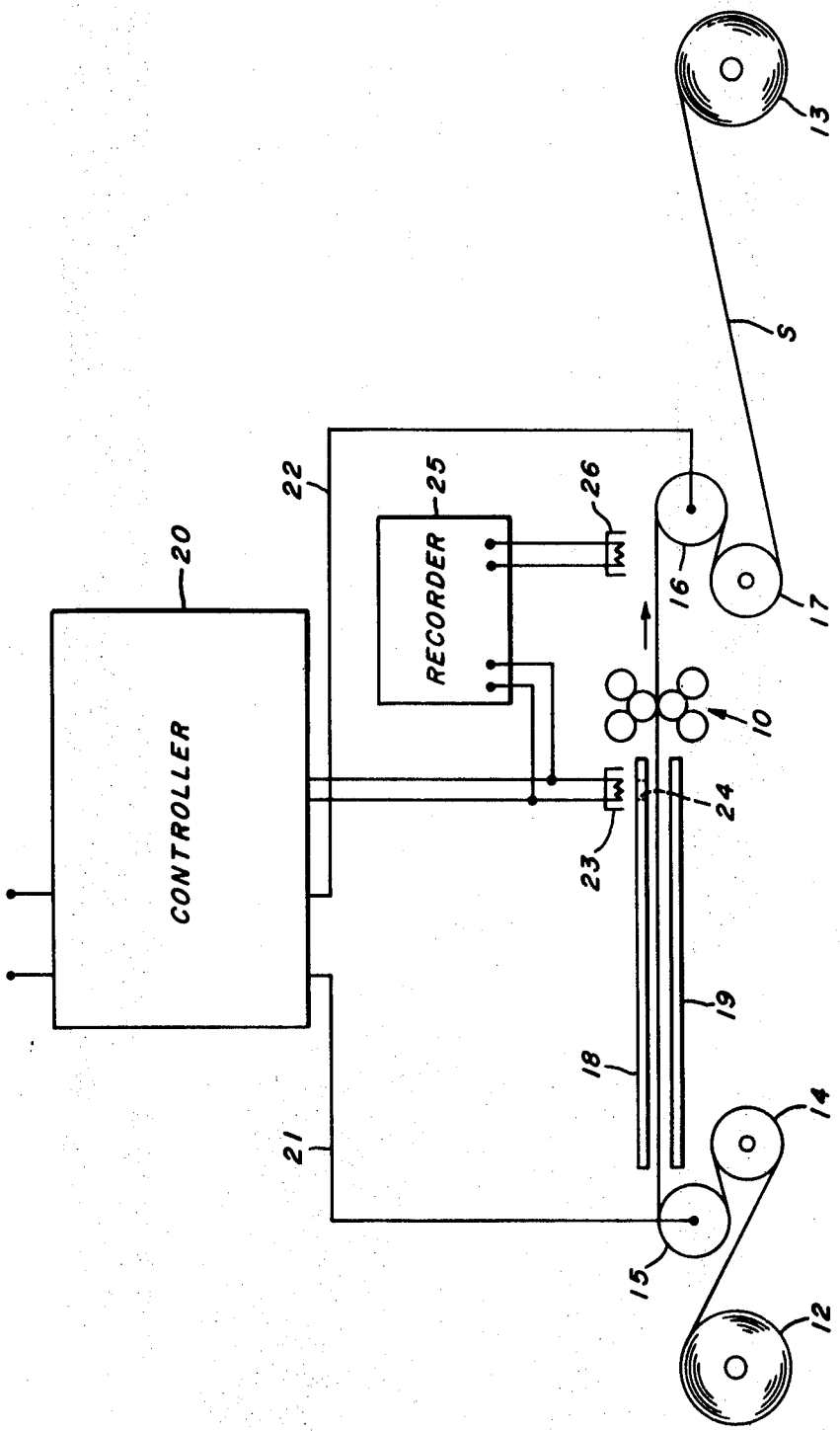
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METHOD AND APPARATUS FOR WARM-ROLLING METAL STRIP

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METHOD AND APPARATUS FOR WARM-ROLLING METAL STRIP

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ABSTRACT OF THE DISCLOSURE

A method and apparatus for warm-rolling metal strip at an intermediate temperature of about 300 to 1400 F. The strip is contacted electrically at opposite sides of a roll stand, and thus heated by electric resistance. Temperature is sensed near the entry side of roll stand and used to control current input to strip to maintain the proper temperature.

This invention relates to an improved method and apparatus for "warm-rolling" metal strip.

Although my invention is not limited to use with any specific metal, it is particularly useful as applied to titanium and its alloys. Popular titanium alloy sheet grades can be cold-reduced only about 15 percent in thickness before they must be re-annealed. Heavier reductions without intermediate annealing usually cause irreparable damage to the strip in the form of internal (strain-induced) porosity, shear cracks, and excessive directionality. Excessive edge-cracking also occurs, and the strip is likely to tear or break. Annealing the strip after each 15 percent reduction is of course costly and should be avoided if possible. The difficulty can be overcome and the strip reduced as much as 70 to 90 percent by "warm-rolling" it at temperatures in range of about 300 to 1400 F.

An object of my invention is to provide an improved warm-rolling method and apparatus which automatically heat metal strip to proper temperature as it is rolled and accurately control this temperature.

A further object is to provide an improved heating method and apparatus which raise the strip temperature to an accurately controlled degree for warm-rolling and maintain the strip at this temperature through and beyond the rolling operation.

A more specific object is to provide an improved warm-rolling method and apparatus in which metal strip is resistance-heated by electric current introduced at opposite sides of a roll stand, and the strip temperature is measured continuously and controlled by regulating the current input.

