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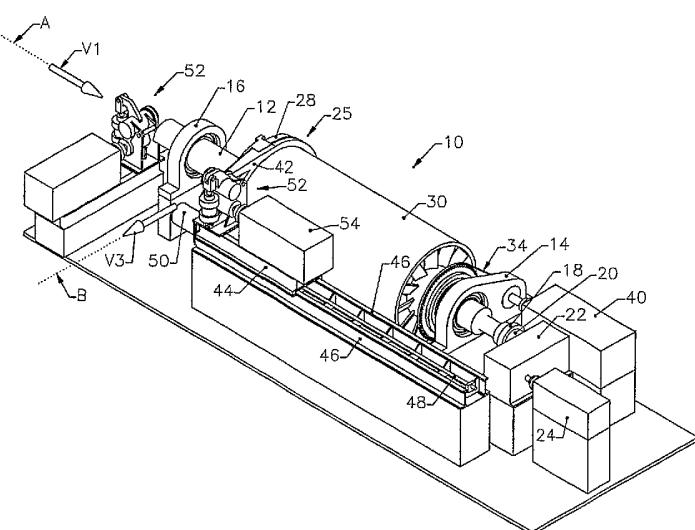
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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHOD AND APPARATUS FOR DECELERATING AND TEMPORARILY ACCUMULATING A HOT ROLLED PRODUCT



WO 2004/103594 A1

(57) Abstract: A method and apparatus is disclosed for decelerating and temporarily accumulating a hot rolled product moving longitudinally along a receiving axis (A) at a first velocity V_1 . The product is directed through a curved guide (26, 28) having an entry end aligned with the receiving axis to receive the product, and an exit end spaced radially from the receiving axis and oriented to deliver the product in an exit direction transverse to the receiving axis. The curved guide is rotated about the receiving axis in a direction opposite to the exit direction of the product and at a speed at which the guide exit end has a velocity V_2 , thereby decelerating the product being delivered from the guide exit end to a reduced velocity V_3 equal to $V_1 - V_2$. The product is formed into a helix and temporarily accumulated on a cylindrical drum (30) which is rotated in a direction opposite to the direction of rotation of the curved guide to thereby unwind the product from the drum.

METHOD AND APPARATUS FOR DECELERATING AND TEMPORARILY
ACCUMULATING A HOT ROLLED PRODUCT

CROSS REFERENCE TO RELATED APPLICATION

5 This application claims priority of Provisional Application Serial No. 60/470,265 filed May 14, 2003.

BACKGROUND OF THE INVENTION

10 1. Field of the Invention

This invention relates in general to continuous rolling mills producing hot rolled long products such as bars, rods and the like, and is concerned in particular with a method and apparatus for decelerating and temporarily accumulating such products at a selected stage in the hot rolling process.

15

2. Description of the Prior Art

In the typical rolling mill installation, billets are heated to an elevated rolling temperature in a furnace. The heated billets are then subjected to continuous rolling in successive roughing, intermediate and finishing sections of the mill, with each mill section being comprised of multiple roll stands. For larger products, the entire mill can usually be operated at or close to the maximum capacity of the furnace. However, when the rolling schedule calls for smaller products, the capacity of the finishing section is often reduced to well below that of the furnace and the roughing and intermediate mill sections. Under these circumstances, the roughing and intermediate sections can be slowed to match the capacity of the finishing section, but there are limits beyond which this becomes impractical. This is because acceptable rolling procedure dictates that the heated billets should be introduced into the first stand of the roughing section at a minimum take in speed of not lower than about 0.09-0.1 m/s. Slower take in speeds will likely cause fire cracking of the work rolls.

In other cases, for example, when rolling high speed tool steels or nickel based alloys, a higher take in speed is required to avoid excess cooling of the billet,

while lower finishing speeds are required to avoid excessive heat generation, which can cause core melting and surface cracking of the product.

In an exemplary modern day continuous rolling operation, with a furnace capacity of 100-150 tons/hr or greater, a nominal carbon low alloy steel billet with a

5 150mm square cross section and a length of 11.7m is rolled into a 2000kg. coil. When rolling 5.5mm diameter rod at the mill's maximum delivery speed of, say, 105m/s, the take in speed is 0.111m/sec, which is safely above the acceptable minimum speed. Under these conditions, the mill can produce 64.42 tons/hr (taking into consideration gap and yield). However, if the rolling schedule calls for a
10 3.5mm diameter rod, the take in speed for the same size billet at the same maximum delivery speed would have to be lowered to an unacceptably low level of 0.045m/s, with a corresponding reduction in the mill's tonnage rate to 26.8 tons/hr.

