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Greenberger

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[54] **TENSION LEVELLING OF STRIP**

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[52] **U.S. Cl.** **72/17,** 72/205, 72/161

[51] **Int. Cl.** **B21d 1/02**

[58] **Field of Search** 72/160, 165, 205, 17

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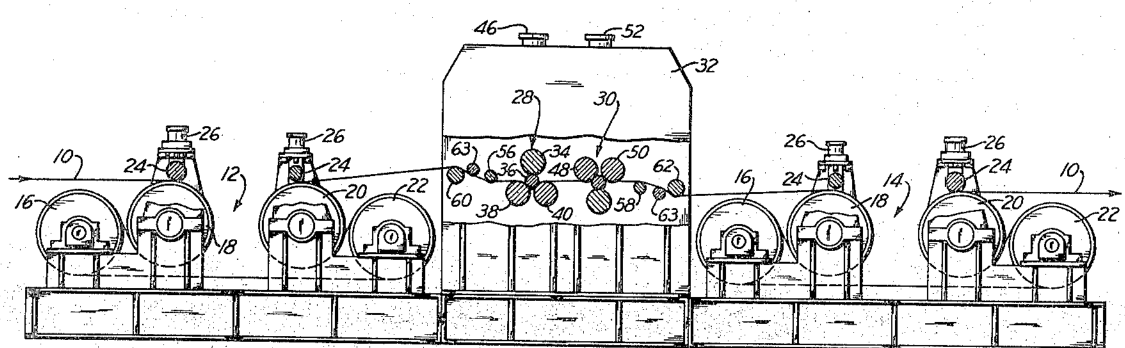
[57] **ABSTRACT**

The disclosure of the invention pertains to a method and apparatus for producing flat rolled steel strip by tension levelling. The unflat strip is subject to varying tensions by a pair of tension bridles. Between the bridles are arranged two sets of nested, flexing and/or rolling rolls and on the entry and delivery sides of the roll sets are arranged strip deflecting rolls which are both skewable and mechanically shapeable to vary the unit tension of the strip during its flexing and/or rolling. Also on the entry and delivery sides of the sets of flexing rolls are strip shape detecting rolls which are associated with a computer control unit that produces both feed forward and/or feed backward control signals for varying the total tension, the flexing and/or rolling, and the unit tension to give the most ideal processing conditions for a strip of given characteristics.

