May 26, 1970 N. H. POLAKOWSKI 3,513,677

METAL STRIP PROCESSING MACHINE

Filed Aug. 2, 1967

FIG. 1

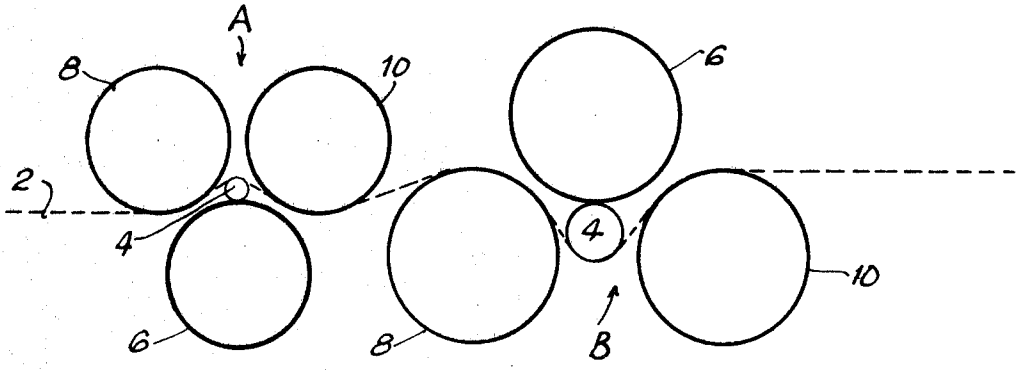


FIG. 2

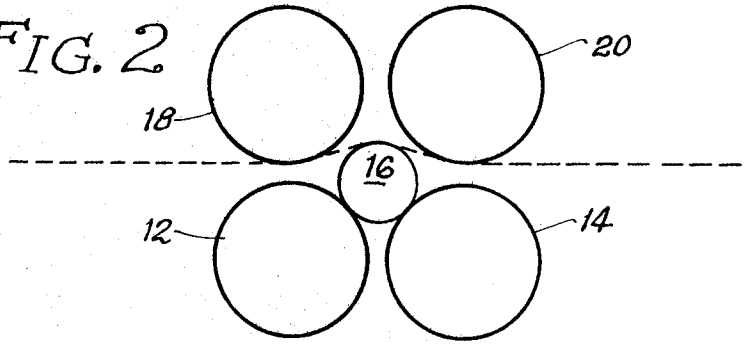
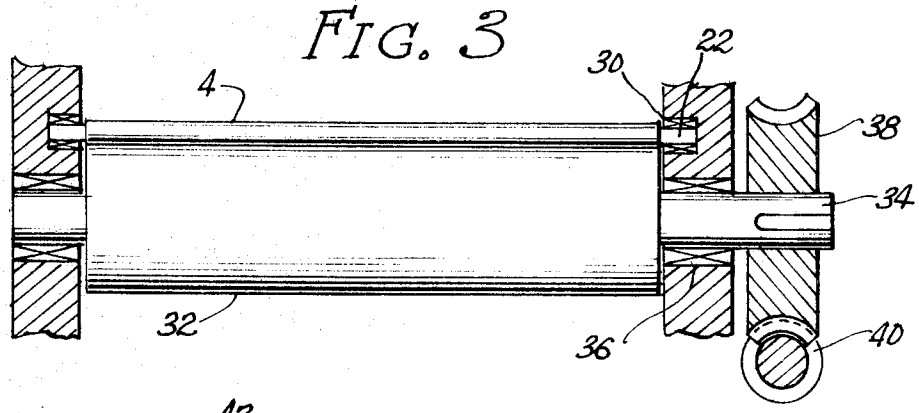


FIG. 3



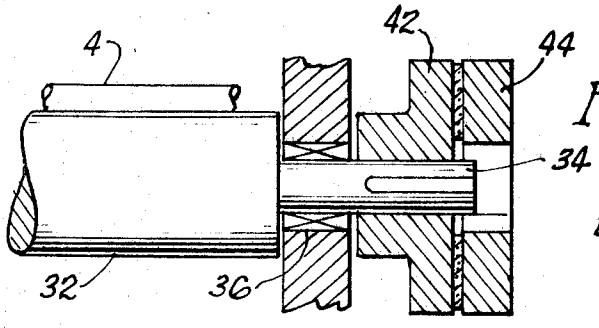


FIG. 4

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METAL STRIP PROCESSING MACHINE

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U.S. Cl. 72—163 11 Claims

ABSTRACT OF THE DISCLOSURE

The invention resides in a machine for the processing of metal strip such as a tension leveler wherein use is made of a small diameter work roll and which embodies the concept of slowing the rotational movement of the work roll to a peripheral speed which is a fraction of the linear speed of the work traveling through the machine at high speed whereby the work is flexed as it slips over the work roll while fresh surfaces are presented by the work roll.

