Nov. 9, 1965 R. M. STIKELEATHER 3,216,232

FIN FORMING DEVICES

Original Filed Oct. 12, 1950 4 Sheets-Sheet 1

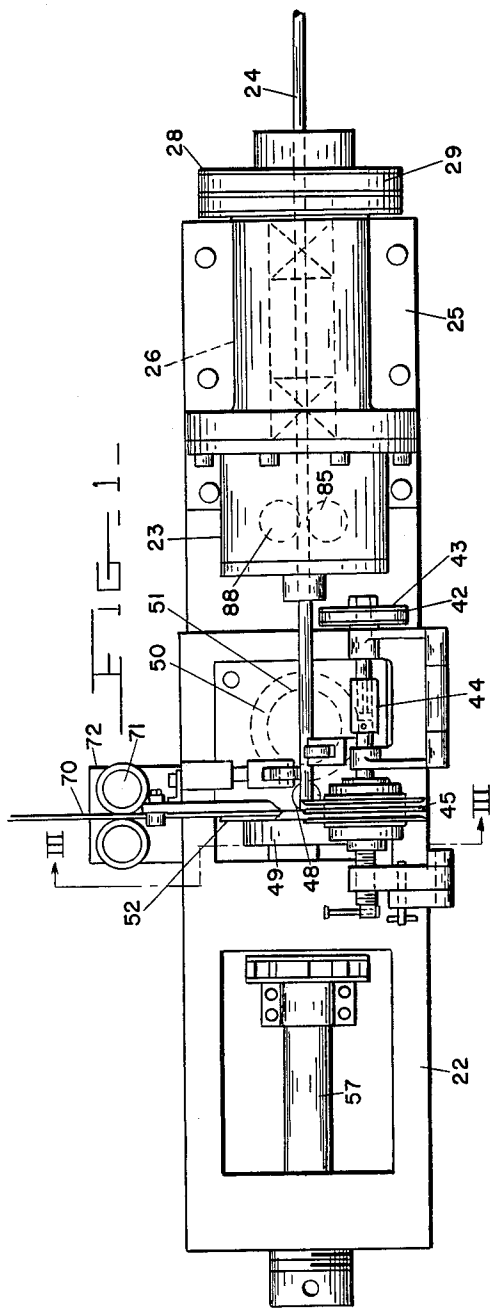

FIG. 1

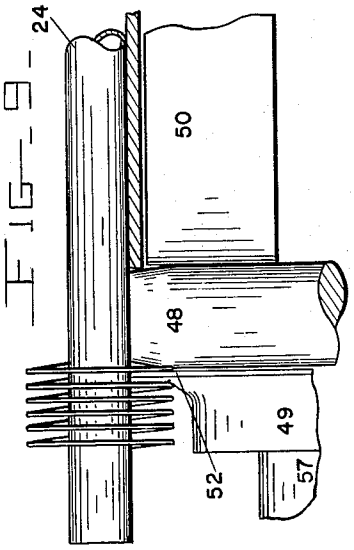

FIG. 9