21 Claims, 4 Drawing Figures



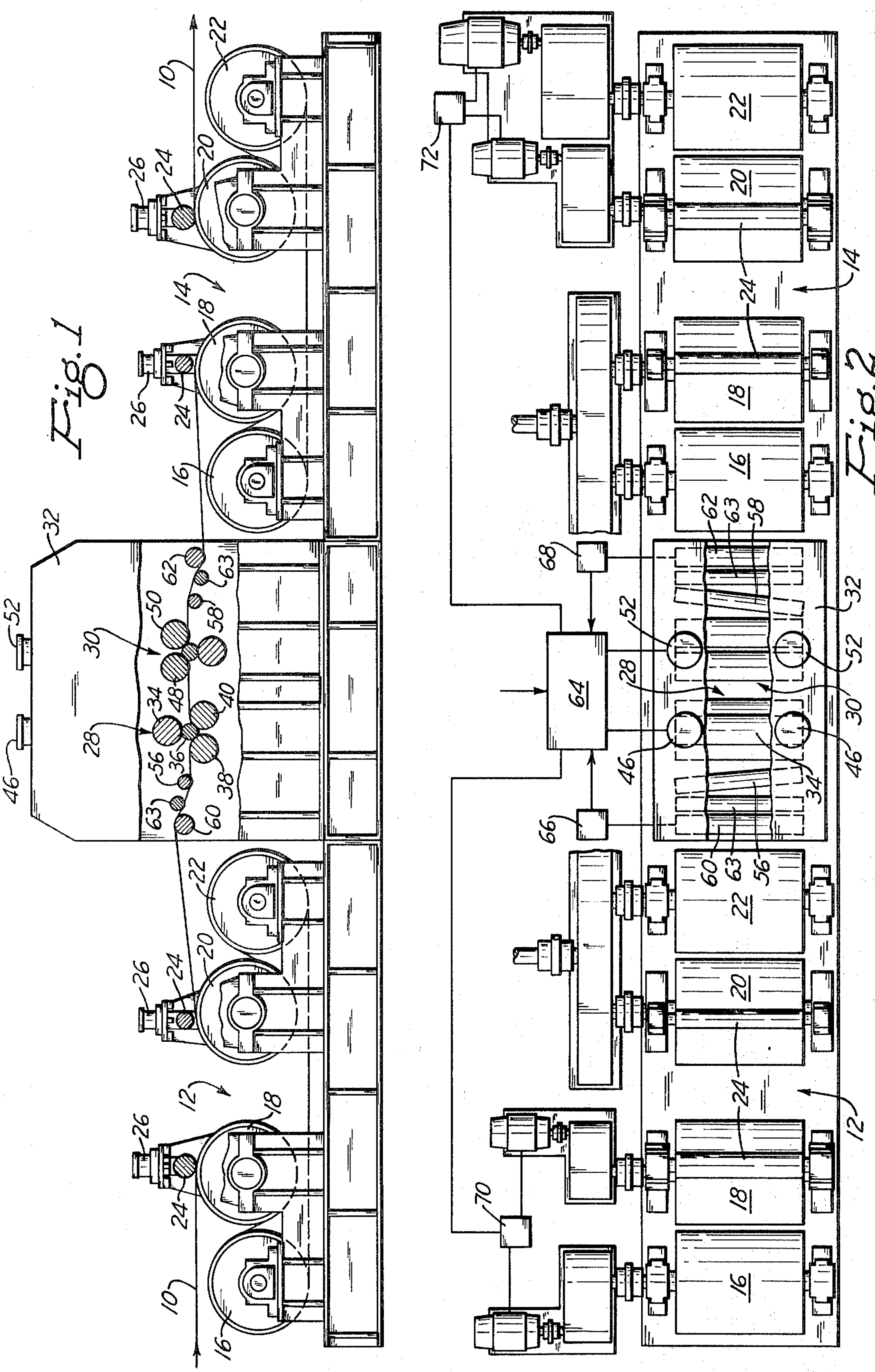


Fig. 1

Fig. 2

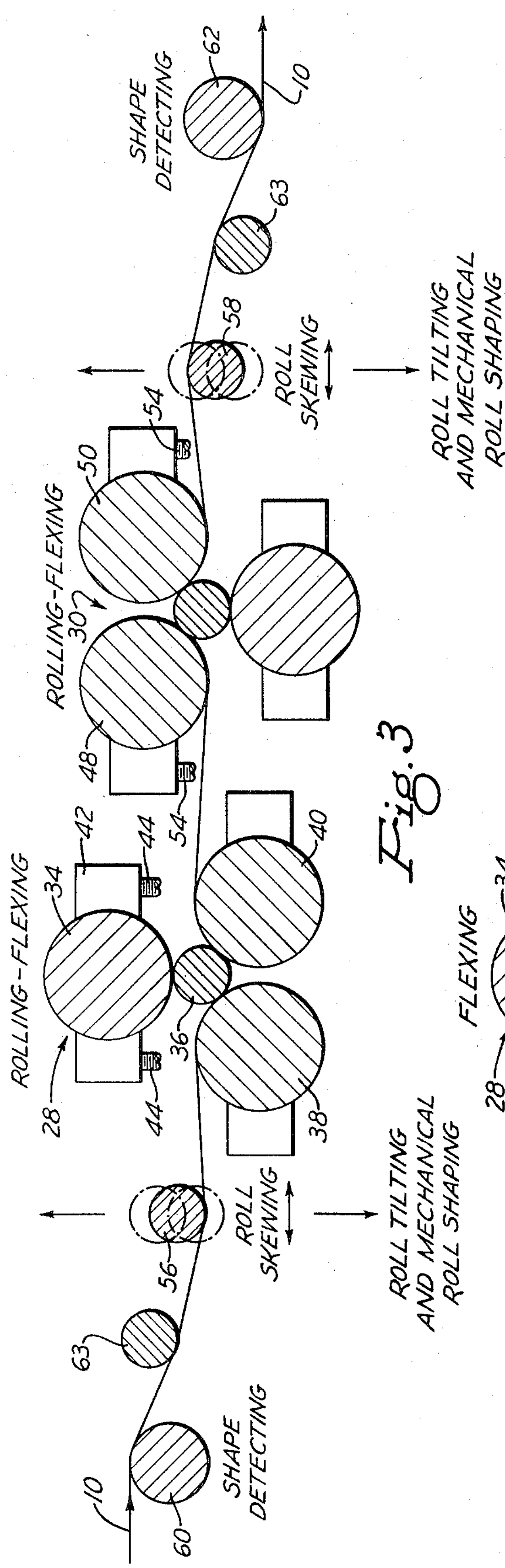

SHAPE DETECTING
62
10
63
58
ROLL SKEWING
ROLL TILTING AND MECHANICAL ROLL SHAPING
54
50
ROLLING-FLEXING
30
48
54
42
44
40
ROLLING-FLEXING
34
36
28
44
38
56
ROLL SKEWING
ROLL TILTING AND MECHANICAL ROLL SHAPING
63
10
60
SHAPE DETECTING

Fig. 3

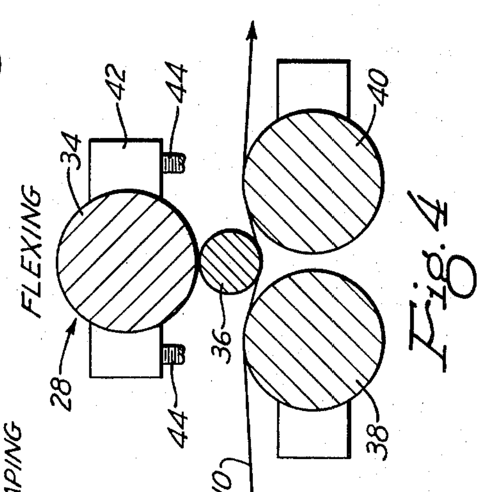

42
44
40
FLEXING
34
28
36
44
38
10

Fig. 4

TENSION LEVELLING OF STRIP

Though many different attempts have been made in the past in the metal industry to produce flat strip in an economical high production manner only partial success has been achieved. One of the reasons for this failure has been the fact that the characteristics of the strip, such as thickness, physical properties, and metallurgy vary considerably not only from strip to strip but within a given strip itself.

While tension levelling employing nested flexing rolls has been suggested in the past their success as best has only been rudimental, because on the one hand the work capable of being performed was not sufficient to meet the varying conditions, and on the other hand the procedures of controlling the working forces was very uncoordinated and ineffectual.

It is therefore an object of the present invention to provide a method and/or apparatus for producing flat metallic strip that will overcome among others the enumerated disadvantages and limitations of prior practices.

More particularly the present invention provides a method and apparatus for producing flat metallic strip at an efficient and high production rate including the steps and apparatus of subjecting the strip to a substantial total tension but below its yield point, causing the strip while under said tension condition to pass between a series of strip flexing rolls where the strip is additionally subjected to reverse flexing sufficient to impart a relatively small amount of permanent elongation to the strip, varying the unit tension transversely of the strip in a manner to vary the transverse unit tension of the portion of the strip being subject to the flexing operation, determining the transverse flatness profile of the strip and changing at least one of said total tension, flexing or unit tension operations to reduce nonflatness in the strip.

