut off the next successive ring, it being understood that during this feeding operation and during the cut-off operation said shaft 330, mandrel 34 and gear 349 are held from turning movement.

A vertical slot 350 is provided in the annular guide member 347 and a corresponding slot 351 is provided in the forward end of the mandrel 34 (Figures 33 and 34). These slots register during the cut-off operation to receive the cut-off wheel 337 when said mandrel is advanced there to sever the strip (Figure 34). The purpose of these slots in said guide member and mandrel is to afford a means for cutting off the spiral ring material while being held from lateral deformation by the spiral rib 39. After the ring has been cut off, as the mandrel returns to its retracted position, the severed ring falls from the end of said mandrel into an inclined chute 352 for discharge from the machine (Figure 30).

The table 333 is guided on opposite side walls of the housing 335 on shouldered guides 353, 353 and is retained thereon by retaining strips 354, 354 secured to the tops of said side walls and slidably engaging top shouldered portions of said casing. An irregular cam 355 on a vertical shaft 356 and engaged by a cam follower 357 is provided to extend or retract said table with respect to the cut-off wheel 337 upon rotation of said cam. Said cam is herein shown as being a downwardly opening groove formed in a circular disk 408 keyed on the vertical shaft 356 beneath the table 33 and rotatably driven thereby. Said groove is so formed as to effect movement of said table along said housing 335 with a relatively slow return stroke and a faster forward stroke and with dwells at the ends of the strokes (Figure 37).

The follower 357 is held from rectilinear movement by means of an adjustably movable bar 409 and is mounted thereon on the upper end of a vertical shaft 410 secured to and projecting upwardly from said bar. Said bar is slidably guided in a guide boss 411 extending inwardly from the rear end wall of the casing 335 and is held stationary during extensible and retractible movement of the table 333 by means of a threaded adjusting screw 413 rotatably connected to the outer end of said bar and extending therefrom. Said adjusting screw is threaded within a sleeve 414 held from rotation and mounted in an upright support lug 415 spaced outwardly from the casing 335 and herein shown as being formed integrally therewith. A hand wheel 416 is mounted on the free end of said shaft to rotate said shaft. The position of the follower 357 may thus be adjusted to regulate the depth of penetration of the cut-off wheel 337 into the slots 350 and 351 of the guide 347 and cut-off mandrel 34.

The shaft 330 and mandrel 34 are intermittently turned 360° upon retractible movement of the table 333 by means of a rack 358 meshing with a pinion 359 on a longitudinal shaft 360, coaxial with and operatively connected with the shaft 330 for rotating said shaft in one direction only through a one-way clutch 361 (Figure 32). Said rack is movable transversely of the table 333 and is mounted on the top of a yoke 362 guided for movement transversely of said table 333 in a transverse guide 363 formed in a housing member 364 secured to and projecting upwardly from the top of said table (Figures 32, 35 and 38). Said yoke has a downwardly opening transverse slot 365 formed therein engaged by a roller 366 mounted on the top of a rotatable disk 367 keyed to the upper end of the shaft 356. Rotation of said shaft 356 will thus reciprocably move said yoke 362 and rack 358 transversely of the table 333 along the guide 363 in an obvious manner.

The one-way clutch 361 is best shown in Figures 32 and 40 and includes a driving member 368 secured to and rotatably driven by the shaft 360 and a driven member 369 secured to the shaft 330 and having spring-pressed jaws 370 mounted therein and urged in the direction of the axis of rotation of said shaft. The outer ends of said jaws are inclined and are engageable with similar inclined notched driving surfaces 371 formed on the face of said driving member 368.

A brake means is provided to engage and hold the shaft 330 from rotation when the table 330 is moving toward the cut-off wheel 337 to assure that said shaft 330 is not rotated through the over-running clutch 365 upon advance or extensible movement of the table 333 and reversal of the direction of rotation of the shaft 360 (Figures 32 and 39). Said brake means, as herein shown, comprises two engaging shoes 373, 373 engageable with the shaft 330 and mounted on the inside of brake arms 374, 374 pivotally connected together adjacent their lower ends and to a support bracket 375 by means of a pin 376. Said arms have integrally formed upwardly projecting lugs 379, 379 through which a rod 380 passes. Said rod is mounted at its ends in threaded plugs 381 threaded within the housing 364 and is encircled by compression springs 382, 382 interposed between said plugs and lugs to yieldably engage said friction shoes 373, 373 with said shaft and hold said shaft from rotation except when positively driven in the desired direction through the one-way coupling 361.