Alternatively, in order to overcome the unacceptably low take in speed, a smaller billet of the same length with, for example, a 106mm square cross section
15 could be rolled at the maximum delivery speed of 105m/s and at a safe take in speed of 0.09m/s. However, this would require a new pass design for the roll stands, different guides, a lowering of the coil weight of the finished product to 1031kg, and a reduced production rate of 26.31 tons/hr, again taking into consideration gap and yield. The necessity to store different size billets would create further
20 problems.

There exists a need, therefore, for a method and apparatus that will make it possible to roll smaller size products while maintaining the mill take in speeds at or above acceptable minimums, without having to reduce the size of the billets being processed, and preferably while continuing to roll at the mill's maximum tonnage
25 rate.

One prior attempt at achieving this objective is disclosed in U.S. Patent No. 3,486,359 (Hein), where a laying head temporarily accumulates hot rolled products exiting from the intermediate mill section on a storage reel. The accumulated product is then unwound from the storage reel at a reduced speed for continued
30 rolling in a mill finishing section. A number of drawbacks are associated with the Hein approach. For example, the product is not decelerated prior to being wound onto the storage reel. This, coupled with a lack of control over how the windings

are distributed along the reel surfaces, can cause the windings to overlap one another, and this in turn can disrupt the unwinding process.

Also, with the Hein arrangement, the laying head cannot be operated continuously, but instead must be brought to a complete stop at the beginning of 5 each storage cycle so that the product front end can be directed past the storage reel to a downstream stationary pinch roll unit. Thus, during the time required to overcome system inertia and to bring the laying head back up to its operating speed, an unsteady state exists, which can further disrupt the pattern of windings on the storage reel.

10 The present invention provides an improved method and apparatus for decelerating and temporarily accumulating hot rolled products that differ from the Hein approach in important respects that eliminate the above described drawbacks.

SUMMARY OF THE INVENTION

15 In accordance with the present invention, a method and apparatus are provided for decelerating and temporarily accumulating a hot rolled product moving longitudinally along a receiving axis at a first velocity V_1 . The apparatus includes a laying assembly having an entry end aligned with the receiving axis to receive the product. The laying assembly has a curved intermediate section leading to an exit 20 end that is spaced radially from the receiving axis and that is oriented to deliver the product in an exit direction transverse to the receiving axis. The curvature of the laying assembly and the orientation of its exit end is such that the exiting product is formed into a helix. The helix is received and temporarily accumulated on a cylindrical drum arranged coaxially with the receiving axis. The drum is rotated 25 continuously about the receiving axis in a direction opposite to the direction of rotation of the laying assembly and at a speed selected to unwind the accumulating helix at the velocity V_3 . The unwinding product is directed away from the drum by a catcher that is shiftable in a direction parallel to the receiving axis. During the time "T" required to roll a complete billet, a product length "L" equal to $T \times V_2$ is 30 temporarily accumulated on the drum.

A preferred embodiment of the invention will now be described in greater detail with reference to the accompanying drawings, wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view showing an apparatus in accordance with the present invention awaiting receipt of a hot rolled product;

5 Figure 2 is a top plan view of the apparatus;

Figure 3 is a side elevational view of the apparatus;

Figure 4 is an end view taken from the receiving end of the apparatus;

10 Figure 5 is a perspective view similar to Figure 1 showing the apparatus during a decelerating cycle;

Figure 6 is a partially sectioned top view of the curved laying assembly and associated catcher;

Figure 7 is a sectional view taken along line 7-7 of Figure 6;

Figure 8 is a diagrammatic illustration depicting the relative directions of rotation and velocities of the curved laying assembly and cylindrical drum;

15 Figure 9 is a schematic layout showing the apparatus in a mill environment; and

Figure 10 is an exemplary control diagram for the apparatus.

20 DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring initially to Figures 1-5, an apparatus in accordance with the present invention is generally depicted at 10 as comprising a laying head drive shaft 12 supported between bearings 14, 16 for rotation about a receiving axis A along which hot rolled product is received at a first velocity V_1 . One end of the drive shaft is coupled as at 18 to the output shaft 20 of a gear box 22, which in turn is driven by a motor 24.

The opposite end of the drive shaft is configured and arranged to support a curved laying assembly 25 comprising a laying pipe 26 and a helical trough extension 28.

30 As can best be seen in Figure 6, the laying pipe has an entry end 26a aligned with the axis A to receive the hot rolled product, and a curved intermediate section 26b leading to an exit end 26c communicating with the entry end 28a of the helical

trough 28. The exit end 28b of the trough is spaced radially from the axis A and oriented to deliver the product in an exit direction along an axis B transverse to the axis A.

