

PATENT SPECIFICATION

(11) 1 424 853

1 424 853

(21) Application No. 14249/73 (22) Filed 23 March 1973

(31) Convention Application No. 2250239

(32) Filed 13 Oct. 1972 in

(33) Germany (DT)

(44) Complete Specification published 11 Feb. 1976

(51) INT CL² B21D 51/18//39/02

(52) Index at acceptance

B3A 122H 83A1 83B5

B3E 10E1 10E2 10E4 1H1 1H2 1H4 3K

B3J 1D 2F



(54) APPARATUS FOR THE PRODUCTION OF A TUBE

(71) We, SILO VERFAHRENS A.G., a Swiss Company, of CH6301 Zug/Schweiz, Hofstraße, 1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a machine for the production of a large-diameter tube, more particularly a silo, from a sheet-metal strip coiled on a feed reel.

According to the present invention there is provided a machine for the production of a vertical tube from a metal strip coiled on a feed reel, comprising a frame of annular construction, supporting rollers carried by the frame and disposed on a helix at a distance from the bottom end of the frame, and operative to support the tube being produced at a folded seam thereof, a profiling station disposed adjacent the frame, and a seam folding station disposed adjacent the frame and operative to receive profiled strip from the profiling station and to fold adjacent turns of the strip together along a path which coincides with the helix defined by the supporting rollers to produce the wall of the tube.

Since the machine stands on the ground together with its frame, profiling station and folding station, the steps of the method required for producing the tube from a sheet metal strip can be carried out from the ground irrespective of the height of the tube or silo, the tube or silo helix being continued in the upward direction on the supporting rollers during the production operation, in accordance with the strip feed. The bottom end of the finished tube resting on the supporting rollers may have a distance from the ground such that the parts of the machine resting on the ground inside the tube can be removed from the latter before it is lowered to the ground, for which purpose the tube is rotated helically in the opposite direction. The supporting rollers support the tube until it rests on the ground.

In a preferred embodiment, each supporting roller is mounted on a pivoting arm which is pivotable about a substantially horizontal axis and which is secured against excessive displacement towards the interior of the frame by means of a strap. The supporting rollers can adjust to small diameter variations of the tube or silo. If the machine has a separate infinitely controllable drive motor for each of the profiling and folding stations, then advantageously two limit switches for controlling one of the motors are provided on the annular frame in radially spaced relationship between the profiling station and the folding station, the inner switch being used to increase the speed and the outer switch to reduce the speed of the controlled motor.

An equalizing mechanism may be associated with the folding station to adjust the tube to the required nominal diameter if the latter is exceeded or not attained.

To assist the profiling and folding station drive motors, at least one of the supporting rollers may be provided with a drive comprising an infinitely controllable motor, so that there may be more than two motors to raise the silo helically. This is advantageous particularly in the production of very high and/or large-diameter silos. Silos of a diameter of more than 20 m and a height of more than 20 m may be built by means of the machine.

A boundary ring surrounds the feed reel and limits any increase in the feed reel diameter.

Figure 1 is a plan view.

Figure 2 is a section through a profiling station on the line II—II in Figure 3 to a different scale.

Figure 3 is a section on the line III—III in Figure 2 again to a different scale.

Figure 4 is a detail of Figure 1 showing a folding station to an enlarged scale.

Figure 5 is a section on the line V—V in Figure 4 to a different scale.

50

55

60

65

70

75

80

85

90

95

Figure 6 is a section on the line VI—VI in Figure 1.

Figure 7 is a plan view of a supporting roller drive.

5 Figures 8 to 13 show variously profiled ends of a metal strip.

Figures 14 to 18 show different stages in joining adjacent edges of the strip by folding, to a different scale.

10 Figure 19 is a graph showing the fold width against the diameter.

The annular frame bearing the general reference 1 comprises a top ring 2 and a bottom ring 3. Each of the rings 2, 3 is formed from annular segments which are adapted to be detached from one another and which are sub-divided into convenient portions. The top ring 2 and the bottom ring 3 are interconnected in spaced relationship by vertical posts 4 which are made up of a rectangular or circular hollow section-member and which are disposed at uniform intervals. In the exemplified embodiment shown in Figure 1, there are ten posts, and the top and bottom rings are each sub-divided into three.