The vertical shaft 355 is rotatably driven to advance and retractably move the table 333 and to intermittently turn the shaft 330 upon retractible movement of said table by means of a motor 383 mounted on a platform 384 beneath the casing 335 and supported by the legs 344 (Figure 30). Said motor is herein shown as being a well known form of electric motor and has driving connection with a transverse worm shaft 385 journaled within the casing 335 by means of a suitable geared reduction and V-belt drive indicated generally by reference character 386. The worm shaft 385 has a worm 387 keyed thereon meshing with and driving a worm gear 388 on a stub shaft 389 (Figure 36). Said stub shaft 389 is journaled at its free end in a ballbearing 391 mounted in a depending bearing bracket 392 and is herein shown as extending from and as being secured to a flanged drive sleeve 390. Said sleeve 390 is journaled in a bearing bracket 393 depending from the top of the casing 335 and is internally splined to slidably receive and drive a longitudinally extending splined shaft 394. Said splined shaft is journaled adjacent its end opposite said sleeve 390 in spaced ball bearings 395, 395 mounted in bearing supports 396, 396 depending from the bottom of the table 333 and secured thereto as by cap screws 397, 397. A worm gear 399 is secured to said shaft 394 between said bearings 395, 395. Sleeves 400, 400 are interposed between said worm and said bearings to transmit the thrust from said worm to said bearings and to effect rectilinear movement of said shaft with said bearings and table upon rectilinear movement of said table. The worm 399 meshes with and drives a worm gear 401 keyed to the vertical shaft 356 above a lower bearing 403 therefor mounted in a horizontal bearing support member 404 secured to the bottom of said right-angled ribs 405, 406 depending from the bottom of the table 333. Said vertical shaft is likewise journaled intermediate its ends on a ball bearing 407 mounted in the top of said table 333.

It may be seen from the foregoing that when the space between the crowns of the strip piston ring material 14 is in engagement with the spiral rib 346 and the slots 12 of the strip are in mesh with the teeth of the gear 349 and said strip has been progressed along said gear and mandrel 34 to a position across the aligned slots 350 and 351, the cutting disk 337, upon forward movement of the table 333, will register with the slots 350 and 351 and come in contact with and sever the strip piston ring material. The table will then travel in its return path, effected by the cam 355 and follower 357. At this time the rack 358 and pinion 359 will rotatably drive shaft 330 through the shaft 360 and one-way clutch 361 to rotate the mandrel 34 through 360° and advance a new length piston ring strip material into position to be cut off. Continued rotation of the cam 355 will then reverse the direction of travel of said table 333 and the direction of rotation of the shaft 360. This will cause said table 333 to again advance until the cut-off disk 337 is again in registry with the slots 350 and 351 to cut off another length of piston ring material, it being understood that during the advancing operation the shaft 330 does not rotate by virtue of the fact that it is driven from the over-riding clutch 362 and is held from rotation by the brake shoes 373, 373.

It should be understood that when initially setting up the machine the leading end of the strip is trained to its various operations and from one operation to the other by hand, that when the leading end of the strip has been trained around the mandrel 34 for the last cutting-off operation the operation of making the ring is continuous until the tailing end of the strip is reached, and that the operation of making the ring requires a minimum amount of controlling operations and when once set up to properly form the ring the operation may be continued with little attention until the end of the strip has passed through the apparatus except to vary the amount of rolling of the crown segments where the thickness of the strip may increase or decrease due to non-uniformity of the strip when originally rolled and that this is effected by raising or lowering the thinning roll 155.

It should further be understood that since the rings are formed from continuous strip material, when the stroboscopic disk shows the rings are too long or too short, caused by improper thinning of the crown segments which may be due to non-uniformity of the strip material, the thinning roll 155 may be adjusted to correct the inaccuracies and properly thin the strip without stopping the thinning operation, and that the improperly rolled portions of the strip will continue to pass through the apparatus and be cut into rings without interrupting the process, after which they may be rejected upon inspection. Non-uniform metal strip therefore causes no interruption in the process.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

I claim as my invention:

1. In a method of making oil piston rings from continuous flexible strip piston ring material having a web and connected parallel spaced slit crowns extending along opposite sides thereof, the improvement comprising working the insides of the crowns with a rolling action directed to thin said crowns toward their outer sides and lengthen the outer sides thereof and form said crowns in the form of segments of a circle, then coiling the material in the form of a spiral coil with the crowns extending outwardly from the web thereof, then grinding the outer peripheries of the crown segments to cylinder bore size in the form of arcs of a true circle, then expanding the spiral ring material to a diameter greater than its diameter when free, and then intermittently severing the spiral piston ring material into rings of uniform length.

