

June 20, 1967

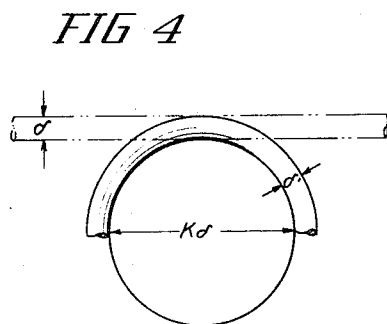
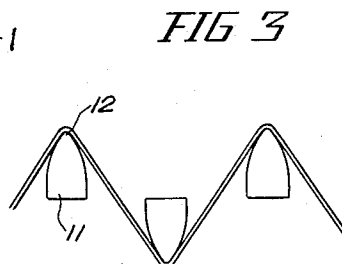
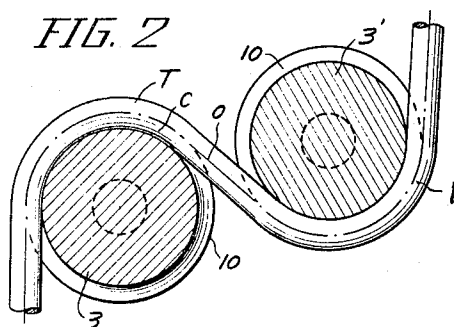
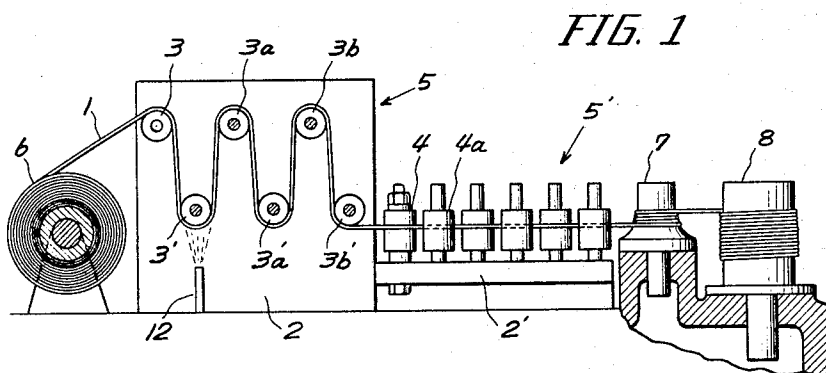
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3,326,025