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FIN FORMING DEVICES

Original Filed Oct. 12, 1950 4 Sheets-Sheet 2

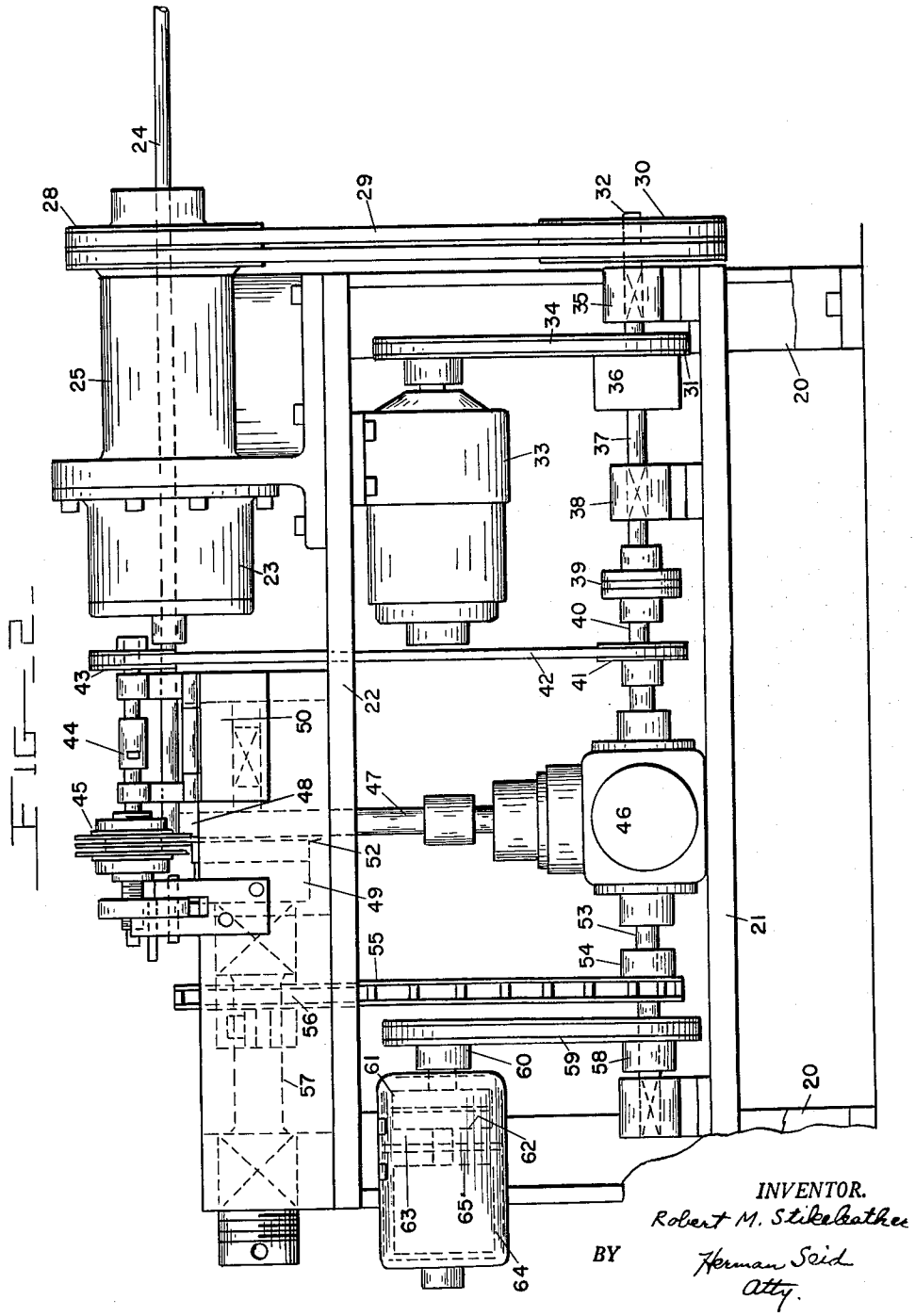

FIG. 2

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FIN FORMING DEVICES

Original Filed Oct. 12, 1950 4 Sheets-Sheet 3