This invention relates to a machine for processing metal strip and it relates more particularly to a tension leveler in which use is made of small diameter work rolls over which the sheet is flexed during movement under high tension.

Pull-through type tension levelers are formed essentially of a series of parallel work rolls arranged in staggered relation with respect to the pass plane so that the metal strip to be flattened, which moves under tension from a payoff reel to a take-up reel, is forced to follow a sinuous path as it passes through the machine. The line tension, which controls the in-process permanent elongation of the metal, is adjusted by changing the drag applied to the payoff reel. To eliminate excessive pressure on the payoff and take-up reels, suitable tension multiplication cylinders, referred to as bridles, may be interposed between the leveler and the respective reels.

Theoretically, in order to achieve effective flattening, the diameter (D) of the work rolls should be small in relation to the strip thickness (H) to insure plastic flow as the tensioned strip is wrapped about a portion of the periphery of the work roll. For best practice, the D/H ratio should be within the range of 30 to 120. The lower ratios are better for highly work hardened metals. For example, if it is desired effectively to level 0.010 inch tin plate, the diameter D of the work roll may be only 0.5 inch while, with double reduced tin plate having a thickness of 0.006 inch, the optimum diameter for the work roll should be about 0.35 to 0.4 inch.

Such tin plate processing lines, which may include degreasing and tinning stations, usually operate at speeds between 1000–2000 feet per minute. With a tension leveler having 0.5 to 0.35 inch diameter work rolls, the rotational speed of the rolls would be from 8,000 to 10,000 r.p.m. to correspond with line speed. Such rotational speeds are extremely high and represent a factor that imposes serious limitations on leveler designs. For proper support, the work rolls have to be journalled at their ends and the significant axial forces produced must be carried by end thrust bearings. Obviously these bearings must be quite small to accommodate the small diameter of the rolls and, at the indicated rotation speeds, their load carrying capacities are generally unsatisfactory. Of further significance is the tendency for the bearings to develop thermal problems. Their reliability becomes marginal, and bearing breakdown occurs quite frequently. By reason of these problems, in-line tension levelers for high speed tension lines of the type described are not employed.

It is an object of this invention to produce a machine for processing of metal strip and particularly for flattening strip in which the machine embodies means whereby

the work rolls can be properly supported by reason of marked reduction in their rotational speeds and end thrust on the supporting bearings and whereby bearings of smaller dimension are capable of being employed in high speed tension lines.

These and other objects of this invention will hereinafter appear and, for purposes of illustration, but not of limitation, embodiments of the invention are shown in the accompanying drawing, in which:

FIG. 1 is a schematic view of a roll assembly for flattening metal strip in accordance with the practice of this invention;

FIG. 2 is a schematic view similar to that of FIG. 1 showing a modification in the roll cluster;

FIG. 3 is an elevational view partially in section of one means for controlling the peripheral speed of a work roll; and

FIG. 4 is an end elevational view similar to that of FIG. 3 showing a modification in the means for regulating the peripheral speed of the work roll.

I have observed that satisfactory levelling action can be achieved when the work rolls are restrained against rotational movement whereby the strip is dragged through the angle of wrap about the work roll. This was particularly apparent when the strip being processed had an oily or wet surface. However, after a short period of time, dirt and debris collected at the nip between the roll and strip so that such operations could be carried out only for a short period of time before the collected dirt and debris caused undesirable scraping and heating.

I discovered, however, that the described relationship could be maintained over an extended period of time for substantially continuous operation if the work roll were controlled continuously to present a changing roll surface to the moving strip, but at a much slower speed than the speed of the strip. Under such circumstances, a fresh roll surface was continuously presented to the strip whereby the collection of dirt was eliminated and local heating was dissipated. This can be achieved by controlling the work roll for rotation preferably, though not necessarily, in the direction of movement of the strip at a peripheral surface speed which is a fraction of the linear speed of the strip whereby a changing work surface is presented to the moving strip. Under these circumstances, the rotational speed of the work roll is maintained at a manageable and easily supportable low value without the collection of dirt at the nip and without temperature buildup to undesirable levels. The concept can be illustrated by an actual experiment in which stainless steel strip having a width of 7 inches and a thickness of 0.015 inch was leveled at speeds of 210 feet per minute over a work roll having a diameter of ⅝ inch and controlled for rotational movement at a peripheral speed of 25–70 feet per minute, without ill effect. The strip surface was slightly oily but litle, if any, heat buildup was observed. Much greater differences in the ratios of roll speed to strip speed could be tolerated. The relative movement or slip between the strip and the periphery of the work roll, as the strip is flexed over the work roll under tension, does not mar the surface of the strip nor does it cause excessive heating of the roll since the portion engaged is continuously being removed. It rotated in the direction opposite the movement of the strip, the work roll will have a tendency to wipe the surface of the strip.