2. In a method of making oil piston rings from continuous flexible strip piston ring material having a web and connected parallel spaced crowns extending along opposite sides thereof, the improvement comprising working the insides of the crown segments with a rolling action while cold directed to thin said crowns toward their outer sides and lengthen the outer sides thereof and form said crowns substantially in the form of segments of a circle, heating the strip, finish working the crowns while hot with a rolling action, gapping the strip by pushing the segments together while confined to cylinder bore size, then bending the strip back over itself and bending it in an opposite direction and coiling it in the form of a spiral coil with the crowns extending outwardly from the web thereof, then grinding the outer peripheries from the web thereof, then grinding the outer peripheries of the crown segments to cylinder bore size, and then intermittently severing the spiral material into rings of uniform length.

3. The method of making piston rings from flexible strip piston ring material having a web and parallel spaced slit crowns extending along opposite sides thereof perpendicular to said web, comprising the steps of longitudinally feeding the strip, thinning the crowns of the strip while cold toward their outer ends and lengthening said crowns to incline the opposite edges thereof to extend radially with respect to the finished ring, heating the strip to a working temperature while continuously traveling in a longitudinal direction, finish thinning the crowns of the hot strip, then gapping and coiling the strip into a spiral coil of cylinder bore size with the crowns thereof facing outwardly from the body thereof and at the same time quenching the strip while still hot from the hot working step, spirally feeding the strip along the axis of the coil thereof and stretching the spiral coil and grinding the outer peripheries at the crowns of the strip to cylinder bore size, and then intermittently severing the coil into rings of equal length.

4. A method of making piston rings from flexible strip piston ring material having a web and parallel spaced slit crowns extending from opposite sides thereof perpendicular to said web, comprising the steps of feeding the strip longitudinally, thinning the crowns of the strip toward their outer ends and lengthening said crowns to incline the edges thereof to conform to radial lines which if extended along said edges would extend through the center of the finished ring when compressed, heating the strip to a working temperature while traveling longitudinally and finish thinning the crowns of the hot strip, gapping the strip by confining it to cylinder bore size and pushing the crowns thereof together and reverse bending it and coiling it to cylinder bore size with the crowns thereof facing outwardly from the web thereof, rotatably feeding the strip in the form of a spiral coil along the axis thereof, stretching and heating the strip to a drawing temperature while so traveling and setting it during the drawing operation, grinding the outer ends of the crowns to cylinder bore size while traveling along the axis of the coil, and severing the expanded coil into rings of equal length.

5. The method of making piston rings from flexible strip piston ring material U-shaped in cross-section and having connected parallel spaced slit crowns extending along opposite sides of the web thereof, comprising the steps of feeding the strip longitudinally, thinning and lengthening the crowns of the strip toward the outer ends thereof to form the opposite edges thereof to conform to radial lines which if projected along said edges would extend through the center of the finished ring by rolling the insides of the crowns thereof, providing uniform gaps between adjacent ends of the crown by confining and compressing the strip to cylinder bore size, reverse bending it and coiling it into spiral coils of cylinder bore size with the crowns thereof facing outwardly from the body thereof, spirally feeding the strip along its axis and at the same time grinding the outer peripheries of the crowns to cylinder bore size, and then intermittently severing the strip into rings of equal length.

6. A method of making piston rings from continuous strip piston ring material U-shaped in cross-section and having connected parallel spaced slit crowns extending along opposite sides of the web thereof, comprising the steps of feeding the strip longitudinally, thinning and lengthening the crowns of the strip toward their outer ends to incline opposite edges thereof to conform to radial lines which if projected along said edges would extend through the center of the compressed finished ring by rolling the lower portions of the crowns with a rolling action diverging from the longitudinal center thereof toward the outer ends thereof, heating the strip to a working temperature while traveling in a longitudinal direction, finish thinning the hot strip by rolling the insides of the crowns with a rolling action diverging from the longitudinal center thereof toward the outer ends thereof, gapping the strip by pushing the crowns together, reverse bending the strip and then coiling the strip in the form of a spiral coil of cylinder bore size with the crowns thereof facing outwardly from the web thereof and at the same time quenching the strip, spirally feeding the strip along its axis, stretching the strip, and grinding the outer peripheries of the crowns to cylinder bore size while so stretched, and then intermittently severing the strip into rings of equal length.