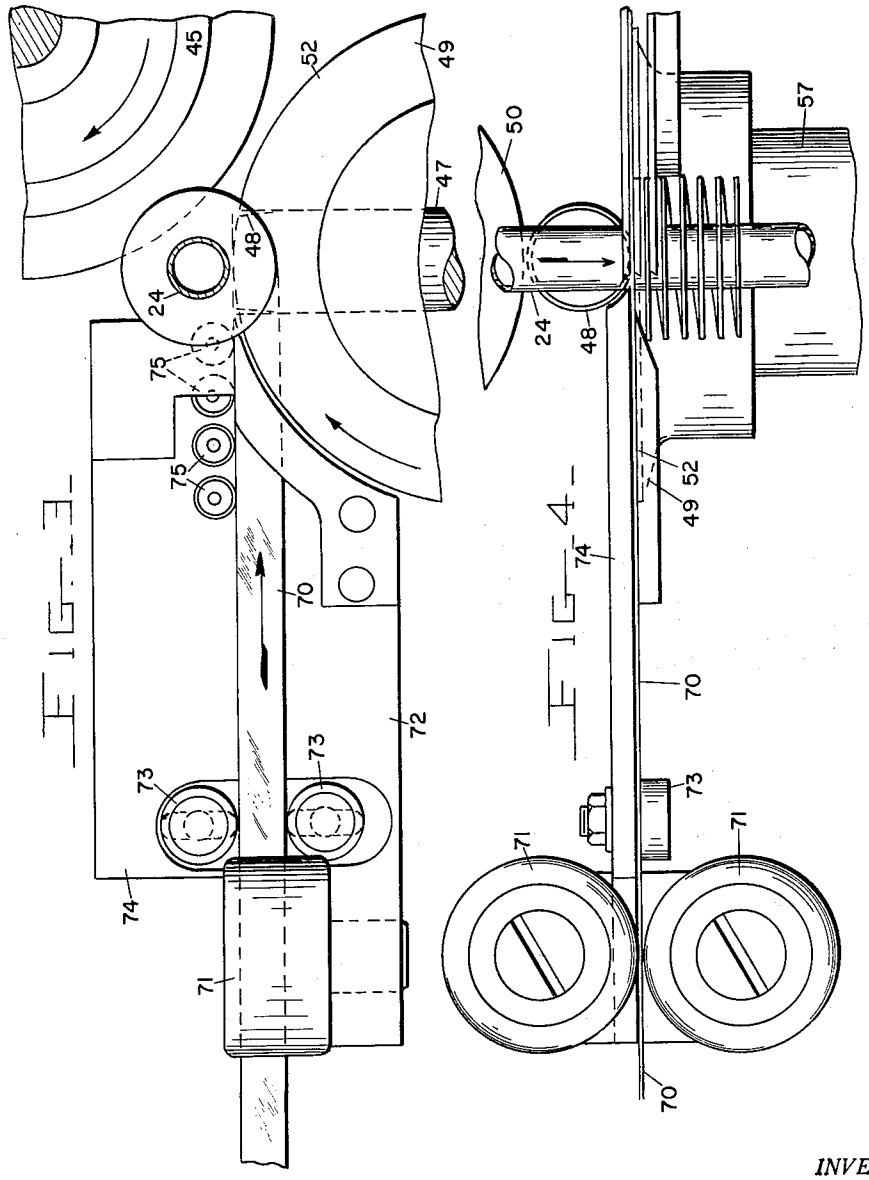

FIG. 3

FIG. 4

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FIN FORMING DEVICES

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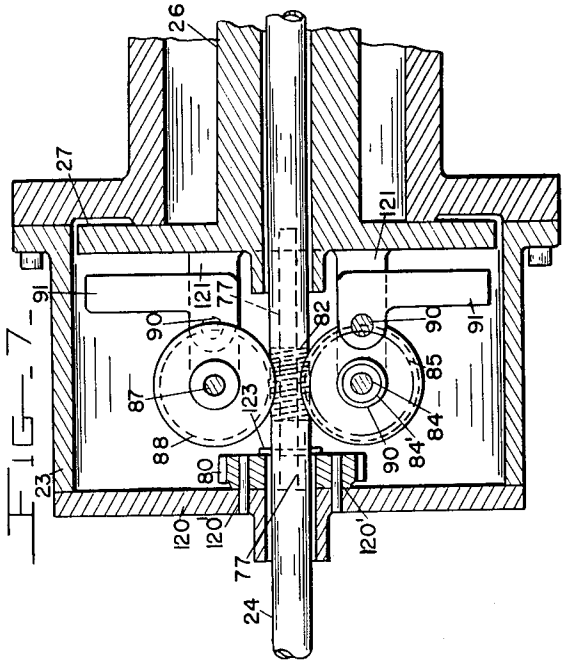