APPARATUS FOR ALTERNATELY BENDING TO DRAW WIRE OR PLATE

Filed Aug. 14, 1964

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 5

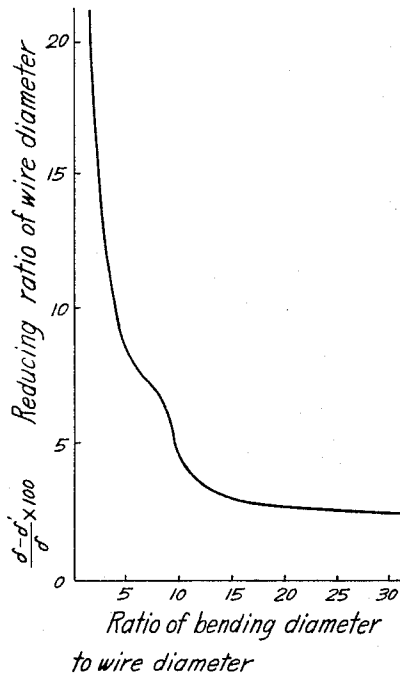


FIG. 6

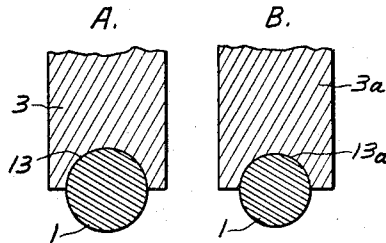


FIG. 7 FIG. 8

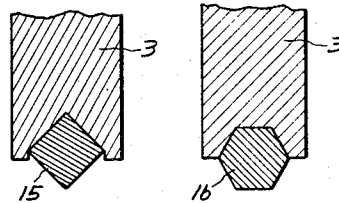
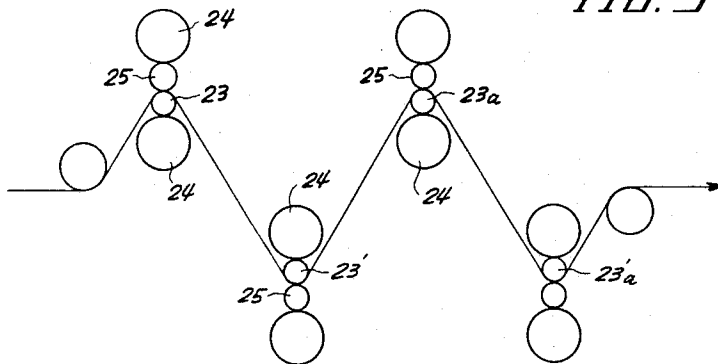


FIG. 9



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3,326,025

## APPARATUS FOR ALTERNATELY BENDING TO DRAW WIRE OR PLATE

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7 Claims. (Cl. 72-161)

The invention relates to the method and apparatus for stretching or drawing a rod, wire, or a plate, hoop, or the elongated material from the raw material.

Prior to the present invention, a method for reducing the diameter of wire for example was to pass the raw material through dies for rolling mills. An object of the present invention is to provide a method and apparatus characterized by novel features of construction wherein the raw material is drawn by zig-zag bending wherein one side alternately is in tension and then in compression.

Another object of the invention comprises the provision of the method and apparatus of drawing for repeating oppositely the bending of the raw material along the various guide members having a radius of curvature from 2 to 20 times relative to the diameter of raw material, and stretching and transferring continuously said repeated bending material which is processed with larger extension on the tension side relative to lesser contraction on the compression side during the repeated bending operation.

Still another object of the invention comprises the provision of the method and apparatus of drawing for repeating oppositely the bending of the raw material along a pass groove of the guide roller having a groove diameter of a range from 4 to 12 relative to the diameter of the raw material.

Accordingly, it would be understood that the method and apparatus of the invention for drawing raw material is fundamentally different from the apparatus of drawing of the prior art, and have the particular advantages of which:

- (1) Power economy reducing the friction loss of dies.
- (2) Equipment economy.
- (3) Operation economy reducing the method of acid pickling to remove the surface scales of raw material.
- (4) Operating economy.
- (5) The reduction of the internal stress produced in the drawn material.

However, when the drawn material of the invention has not generally the accurate round section thereof, if desired, it may pass through the dies, or rollers to correct to the accurate round section thereof.

Other objects and advantages of the invention will become apparent upon reading the annexed detailed description in connection with the drawing in which:

FIG. 1 is a side elevational view, partially in section, of the apparatus of the invention;

FIG. 2 is a side view of the wire and the rollers disclosed by the invention;

FIG. 3 is an enlarged side view of the wire and the triangular edges for drawing of finer wire;

FIG. 4 is a diagram for illustrating the relation between the wire and the roller of the invention;

FIG. 5 is the drawing showing the relation between the reducing ratio of wire diameter and the ratio of bending diameter;

FIGS. 6A and B are the sectional views of the first roller and the second roller with a round wire respectively;

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FIG. 7 and FIG. 8 are the sectional views similar to FIG. 6, but the wire is the rectangular or hexagonal form respectively instead of the round bar;

FIG. 9 is a diagrammatic view illustrating schematically drawing apparatus for plate according with the invention.

