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T. W. ABERNATHY

3,499,305

ROLLING MILL AND METHOD OF ROLLING STRIPS

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2 Sheets-Sheet 1

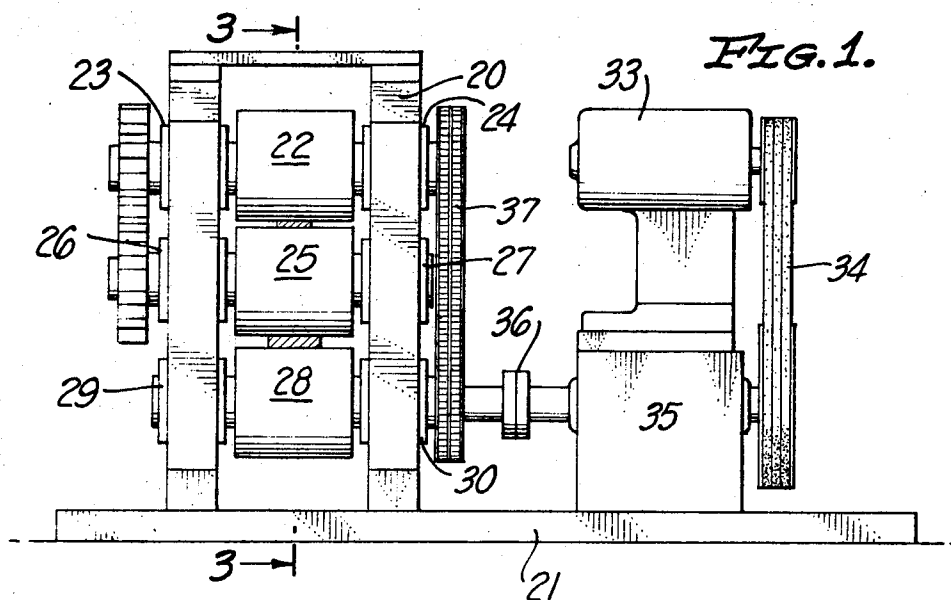
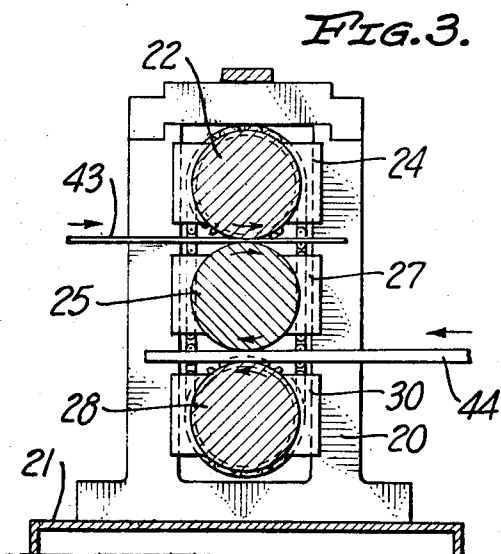
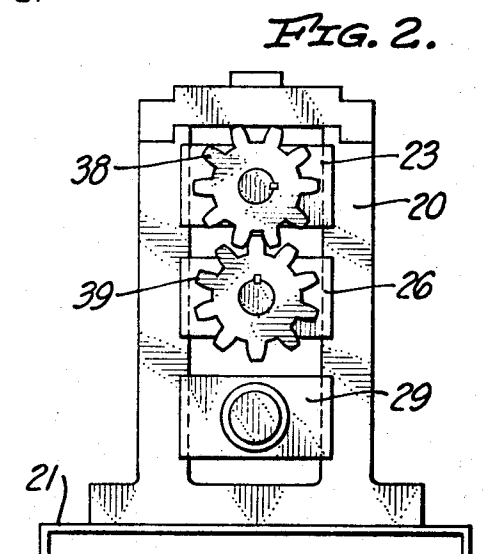
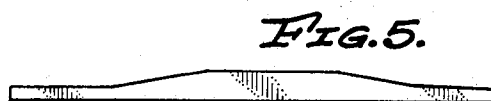
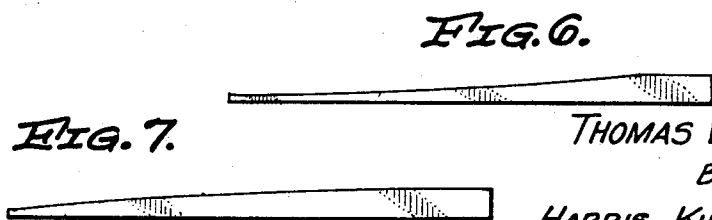


FIG. 7.