7. In a method of making piston rings from flexible piston ring strip material of substantially U-shaped cross-section having connected parallel spaced slit crowns extending along opposite sides of the web of the strip, the steps of feeding the strip longitudinally, working the crowns of the strip with a rolling action while cold and thinning said crowns toward their outer sides and at the same time gradually lengthening the outer sides of said crowns to incline the opposite edges thereof to conform to radial lines which if extended would extend through the center of the finished ring, heating the strip to a working temperature while traveling along its axis and finish working the strip while hot with a rolling action, then quenching the strip while hot from the hot working step and coiling the strip into a spiral coil with the crowns thereof facing outwardly from the body thereof and rotatably feeding the spiral strip along its axis, stretching the strip a predetermined amount and continuing to feed the strip along its axis, gauging the accuracy in the formation of the radial edges of the crowns during the stretching operation by observing the uniformity of travel of the strip into a stretched condition, heating the strip to a drawing temperature while so stretched and allowing the strip to cool in air and set to its final form, then allowing the strip to contract while continuing to feed it along its axis and again stretching the strip and grinding it to cylinder bore size, and then intermittently severing the strip into rings of equal length.

8. In a piston ring making apparatus for producing flexible strip piston ring material having a central slotted web, the slots of which extend transversely thereof and are spaced therealong for the length thereof and having parallel spaced alternately slit crown segments extending along opposite sides thereof, a frame structure, a horizontal shaft journaled in said frame structure and adapted to have the strip spirally coiled therearound for movement therealong beyond one end thereof, means for driving said shaft, a collar at the discharge end of said shaft in axial alignment therewith and mounted for free rotation with respect thereto, a gear in axial alignment with said collar at the opposite end thereof from said shaft and driven at the speed of rotation of said shaft, said gear having a predetermined number of teeth adapted to mesh with the slots in the web of the strip, determined by the circumference of the completed ring when free, means for guiding the strip from said shaft around said collar, spiral guide means guiding the strip into mesh with the

teeth of said gear and causing said strip to advance along said gear by relative movement between said gear and guide means, indicia marks on said collar the same in number as there are teeth on said gear, corresponding indicia marks on said shaft, means enabling ready detection of relative movement between said indicia marks caused by improper meshing of the slots of the web with said gear with the resultant irregular travel of said collar including a stroboscopic disc having a plurality of radial slits spaced therearound the same in number as the indicia marks on said arbor and collar, and means for driving said disc at the speed of travel of the strip.

9. In an apparatus for producing flexible strip piston ring material having a central slotted web, the slots of which extend transversely thereof and are spaced therealong for the length thereof and having parallel spaced alternately slit crown segments extending along opposite sides thereof, a frame structure, a horizontal shaft journaled in said frame structure and adapted to have the strip spirally coiled therearound for movement therealong beyond one end thereof, means for driving said shaft, a collar at the discharge end of said shaft in axial alignment therewith and mounted for free rotation with respect thereto, a gear in axial alignment with said collar at the opposite end thereof from said shaft and driven at the speed of rotation of said shaft, said gear having a predetermined number of teeth adapted to mesh with the slots in the web of the strip determined by the circumference of the completed ring when free, means for guiding the strip from said shaft around said collar, spiral guide means guiding the strip into mesh with the teeth of said gear and causing said strip to advance along said gear by relative movement between said gear and guide means, indicia marks on said collar the same in number as there are teeth on said gear, corresponding indicia marks on said shaft, means enabling ready detection of relative movement between said indicia marks caused by improper meshing of the slots of the web with said gear with the resultant irregular travel of said collar including a stroboscopic disc having a plurality of radial slits spaced therearound the same in number as the indicia marks on said arbor and collar, means for driving said disc at the speed of travel of the strip including a gear journaled in said frame structure to mesh with the slots in the web of the strip and to be driven thereby, said gear having the same number of teeth as said first-mentioned gear, and a positive drive connection between said last-mentioned gear and disc.