A pivoting arm 5 is mounted on each of the posts 4 with a substantially horizontal axis so as to pivot towards the inside of the annular frame 1. The range of pivoting movement of the pivoting arm is limited by a strap 6 which is formed with a slot to receive a stop member secured to the post 4. A supporting roller 7 is mounted rotatably at the free end of each pivoting arm 5. A co-acting roller 8 disposed on the same pivoting arm 5 may be associated with the supporting roller 7 to prevent the fold from opening in the tube under production. A bracket 9 which projects radially inwards is disposed on one of the posts and bears two limit switches 10 and 11 in radially spaced relationship.

A profiling station 15 is provided on the inside of the annular frame 1 near one of the supporting rollers 7 and has, in each of two planes, eight cooperating roller groups, more particularly pairs of rollers disposed with their axes parallel to the axis of the helix under production, Figure 3 showing the top and bottom fifth pairs of rollers 18 and 19. Instead of two rollers 18 disposed at the top, it would be possible to provide three cooperating rollers. The rollers of the profiling station 15 are so constructed and disposed that the side edges of a sheet-metal strip are bent as shown in Figures 8—13.

Referring to Figure 3, superposed coaxial rollers are each disposed on identical substantially vertical shafts 22 and 23 respectively. While the shaft 22 is disposed in a fixed position between a top plate 24 and a base plate 25, the shaft 23 can be adjusted transversely of its axis, for which purpose an adjustment mechanism is

provided in the region of each bearing. The adjustment mechanism comprises two U-shaped frames 26 secured respectively to the top plate 24 and the base plate 25. A bush which receives a bearing and which has a square outer periphery, is slidable horizontally between the arms of the frame 26 secured to the base plate 25. To limit the sliding movement of the bush 27 away from the shaft 22 a set-screw 28 is provided, said screw being screwed into the web of the frame 26. The bearings at the two ends of the shaft 23 are adjustable in the same way.

As shown in Figure 3, the top plate 24 and the base plate 25 are interconnected on the left-hand side by a supporting tube 30, a set-screw 31 and annular segments 32—34 disposed therebetween. Apertures for the passage of the set-screw 28 are provided above the annular segment 32 and in the annular segment 34. On the right-hand side of the drawing, (but not visible therein), a supporting bar is provided, which has a screw-thread at each end, is non-adjustable, and bears at the top a supporting plate 36 provided with the top plate 24, the bottom of said bar being screwed into the base plate 25. A motor support 37 is secured to the supporting bar at a distance from the base plate 25.

If two substantially horizontal-axis and possibly adjustable rollers are provided instead of the upper substantially vertical-axis roller on the shaft 23, a substantially vertical shaft equivalent to the shaft 23 is disposed below or above the two rollers and extends upwards or downwards only as far as the annular segment 33. A short shaft of this kind is adjustable at the annular segment 33 in the same way as the shaft 23 is in relation to the annular segments 32 and 34.

The bottom end of each of the substantially vertical shafts is provided with an identical gearwheel, the gearwheels of associated pairs of shafts, for example shafts 22 and 23, being in mesh with one another. Between two meshing pairs of gearwheels an intermediate gearwheel 43 is provided in each case so that when one of the intermediate gearwheels is driven via a drive wheel 44 of a transmission 45 all the gearwheels are jointly drivable by an infinitely controllable drive motor 46.

A raisable and lowerable wheel 48 is provided at each of the two large-area sides of the profiling station and is mounted for rotation in a U-shaped carriage 49, which is adapted to be raised and lowered by means of a set-screw 50. The carriage 49 is guided in a T-shaped recess of a guide track 51. During operation, the profiling station 15 bears on its base plate 25 and can be moved along by means of the wheels 48.

Figures 4 and 5 show the folding station.

It is disposed on an inclined table 54 in the form of annular segments, said table being inclined radially in accordance with the pitch of a helix and transversely thereto, as described hereinafter. Four folding units 55 are disposed on the table 54, each folding unit being of identical construction except for its folding rollers 56, 57 (Fig. 5.) A transmission gear is disposed between a base part 58 and two side walls 59 and 60 comprises a substantially vertical drive shaft 61 with a drive sprocket wheel 62 and a bevel gear 63 meshing with a bevel gear 64 disposed on a substantially horizontal shaft 65 and bearing the folding roller 56 at the end remote from said bevel gear. The folding roller 57 is disposed on a shaft 66 so as to rotate therewith, said shaft being mounted so as to be pivotable away from the roller 56 and being connected to the shaft 65 via a gearwheel transmission 67, the pivoted position being adjustable by means of a set-screw 68 which is borne against the side wall, the position of the folding roller 57 relatively to the folding roller 56 depending on the thickness of the fold.