Referring to FIG. 1 and FIG. 2, the bending device 5 of the drawing apparatus embodying the invention comprises a plurality of parallel rollers 3, 3', 3a, 3a' with pass grooves 10 having the size similar to the half size of cross section of the raw material 1 and the support 2 rotatably receiving said rollers with the zigzag relation. If desired, the separate bending device 5' with a plurality of parallel rollers 4, 4a may be provided in series at right angle to said bending device 5. Therefore, the drawing apparatus of the invention includes the source 6 of elongated material, the bending device 5 and/or 5' and the capstan 7 and/or the spool 8. The sectional size of the groove 10 of the roller should be preferably similar to the half size of rolling material section and the diameter of roller preferably provides to from 4 to 12 times the diameter or width of material to be rolled, after all in any case it is necessary to provide the permanent strains on the tension side i.e. the outside of the bent material. If desired, there may be provided to a plurality of stationary edge or triangular edge in zigzag relation through which the material is passed, but in this case it is necessary to supply the lubricant to reduce the friction. This triangular edge is suitable for the drawing of very fine wire, while it is difficult to drilling the small aperture in the dies for drawing the very fine wire such as tungsten wire.

The theoretical description for the reduction of the wire diameter due to the bending of the invention is as follows.

FIG. 2 shows one example bending the round bar 1 along the groove 10 of the roller 3. If the factor of elasticity, elastic limit, yield point, and the factor of plasticity on the tension side or the compression side of the raw material is substantially equal to each other, the neutral axis of bending is coincident with the axis of wire.

If the physical property between the tension and the compression has a difference, the neutral axis is biased to whether the tension side, or the compression side relative to the axis of wire. Now, I assume that the compressive strain is not generated, but only the tensile strain is generated, then the neutral axis of bending will present on the contact line between the groove surface of roller and the inner surface of wire.

I assume that, after bending, the cross section of wire is maintained circular and the volume of wire is not changed always; through the calculation, I obtained the reduction curve as shown in FIG. 5 from the relation between the diameter of wire and the diameter of roller. The calculation form for said reduction curve is as follows:

$$\delta' = \left( \sqrt{\frac{2k^3 - 27k}{54} - \frac{\sqrt{729k^2 - 108k^4}}{54}} + \sqrt{\frac{2k^3 - 27k}{54} - \frac{\sqrt{729k^2 - 108k^4}}{54} - \frac{k}{3}} \right) \delta$$

wherein

$\delta$  is the diameter of original wire;

$k\delta$  is the diameter of bending member;

$\delta'$  is the diameter of wire after bending.

The condition of bent wire is as follows:

- (1) The length of inner surface of bent wire, i.e., the neutral axis thereof, is not changed;
- (2) The outer section of wire presents the plastic extension;
- (3) The volume of wire is not changed between before and after when the wire is bent;
- (4) The cross section of wire is constantly maintained a regular circular form.

Reducing ratio of wire diameter percent= $\frac{\delta-\delta'}{\delta}+100$

| k: | Reducing ratio<br>of wire dia. |
|----|--------------------------------|
| 1  | 24.5                           |
| 2  | 16.6                           |
| 4  | 10.0                           |
| 6  | 7.8                            |
| 8  | 6.9                            |
| 10 | 4.3                            |
| 20 | 2.7                            |
| 30 | 2.6                            |

In FIG. 5, the vertical axis shows the reducing ratio of wire diameter in percentage, and the lateral axis shows the magnification of the roller's diameter against the wire diameter, I discovered that the reducing ratio is remarkably decreased on the upper portion of the magnification 10 of roller diameter, and the reducing ratio is remarkably increased in the under portion of the magnification 9 thereof. Therefore, it is desirable to provide a ratio between the roller diameter and the wire diameter to the lesser ratio than a ratio about 9:1, consequently, the lesser the magnification, the better the appreciable effect.

However, when I use the lesser roller diameter for bending of steel wire, the reducing ratio of wire diameter is greater, but it may have a defect to break down the wire according to the hardening effect of reducing or drawing process at room temperature. Therefore I presumed that it may be preferred to define the ratio of bending diameter to wire diameter into the range from 4 to 10. In the results of experiment, I found that the preferred ratio of bending diameter to wire diameter is to be enlarged the range from 4 to 15, while the wire bending on the roller includes always both the permanent deformation and the elastic deformation. I ascertained the theory of the invention by experiment in which the steel wire, copper wire, aluminum wire and like, is drawn by only its bending without compression on the surrounding surface of wire by the inwardly radial force, and which the oppositely repeated bending of wire by applying the preferred ratio of bending diameter is able to draw effectively practically. This invention is

able to apply the elongated material with various sizes or shapes. The ratio of bending diameter to wire diameter may be changed according to the composition of material to be bent and/or the shape of raw material.

