

VERTICAL SHEET METAL DECOILING SYSTEM

This application claims priority to U.S. Patent Application No. 12/659,887 filed March 24, 2010, the entire contents of which are incorporated herein by reference.

BACKGROUND

Field of the Invention

[0001] The present disclosure relates to equipment for constructing metal buildings at job sites and, more particularly, to decoiling system for feeding coiled sheet metal to devices for fabricating metal building panels.

Background Information

[0002] In the metal building construction process, sheet metal may be roll-formed and curved into metal building panels, and the building panels can then be fastened together to make metal buildings. Typically the sheet metal, which can be of various different gauges (thicknesses), is manufactured, shipped, and stored in large diameter coils. The coiled sheet metal must be decoiled so that it can be fed into apparatuses that perform various roll-forming operations.

[0003] Various devices for decoiling coiled sheet material are known in the related art, such as disclosed in U.S. Patent Nos. 4,160,531, 2,020,889, 2,762, 418, 6,691,544, RE20,000, 2,757,880, 2,899,145, 2,653,643, and 4,094,473 and US Patent Application Publication No. 20070170301. A typical feature of conventional devices is that they configured to support a coil of sheet material horizontally, i.e., such that the rotational axis of the coil of sheet material (i.e., the cylindrical axis of the coil) is oriented horizontally relative to a vertical direction

(the vertical direction being approximately oriented along a direction of gravitational force). Conventional devices may include a horizontal mandrel or shaft to support the coil from inside a hollow cylindrical core of the coil.

Conventional devices may also include horizontal support rollers whose lengths span the width of the coil and whose rotational axes are oriented horizontally, to support the coil from underneath at an outer-most surface of the coil.

[0004] The present inventors have observed a need for a decoiling device that can support and decoil a coil of sheet material where the rotational axis (cylindrical axis) of the coil is oriented substantially vertically.

SUMMARY

According to an exemplary embodiment, a device for decoiling a coil of sheet material comprises a support frame, a rotatable spindle supported by the support frame, the rotatable spindle configured to be positioned in a hollow core of a coil of sheet material, the rotatable spindle having an axis of rotation directed in a substantially vertical direction, and multiple conical support rollers supported by the support frame. The multiple conical support rollers are configured to support a base of the coil of sheet material, each conical support roller having a conical shape with a wide end and narrow end, each conical support roller having an axis of rotation, each conical support roller being arranged such that its respective axis of rotation is directed toward the axis of rotation of the rotatable spindle, each conical support roller being arranged such that its narrow end is positioned toward the rotatable spindle.

According to another exemplary embodiment, the device may comprise an adjustable frame assembly supporting the support frame, wherein the adjustable

frame assembly is configured to controllably change an orientation of the support frame.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. 1 illustrates a perspective view of an exemplary decoiling system according to the present disclosure.

[0006] FIG. 2 illustrates a perspective view of the decoiling system shown in FIG. 1 with a coil of sheet material positioned thereon.

[0007] FIG. 3 illustrates a side view of an exemplary roller assembly having a conical support roller for exemplary decoiling systems according to the present disclosure.

[0008] FIG. 4 illustrates a perspective view of an exemplary expandable rotating mandrel with a tensioning mechanism for exemplary decoiling systems according to the present disclosure.

[0009] FIG. 5 illustrates a perspective view of another exemplary decoiling system according having an adjustable mechanism for changing an orientation of the decoiling system according to the present disclosure.

[0010] FIG. 6 illustrates a perspective view of the exemplary decoiling system shown in FIG. 5 with the orientation changed for transporting.

[0011] FIG. 7 illustrates a side cross-sectional view of a portion of the decoiling system of FIG. 5.