FIG. 6.

INVENTOR

THOMAS WILLIAM ABERNATHY

BY HIS ATTORNEYS

HARRIS, KIECH, RUSSELL & KERN

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T. W. ABERNATHY

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FIG. 8.

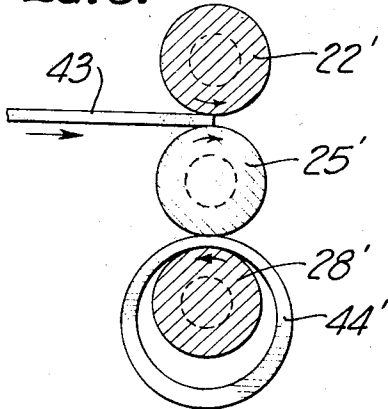


FIG. 9.

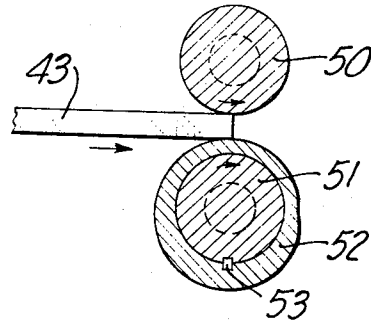


FIG. 10.

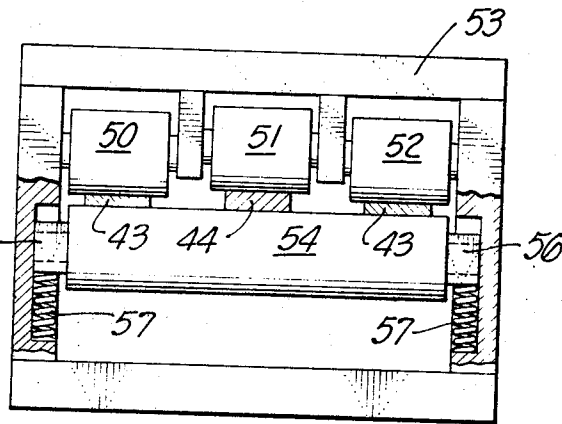


FIG. 13.

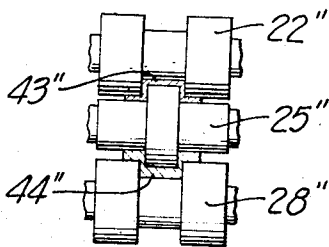


FIG. 11.

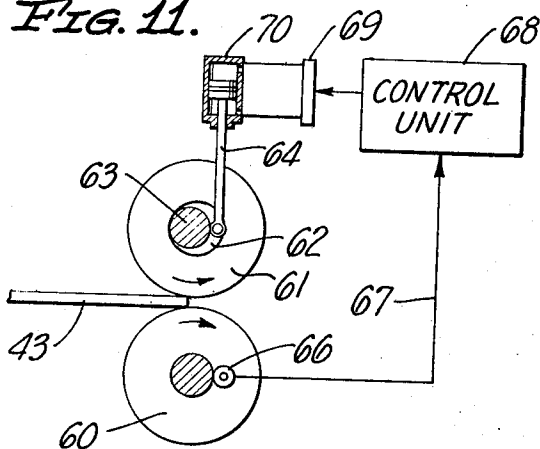
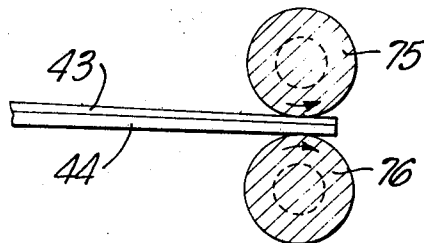


FIG. 12.