In the drawing:

The single figure is a diagrammatic view of a warm-rolling apparatus constructed in accordance with my invention.

The drawing shows a roll stand **10** through which a strip S travels from an uncoiler **12** at the left to a coiler **13** at the right, all per se of conventional construction but insulated from ground. In accordance with my invention the strip passes around a first deflector roll **14** insulated from ground and located adjacent the uncoiler **12**, and next around a first conductor roll **15** spaced about 5 to 25 feet ahead of the roll stand **10**. Beyond the roll stand the strip passes around a second conductor roll **16** and a second deflector roll **17** insulated from ground and located near the coiler **13**. I mount upper and lower removable heat shields **18** and **19** above and below the strip between the first conductor roll **15** and roll stand **10**.

I connect the two conductor rolls **15** and **16** to a controller **20** through lines **21** and **22** respectively, and connect the controller to a suitable power source. I mount a first non-contacting radiation pyrometer **23** above the upper heat shield **18** at the entry side of the roll stand **10**. The heat shield has an opening **24** through which the strip is exposed to the pyrometer. I connect the pyrometer to the controller **20** and to a multipoint recorder **25**. I mount a second non-contacting radiation pyrometer **26** above the strip at the exit side of the roll stand **10** adjacent the second conductor roll **16** and connect this pyrometer also to the multipoint recorder **25**. The pyrometers, controller and recorder are all standard instruments available commercially; hence I have not shown them in detail. Examples of suitable pyrometers are the L and N "Rayotube," available from Leeds and Northrup Company, Philadelphia, Pa., or the "300 Series" Infrared Radiation Thermometers available from Ircon Inc., Chicago, Ill. One example of a suitable controller is the L and N "D.A.T." Model S, Type G, available from Leeds and Northrup Company.

According to my method, I set the controller **20** to the temperature I desire to maintain in the strip S as it passes through the roll stand **10**. For example, I can roll strip of one popular titanium-base alloy which contains 6 percent aluminum and 4 percent vanadium advantageously at a temperature in the range of 900 to 1100 F. Other titanium-base alloys are rolled advantageously at 1100 F. At these temperatures the strip can be reduced quite drastically without re-annealing, as already explained. Electric current which passes through the portion of the strip between the conductor rolls **15** and **16** heats the strip. The first pyrometer **23** senses the strip temperature as the strip enters the roll stand. This pyrometer automatically actuates the controller **20** to adjust the current through the strip to maintain the strip passing the pyrometer at the temperature to which I have set the controller. For example, to heat a strip of the aforementioned 6–4 titanium alloy 0.050-inch thick by 36-inches wide, traveling at 50-feet per minute to 1000 F., requires about 40 kilowatts per minute. By locating the second conductor roll **16** at the exit side of the roll stand **10** and the first pyrometer **23** immediately adjacent the entry side, I assure that the strip actually is at its optimum rolling temperature as it passes through the roll stand. The strip attains its maximum temperature after it leaves the roll stand to relieve stresses and serve as a final anneal. The recorder **25** furnishes indications of both the rolling temperature and finishing temperature.

From the foregoing description it is seen that my invention affords a simple effective method and apparatus for warm-rolling metal strip, especially strip of titanium or its alloys. The strip is heated accurately and automatically to the optimum temperature for maximum reduction, and the temperature maintained through the rolling step and actually raised therebeyond.

I claim:

1. A method of warm-rolling metal strip at a temperature of about 300 to 1400 F. comprising continuously passing the strip through a roll stand, electrically contacting the strip at opposite sides of said roll stand, passing an electric current through the portion of the strip between the contacts, sensing the strip temperature adjacent the roll stand, and adjusting the magnitude of the current to maintain the strip at a predetermined temperature in the range of about 300 to 1400 F. as it goes through the roll stand.

2. A method as defined in claim **1** in which the temperature sensed adjacent the roll stand is used to adjust the current automatically.

3. A method as defined in claim **1** in which the strip attains its maximum temperature after it leaves the roll stand to relieve stresses and serve as a final anneal.

4. A method as defined in claim 3 in which the strip temperature is sensed again at the exit side of the roll stand to determine its finishing temperature.

5. A warm-rolling apparatus for metal strip comprising a roll stand having entry and exit sides, an uncoiler for the strip spaced from said entry side, a coiler for the strip spaced from said exit side, a first means for electrically contacting the strip between said uncoiler and said entry side at a location spaced from said roll stand, a second means for electrically contacting the strip between said exit side and said coiler, means for supplying electric current to said contacting means and to the portion of the strip therebetween for heating the strip, means for sensing the strip temperature adjacent said entry side, and a controller connected with said sensing means and said current-supplying means for adjusting the magnitude of current and thereby maintaining the strip at a predetermined temperature as it passes through said roll stand.

6. An apparatus as defined in claim 5 in which the means for electrically contacting the strip are in the form of first and second conductor rolls around which the strip passes.

7. An apparatus as defined in claim 6 further comprising a first deflector roll around which the strip passes between said uncoiler and said first conductor roll, and a second deflector roll around which the strip passes between said second conductor roll and said coiler.

8. An apparatus as defined in claim 5 in which said sensing means is a radiation pyrometer.

9. An apparatus as defined in claim 8 further comprising a second radiation pyrometer for sensing the finishing temperature of the strip adjacent said coiler, and a recorder connected to both said pyrometers.

10. An apparatus as defined in claim 8 further comprising upper and lower removable heat shields above and below the strip between said first contacting means and said entry side, said upper heat shield having an opening through which the strip is exposed to said pyrometer.

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