[0012] FIG. 8 illustrates an exemplary drive mechanism for driving conical support rollers for decoiling systems according to the present disclosure

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0013] FIG. 1 illustrates an exemplary decoiling device 100 (also referred to herein as a decoiler) in accordance with exemplary embodiments. As shown in FIG. 1, the decoiler 100 comprises a frame 102 (e.g., a horizontal metal platform) and multiple support roller assemblies 104 supported by the frame 102, each support roller assembly 104 comprising a conical support roller 106, an outer support member 108, and an inner support member 110. The inner and outer support members 110 and 108 support each of the support rollers 106 via suitable bearings. In the example of FIG. 1, there are four support roller assemblies 104, one of which is hidden from view. The decoiler 100 also includes a central rotatable spindle 109, which serves to maintain a coil of sheet material centered on the decoiler 100. FIG. 2 illustrates the decoiler 100 with a coil of sheet material 150 positioned thereon, wherein it is seen that the coil of sheet material 150 has an outer surface 152, a hollow core 154, and an inner surface 156 within the hollow core 154.

[0014] As shown by comparing FIGS. 1 and 2, the rotatable spindle 109 is positioned to coincide with the bottom opening of a hollow core 154 of the coil 150 of sheet material. Also shown in FIGS. 1 and 2, the dotted line “B” designates the rotation axis of the rotatable spindle 109, which coincides with the cylindrical axis of the coil 150. The rotation axis “B” of the spindle 109 is oriented perpendicularly to a horizontal plane associated with the frame 102 (e.g., a plane of a supporting platform such as shown in the example of FIGS. 1 and 2). The rotation axis B is oriented substantially vertically along the Z direction when the decoiler is in use. As referred to herein “substantially vertical” means that the

rotation axis B of the decoiler is within a few degrees (*e.g.*, 1-2 degrees or less) of a gravitational force direction. In other words, when the support frame 102 is horizontally oriented to within a few degrees of “level” (*e.g.*, 1-2 degrees or less), the rotation axis B will be oriented substantially vertically.

[0015] Referring again to the example of FIG. 1, the rotatable spindle 109 may comprise a rotating platform 114 (*e.g.*, a disk of metal plate), a set of radial members 112a and 112b supported by the rotating platform 114, a vertical shaft 116 (and associated housing and bearings), and a cap 118 that secures and/or guides the radial members 112a, 112b. The rotatable spindle 109 may comprise an adjustable mechanism wherein some radial members 112b are movable inward and outward in radial directions perpendicular to the rotation axis B via scissors mechanisms, while other radial members 112a have fixed positions. A suitable scissors mechanism can be provided, for example, by connecting a lower linkage of the scissors mechanism to a vertical sleeve that slides up and down an outer surface of the central rotating shaft of the spindle 109 such that when the sleeve is pushed upward (*e.g.*, via hydraulics), the upper and lower scissors linkages are brought closer together, thereby moving the radial members 112b radially outward, and vice versa. A control switch 170 can control the hydraulics (described further below) to expand or retract the radial members 112b. Of course, the positions of the radial members 112b could also be controlled via a wedge mechanism instead of a scissors mechanism and be driven by a hand-crank instead of hydraulics as will be appreciated by those skilled in the art.

[0016] The radial members 112a, 112b preferably are shaped to have sloped upper edges as shown in FIG. 1 such that when a coil of sheet material 150 is

positioned onto the decoiler (*e.g.*, lowered onto the decoiler 100 via straps held from a hoist or forklift) the sloped edges of the radial members 112a, 112b serve to guide the coil 150 to an approximately centered position. Then, radial members 112b (whose positions are adjustable) may be moved outward in a cooperative manner so as to contact the inner surface 156 of the coil 150 to push the coil 150 into a centered position such that the cylindrical axis of the coil coincides with the rotation axis B of the rotatable spindle 109. When a coil of sheet material 150 has been consumed, the radial members 112b can be retracted radially inward.

[0017] FIG. 3 illustrates a side cross-sectional view of a support roller assembly 104 comprising an inner support member 110 and an outer support member 108 that support the support rollers 106 via suitable bearings. As illustrated in FIG. 3, the conical support rollers 106 each have a conical shape with a wide end and a narrow end, wherein each of the conical support rollers 106 has a respective axis of rotation C. The conical support rollers 106 are oriented such that their respective rotational axes C are directed radially toward the rotation axis B of the rotatable spindle, *i.e.*, toward, a center of the coil 150, and oriented at an angle θ upward relative to a horizontal direction that is perpendicular to the axis of rotation B of the rotatable spindle, so that the portions of the conical support rollers 106 that contact the bottom of the coil 150 are arranged substantially horizontally. This orientation of the conical support rollers 106 permits the flat bottom of the coil 150 to be supported along the length of each support rollers 106. Each support roller assembly 104 may also include a side roller 111 whose axis of rotation is oriented parallel to axis of rotation B supported by outer support member 108, wherein the side roller 111 can provide lateral support to prevent the coil of sheet

material 150 from shifting radially outward past an outer edge of the support roller 106.