The inclination of the table 54 in the radial direction is such that in the position shown in Figure 5, the folding rollers 56 and 57 about the fold only at the adjacent parts, while there is a gap between the other parts of the rollers 56 and 57 and the tube or silo under production.

The folding station 53 is adapted to be driven by a drive motor 69, which drives the individual folding units 55 via chains. Respective tensioning wheels 70 are provided in each case between each pair of adjacent folding units and between the motor and each adjacent folding unit. The drive is so constructed that each chain interconnects only two sprocket wheels, so that a pair of drive sprocket wheels 62 is arranged one above the other at the folding units 55 adjacent the drive motor 69.

The folded joints shown in Figures 14-18 are produced at the folding station 53.

A helically extending table 73 is disposed at the table 54 by means of yokes 72 and bears a plurality of (six in this case) radially slidable co-acting rollers 74 of a mechanism for urging the strip into the folding rollers. Each of the co-acting rollers is mounted in a bearing 75, the outer square periphery of which is slidable in a yoke 76 engaging around it in the form of a U on the table 73, a set-screw 77 being screwed into the web of the yoke and being adjustable against the bearing.

A co-acting roller 74a is disposed above each of the co-acting rollers 74 and its bearing is constructed in the same way and is transversely slidable in the same way as the bearing 75 of the co-acting roller 74. The yokes 78 are secured to a retaining plate 79

disposed thereabove and borne relatively to the table 73 by supports 80.

Each pair of co-acting rollers 74, 74a are respectively adjustable against the bottom and upper parts of the strip situated on opposite sides respectively of the fold. By means of each separately adjustable co-acting roller, the sheet-metal strip can be pressed into the folding rollers and it is possible to vary the tube diameter within given limits.

Only a few operations are required to dismantle the machine into readily transportable parts, the annular frame 1 being dismantled while the profiling station 15 and the folding station 53 are removed from the annular frame, the yokes 72 being removable from the table 54.

A reel 83 is disposed next to the profiling station 15 and serves to receive a reel of strip. A guide mechanism is provided to guide the strip before entry to the profiling station 15 at the side wall thereof adjacent the reel 83, said side wall having a substantially vertical slot, the guide mechanism comprising a guide plate which at this side is vertically adjustable and, in particular, is formed with a slot and a top guide member and a bottom guide member 84 for the strip are disposed preferably adjustably at said guide plate. The correct width of the fold required to be produced in the profiling station can be adjusted by means of the guide members. The latter project about 30 cm beyond the guide plate and extend approximately as far as the first roller, while the bottom guide member 84 can project further as illustrated. By means of the guide members the strip can be pressed downwardly or upwardly as it enters the profiling station 15. The guide members may be straight or curved and be disposed at an angle. The stationary part of the reel 83 has a reel winch for unwinding the strip comprising a boundary ring 85 which is open in the direction of the annular frame 1 and which surrounds the reel of strip in spaced relationship and prevents excessive increase in the diameter of the reel if the speed of the rotary movement thereof is reduced.

Figure 7 illustrates a drivable supporting roller 7a mounted on a shaft 87 and being adapted to be driven via a slipping coupling in the form of a V-belt (not shown) by means of an infinitely speed-variable drive motor 88. The shaft 87 is mounted in a frame 89 disposed on one side of one of the posts 4, on the other side of which the drive motor 88 is disposed on a base plate 90 connected to the frame 89. The frame 89 and the base plate 90 may be connected to the associated post either rigidly or by means of a pivoting arm 5. A gearwheel mounted on the shaft 87

(13)

may be used to drive a co-acting roller 8 mounted in the frame 89.

In order to produce a silo, the machine is assembled in the arrangement shown in Figure 1 at the erection site which has been prepared by means of a concrete slab or the like, the distance between the two rings 2 and 3 of the annular frame 1 preferably being greater than twice the pitch of the helix of the tube under production, the strip path determined by the roller path in the profiling station extending a slight distance from the helix determined by the supporting rollers 7. The top ring of the annular frame 1 may also extend helically, while the superposed ends of the top ring may be interconnected by a vertical connecting portion. The top supporting roller 7 is preferably at a level equivalent at least to twice the pitch of the tube under construction.

The strip path within the profiling station 15 is so devised that the edges of the strip are bent as shown in Figures 8 to 13 while the part of the strip situated therebetween is at the same time bent according to the diameter of the tube under production.