These objects and other novel features and advantages of the present invention will be better appreciated when the following description of a preferred embodiment thereof is read along with the accompanying drawings of which:

FIG. 1 is an elevational view, partly in section, of an arrangement of equipment for practicing the present invention,

FIG. 2 is a plan view of FIG. 1

FIG. 3 is a schematic enlarged elevational view, partly in section, of some of the equipment illustrated in FIG. 1 and wherein the strip flexing units are shown in their rolling and flexing positions and

FIG. 4 is a partial view of one of the strip flexing units illustrated in FIG. 3 shown in a strip flexing position.

In referring to FIGS. 1 and 2 a rolled carbon steel strip **10** is shown, the two arrows indicating the entrance and delivery of the strip to a tension levelling zone of a strip processing line. At the entrance and delivery ends of the zone there are arranged identical strip tension bridle units **12** and **14** each having a entry set of horizontally spaced-apart driven rolls **16** and **18** from where the strip **10** passes to a delivery set of similar driven rolls **20** and **22.** The rolls **18** and **20** cooperate with pinch rolls **24** which are vertically adjusted by piston cylinder assemblies **26.** Bridle units of the type illustrated are well known in the steel strip producing industry so that the details of their functions and operations are not deemed necessary. Sufficient is to note that they are employed, by virtue of a speed differential and the wrap angle between the cooperative sets of rolls **16–18** and **20–22,** to subject the strip **10** to substantial total tension up to the yield point of the strip, and that the total tension is variable by changing the power furnished to the roll sets. In the case of mild carbon rolled steel strip 48 inches wide and having a thickness of 0.125 inch a desirable overall operating tension would be of the order of 60,000 lbs. total tension.