A cylindrical drum 30 is carried by and freely rotatable on the drive shaft 5 12. One end of the drum is partially overlapped by the exit end 26c of the laying pipe 26 and the helical trough 28. A driven sprocket 32 on the opposite end of the drum is mechanically coupled by a drive chain 34 to a drive sprocket 36 on the output shaft 38 of a second motor 40.

The guide trough 28 rotates with the laying pipe 26 and coacts with the drum 10 surface to provide an extension of the guide path defined by the laying pipe. This extension is sufficient to insure that the exiting product is formed into a helical formation of rings.

As can best be seen by further reference to Figures 6 and 7, the exit end of the guide trough 28b terminates at a plane P perpendicular to the axis A. At the 15 commencement of a deceleration cycle, the product front end is delivered from the trough 28 into a catcher 42. The curvature of the rotating laying pipe 26 and trough 28 coupled with the orientation of the delivery end 28b of the trough results in the product being delivered in the form of a helix H (see Figure 5). The rings of the helix have a diameter slightly larger than the outside diameter of the drum 30, thus 20 enabling the helix to advance along the drum axis.

With reference additionally to Figure 8, it will be seen that motor 24 operates to rotate the laying assembly 25 in a direction opposite to the exit direction of the product at circumferential velocity V_2 that is less than V_1 . This results in a deceleration of the exiting product to a velocity V_3 equal to $V_1 - V_2$.

25 Motor 40 operates to rotate the drum 30 in a direction opposite to the direction of rotation of the laying assembly 25 and at a speed such that its peripheral velocity is V_3 , resulting in the product being unwound from the drum into the catcher 42 at velocity V_3 .

The catcher 42 is carried on a carriage 44 movable along rails 46 parallel to 30 the axis A. Carriage 44 is threadedly engaged by a screw shaft 48 driven by a motor 50. A pinch roll unit 52 having pinch rolls 52a driven by a motor 54 is also mounted on the carriage 44. The catcher 42 is arranged to direct the product being

delivered from the exit end 28b of the trough 28 to the pinch roll unit 52, which operates to propel the product to downstream equipment, e.g., the roll stands of a mill finishing section.

5 Motor 50 is controlled to maintain the catcher 42 in alignment with the product being unwound from the helix H temporarily accumulating on drum 30. Thus, during an initial stage of the unwinding cycle, motor 50 will operate to traverse the carriage away from the trough 28, and during the final stage of the unwinding cycle, motor 50 will reverse to traverse the carriage back towards the trough.

10 With reference to Figure 9, the apparatus 10 is shown positioned between a rolling mill intermediate section 56 and a finishing block 58 comprising the mill finishing section. A velocity gauge 60 measures the velocity of the product exiting from the intermediate mill section 56, and a hot metal detector 62 detects the arrival of a product front end. The distance S_1 between the hot metal detector 62 and the 15 entry end of the laying pipe 26 is known, as is the length S_2 of the laying pipe and associated trough 28 making up the laying assembly 25. An encoder 64 associated with motor 24 provides a means of determining the exact angular position of the exit end 28b of the trough 28 at any given instant.

20 An exemplary control diagram is illustrated in Figure 10. A controller 66 receives signals from the velocity gauge 60 and hot metal detector 62 indicative respectively of the velocity V_1 of the product and the presence of a product front end. Based on this data, and the known fixed distances S_1 and S_2 , the controller calculates and predicts the exact time of arrival T_a of the product front end at the exit end 28b the trough 28.

25 The signal from encoder 64 enables the controller to predict where the exit end of the trough will be at time T_a , and to make adjustments to the speed of motor 24 to insure that the delivery end of the trough is properly located with respect to the catcher at time T_a . At time T_a , the product front end is delivered from the exit end 28b of the trough into the catcher 42, and the controller signals motor 50 to 30 begin traversing the carriage 44 along rails 46 to maintain the catcher in alignment with the product being unwound from accumulating helix H on drum 30.

It will be seen, therefore, that with the present invention, rotation of the

laying assembly effects a deceleration of the product from velocity V_1 to velocity V_3 while simultaneously forming the product length resulting from the velocity differential between V_1 and V_3 into an ordered helical formation. The laying assembly is rotated continuously, with only minor speed adjustments to insure

5 proper positioning of the trough delivery end 28b with reference to the catcher 42 at time T_a when a product front end emerges from the trough delivery end 28b.

A second pinch roll unit 52 is advantageously employed in advance of the apparatus to continue propelling the product forward at the velocity V_1 after the product tail end drops out of the upstream roll stands of the intermediate mill.

10 The receiving end of the drum 30 may advantageously be provided with a short helical track to assist in achieving an ordered spacing between the successive rings of the accumulating helix, and the laying pipe 26 and helical trough extension 28 may be rollerized to minimize frictional resistance.