Coming from the reel 83, the strip is fed to the profiling station 15 and then, as shown in Figure 6, is borne by its top bent edge by the supporting rollers 7. The bottom end of the strip is fed between the limit switches 10 and 11. The outer limit switch 10 serves to reduce the speed of the drive motor 46 of the profiling station 15 while the limit switch 11 serves to increase its speed so that it is controlled according to the speed of the drive motor 69 of the folding station 53. After the limit switches 10, 11, the strip which has been bent at both edges is passed through the folding station, where the adjacent edges of the strip are interconnected by folding as shown in Figures 15-18, after prior engagement as shown in Figure 14, as soon as two turns are disposed one above the other.

The tube or silo is produced continuously as described above, the tube being slowly formed into a helix in the upward direction according to the required height. As soon as this has been reached, the tube is cut off level at the bottom. The profiling station 15 and the reel 83 are removed from the interior of the annular frame 1, and the same applies to the inner parts of the folding station 53 and the equalizing mechanism 74, 74a, and the bracket 9 with the limit switches 10 and 11. The tube is then lowered by rotation in the opposite direction until it rests on the ground.

Figure 19 is a graph showing favourable fold widths F (the dimension at right angles to the tube wall) in mm against the diameter D in m of the tube and against the thickness

of the strip, the curve *a* applying to a strip thickness of 1-2.5 mm, and curve *b* applying to a strip thickness of 2-5 mm, and curve *c* a strip thickness of 4-8 mm. Tolerances of $\pm 50\%$ from the indicated values are possible.

WHAT WE CLAIM IS:—

1. A machine for the production of a vertical tube from a metal strip coiled on a feed reel, comprising a frame of annular construction, supporting rollers carried by the frame and disposed on a helix at a distance from the bottom end of the frame, and operative to support the tube being produced at a folded seam thereof, a profiling station disposed adjacent the frame, and a seam folding station disposed adjacent the frame and operative to receive profiled strip from the profiling station and to fold adjacent turns of the strip together along a path which coincides with the helix defined by the supporting rollers to produce the wall of the tube.

2. A machine according to claim 1, in which the frame comprises a bottom ring which is adapted to be supported on the ground, and a top ring which is disposed thereabove and which is connected to the bottom ring by vertical posts, the distance between the top and bottom rings being greater than twice the pitch of the helix defined by the supporting rollers.

3. A machine according to claim 1 or 2, in which each supporting roller is mounted on a pivoting arm which is pivotable about a substantially horizontal axis and which is secured against excessive displacement towards the interior of the frame by means of a strap.

4. A machine according to claim 3, in which each pivoting arm is pivotally mounted on a vertical post.

5. A machine according to any of the preceding claims, in which an upper roller is disposed to coact with each supporting roller.

6. A machine according to any of the preceding claims, in which a separate steplessly variable drive motor is provided for each of the profiling station and the folding station, and two limit switches for controlling one of the motors are provided on the annular frame in radially spaced relationship between the profiling station and the folding station, the inner switch being used to increase the rotary speed and the outer switch to reduce the rotary speed of the controlled motor.

7. A machine according to any of the preceding claims, in which a mechanism is provided for urging the metal strip into the folding rollers.

8. A machine according to any of the

may be used to drive a co-acting roller 8 mounted in the frame 89.

In order to produce a silo, the machine is assembled in the arrangement shown in Figure 1 at the erection site which has been prepared by means of a concrete slab or the like, the distance between the two rings 2 and 3 of the annular frame 1 preferably being greater than twice the pitch of the helix of the tube under production, the strip path determined by the roller path in the profiling station extending a slight distance from the helix determined by the supporting rollers 7. The top ring of the annular frame 1 may also extend helically, while the superposed ends of the top ring may be interconnected by a vertical connecting portion. The top supporting roller 7 is preferably at a level equivalent at least to twice the pitch of the tube under construction.

The strip path within the profiling station 15 is so devised that the edges of the strip are bent as shown in Figures 8 to 13 while the part of the strip situated therebetween is at the same time bent according to the diameter of the tube under production.

Coming from the reel 83, the strip is fed to the profiling station 15 and then, as shown in Figure 6, is borne by its top bent edge by the supporting rollers 7. The bottom end of the strip is fed between the limit switches 10 and 11. The outer limit switch 10 serves to reduce the speed of the drive motor 46 of the profiling station 15 while the limit switch 11 serves to increase its speed so that it is controlled according to the speed of the drive motor 69 of the folding station 53. After the limit switches 10, 11, the strip which has been bent at both edges is passed through the folding station, where the adjacent edges of the strip are interconnected by folding as shown in Figures 15-18, after prior engagement as shown in Figure 14, as soon as two turns are disposed one above the other.