Between the entry roll set **20** and **22** and the delivery roll set **16–18** two sets of flexing or flexing and rolling rolls are provided, the entry set being identified at **28** and the delivery set at **30,** both of which are rotatably supported in a common housing **32.**

Roll set **28** comprises an upper quickly adjustable backup roll **34** which engages a smaller diameter nested roll **36,** the lower surface of which engages one surface of the strip while the opposite surface of the strip is engaged by two larger diameter rolls **38** and **40.** As best shown in FIGS. 3 and 4 the backup roll **34** which is carried at each of its opposite ends by a bearing chock assembly **42** is vertically positioned against motor operated screw stops **44** associated with each chock assembly, by virtue of piston cylinder assembly one being shown at **46,** which is shown only in FIGS. **1** and **2.** The screw stops **44** and piston cylinder assemblies **46** permit the nested smaller roll **36** to vary its penetration into the space between the rolls **38** and **40** from a rolling condition where the strip is both flexed and compressed by rolling between the rolls **36** and **38** and **40** to only a pure flexing action where the roll **36** is spaced from and out of direct contact with the rolls **38** and **40.** FIG. **3** is meant to portray the flexing and rolling condition where the total permanent elongation imparted by these forces will not exceed 2 to 4 percent while FIG. **4** portrays the pure flexing condition where the total permanent elongation will be less than 2 percent. A desirable roll size range for various carbon steels will find the large rolls **34, 38** and **40** being of a diameter between 12 to 14 inches and the small nested roll **36** having a diameter of between 3 to 6 inches.

The rolls of the flexing or flexing and rolling set **30** are identical but inverted with respect to the roll set **28,** in which as shown in FIG. 3 the upper larger rolls **48** and **50** are vertically positioned by piston cylinder assemblies **52** against motor operated screw stops **54** for the purpose already explained with respect to the roll set **28.**

On the entry and delivery sides of the roll set **28** and **30** there are arranged transversely of the path of the strip **10** strip engaging rolls **56** and **58** rotatably supported in the housing **32.** The roll **56** is arranged to engage the upper surface of the strip while the roll **58** engages the lower surface. As shown by the legends and arrows in FIG. 3 the rolls **56** and **58** are vertically tiltable and which is indicated in legend in FIG. 3 as ROLL TILTING. The rolls are also mechanically shaped to change the crown which is legend MECHANICAL ROLL SHAPING and/or to have their ends moved in a horizontal plane whis is legend SKEWING in FIG. 3. The result of tilting, mechanical shaping and skewing, as is well known in the art, is to vary the unit tension of the strip in the roll bite of the roll units **28** and **30.** In other words in changing the crown of rolls **56** and **58** and/or its end to end position, in which the roll is rotated about its minor axis, a greater or less unit tension can be brought into play transversely of the strip as it is being worked in the roll set units **28** and **30**, by virtue of varying the lengths of the paths of travel of different portions of the strip width. Since the use of strip deflecting rolls in which the crown of the rolls may be varied by outboard bending forces or skewing or tilting end to end by power means are well known details of construction need not be given.

Also mounted in the housing **32** at its extreme outer ends are rolls **60** and **62** which are identified by the legends SHAPE DETECTING appearing in FIG. **3** and which are provided to detect the transverse flatness profile of the strip passing to and from the roll flexing units **28** and **30**. There are several well known types of such measuring devices in the industry such as that illustrated and described in U.S. Pat. Nos. 3,481,194 dated Dec. 2, 1969 and 3,499,306 dated Mar. 10, 1970, among others not as well publicized. The basic purpose of these units is to determine the transverse strip profile, i.e., both the magnitude and location of the hills and valleys of non-flatness. Arranged between the rolls **56–60** and **58–62** are strip deflecting rolls **63** provided to assure proper contact between the rolls **56–60** and **58–62**.