As shown FIG. 6A and 6B, the sectional diameter of the pass groove 13a of the second roller 3a has lesser diameter relative to the sectional diameter of the pass groove 13 of second roller 3, and is similar to the drawn wire passed through said pass groove 13, and then the diameter of pass grooves of successive roller is decreased step by step. Then, in passing through a plurality of rollers it is able to draw from thick wire to fine wire by the oppositely repeated bending without trouble to flatten the wire. If desired, both horizontal roller and vertical roller may be arranged alternately to prevent the slightly unround deformation.

In FIG. 7, when the wire to be drawn is a rectangular shape and, the cross section of pass groove of roller should be a right-angled triangle shape. In FIG. 8, when the wire 16 to be drawn is a hexagonal shape, the cross section of pass groove of roller should be a half size form divided along the diagonal line thereof.

If desired, when electric current flows between the preferred two points of wire on the drawing apparatus of the invention, said wire can be annealed from the hardened and cold stressed condition during the bending process.

While the scales of the wire surface such as the oxide of metal have not generally a flexibility, then said scales are separated from the surrounding surface of wire according to the outside extension of wire bending, and there is no need to use the acid pickling to separate said scales of wire surface.

The water nozzle 12 as shown in FIG. 1 will aid in the removal of said scales. As the invention has advantage which is substantially no slip between the wires surface and the pass groove of roller, it is not necessary to supply the high class lubricants different from the drawing with dies as known in prior arts. When it is insufficient to provide only one spool on the last end portion of apparatus to feed and transfer the wire along a plurality of pass grooves of rollers, it may be provided some capstan on the intermediate desired portions of apparatus to supply the drawing force to said wire.

It will be understood that the drawing apparatus of the invention has a simple construction and is easily replaced with the conventional dies or rollers.

Heretofore, it is difficult to draw the wire through the dies with the reducing ratio under 10%, however, the apparatus of the invention is proceeded easily with the reducing ratio of few percentages or more percentages. Also, the apparatus of the invention is easily finely controlled the reducing ratio of drawing by changing the pass groove on the roller.

The experimental data of the invention are as follows:

| Material                  | N | R  | Wire dia., mm. |      |      | Round factor, percent | Strength, kg./mm. <sup>2</sup> | E, percent | Reducing ratio, percent |
|---------------------------|---|----|----------------|------|------|-----------------------|--------------------------------|------------|-------------------------|
|                           |   |    | Max.           | Min. | Mean |                       |                                |            |                         |
| Lead coated wire.....     | 0 | 10 | 5.90           | 5.40 | 5.65 | 91.6                  | 111.0                          | 7.21       | 6.5                     |
|                           | 1 |    | 5.70           | 5.25 | 5.48 | 92.1                  | 113.9                          | 4.00       |                         |
| Steel wire, 5.5 m./m.---- | 0 | 8  | 5.79           | 5.56 | 5.68 | 95.9                  | 36.4                           | 28.2       | 30.8                    |
|                           | 1 |    | 4.81           | 4.64 | 4.73 | 96.6                  | 56.8                           | 2.12       |                         |
|                           | 2 |    | 3.91           | 3.82 | 3.87 | 97.8                  | 62.4                           | 2.07       |                         |
|                           | 3 |    | 3.33           | 3.02 | 3.18 | 90.8                  | 62.6                           | 0.96       |                         |
| Cu wire.....              | 0 | 8  | 2.52           | 2.50 | 2.51 | 100.0                 | 75.7                           | 1.51       | 36.5                    |
|                           | 1 |    | 5.52           | 5.51 | 5.52 | 100.0                 | 27.6                           | 12.10      |                         |
| Al wire.....              | 0 | 8  | 4.58           | 4.36 | 4.47 | 95.1                  | 37.4                           | 3.44       | 34.3                    |
|                           | 1 |    | 5.61           | 5.61 | 5.61 | 100.0                 | 12.3                           | 4.06       |                         |
|                           | 1 |    | 4.38           | 4.08 | 4.23 | 93.3                  | 13.0                           | 2.52       | 43.2                    |

in which "N" is a number of wire drawing device, "R" is a number of roller.