15 As shown in Figure 9, the apparatus 10 may be employed in a single strand mode between an intermediate mill section 56 and a finishing section 58, the main advantage here being the ability to roll smaller diameter products at velocity V_3 in the finishing section 58 while allowing the preceding mill sections to roll at the higher speed V_1 .

20 Thus, for example, the previously described billet with a 150mm cross section and a length of 11.7m could be rolled on a continuous mill at a higher and safe take in speed on the order of 0.09m/s to produce 3.5mm diameter rod at a finishing speed of 105m/s. This avoids any need to change the pass design and guides, allows heavier coils to be produced, and eliminates billet inventory problems.

25 Advantageously, a second decelerator 10' and an additional finishing section 58' can be employed alternatively by means of a switch 68. By employing multiple decelerators 10, 10' and finishing sections 58, 58' to alternatively process successive billet lengths, the entire mill can be operated continuously at the higher delivery velocity V_1 , resulting in a substantial increase in the rolling capacity of the mill.

30 Thus, for example, with an additional decelerator 10' and finishing mill 58' as shown in Figure 9, a mill rolling billets having 150mm cross sections and lengths of 11.7m into 5.5mm diameter rods at a delivery speed of 105m/sec can achieve a tonnage rate approximating that of the furnace output, e.g., 128 tons/hr.

I claim:

1. A method of decelerating and temporarily accumulating a hot rolled product moving longitudinally along a receiving axis at a first velocity V_1 , said method comprising:

1 directing said product through a curved guide having an entry end
2 aligned with said axis to receive said product, and an exit end
3 spaced radially from said axis and oriented to deliver said
4 product in an exit direction transverse to said axis,
5 rotating said curved guide about said axis in a direction opposite to
6 said exit direction and at a speed at which said exit end has a
7 velocity V_2 , thereby decelerating the product being delivered
8 from said exit end to a reduced velocity V_3 equal to $V_1 - V_2$, the
9 curvature of said guide and the orientation of said exit end
10 being such as to form the product delivered from said exit end
11 into a helix;
12 depositing and temporarily accumulating said helix on a cylindrical
13 drum; and
14 rotating said drum in a direction opposite to the direction of rotation
15 of said curved guide to thereby unwind said product from said
16 drum.

1 2. The method of claim 1 wherein said drum is rotated at a surface
2 velocity that causes said product to be unwound at velocity V_3 .

1 3. The method of claim 1 further comprising providing a second guide
2 for receiving the product being unwound from said drum, and reciprocally shifting
3 said second guide in parallel with said axis to maintain said second guide in
4 alignment with the product being unwound from said drum.

1 4. Apparatus for decelerating a hot rolled product moving longitudinally
2 along an axis at a first velocity V_1 , said apparatus comprising:
3 a curved guide having an entry end aligned with said axis to receive
4 said product, and having an exit end spaced radially from said

5 axis and orientated to deliver said product in an exit direction
6 transverse to said axis;
7 a first drive means for rotating said curved guide about said axis in a
8 direction opposite to said exit direction and at a speed at which
9 said exit end has a second velocity V_2 such that said product is
10 delivered from said exit end in the form of a helix and at a third
11 velocity V_3 equal to V_1-V_2 ;
12 a cylindrical drum rotatable about said axis and arranged to axially
13 receive said helix;
14 a second drive means for rotating said drum in a direction opposite to
15 the direction of rotation of said curved guide and at a speed such
16 that said product is unwound from said drum at said third
17 velocity; and
18 receiving means for receiving the product being unwound from said
19 drum.

1 5. The apparatus as claimed in claim 4 wherein a receiving end of said
2 drum is overlapped by the exit end of said curved guide.