As noted before an important aspect of the invention is to provide a method and means that will enable the best possible individual or collective usage of the several corrective forces developed by the units **12, 14, 28, 30, 56**, and **58** in removing or reducing the non-flatness from the strip as determined by either or both of the shape detectors **60** and **62**. With this in mind these corrective forces are correlated and varied with reference to a given condition of the strip by a master control computer **64**. The control receives signals from the detector rolls **60** and **62** of the non-flatness of the strip and issues command signals to one or more of the units **12, 14, 28, 30, 56** and **58** as is determined to be necessary to correct totally or in part for the particular non-flat condition of the strip. The computer control **64** will follow the type customarily provided in the steel industry for strip processing equipment, in which as shown in FIG. **2** the control receives signals from the shape detector rolls **60** and **62** from signal generating units **66** and **68** respectively, along with signals of tension values from the tension bridles **12** and **14** by signal units **70** and **72** and pressure signals from the piston cylinder assemblies **46** and **52**. It then employs this data to obtain the best coordinated use of the equipment in removing totally or in part the non-flatness from the strip.

In briefly describing the operation of the above explained equipment and control let it be assumed as suggested by FIG. **1** that a strip **10** is being fed through the bridle units **12** and **14** as it is being processed. While the equipment can be operated in a number of different ways, such as by a feed forward and/or a feed backward control system, semi-automatic or fully automatic, a fully automatic feed forward and feed backward system will be described.

As shown in FIG. **1** as the strip passes over the shape detecting roll **60**, the signal generator **66** will issue a feed forward signal to the control unit **64** and cause the effective working forces produced by entry units i.e., the bridle **12**, deflector roll **56** and the flexing and rolling unit **28** to vary if necessary to give the ideal combination of total tension, roll crowning and/or skewing or tilting and mechanical shaping and flexing and/or rolling required. As the strip **10** passes over the delivery shape detecting roll **62** should there still exist any non-flatness a vernier or trim correction will be initiated by a feed backwards signal from the signal units **68** to the control **64**. The control then will initiate a trim control signal to one or more of the delivery units **30, 58** or **14** to still further reduce or eliminate any non-flatness in the strip. The control unit will enable the entry and delivery units to be always operated in a correlated manner and maintained within a desirable operating range to thus cover a very wide range of entry strip conditions.

In accordance with the provisions of the patent statutes, I have explained the principle and operation of my invention and have illustrated and described what I consider to represent the best embodiment thereof.

I claim:

1. A method of producing flat metallic strip comprising the steps of:

causing the strip to pass through a controlled elongation zone created by two spaced-apart strip tensioning means where the strip is subject to a substantial total tension but below its yield point,

causing the strip while subject to said tension to pass around a series of strip flexing rolls where the strip is subject to reverse flexing whereby the tension and flexing imparts a controllable amount of permanent elongation to the strip,

varying the unit tension transversely of said strip to vary the transverse unit tension of the portion of the strip being subject to the flexing operation,

determining the transverse flatness profile of the strip when under said tension and between said tensioning means and changing at least one of said total tension, flexing or unit tension operations to reduce the non-flatness in the strip.

2. A method of producing flat strip according to claim **1**,

wherein said strip flexing step includes subjecting the strip to a simultaneous rolling and flexing operation,

and changing atleast one of said total tension, rolling and flexing or unit tension operations to reduce the non-flatness in the strip issuing from said rolling and flexing operation.

3. A method of producing flat metallic strip according to claim **1**,

wherein said flexing operation includes the step of passing the strip between a set of three rolls, one of which is arranged in a nested relationship with the others and being of a much smaller diameter than the others.

4. A method of producing flat metallic strip according to claim **1**, wherein said flexing operating includes the step of passing the strip through two succeeding and separate flexing operations wherein the opposite surfaces of the strip are subjected to an equal number of tension-compression steps caused by flexing.

5. A method of producing flat metallic strip according to claim **1** wherein said step of varying the unit tension of the strip is accomplished by varying the length of the path of travel of different portions of the strip width by manipulation of a deflecting roll arranged to engage one of the surfaces of the strip when subject to said total tension condition.

6. A method of producing flat metallic strip according to claim **5**, wherein said variation of length of path of travel is accomplished by applying a bending moment to the ends of said deflecting roll.

7. A method of producing flat metallic strip according to claim 5, wherein said variation of length of path of travel is accomplished by applying a rotation to said deflecting roll about its minor axis.