INVENTOR
THOMAS WILLIAM ABERNATHY
BY HIS ATTORNEYS
HARRIS, KIECH, RUSSELL & KERN

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ROLLING MILL AND METHOD
OF ROLLING STRIPSThomas William Abernathy, Sunland, Calif., assignor to
PRP Corporation, Sun Valley, Calif., a corporation of
California

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U.S. Cl. 72—7

2 Claims

ABSTRACT OF THE DISCLOSURE

A rolling mill and method for rolling a strip with a varying thickness, including at least two power rolls and means for varying the spacing between the rolls during a rolling operation. Several mechanisms for controlling the spacing variation according to a predetermined program, including a roll position indicator coupled to one of the rolls providing a signal indicative of roll rotational position as an input to the control for the space variation.

This invention relates to a new and improved rolling mill and method for rolling a strip to produce a rolled strip having a varying thickness.

Strips of material having a varying thickness are desired for various purposes, such as providing structural support for thin-wall aircraft fuselages. A typical strip may be in the order of ten to thirty feet long, four to eight inches wide, and tapering from 0.050 inch thick at one end to 0.090 inch thick at the other end. The strips may be made of various metals and metal alloys, including aluminum, steel, titanium and nickel, as well as other materials which are rollable, such as the thermoplastic materials. The strips may be provided in various cross-sectional shapes, including rectangular, angle sections, Z sections, and hat sections. The basic objective with all of these strips is to obtain maximum strength with minimum weight.

At the present time, the strips are being produced by machining operations, such as grinding or milling. The machining operations are expensive and time consuming and wasteful, since a quantity of material is removed as scrap.

It is an object of the present invention to provide a new and improved apparatus and method for forming a strip with varying thickness, which apparatus and method do not require material removal or material waste. A further object is to provide such apparatus and method which eliminate machining operations entirely. A further object is to provide such apparatus and method which can be used to produce strips with a variety of contours and not limited to mere tapered strips. A still further object is to provide such apparatus and method which can be used with strips having various cross-sectional shapes.

It is a specific object of the invention to provide a new and improved mill including first and second rolls mounted in a frame with a strip rolling space therebetween, means for driving at least one of the rolls in rotation to move the strip through the rolling space, and means for varying the size of the space as the strip is moved through the space. A further object is to provide such a mill including a pattern having a varying thickness for passing through the mill in conjunction with the strip with the pattern controlling the size of the rolling space. It is a further object to provide various unique configurations of rolls and patterns for producing the strip with varying thickness. An additional object is to provide such a mill wherein the size of the rolling space is controlled by an external power unit which is actuated by a control

unit as a function of the position of the strip in the mill.

It is also an object of the invention to provide a new and improved method of rolling a strip with a controlled varying thickness including the steps of passing the strip through a rolling space between first and second rolls and varying the size of the rolling space in a predetermined manner as a function of position of the strip within the rolling space. An additional object is to provide such a method including varying the size of the rolling space by passing a pattern through the mill simultaneously with the strip.

The invention also comprises novel details of construction and novel combinations and arrangements of parts, which will more fully appear in the course of the following description. The drawings merely show and the description merely describes preferred embodiments of the present invention which are given by way of illustration or example.

In the drawings:

FIG. 1 is a side view of a rolling mill illustrating a preferred embodiment of the invention;

FIG. 2 is an end view of the mill of FIG. 1, viewed from the left of FIG. 1;

FIG. 3 is a sectional view taken along the line 3—3 of FIG. 1;

FIGS. 4, 5, 6 and 7 are side views of patterns suitable for use in the invention, with the thicknesses exaggerated for illustrative purposes;

FIG. 8 is a partial sectional view similar to that of FIG. 3 showing an alternative embodiment of the invention;

FIG. 9 is a partial sectional view similar to that of FIG. 3 showing another alternative embodiment of the invention;

FIG. 10 is a view similar to that of FIG. 1, shown partly in section, illustrating another embodiment of the invention;

FIG. 11 is a partial sectional view similar to that of FIG. 3 illustrating another embodiment of the invention;

FIG. 12 is a partial sectional view similar to that of FIG. 3 illustrating yet another embodiment of the invention; and

FIG. 13 is a view similar to that of FIG. 1 illustrating the use of the invention in rolling hat sections.