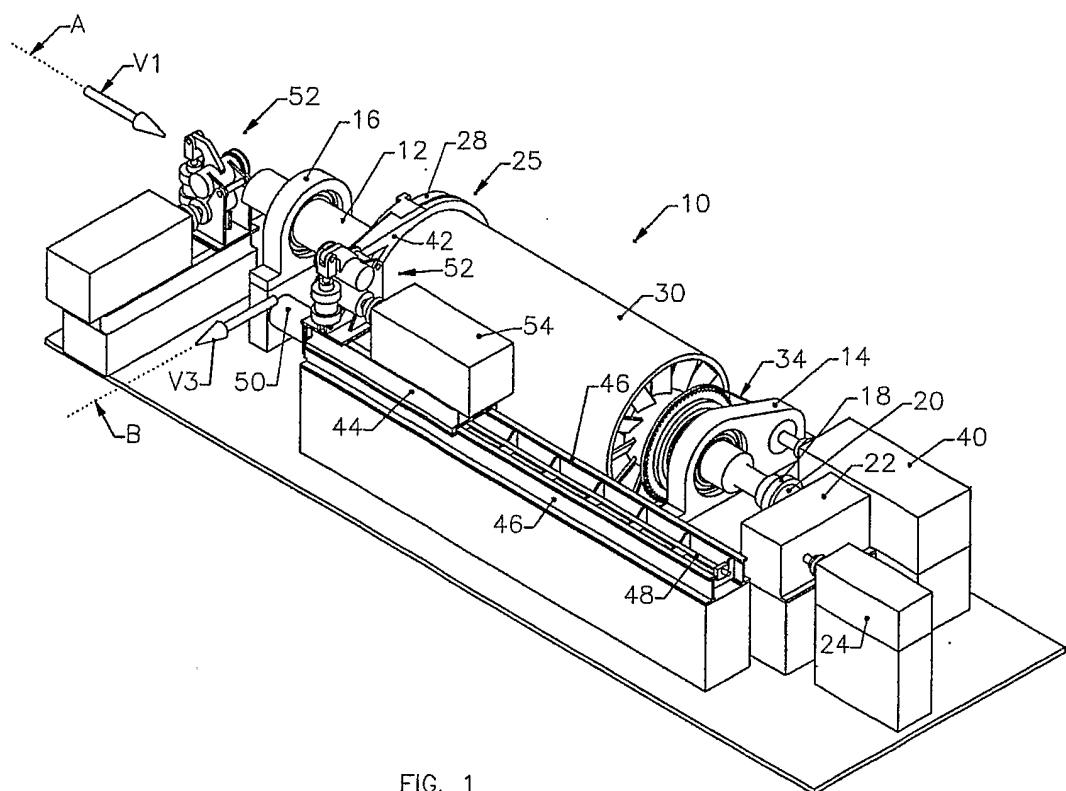
1 6. The apparatus as claimed in claim 4 wherein said receiving means
2 comprises a carriage movable along a track parallel to said axis, a second guide
3 positioned on said carriage to receive the product unwinding from said drum, and a
4 third drive means for moving said carriage along said track to maintain said second
5 guide in alignment with the unwinding product.

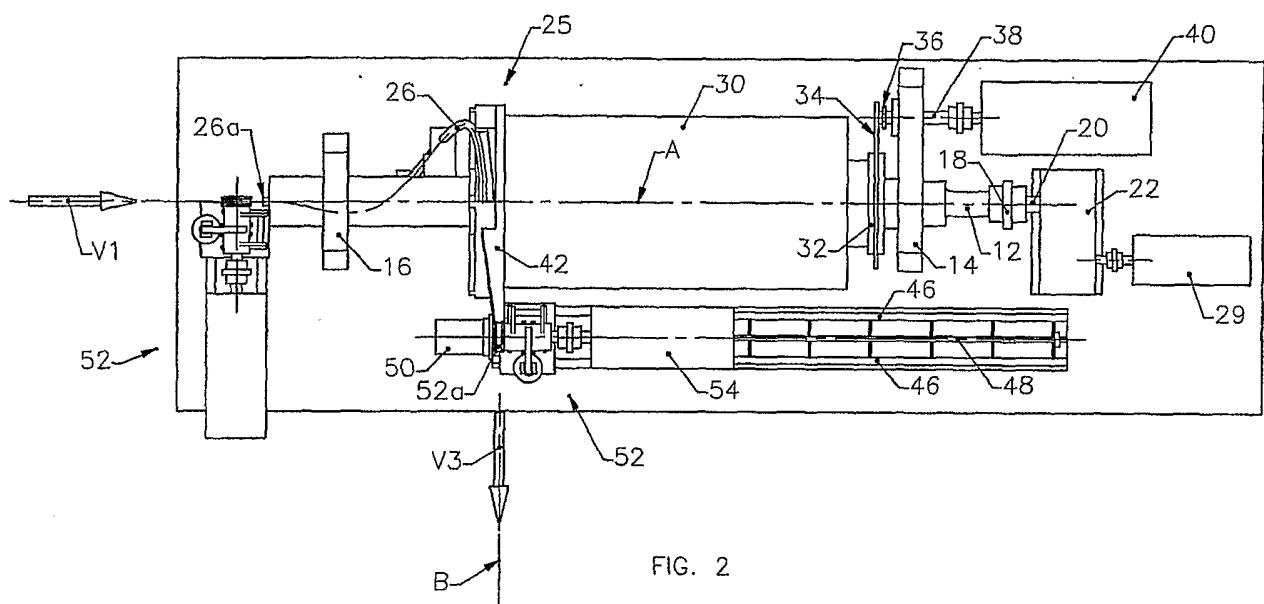
1 7. The method as claimed in claim 1 further comprising forcibly
2 advancing the product along said axis and into said curved guide.