The tube or silo is produced continuously as described above, the tube being slowly formed into a helix in the upward direction according to the required height. As soon as this has been reached, the tube is cut off level at the bottom. The profiling station 15 and the reel 83 are removed from the interior of the annular frame 1, and the same applies to the inner parts of the folding station 53 and the equalizing mechanism 74, 74a, and the bracket 9 with the limit switches 10 and 11. The tube is then lowered by rotation in the opposite direction until it rests on the ground.

Figure 19 is a graph showing favourable fold widths F (the dimension at right angles to the tube wall) in mm against the diameter D in m of the tube and against the thickness

of the strip, the curve *a* applying to a strip thickness of 1-2.5 mm, and curve *b* applying to a strip thickness of 2-5 mm, and curve *c* a strip thickness of 4-8 mm. Tolerances of $\pm 50\%$ from the indicated values are possible.

WHAT WE CLAIM IS:—

1. A machine for the production of a vertical tube from a metal strip coiled on a feed reel, comprising a frame of annular construction, supporting rollers carried by the frame and disposed on a helix at a distance from the bottom end of the frame, and operative to support the tube being produced at a folded seam thereof, a profiling station disposed adjacent the frame, and a seam folding station disposed adjacent the frame and operative to receive profiled strip from the profiling station and to fold adjacent turns of the strip together along a path which coincides with the helix defined by the supporting rollers to produce the wall of the tube.

2. A machine according to claim 1, in which the frame comprises a bottom ring which is adapted to be supported on the ground, and a top ring which is disposed thereabove and which is connected to the bottom ring by vertical posts, the distance between the top and bottom rings being greater than twice the pitch of the helix defined by the supporting rollers.

3. A machine according to claim 1 or 2, in which each supporting roller is mounted on a pivoting arm which is pivotable about a substantially horizontal axis and which is secured against excessive displacement towards the interior of the frame by means of a strap.

4. A machine according to claim 3, in which each pivoting arm is pivotally mounted on a vertical post.

5. A machine according to any of the preceding claims, in which an upper roller is disposed to coact with each supporting roller.

6. A machine according to any of the preceding claims, in which a separate steplessly variable drive motor is provided for each of the profiling station and the folding station, and two limit switches for controlling one of the motors are provided on the annular frame in radially spaced relationship between the profiling station and the folding station, the inner switch being used to increase the rotary speed and the outer switch to reduce the rotary speed of the controlled motor.

7. A machine according to any of the preceding claims, in which a mechanism is provided for urging the metal strip into the folding rollers.

8. A machine according to any of the



* C L M S *

14

5

1,424,853

5

preceding claims, in which the frame comprises a plurality of detachable parts.

5 9. A machine according to any of the preceding claims, in which the folding station comprises individual folding units each having at least one pair of rollers.

10 10. A machine according to claim 9, in which the axes of rollers of each folding unit are disposed, in operation of the machine, at an angle to the wall of the tube under production such that those parts of the rollers which are remote from the fold are at a distance from the tube wall.

15 11. A machine according to any of the preceding claims, in which at least one supporting roller is provided with a drive comprising a steplessly variable drive motor.

20 12. A machine according to claim 11, in which a slipping coupling is provided between the supporting roller and the variable drive motor.

25 13. A machine according to claim 12, in which the slipping coupling is a V-belt.

30 14. A machine according to any of the preceding claims, in which a reel winch is provided for unwinding the feed reel and comprises a boundary ring which is open the side adjacent the frame and which surrounds the feed reel.

15. A machine according to claim 14 in which an adjustable mechanism for guiding the metal strip is provided between the reel winch and the profiling station, said mechanism comprising a vertically adjustable guide plate formed with a slot and having guide members for the two edges of the sheet metal strip.

16. A machine according to claim 15, in which the guide members are adjustable.

17. A machine according to any preceding claim, in which the major part of the folding station is disposed to the outside of the tube wall under production during operation of the machine.

18. A machine substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

19. A tube made from sheet metal strip coiled on a feed reel when made by the machine as claimed in any preceding claim.

Agents for the Applicants
WILSON, GUNN & ELLIS
Chartered Patent Agents
41—51 Royal Exchange
Cross Street
Manchester M2 7DB.