Note: Line No. 4 for steel wire has been drawn through a die to finish a round section for comparing with the drawn wire passed through four dies.

Experimental data of dies drawing is as follows:

| Material                  | N | R | Wire dia., mm. |      |      | Round factor, percent | Strength, kg./mm. <sup>2</sup> | E, percent | Reducing ratio, percent |
|---------------------------|---|---|----------------|------|------|-----------------------|--------------------------------|------------|-------------------------|
|                           |   |   | Max.           | Min. | Mean |                       |                                |            |                         |
| Lead coated wire.....     | 1 | 1 | 5.48           | 5.48 | 5.48 | 100                   | 114.2                          | 5.10       | 6.0                     |
| Steel wire, 5.5 m./m..... | 1 | 1 | 4.72           | 4.72 | 4.72 | 100                   | 57.1                           | 2.83       | 31.0                    |
|                           | 2 | 1 | 3.86           | 3.84 | 3.85 | 100                   | 63.2                           | 2.15       | 33.5                    |
|                           | 3 | 1 | 3.16           | 3.15 | 3.16 | 100                   | 68.8                           | 1.80       | 32.8                    |
|                           | 4 | 1 | 2.52           | 2.50 | 2.51 | 100                   | 76.3                           | 1.72       | 36.2                    |
| Cu wire.....              | 1 | 1 | 4.48           | 4.46 | 4.47 | 100                   | 38.1                           | 3.51       | 34.3                    |
| Al wire.....              | 1 | 1 | 4.23           | 4.23 | 4.23 | 100                   | 13.3                           | 2.78       | 43.1                    |

It will be seen from which eight rollers of the invention corresponds to one die with the reducing ratio of from 30 to 33 percentages for steel wire and with the reducing ratio of about 43% for aluminum wire.

If desired, it may be provided outwardly complementary roller for contact with the roller of the invention to promote the drawing of wire by its rolling press.

FIG. 9 shows another embodiment of the invention for the elongated plate, in which several rollers 23, 23', 23a, 23a' for plate to be drawn is provided. When the width of roller is larger, it may be provided the back up roller 24 to prevent the bending tendency of said rollers 23, 23' along their axes. To promote the drawing of wire, it may be provided outwardly complementary roller 25 for contact with said roller 23, 23' to reduce the rolling steps.

Whereas the invention has been shown and described with respect to the preferred embodiments thereof which gives satisfactory results, it should be understood that changes may be made and equivalents substituted without departing from the spirit and scope of the invention.

I claim as my invention:

1. Drawing apparatus for raw material such as wire or plate comprising a source from which the raw material is supplied, a bending device having a plurality of parallel rollers arranged in zig-zag relation and take up means on which the drawn wire or plate is accumulated, said roller comprising horizontal and vertical rollers arranged alternatively to prevent the un-round section.

2. Drawing apparatus as described in claim 1, wherein said roller has on its outside surface one or more pass grooves which comprise substantially half size cross section of the material to be drawn.

3. Drawing apparatus as described in claim 1, wherein another bending device with a plurality of parallel rollers

is provided in series at right angle relation to said bending device.

4. Drawing apparatus as described in claim 1 wherein the ratio of bending diameter to wire diameter has a range from about 2 to 20.

5. Drawing apparatus as described in claim 1, wherein several capstan are arranged on the suitable intermediate portion of said bending device.

6. Drawing apparatus as described in claim 1, wherein a complement roller is arranged on the outside portion of bending roller to promote the reducing ratio of raw material.

7. Drawing apparatus for raw material such as wire or plate comprising a source from which the raw material is supplied, a bending device having a plurality of parallel rollers arranged in zig-zag relation, take up means on which the drawn wire or plate is accumulated and at least one die behind the bending device to shape the drawn wire to a desired cross section.

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