1 8. The apparatus as claimed in claim 4 further comprising means forcibly
2 advancing the product along said axis and into said curved guide.

1 9. The apparatus of claims 4 or 8 further comprising means for forcibly

2 retracts the product being unwound from said drum.





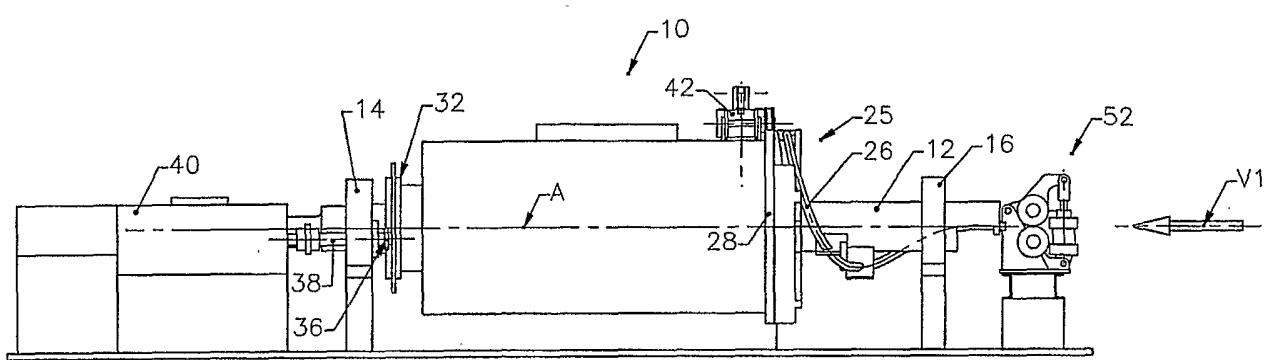


FIG. 3

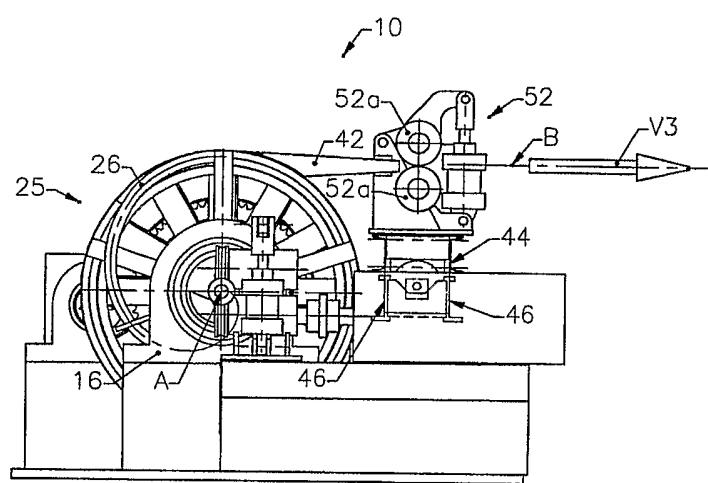


FIG. 4

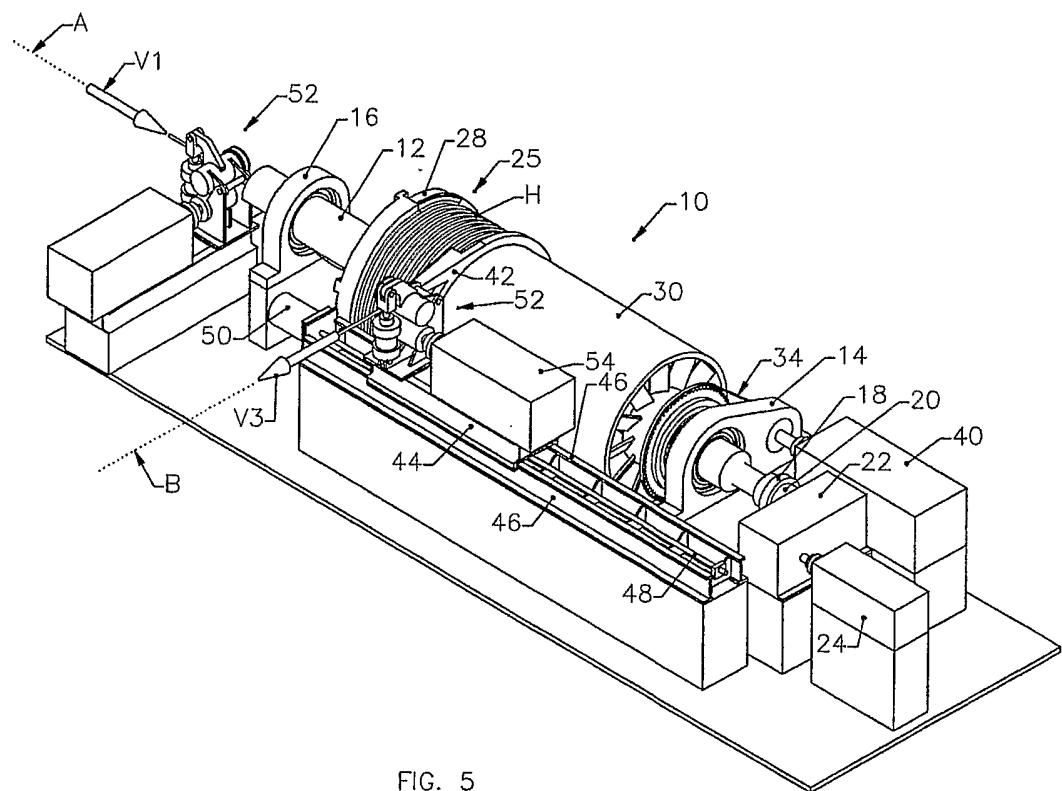


FIG. 5

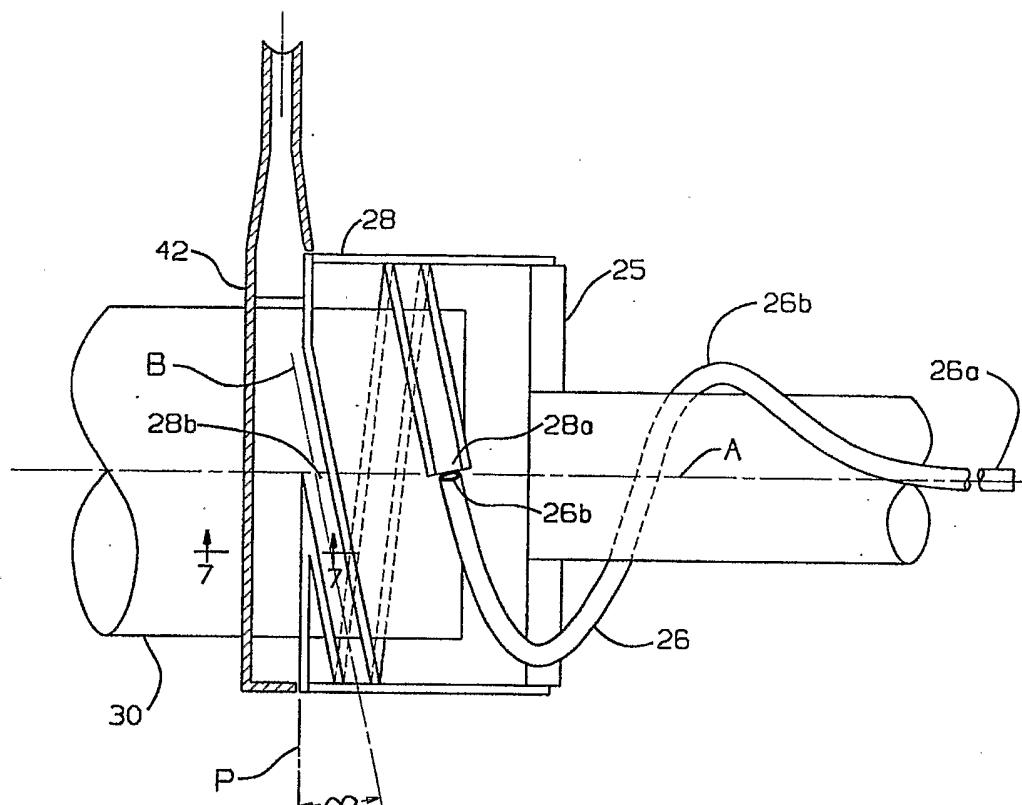


FIG. 6

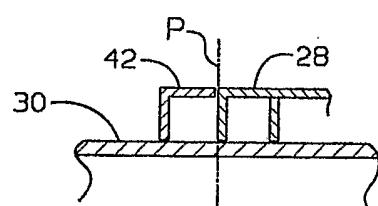
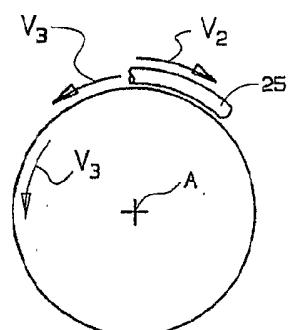
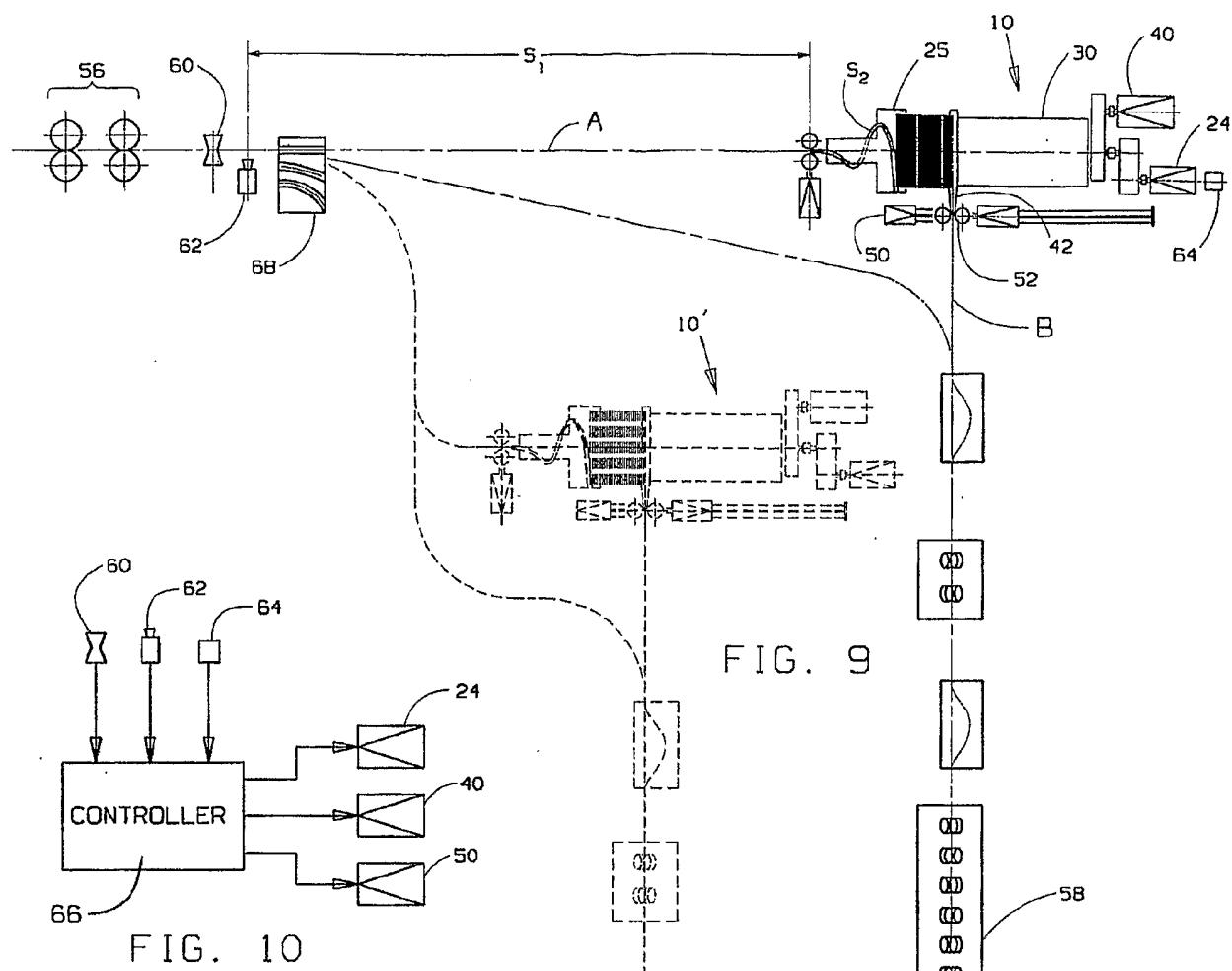


FIG. 7



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US04/13386

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : B21B 41/00
US CL : 72/66

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 72/66, 227, 231, 250, 279, 280; 242/361.2, 361.3, 361.5, 364, 364.1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,595,354 A (JOSOFF) 21 January 1997 (21.01.1997), See The Whole Document.	1, 2, 4, 5, 7 & 8
A	US 5,312,065 A (SHORE et al.) 17 May 1994 (17.05.1994), See The Whole Document.	1-8
A	US 3,486,359 A (HEIN) 30 December 1969 (30.12.1969), See The Whole Document.	1-8

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means		
"P" document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search

30 July 2004 (30.07.2004)

Date of mailing of the international search report

13 SEP 2004

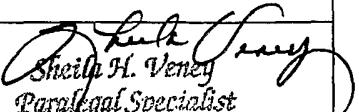
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US04/13386

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claim Nos.: because they relate to subject matter not required to be searched by this Authority, namely:

2. Claim Nos.: 9 because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically: the technical feature of this claim is not described in the specification.

3. Claim Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

The additional search fees were accompanied by the applicant's protest.

No protest accompanied the payment of additional search fees.