10. In a machine for making slotted piston rings, a rotatable mandrel, power means for driving said mandrel at a predetermined speed, a gear mounted on said mandrel at the advance end thereof and having a predetermined number of teeth determined by the desired length of the piston ring and adapted to mesh with the slots of the piston ring material, and a spiral guide encircling said gear and extending over said mandrel and engaging the piston ring material and progressing the piston ring material along the teeth of said gear upon relative movement between said gear and guide and guiding the piston ring material from said gear onto said mandrel in the form of a spiral.

11. In a machine for making slotted piston rings, a rotatable mandrel, power means for driving said mandrel at a predetermined speed, a gear mounted on said mandrel at the advance end thereof and having a predetermined number of teeth determined by the desired length of the piston ring material and adapted to mesh with the slots of the piston ring material, a spiral guide encircling said gear and extending over said mandrel and opening toward said gear and mandrel and engaging the sides and outer periphery of the piston ring material and progressing the piston ring material along the teeth of said gear upon relative movement between said gear and guide and guiding the piston ring material from said gear onto said mandrel in the form of a spiral, and a key mounted on and extending along said mandrel and registering with one of the teeth of said gear and engaging certain of the slots of the piston ring material and holding the piston ring material from relative rotatable movement with respect to said mandrel and in tight engagement therewith, and cooperating with said spiral guide to progress the material along said mandrel to the end thereof opposite from said gear and spiral guide by relative movement between said mandrel and guide.

12. In a machine for making piston rings having a web with uniformly spaced transverse slots extending therealong and having alternately slit crowns extending from said web with opposite edges thereof beveled to conform to segments of a circle, a rotatable mandrel adapted to have the piston ring material coiled thereon and to progress therealong from one end to the other, said mandrel being of a diameter determined by the work to be performed on the piston ring material, a gear mounted on said mandrel at the advance end thereof and having a predetermined number of teeth determined by the diameter of said mandrel, an annular guide member having a stationary spiral guide encircling and extending along said gear and the advance end of said mandrel and facing said gear and mandrel, the teeth of said gear meshing with the slots in the web of the piston ring material and cooperating with said spiral guide to progress the material onto said mandrel in the form of a tightly coiled spiral upon relative movement between said gear and guide.

13. In a machine for making piston rings having a web with uniformly spaced transverse slots extending therealong and having alternately slit crowns extending from said web with opposite edges thereof beveled to conform to segments of a circle, a rotatable mandrel adapted to have the piston ring material coiled thereon and progressed therealong from one end to the other, said mandrel being of a diameter determined by the work to be performed on the piston ring material, a gear mounted on said mandrel at the advance end thereof for rotation therewith and having a predetermined number of teeth determined by the diameter of said mandrel, a stationary annular guide member encircling said gear and the advance end of said mandrel and having a spiral guide formed therein facing and encircling said gear at the advance end of said mandrel, said guide maintaining the slots in the web of the piston ring material in mesh with the teeth of said gear and cooperating with said gear to progress the material onto said mandrel in the form of a tightly coiled spiral, and a key mounted on and extending along said mandrel and projecting from the face thereof in alignment with one of the teeth of said gear for engagement with certain of the slots in the web of the piston ring material and cooperating with said guide to hold the material in tight engagement with and progress it along said mandrel.

14. In a cut-off device adapted to cut off individual oil piston rings of equal length from continuous strip piston ring material having a central web and parallel spaced slit crowns extending along opposite sides thereof, a frame, a cut-off wheel journaled on said frame for rotation about a fixed axis, a table mounted on said frame for rectilinear movement toward and from said cut-off wheel, means operable to continuously move said table toward and from said cut-off wheel, a mandrel journaled on said table for rotation about a horizontal axis, means for rotatably driving said mandrel a distance sufficient to feed the strip into position to have one ring cut therefrom during travel of said mandrel away from said cut-off wheel, means on said mandrel engaging the strip and coiling it therearound upon rotation thereof, and a spiral guide encircling said mandrel and so constructed and arranged as to advance the strip along said mandrel upon relative movement between said mandrel and guide and to cooperate with said mandrel and hold the strip from deformation during the cut-off operation.