8. A method of producing flat metallic strip according to claim 1, wherein said determining of the flatness profile of the strip is accomplished by causing the strip to engage a shape detecting roll arranged on either side of said flexing operation.

9. A method for producing flat metallic strip according to claim 8, wherein said strip is caused to engage said shape detecting rolls on the entry and delivery sides of said flexing operation.

10. A method of producing flat metallic strip according to claim 1, wherein said step of subjecting the strip to a substantial total tension includes with respect to said flexing step causing the strip to pass between entry and delivery tension bridle units.

11. A method of producing flat metallic strip according to claim 1, wherein said step of subjecting the strip to a substantial total tension includes with respect to said flexing step, causing the strip to pass between entry and delivery tension bridle units,

and wherein said determining of the flatness profile of the strip is accomplished by causing said strip to engage a shape detecting roll arranged on either side of said flexing operation,

and wherein said step of varying the unit tension of the strip is accomplished by variation of length of path of travel by manipulation of a strip deflecting roll arranged to engage one of the surfaces of the strip when subject to said total tension condition,

and further wherein said flexing operation includes the steps of passing the strip through two succeeding and separate flexing operations wherein the opposite surfaces of the strip are subjected to an equal number of tension-compression steps caused by flexing.

12. A method of producing flat metallic strip according to claim 11, wherein said strip flexing operations include subjecting this strip to a simultaneous rolling and flexing operation and changing atleast one of said total tension, rolling and flexing, or unit tension operations to reduce for non-flatness in the strip issuing from said rolling and flexing operation.

13. An apparatus and control for producing flat metallic strip comprising:

means for passing the strip to a controlled elongation zone,

said elongation zone including two spaced-apart strip tension means for subjecting the strip to a substantial total tension but below its yield point,

said zone also including a series of strip flexing roll means constructed and arranged to subject the tensioned strip to reverse flexing whereby the tension and flexing imparts a controllable amount of permanent elongation to the strip,

a deflector roll arranged to be engaged by said tensioned strip,

means for manipulating said deflector roll to vary the unit tension transversely of the strip to thereby vary the transverse unit tension of the portion of strip being subject to the flexing operation, and

means arranged between said tension means for determining the transverse flatness profile of the strip while under said tension and for effecting a change in at least one of said total tension, flexing or unit tension operations to reduce the non-flatness in the strip.

14. An apparatus and control according to claim 13, wherein said flexing roll means includes means for bringing said roll means in a rolling and flexing relationship with said strip.

15. Apparatus and control according to claim 13, wherein said flexing roll means includes a set of three rolls one of which is arranged in a nested relationship with the others and being of a much smaller diameter than the others.

16. An apparatus and control according to claim 13, wherein said flexing roll means includes two succeeding and separate sets of rolls constructed and arranged to subject the opposite surfaces of the strip to an equal number of tension-compression steps caused by flexing.

17. An apparatus and control according to claim 13, wherein said means for manipulating said deflector roll comprising a means for bending said roll in order to change its effective crown.

18. An apparatus and control according to claim 13, wherein said means for manipulating said deflector roll comprises a means for cocking said roll by applying a rotational force about its minor axis.

19. An apparatus and control according to claim 13, wherein said means for determining the flatness profile of the strip includes a shape detecting roll arranged on either side of said strip flexing roll means.

20. An apparatus and control according to claim 13, wherein said means for subjecting the strip to a total tension includes with respect to said flexing roll means, entry and delivery tension bridle units.

21. An apparatus and control according to claim 13, wherein said means for subjecting the strip to a substantial total tension comprises with respect to said flexing roll means, entry and delivery tension unit bridles,

said means for determining the flatness profile of the strip includes a shape detecting roll arranged on either side of said flexing roll means,

wherein said deflector roll is arranged to engage one of the surfaces of said strip when subject to said total tension condition,

wherein said flexing roll means includes two succeeding and separate sets of flexing rolls wherein the opposite surfaces of the strip are subject to an equal number of tension-compression steps caused by flexing,

wherein said flatness profile determining means includes a shape detecting roll for producing a signal of the non-flatness condition of the strip, and

a control unit for receiving said signal from said detecting roll and producing a command signal to selectively and simultaneously vary one or more of the operations of said total tension, flexing and unit tension means.

* * * * *