[0018] The dimensions of the conical support members 106 can be selected based upon the expected sizes of coils of sheet material anticipated. A typical coil 150 may have, for example, an inner diameter of about 24 inches, an outer diameter of about 40 inches, and a height of about 36 inches. Generally, the length of each conical support roller 106 should be at least as large as the difference between the inner and outer radii of the coil 150, *i.e.*, the length of each conical support roller 106 should be at least as large as the radial width of the sheet material coiled on the coil 150. To accommodate typical sized coils of sheet material, the conical support rollers 106 can be about 12.3 inches long with a narrow-end diameter of about 2.25 inches and a wide-end diameter of about 5.3 inches. The narrow end of the support roller 106 can be positioned at a distance of about 9 inches from the rotation axis B of the rotatable spindle 109 (*i.e.*, from the cylindrical axis of the coil 150), and the wide end of the support roller 106 can be positioned at a distance of about 12.3 inches from the rotation axis B. The wide-end and narrow-end diameters of the conical support rollers 106 should be chosen according to the relationship $R1/R2 = A1/A2$, where A1 is a diameter of the roller 106 near its narrow end, A2 is a diameter of the roller 106 near its wide end, R1 is a distance from the rotation axis B to a contact point on the roller 106 at diameter A1, and R2 is a distance from the rotation axis B to a contact point on the roller 106 at diameter A2, such as shown in FIG. 3. Choosing the support roller dimensions according to satisfy this relationship ensures that at any given distance from the rotation axis B, the linear speed of the sheet material riding on the support

roller 106 matches the linear speed of the surface of the support roller 106 at that point. Thus, R1 and R2 can be chosen to accommodate the expected sizes of coils, A1 can be selected to a desired value (e.g., large enough for desired structural strength such as , e.g., 2.25 inches, 2.5 inches, 3 inches, etc.), and A2 can then be calculated based on R1, R2 and A1. As seen from FIG. 3, the angle θ can be given by $\sin\theta=A1/(2\cdot R1)=A2/(2\cdot R2)$. Suitable dimensions for support rollers to accommodate other coil sizes can be selected by those skilled in the art in light of the explanation above.

[0019] Choices for the materials used in fabricating various components of the decoiler 100 and other decoiling devices described herein can be made based upon the expected size and weight of coils to be accommodated. The coil 150 of sheet material can be, for example, galvanized steel sheet metal, other type of steel, galvalume, zincalume, aluminum, or other sheet material. The thickness of the sheet material may range from about 0.035 inches to about 0.080 inches in thickness. As noted above, a typical coil for use in metal building fabrication may have, for example, an inner diameter of about 20 inches (i.e., the diameter of the hollow core 124 is about 20 inches), an outer diameter of about 40 inches, and a height of about 36 inches. The weight of such coils may range from about 4000 to 9000 pounds typically, for example. The materials used for fabricating various components of decoilers according to the present disclosure should be chosen to accommodate the weight of the coils being used. For example, frame pieces may be made from stainless steel or aluminum-alloy plates, e.g., 0.5-0.75 inches in thickness, support rollers made be made from stainless steel, connecting rods and

shafts may be made from stainless steel or hardened steel, bearings and gears may be made from hardened steel, etc.