15. In a cut-off device adapted to cut off individual oil piston rings of equal length from continuous strip piston ring material having a central web and parallel spaced slit crowns extending along opposite sides thereof, a frame, a cut-off wheel journaled on said frame for rotation about a fixed axis, a table mounted on said frame for rectilinear movement toward and from said cut-off wheel, means operable to continuously move said table toward and from said cut-off wheel, a mandrel journaled on said table for rotation about a horizontal axis, means for rotatably driving said mandrel a distance sufficient to feed the strip into position to have one ring cut therefrom during travel of said mandrel away from said cut-off wheel, means on said mandrel engaging the strip and coiling it therearound upon rotation thereof, a spiral guide encircling said mandrel and so constructed and arranged as to advance the strip along said mandrel upon relative movement between said mandrel and guide, and a cut-off wheel receiving slot formed in said guide and mandrel adapted to receive said cut-off

wheel during the cut-off operation, whereby said guide and mandrel may hold the strip from deformation during cutting of the strip into rings of equal length.

16. In a cut-off device adapted to cut off individual oil piston rings of equal length from continuous strip piston ring material having a central web and parallel spaced slit crowns extending along opposite sides thereof, a frame, a cut-off wheel journaled on said frame for rotation about a fixed axis, a table mounted on said frame for rectilinear movement toward and from said cut-off wheel, means operable to continuously move said table toward and from said cut-off wheel, a mandrel journaled on said table for rotation about a horizontal axis, means for rotatably driving said mandrel a distance sufficient to feed the strip into position to have one ring cut therefrom during travel of said mandrel away from said cut-off wheel, means on said mandrel engaging the strip and coiling it therearound upon rotation thereof, said mandrel being of a larger diameter than the diameter of the finished ring when free and expanding the ring a distance sufficient to compensate for the material cut therefrom during the cut-off operation, and a spiral guide encircling said mandrel and so constructed and arranged as to advance the strip along said mandrel upon relative movement between said mandrel and guide and hold the strip from deformation during the cut-off operation.

17. In the method of making piston rings from continuous strip piston ring material having a web and connected parallel spaced slit crowns extending from opposite sides thereof, the improvement comprising working the insides of the crowns with a rolling action directed to thin said crowns toward their outer sides and then spacing the crowns with uniform gaps therebetween by confining the thinned crowns to a curved path and pushing them together while so confined, and then reversely bending the crowns and coiling them to substantially cylinder bore size.

18. A method of spacing the gaps of the thinned crowns of continuous strip piston ring material uniform distances apart comprising the confining of the thinned crowns to a curved path of substantially cylinder bore radius, pushing the crowns together while so confined, then reversely bending the crowns and coiling them to substantially cylinder bore size.

19. A method of spacing the gaps of the thinned crowns of continuous strip piston ring material uniform distances apart comprising the feeding of the strip longitudinally, confining the crowns to a curved path of substantially cylinder bore radius while continuing to move in a longitudinal direction, pushing the crowns together while so confined, bending the crowns backwardly in a direction opposite to the curvature of said curved path, then bending the crowns in the direction of curvature of said curved path and coiling the strip to substantially cylinder bore size.

20. In an apparatus for making piston rings from flexible strip piston ring material having a slotted web and parallel spaced slit crowns extending along opposite sides of said web, a frame, a plurality of power driven feed rolls journaled on said frame for engagement with the strip to feed the strip longitudinally, other means on said frame in advance of said feed roll for gapping the crowns of the strip uniform distances apart, including a guide shoe in alignment with the nip between said feed rolls along which said crowns are adapted to move and having a concave guide surface curved to cylinder bore size, a guide member maintaining said crowns in engagement with said guide shoe during movement therealong and with said shoe reacting against the force exerted by said feed rolls to push said crowns together, and a plurality of horizontally and vertically spaced rollers cooperating with guide member and guide shoe and arranged at the discharge side of said guide shoe to bend said crowns backwardly of their direction of travel and then bend them in an opposite direction and coil the strip to substantially cylinder bore size.

21. In an apparatus for making piston rings from flexible strip piston ring material having a slotted web and parallel spaced slit crowns extending along opposite sides of said web, a frame, a plurality of power driven feed rolls journalled on said frame for feeding the strip longitudinally, other means on said frame in advance of said feed rolls for gapping the crowns of the strip uniform distances apart, including a concavely curved guide shoe in alignment with the path of travel of the strip and adapted to be engaged by the outer edges of the crowns of the strip and curve the strip about the web thereof, a guide roll engaging the web of the strip for holding said crowns in engagement with said guide shoe and with said guide shoe reacting against the strip and said feed rolls for pushing said crowns together during movement along said guide shoe, and a plurality of spaced rolls spaced from said guide shoe and engaging opposite sides of the strip and so constructed and arranged as to bend the strip oppositely to its direction of curvature along said shoe as it leaves said shoe and then bend the strip about its web and coil it to cylinder bore size.