The concepts of this invention are applicable not only to work rolls of tension levelers of conventional construction but the invention finds particular adaptability to small diameter work rolls of the type employed in the more recently developed tension levelers and strip processing equipment of the type described in my Pat. No. 3,245,-244, issued Apr. 22, 1966, and entitled "Mechanism for Flattening Metal Strip"; No. 3,260,093, issued July 12,

1966, and entitled "Strip Flattening Device"; No. 3,270,-543, issued Sept. 6, 1966, and entitled "Machine for Flattening and Curling of Metal Strip"; and my copending application filed concurrently herewith, entitled "Metallurgical Process and Means for Treatment of Strip to Reduce Stretcher Strains and Luders Markings," which application is a continuation-in-part of my application Ser. No. 508,945, filed Nov. 22, 1965, and entitled "Metallurgical Process and Means for Treatment of Strip to Reduce Stretcher Strains and Luders Markings."

With reference now to the drawing for illustration of techniques for carrying out the invention, FIG. 1 shows the roll assembly in a tension leveler through which metal strip is advanced. A pair of roll clusters A and B is illustrated but it will be understood that the roll assembly can include additional pairs of somewhat the same arrangement so that the description of but a single pair will suffice. Each roll cluster is formed of a small diameter work roll **4** backed by a back-up roll **6** of considerably larger diameter. The angle of wrap of strip **2** about the periphery of the work roll **4** is controlled by a pair of deflector rolls **8** and **10** which straddle the work roll with the inner peripheries of the deflector rolls offset inwardly from the outer peripheries of the work roll so that the strip **2** will follow a sinuous path during passage between the outer periphery of the work roll and the inner peripheral portion of the adjacent deflector rolls on each side of the work roll. The other roll cluster B is the same as the roll cluster A except that the rolls are arranged in the opposite direction so that the strip **2** will be flexed in the opposite direction during passage about the work roll.

In the modification shown in FIG. 2, use is made of a pair of back-up rolls **12** and **14** of larger diameter than the work roll **16** and between which the work roll **16** is cradled. Deflector rolls **18** and **20** are of somewhat the same arangement as in the modification shown in FIG. 1 to cause the strip to follow a sinuous path during passage therebetween for flexing the strip about the work roll **16**. Normally, the deflector rolls are mounted for adjustment normal to the work roll to increase or decrease the angle of wrap. For this purpose, the deflector rolls are supported at their ends in suitable bearings carried by adjustable bearing plates or frame members.

The roll arrangements illustrated in FIGS. 1 and 2 are particularly suitable for use in the practice of this invention since the speed of rotation of the work roll can conveniently be controlled by way of the back-up rolls. Ordinarily, the work roll is driven in rotational movement in response to frictional engagement with the strip **2** so that its peripheral speed will correspond to the linear speed of the strip. The back-up rolls merely engage the work roll to support the thin roll but with little, if any, influence on its speed.

Because of the frictional engagement between the small diameter work roll and the larger diameter back-up rolls, it is possible completely to stop rotational movement of the work rolls in response to stoppage of the rotational movement of the back-up rolls. Thus it becomes possible to brake the speed of the work rolls by a positive control of rotational speed of its back-up roll or rolls. The speed of the back-up rolls can be positively controlled by direct engagement with driving means or indirectly controlled by utilization of the forces imparted to the rolls from the moving strip but with variable braking load applied to the backing rolls for retardation of rotational movement with corresponding retardation in the rotational movement of the engaged work roll.