[0020] FIG. 4 shows additional detail regarding the rotatable spindle 109 and associated components. As shown in FIG. 4, the radial positions of adjustable radial members 112b may be controlled via scissors mechanisms. In the example of FIG. 4, a first scissor arm 126 is rotatably attached at an upper end to an inner support member 122 via a fastener 130 (e.g., pin, bolt, etc.) wherein the inner support member 122 has a vertical slot therein. An opposing end of the first scissor arm 126 is free to move up and down in a vertical slot of radial member 112b while being guided by a fastener 130 passing through the scissor arm that rides in the vertical slot of support member 122b. A second scissor arm 128 is rotatably attached at its upper end to an upper portion of radial member 112b via a fastener 130, and a lower end of the second scissor arm 128 is rotatably attached to a sleeve 124 that can move up and down, e.g., under the control of a hydraulic mechanism.

[0021] As further shown in FIG. 4, the rotatable spindle 109 is supported by bearing housing 138 and shaft 140 that include bearing housings and associated bearings wherein the bottom flange 139 of bearing housing 138 can be mounted on a horizontal plate member of frame 102 shown in FIG. 1. Below bearing housing 138 is a hydraulic cylinder 136 having an associated vertical hydraulic shaft that can move up and down under control of a hydraulic control mechanism to drive the shaft 116 up and down. The upper end of the shaft 116, driven by the hydraulic cylinder 136, drives the bottom portion of sleeve 124 upward via a bearing such that the entire rotatable spindle 109 can rotate about the shaft 116

such that the shaft 116 itself does not need to rotate. By moving the shaft 116 upward using the hydraulic cylinder 136, the radial members 112b can be moved outward in a radial direction to center and hold the coil 150 in place. By reversing the pressure in the hydraulic cylinder or by actuating the shaft 116 downward, the radial members 112b can be moved inward in the radial direction to release and/or reposition the radial members 112b to accept a new coil 150.

[0022] The decoiler 100 may also include a tensioning mechanism for opposing a rotation of the rotatable spindle 109 so as to permit tensioning of the sheet material as it is fed from the coil 150. As shown in FIG. 4, for example, the tensioning mechanism may be provided by a disk member 144 attached to rotating disk 114 which rotates with the rotatable spindle 109, against which a brake shoe 144 or other device may be pressed via a hydraulic cylinder 142 so as to provide a controllable frictional force against the disk 144 to thereby oppose a rotation of the rotatable spindle 109. The various hydraulic cylinders 136 and 142 can be actuated under control of a control panel (not shown) having valves for controlling the pumping of hydraulic fluid from a hydraulic pump to the various hydraulic cylinders 136 and 142. The control panel and hydraulic pump can be provided on a support structure (*e.g.*, a mobile trailer that can be towed behind a truck) that also supports the decoiler 100.

[0023] FIG. 5 illustrates another exemplary decoiler 200 having an adjustable frame structure that permits adjusting an orientation of the decoiler 200, *e.g.*, for rotating the support frame 202 of the decoiler 200 by nearly 90 degrees so as to position the decoiler 200 in a non-use position for transport to and from a job site. The decoiler 200 is like decoiler 100 described above in many respects and

includes a rotatable spindle 109 with expandable radial members 112b, multiple support roller assemblies 104 with conical support rollers 106, a control switch 170 to control hydraulics for the adjustable aspect of the rotatable spindle 109, etc., such as described above for decoiler 100. In addition, as shown by comparing FIGS. 5 and 6, the decoiler 200 also comprises a frame assembly that permits rotating the support frame 202 by nearly 90 degrees. This aspect will now be further described.

[0024] In particular, referring to FIGS. 5 and 6, the support frame 202 of decoiler 200 is further supported by a frame assembly comprising a first frame member 250, a first hinged frame arm 252, a second frame member 254 and a second hinged frame arm 256. The first frame member 250 and second frame member 254 can be attached (e.g., welded or otherwise fastened) to a support structure 290 (e.g., a steel frame member of a wheeled trailer). The frame assembly also includes first and second hydraulic cylinders 258 and 260, each comprising a vertical shaft that is rotatably connected to support frame 202 via suitable hinge mechanisms. By actuating the hydraulic cylinders 258 and 260 shown in FIG. 5 with a control switch (not shown), the associated vertical shafts of hydraulic cylinders 258 and 260 can be translated upward, and a rear side of the support frame 202 is also translated upward via the upward motion of the shafts of the hydraulic cylinders 258 and 260, so as to position the decoiler 200 in the orientation shown in FIG. 6.