FIGS. 1, 2 and 3 illustrate a rolling mill which may be conventional in construction with exceptions to be mentioned hereinbelow. A frame 20 is mounted on a base 21. A roll 22 is mounted in the frame 20 on bearing blocks 23, 24. Another roll 25 is mounted in the frame on bearing block 26, 27, and a third roll 28 is mounted in the frame on bearing blocks 29, 30.

The roll 28 is driven by an electric motor 33, through a belt drive 34, gear reducer 35 and shaft coupling 36. The roll 22 is driven from the roll 28 by a chain drive 37. The roll 25 is driven from the roll 22 through gears 38, 39, which are illustrated here as equal diameter gears with relatively large diametral pitch to permit movement of one roll relative to the other roll.

In the embodiment illustrated in FIGS. 1, 2 and 3, the bearing blocks for the rolls 22 and 28 are fixed in the frame. The bearing blocks for the roll 25 are slidably mounted in the frame, permitting vertical movement of the roll 25 relative to the rolls 22 and 28.

In the operation of the mill, a strip 43 of the material to be rolled is inserted between the rolls 22, 25 and a pattern 44 is inserted between the rolls 25, 28. The pattern 44 is made of a material which is harder to form than the material of the strip 43. Therefore, the position of the roll 25 and the size of the rolling space between the rolls 22, 25 will be controlled by the thickness of the pattern 44, so that the rolled strip will have a thickness

which varies inversely with the thickness of the pattern. For example, consider a mill where the sum of the spacing between the rolls 22, 25 and between the rolls 25, 28 is 1.000 inch, and it is desired to roll a strip of material with a straight taper increasing from 0.050 inch at one end to 0.090 inch at the other end. The pattern will be made the same length as the desired strip and will have a thickness at one end of 0.950 inch and a thickness at the other end of 0.910 inch, with a straight taper therebetween. Then passing the pattern and the strip through the respective spaces at the same time will produce a rolled strip with the desired thickness and taper.

It will readily be seen that the invention is not limited to the production of straight tapers and that a large variety of varying thickness configurations can be produced. Some of these configurations are illustrated in FIGS. 4, 5, 6, and 7, which show side views of patterns, with the thicknesses exaggerated for illustrative purposes.

The alternative embodiment of FIG. 8 includes rolls 22', 25', 28' which may be constructed and operated in the same manner as the rolls 22, 25, 28 of the embodiment of FIGS. 1-3. A pattern 44' in the form of a ring may be positioned about the roll 28'. The ring 44' has a varying thickness and passes between the rolls 25', 28' continuously to generate a repetition of the thickness pattern.

The alternative embodiment of FIG. 9 utilizes rolls 50, 51, with the roll 50 having a constant radius and the roll 51 having a varying radius. In the particular embodiment illustrated, the varying radius is produced by fitting a sleeve 52 of vary thickness over a roll of constant radius, with the two components being held together by a key 53. In this construction, the spacing between the rolls is varied as a function of the angular position of the roll 51 to provide the varying size for the rolling space through which the strip 43 passes. If desired, a varying radius could be provided on the roll 50 also.

Another alternative embodiment is illustrated in FIG. 10, wherein rolls 50, 51 and 52 are mounted in fixed bearings in a frame 53 and a roll 54 is mounted in bearings 55, 56 which are urged toward the rolls 50-52 by springs 57. Strips 43 to be rolled are positioned between the roll 54 and the rolls 50, 52 and the pattern 44 is positioned between the roll 54 and the roll 51, with the pattern controlling the position of the roll 54 and thereby the size of the rolling space at the rolls 50 and 52.

In another alternative embodiment, two rolls are utilized, with the axis of rotation of one roll being moved relative to the axis of rotation of the other roll by a power unit to vary the rolling space between the rolls. The power unit is controlled to move the axis of the roll as a predetermined function of the position of the strip in the rolling space. This provides for programming the position of the roll as a function of movement of the strip through the rolling space to provide the desired thickness variation. A typical embodiment of this mechanism is illustrated in FIG. 11, including a roll 60 with a fixed axis and a roll 61 with a movable axis. The roll 61 rotates on a sleeve 62 which in turn is rotated about a shaft 63 by a piston 64. A shaft position indicator 66 is coupled to the roll 60 to provide an output signal on line 67 to a control unit 68, with the output signal being indicative of the position of the roll and hence the position of the strip 43 in the rolling space. The control unit drives a control valve 69 which directs fluid under pressure to a cylinder 70 for actuating the piston 64. The control unit may be similar to those used in programming and controlling the operation of machine tools. For example, a template with a follower driven as a function of roll position may be utilized. Alternatively, the program may be stored on punched cards, punched tape or magnetic tape and fed to the control valve as a function of roll or strip position.