22. In an apparatus for making piston rings from flexible piston ring material having a slotted web and parallel spaced slit crowns extending along opposite sides of said web, a frame, a plurality of power driven feed rolls on said frame for feeding the strip longitudinally, other means on said frame in advance of said feed roll arranged to gap the crowns of the strip uniform distances apart, including a guide shoe having a concave guide surface curved to cylinder bore size, a roll engaging the outer edges of the crowns with said shoe while traveling therealong and cooperating with said guide shoe and feed rolls and exerting sufficient resistance against the strip to push adjacent ends of the crowns together, and a plurality of longitudinally and vertically spaced rolls at the discharge end of said guide shoe and engaging opposite sides of the strip and so positioned to bend the strip about the discharge end of said guide shoe in a direction opposite to the curvature of said shoe and then bend the strip in the direction of curvature of said shoe and coil it to cylinder bore size.

23. In an apparatus for making flexible piston rings from continuous strip piston ring material U-shaped in cross section and having a central transversely slotted web and parallel spaced slit crowns extending at right angles thereto, a frame structure, a horizontal shaft journaled thereon, means for feeding the strip onto said shaft in the form of a coil of substantially the diameter of the finished ring, said shaft being smaller in diameter than the inside diameter of the finished ring, a freely rotatable measuring collar on said shaft, a power-driven mandrel forming a continuation of said collar and rotating at the speed of rotation of said shaft, spiral guide means encircling said mandrel and collar and slidably engaged by the strip and coiling it around said collar and mandrel and feeding it therealong by relative movement between said mandrel and guide means, a key extending along said mandrel and engaged by a slot of the piston ring for progressing the strip around said guide, indicating marks on said collar and shaft, for indicating variations between the speed of rotation of said collar and shaft caused by piston ring material of improper length passing from said shaft over said collar to said mandrel and thereby to indicate imperfections in the ring and variations in the circumference of the finished ring.

24. In an apparatus for making flexible piston rings from continuous strip piston ring material U-shaped in cross section and having a central transversely slotted web and parallel spaced slit crowns extending at right angles thereto, a frame structure, a horizontal shaft journaled thereon, means for coiling the strip on said shaft to cylinder bore diameter, a freely rotatable measuring collar at the discharge end of said shaft, said collar having an outside diameter of substantially the inside diameter of the finished ring and measuring piston ring material of piston ring length during each revolution thereof, a power-driven mandrel forming a continuation of said collar and rotating at the speed of rotation of said shaft, a stationary spiral guide opening toward said collar and mandrel and encircling said collar and the end of said mandrel adjacent said collar, a gear spaced from said shaft and meshing with the slots in the piston ring strip material and driven thereby upon feeding movement of the strip, indicating marks on said collar the same in number as teeth on said gear, visual indicating means driven by said gear at the speed of rotation thereof and indicating variations in travel between said collar and said gear and thereby indicating variations in the circumference of the finished ring.

25. In an apparatus for making piston rings from flexible strip piston ring material U-shaped in cross section and having a slotted web and parallel spaced slit crowns extending from opposite sides of said web, a

frame, a plurality of power-driven feed rolls journaled on said frame for engagement with opposite sides of the web of the strip to feed the strip piston ring material longitudinally, means on said frame in advance of said feed rolls for gapping the crowns of the strip piston ring material uniform distances apart, including a guide shoe in alignment with the nip between said feed rolls and having a concave guide surface curved to cylinder bore curvature, a guide member engaging the webs and the strip piston ring material and maintaining the inside of the web of the piston ring material in engagement with said guide shoe during movement therealong effected by operation of said feed rolls and with said shoe reacting against said feed rolls to effect the pushing the crowns of the strip piston ring material together, and a plurality of horizontally and vertically spaced guide and reaction members at the discharge end of said shoe, one positioned to engage the web of the strip piston ring material and bend the crowns backwardly over the discharge end of the shoe and another positioned above and on the opposite side of the strip piston ring material from said one guide to engage the edges of the crowns of the strip piston ring material and bend the strip piston ring material in an opposite direction in the direction of the coil of the ring and coil the strip piston ring material to substantially cylinder bore size.