[0025] As shown in FIG. 5, the decoiler 200 may also include a set of guide rollers 272, 274, 276 supported by the frame (e.g., frame member 256 in this example) to guide a portion of the sheet material as it is unwound from the coil,

wherein the guide rollers 272, 274, 276 have axes of rotation oriented parallel to the axis of rotation B of the rotatable spindle 109. Of course the guide rollers 272, 274, 276 could be positioned elsewhere on the decoiler 200 and support by other frame portions.

[0026] Referring again to FIG. 5, the decoiler 200 may also include a radially adjustable retaining mechanism 280 that may include a vertically oriented retaining roller 282 that can be moved radially inward and outward and positioned against the outermost sheet of the coil 150 to prevent the coil from unwinding when its holding strap is released. In the example of FIG. 5, the position of the retaining roller 282 of the adjustable clamping mechanism 180 can be controlled via a hand-crank mechanism having a socket as shown in FIG. 5 that can accept a hand-crank, such that turning the hand-crank turns a screw hidden from view so as to translate the vertical retaining roller 282 radially inward and outward depending upon which direction the hand-crank is turned.

[0027] The decoiler 200 may also include a drive mechanism to drive at least one of the conical support rollers 106 to rotate the coil, e.g., to facilitate feeding sheet material from the coil 150 into an adjacent metal forming apparatus. FIG. 7 shows a cross sectional view of the decoiler 200, and in particular shows a drive mechanism 300 for driving a pair of conical support rollers 106 that will be further described with reference to FIG. 8. As shown in FIG. 8, the drive mechanism 300 includes a socket assembly 302 that can accept a hand-crank, a shaft 306 that can be driven by the hand-crank, and various other sprockets, shafts and gears to turn a pair of conical support rollers 106. In particular, rotational motion of shaft 306 is transferred to sprocket 308 which drives a rotation of two sprockets 310 via a chain

312. Each sprocket 310 is connected to and drives a shaft 314, which drives a bevel gear 316. Each bevel gear 316 in turn drives another bevel gear 318 connected to a shaft 320 (the shaft 320 is hidden from view for the left hand support roller 106). A bevel gear 322 connected to shaft 320 then drives another bevel gear 324 connected to roller 106. Thus, in this example, the decoiler 200 includes a drive mechanism 300 capable of turning a pair of opposing conical support rollers to assist with rotating a coil of sheet materials 150 about the rotation axis B of the rotatable spindle 109.

[0028] It will be appreciated that the various features of the decoiler 200 illustrated in FIGS. 5 and 6 can also be used in connection with the decoiler 100 shown in FIGS. 1 and 2, such as the tensioning mechanism for opposing a rotation of the rotatable spindle 109, the drive system for driving one or more conical support rollers 106, a set of guide rollers to guide sheet material as it is removed from the coil of sheet material, and a radially adjustable retaining mechanism including vertically oriented retaining roller.

[0029] The decoilers 100 and 200 can be operated in a straightforward manner. First, a coil of sheet material 150 can be lowered onto the decoiler 100, 200 by looping three or four straps around the sheet material with the coil positioned with its cylindrical axis oriented vertically (one end of a given strap threaded through the hollow core 156 of the coil 150 and the other end of that same strap directed upward along the outer surface of the coil 150), lifting the coil 150 from above via the straps using a hoist or forklift, and then lowering the coil 150 onto the decoiler 150. If the decoiler possesses four support rollers 106, use of four straps can be advantageous since the straps can be positioned between the support rollers.

Similarly, if the decoiler possess three support rollers 106, use of three straps can be advantageous. Such a coil will still have a metal retaining strap wrapped around it to prevent the sheet material from unraveling (coils are shipped with such retaining straps to prevent unraveling). If the decoiler is equipped with a retaining mechanism such as retaining mechanism 280, the retaining mechanism can be positioned such that the vertical retaining roller 282 is pushed against the outer sheet of the coil (see, e.g., FIG. 5.) With the retaining roller 282 in place, the metal retaining strap present on the coil can be removed. If the decoiler is not equipped with a retaining mechanism, a large C-clamp can be suitably positioned and clamped to the inner and outer surfaces of the coil 150 so as to free some length of sheet material so that it can be fed into an adjacent machine and effectively held to prevent unraveling. If the decoiler includes a drive mechanism for driving one or more of the support rollers 106, that drive mechanism can be operated to facilitate initially feeding sheet material from the coil into an adjacent machine.