FIG. 7

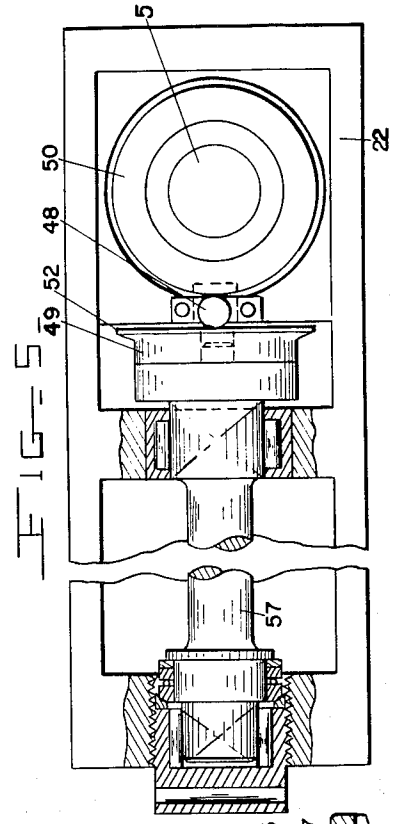

FIG. 5

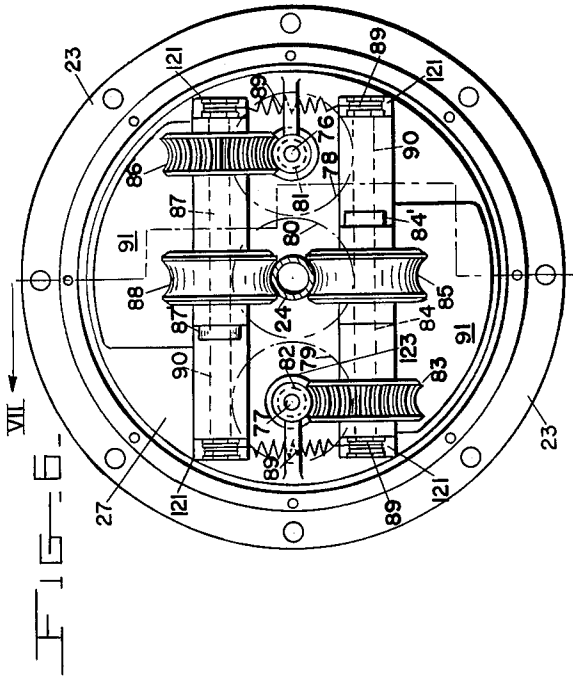

FIG. 6

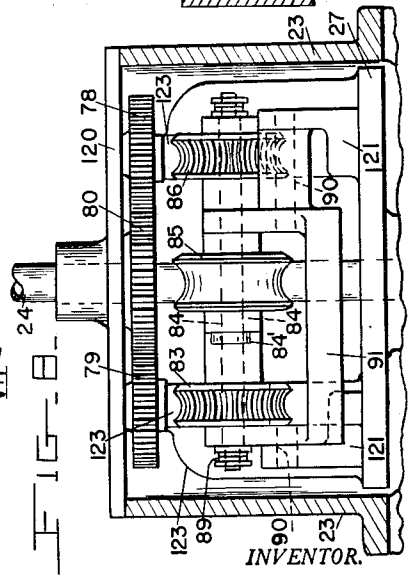

FIG. 8

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3,216,232

Patented Nov. 9, 1965

3,216,232

FIN FORMING DEVICES

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Continuation of application Ser. No. 433,601, June 1, 1954, which is a division of application Ser. No. 189,854, Oct. 12, 1950, now Patent No. 2,713,375, dated July 19, 1955. This application Nov. 28, 1960, Ser. No. 76,435

3 Claims. (Cl. 72—100)

This invention relates to the production of heat exchanger tubing with closely spaced spiral or helical fins, and to apparatus for forming same.

This application is a continuation of co-pending application S.N. 433,601, filed June 1, 1954, now abandoned, which was a division of co-pending application S.N. 189,854, filed October 12, 1950, and now Patent No. 2,713,375, issued on July 19, 1955.

As disclosed in the aforementioned applications, a machine is provided for forming a spiral or helical fin on a tube, and more particularly means permitting the application of a smooth spirally wound fin about a tube in such manner as to cause the fins to adhere to the tube surface.

A successful form of heat exchanger for conditioning air or other gases is a tube through which a heat exchange fluid is circulated, having a metal ribbon wound spirally on its exterior surface and serving as an extended heat exchange surface. Such ribbons on such tubes are usually referred to as "fins."

Prior methods of forming closely spaced fins spirally on tubes have involved either crimping the inner edge of a ribbon to cause it to curl around the tube, or forming the ribbon into a spiral before it is placed on a tube. Crimped fins are not suitable for some types of heat exchangers where smooth fins are preferred due to their lower resistance to gas flow. Pre-forming a spiral provides a smoth fin, but placing it satisfactorily on a tube for proper spacing and tension is troublesome.

This invention departs from prior practices by rolling a smooth ribbon or wire directly upon a tube so as to wind spirally thereon and form spaced fins when the tube is rotated and advanced. This is accomplished by deforming the ribbon so that its thickness is less at the outer edge than at its inner edge. Deforming the ribbon in this manner causes an increase in the length of the outer edge of the ribbon thereby causing it to curl tightly around the tube.

In one embodiment of the invention, a ribbon is fed between two rolls, one having a plane backing-up surface, and the other having a beveled surface shaped to form the ribbon as it passes between the rolls. Preferably, the roll having the plane surface is a disk roll having an outer flange which extends between the fin being formed and the adjacent previously formed fin. The roll having the beveled surface preferably has such a small diameter compared to the disk roll, that the pressure it exerts rolling the ribbon is not sufficient to break the disk.