26. A method of making piston rings from strip U-shaped in cross section and having parallel spaced crown segments, which comprises forming the segments to the desired shape and hardening the same by heating and quenching, spacing the ends of the segments equidistantly apart and coiling the formed strip into a spiral and feeding the coil along the axis of the spiral, heating the spiral coil to drawing temperature and cooling the thus heated spiral to temper and set the metal, rotatably supporting the spiral at internal piston ring diameter and grinding the periphery of the spiral coil to a desired piston ring diameter while traveling in the direction of its axis, and then successively severing the ground coil to piston ring length.

27. A method of making piston rings from strip U-shaped in cross section and having parallel spaced crown segments, which comprises hardening the strip by heat and quenching, feeding the strip longitudinally and confining the crown segments to a curved path of substantially cylinder bore diameter and coiling the strip in the form of a spiral, stretching the strip and feeding the spiral strip along the axis of the spiral, heating the strip to drawing temperature while so stretched, and cooling the thus heated spiral to temper and set the metal, rotatably supporting the inside of the set spiral coil and grinding the periphery of the spiral coil to a desired piston ring diameter while traveling in the direction of its axis, and then severing the coil into rings of equal length.

28. The method of making piston rings from a stamped channel shaped metal strip having a web and connected parallel spaced slit crowns extending along opposite sides thereof, which comprises heating the strip to a hot working temperature, hot working portions of the strip to a desired shape, quenching the hot worked strip while still hot from the hot working step to harden the metal, coiling the strip into a spiral, heating the coil to drawing temperatures and cooling the thus heated coil to temper the hardened metal, then stretching the tempered coil and supporting the stretched coil and feeding the same along its axis, grinding the edges of the crowns of the stretched coil to a desired piston ring diameter, and successively severing the leading end portions of the ground coil to form piston rings.

29. A continuous method of making piston rings from a stamped channel-shaped ribbon of metal having a web and connected parallel spaced slit crowns extending along opposite sides thereof, which comprises continuously advancing the stamped channel-shaped ribbon of metal and during the advance of the metal rough working the slit crowns while cold, heating the advancing metal to hot working temperatures, hot working the slit crowns of the advancing metal into a desired shape, liquid quenching the hot worked metal while still hot from the hot working step to harden the metal, coiling the advancing hot worked metal and continuing the advance of the coiled metal along the axis of its coil, drawing and setting the coiled metal by heating and slowly cooling as it advances along its axis, then stretching the drawn and set coil to separate the crowns with respect to each other as it continues to advance along its axis and supporting the stretched coil, grinding the edges of the crowns of the advancing coil to cylinder bore size, allowing the stretched coil to contract while advancing along its axis, then again stretching the coiled metal and successively severing the leading end coils of the coil in the form of piston rings.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
242,616	Edge	July 7, 1881
548,000	Lloyd	Oct. 15, 1895
788,970	Waterman	May 2, 1905
970,559	Sack	Sept. 20, 1910
1,055,964	Ackley et al.	Mar. 11, 1913
1,107,005	White	Aug. 11, 1914
1,151,721	Sahlin	Aug. 31, 1915
1,156,986	Dunn	Oct. 19, 1915
1,182,778	Leaming	May 9, 1916
1,223,966	Gutt	Apr. 24, 1917
1,385,644	Roberts	July 26, 1921
1,715,219	Biggert	May 28, 1929
1,762,556	Marshall	June 10, 1930
1,812,248	Oberg	June 30, 1931
1,868,063	Harter	July 19, 1932
1,930,698	Stiefel	Oct. 17, 1933
2,084,411	Robarge	June 22, 1937
2,114,667	Maul	Apr. 19, 1938
2,209,114	Dorr	July 23, 1940
2,223,011	Stephens	Nov. 26, 1940
2,311,730	Bowers	Feb. 23, 1943
2,334,243	Bowers	Nov. 16, 1943
2,339,884	Schlumpf	Jan. 25, 1944
2,346,898	Bowers	Apr. 18, 1944
2,355,601	Cudini	Aug. 8, 1944
2,374,802	Breuer	May 1, 1945
2,475,315	Doty	July 5, 1949