In FIG. 3, illustration is made of a means for positive control wherein the ends of the shafts **22** of the work roll **4** or **16** or the like are supported for free rotational movement in radial thrust bearings **30**. The back-up roll **32**, in peripheral engagement with the work roll, is formed with end journals **34** supported in bearings **36** fixed to the machine frame with a worm gear **38** keyed to the end of the journal for rotational movement therewith. The worm gear **38** is in turn engaged by a worm **40** connected to a variable drive motor (not shown) for effecting rotational movement of the worm and which in turn drives the worm gear and back-up roll. Thus the back-up roll will be operated at a controlled rate of rotational movement and the peripheral speed of the work roll will be retarded to correspond with the peripheral speed of the back-up roll. Thus the strip, travelling at a much higher linear speed than the peripheral speed of the work roll, will slip over the work roll while the work roll is being turned slowly continuously to present a fresh surface to the strip. By reason of the much lower rotational speed of the work roll, smaller bearings can be employed for its support and less difficulties are encountered in the proper retention of the work roll for operation in the machine through which strip is processed at high speed.

In FIG. 4, illustration is made of a braking means which still utilizes the force of the strip to effect turning movement of the work roll and back-up roll **32** but in which the braking force retards the turning movement of the back-up roll and, as a result, the work roll to achieve the described effects.

In the modification shown in FIG. 4, instead of making use of a worm and gear in driving connection with the back-up roll, the journal **34** is mounted in a conventional slip clutch. Use is made of a magnetic brake **42** keyed to the journal **34** with the brake rotor in frictional engagement with the friction face of a fixed electromagnet **44** for variation in the braking force responsive to variation in the current energizing the magnet. It will be understood that other slip clutches of conventional construction can be employed to effect slowdown of the back-up rollers by variable amounts.

With the reduction in rotational speed of the work roll, the current problems of load capacity, durability, ease of lubrication, radial thrust and thrust bearings are greatly minimized. As a result, tension levelers and other metal processing equipment embodying small diameter work rolls can be designed for operation at very high through-put speeds.

It will be understood that other ways for reducing the speed of the work roll relative to the speed of the strip will be apparent to those skilled in the art and that other changes may be made in the details of construction, arrangement and operation without departing from the spirit of the invention, especially as defined in the following claims.

I claim:

1. In a metal strip processing machine having a small diameter work roll over which the strip is flexed during passage at high speed through the machine and at least one back-up roll in surface contact with the work roll for support, means mounting the work roll at its ends for free rotational movement, means mounting the back-up roll at its ends for rotational movement, and means controlling the rotational movement of the back-up roll for slowing the rotational speed of the work roll to a peripheral speed which is considerably less than the linear speed of the strip in the direction of movement of the strip.

2. A machine as claimed in claim **1** in which the means for controlling the rotational movement of the back-up roll comprises a positive driving means and an operative connection between said positive driving means and the back-up roll for driving the back-up roll in rotational movement.

3. A machine as claimed in claim **2** in which the positive driving means comprises a gear mounted on an end of the back-up roll for rotational movement therewith, gear actuating means operatively engaging the gear and power means for driving the gear actuating means.

4. A machine as claimed in claim **2** in which the position driving means comprises a worm gear mounted on the end of the back-up roll, a worm operatively engaging

the worm gear and a driving motor for rotation of the worm.

5. In a metal strip processing machine having a small diameter work roll over which the strip is flexed during passage at high speed through the machine and at least one back-up roll in surface contact with the work roll for support, means mounting the work roll at its ends for free rotational movement, means mounting the back-up roll at its ends for rotational movement, and means controlling the rotational movement of the back-up roll for slowing the rotational speed of the work roll to a peripheral speed which is less than the linear speed of the strip in the direction of movement of the strip in which the means for controlling the rotational movement of the back-up roll comprises a clutch operatively engaging the back-up roll for braking the rotational movement of the back-up roll which rotational movement is transmitted to the back-up roll by the strip through the work roll.

6. A machine as claimed in claim 5 in which the clutch is a slip clutch.

7. A machine as claimed in claim 5 in which the clutch is a magnetic clutch and which includes means for varying the magnetic field to adjust the amount of braking action.

8. In the processing of metal strip at high throughput speed by flexure of the metal strip over a work roll of small diameter, the improvement of slowing the rotational movement of the work roll to a peripheral speed

which is considerably less than the linear speed of the strip whereby the forces and thrusts for support of the work roll are reduced to manageable levels.

9. The process as claimed in claim 8 in which the work roll is slowed in its rotational movement by retarding the rotational movement of a back-up roll in peripheral surface engagement with the peripheral surface of the work roll.

10. The process as claimed in claim 8 in which the rotational movement of the work roll is slowed by driving a back-up roll in peripheral engagement with the periphery of the work roll at a lower rotational speed than the normal speed at which it would be driven by the strip.

11. The process as claimed in claim 8 in which the work roll is slowed by braking the rotation of a back-up roll in peripheral engagement with the work roll.

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MILTON S. MEHR, Primary Examiner

U.S. Cl. X.R.

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