[0030] Decoilers according to the present disclosure may have various advantages compared to conventional decoiling systems, which are configured such that the cylindrical axis of the coil is oriented in a horizontal direction during use. For example, by orienting decoilers vertically as taught herein, a substantial degree of overall compactness can be provided when considering that other equipment for metal forming will be positioned in proximity to the decoiler 100, 200. By providing a vertically oriented decoiler, other metal forming apparatuses can also be oriented vertically, in contrast to the traditional horizontal orientations, so that more equipment can be efficiently placed on the platform of a wheeled

trailer. This is a significant advantage for mobile applications where the building construction equipment must be transported to a job site.

[0031] In addition, vertical decoilers according to the present disclosure may naturally avoid “telescoping,” which is an undesirable shift of some layers of the coiled material axially such that one end of a layer or layers extends beyond an end of the coil. Telescoping in conventional decoilers can cause alignment problems and in severe instances can render a coil unusable, such that an operator then must manually straighten out the coil before the coil can be further used. Vertical decoilers according to the present invention naturally avoid telescoping because the gravitational force keeps the bottom edges of all layers of the coil of sheet materials desirably against the support rollers, which support the weight of the coil.

[0032] While this invention has been particularly described and illustrated with reference to exemplary embodiments thereof, it will be understood by those skilled in the art that changes in the above description or illustrations may be made with respect to form or detail without departing from the spirit or scope of the invention.

WHAT IS CLAIMED IS:

1. A device for decoiling a coil of sheet material, comprising:
a support frame;
a rotatable spindle supported by the support frame, the rotatable spindle configured to be positioned in a hollow core of a coil of sheet material, the rotatable spindle having an axis of rotation directed in a substantially vertical direction; and
multiple conical support rollers supported by the support frame, the multiple conical support rollers configured to support a base of the coil of sheet material, each conical support roller having a conical shape with a wide end and narrow end, each conical support roller having an axis of rotation, each conical support roller being arranged such that its respective axis of rotation is directed toward the axis of rotation of the rotatable spindle, each conical support roller being arranged such that its narrow end is positioned toward the rotatable spindle.
2. The device of claim 1, wherein the axes of rotation of the conical support rollers are oriented at an angle θ relative to a horizontal direction that is perpendicular to the axis of rotation of the rotatable spindle.
3. The device of claim 1, wherein the rotatable spindle comprises an adjustable mechanism comprising plural members for contacting an inner surface of the hollow core of the coil of sheet material, the rotatable spindle configured

such that positions of the plural members can be moved radially relative to the axis of rotation of the rotatable spindle.

4. The device of claim 1, comprising a set of guide rollers supported by the support frame to guide a portion of the sheet material as it is unwound from the coil, the guide rollers having axes of rotation oriented along the axis of rotation of the rotatable spindle.

5 The device of claim 1, comprising a drive mechanism for driving a rotation of at least one of the multiple support rollers.

6. The device of claim 1, comprising an adjustable frame assembly supporting said support frame, the adjustable frame assembly configured to controllably change an orientation of said support frame.

7. The device of claim 1, comprising a retaining roller supported by the support frame, a position of the retaining roller being adjustable in a radial direction, the retaining roller having an axis of rotation oriented along the vertical direction and being configured to be pressed against an outer surface of the coil of sheet material.

8. The device of claim 1, comprising a tension mechanism for opposing a rotation of the rotatable spindle so as to permit tensioning of the sheet materials as it is fed from the coil.

9. The device of claim 8, wherein the tension mechanism comprises a rotating disk that rotates with the rotatable spindle and a shoe configured to be pressed against the disk to provide a frictional force.