In an alternative arrangement for the roll movement, the moving roll 61 may be mounted in conventional concentric bearings, with the bearings being moved relative

to the frame by a power unit. In another alternative arrangement, the programming may be produced by utilizing a cam or an electrical signal generator directly driven by the roll 60 to provide the control signal for the power unit.

Another alternative embodiment somewhat similar to that of FIG. 9, is illustrated in FIG. 12 with the strip 43 and the pattern 44 placed side by side and passed between rolls 75, 76. The distance between the rolls is maintained constant for the rolling operation, with the varying thickness pattern 44 providing for varying the rolling space to produce the rolled strip with the conversely varying thickness.

While all three rolls are shown as being directly driven in the embodiment of FIGS. 1-3, this particular arrangement is not necessary and one or more of the rolls might be idler rolls obtaining their movement from another driven roll. While the rolls have been illustrated as substantially the same diameter, this is not essential and one roll could readily be of a considerably greater diameter than another. While the three high mills show the centers of the rolls in a line, and while the axes of the rolls have been illustrated as parallel, these particular arrangements are not essential although they would be utilized in most applications. Similarly, the rolls are illustrated as being vertically aligned but other arrangements such as oblique or horizontal may be desirable for certain applications.

As indicated above, strips with various cross-sectional shapes can be produced and a simple rectangular cross section has been illustrated in FIGS. 1-12. FIG. 13 illustrates a roll configuration similar to that of FIG. 1 for producing a hat cross section strip. The pattern 44' has the desired thickness variation and the desired cross-sectional configuration. The rolls 25' and 28' have a mating configuration with a pattern space therebetween for the pattern 44'. The roll 22' has a mating configuration with the roll 25' to define the desired rolling space for the strip 43'. This hat configuration and other cross-sectional shapes can be utilized in the other embodiments illustrated in the same manner.

Although exemplary embodiments of the invention have been disclosed and discussed, it will be understood that other application of the invention are possible and that the embodiments disclosed may be subjected to various changes, modifications and substitutions without necessarily departing from the spirit of the invention.

I claim as my invention:

1. In a mill for rolling a strip with a controlled varying thickness, the combination of:

a frame;
a first roll mounted in said frame;
a second roll mounted in said frame providing a strip rolling space between said first and second rolls;
means for driving at least one of said rolls in rotation to move a strip through said rolling space; and
means for varying the size of said space as a strip is moved through said space and including
power means for moving the axis of rotation of one of said rolls relative to the axis of rotation of the other of said rolls, and

control means for actuating said power means as a function of position of a strip in said rolling space to provide a predetermined variation in rolling space size during the rolling operation,
with said size varying as a function of the position of the strip in said space, and with the thickness of the rolled strip corresponding to said size variation.

2. In a mill for rolling a strip with a controlled varying thickness, the combination of:

a frame;
a first roll mounted in said frame;
a second roll mounted in said frame providing a strip rolling space between said first and second rolls;

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means for driving at least one of said rolls in rotation
to move a strip through said rolling space;
means for varying the size of said space as a strip is
moved through said space and including
power means for moving the axis of rotation of one of
said rolls relative to the axis of rotation of the other
of said rolls, and
control means for actuating said power means as a
function of position of a strip in said rolling space to
provide a predetermined variation in rolling space
size during the rolling operation;
a roll position indicator coupled to one of said rolls
providing a signal indicative of roll rotational posi-
tion; and
means for connecting said signal as an input to said
control means,
with said size varying as a function of the position of
the strip in said space, and with the thickness of the
rolled strip corresponding to said size variation.

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MILTON S. MEHR, Primary Examiner

U.S. Cl. X.R.

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