In prior fin winding machines, great difficulty was encountered in coordinating the formation of a ribbon into a spiral, and the advance and rotation of a tube upon which the ribbon was applied, resulting in improper spacing of the turns of the fin, and in irregularities in the tension of the ribbon.

A feature of this invention resides in providing means for advancing and rotating a tube upon which a ribbon is being wound, which is so coordinated with the tension of the ribbon as it is placed upon the tube, that such means slips continuously around the tube, its rate of slip increasing when the tension of the ribbon increases above normal, and its rate of slip decreasing when the tension on the ribbon decreases below normal; thus, the proper tension is maintained at all times on the ribbon so that it cannot become loose on the tube, nor become too tight so as to break or become distorted.

A feature of this invention resides in providing a relatively large flanged roll and a relatively small beveled roll which cooperates with the flange of the flanged roll for deforming the outer portion of a ribbon for causing it to curl about a tube, and in providing a relatively large backing-up roll against the beveled roll opposite the flanged roll. The flanged roll has a relatively large diameter for providing minimum difference between its rotational pressure against the inner and outer deformed portions of the ribbon, and it has a relatively thin flange for passage between the first and second convolutions of the fin being formed. By using a relatively small beveled roll, the pressure against the flange of the flanged roll is substantially smaller than if a large beveled roll was used, permitting the flange of the flanged roll to be thin enough to pass between adjacent closely spaced fins. The small beveled roll has insufficient strength in itself to withstand the pressure involved in deforming the ribbon so that the large backing-up roll is used to prevent damage to the beveled roll.

Prior machines of this general type have employed beveled rolls having substantially the same diameters as the flanged rolls, requiring very thick flanges for withstanding the great pressures against them. Such thick flanges prevented the fin being wound from being closely spaced.

As the fin passes from between the forming rolls, if very thin stock is used, it may have a wave formed therein which is undesirable where smooth fins are preferred. A straightening roll is provided for removing this wave.

An object of the invention is to provide an improved method of forming a metal fin spirally about a metal tube.

Another object of the invention is to provide an improved machine for forming a metal fin spirally about a metal tube.

Another object of the invention is to coordinate the advance and rotation of a tube upon which a ribbon is wound with the tension of the ribbon.

The attached drawings illustrate a preferred embodiment of my invention, in which

FIGURE 1 is a plan view of a fin winding machine embodying the invention;

FIGURE 2 is a view in front elevation of the machine shown in FIGURE 1;

FIGURE 3 is an enlarged sectional view taken along the line III—III of FIGURE 1;

FIGURE 4 is a plan view of the portion of the machine shown in FIGURE 3;

FIGURE 5 is an enlarged view, partly in plan and partly in section, of the left-hand end of the machine shown in FIGURE 1, having the straightening disk assembly omitted;

FIGURE 6 is an enlarged end view, with the end plate removed, of the assembly for rotating and advancing a tube upon which a ribbon is to be wound;

FIGURE 7 is a sectional view taken along the line VII—VII of FIGURE 6;

FIGURE 8 is a plan view of the head assembly shown in FIGURE 6, having the upper portion of the housing of the assembly removed; and

FIGURE 9 is a fragmentary view, partly in elevation and partly in section, of the forming rolls and of several turns of a spiral fin formed thereby on a tube.

Referring to the attached drawings, there is shown the fin forming machine of the present invention. Such machine includes uprights **20** which support a lower table

21 and an upper table 22. A head 23 for rotating and advancing a tube 24, on which a fin is to be applied, is bolted to an upstanding annular flange forming one end of the bearing housing 25. Shaft 26 in head 23 has the head member 27 formed on its inner end (refer to FIGURE 7) and has pulley 28 attached to its outer end. Pulley 28 is driven through belt 29 by pulley 30 on shaft 32. The geared-down electric motor 33, bolted to the underside of table 22, rotates shaft 32 through a pulley 31 attached thereto. Belting 34 connects pulley 31 and motor 33. Shaft 32 extends through a bearing 35 supported on table 21 and is connected through an over-running clutch 36 with an aligned shaft 37 which extends through bearing 38 to coupling 39 which connects it to an aligned shaft 40 carrying pulley 31.

Belt 42 connects pulley 41 with pulley 43 which drives, through a slip joint 44, a straightening disk assembly indicated generally at 45.

Shaft 40 extends into one side of gear box 46. Vertical shaft 47 extends from the upper end of gear box 46. Preferably, the upper end of shaft 47 is tapered inwardly at its upper end (refer to FIGURE 3) to provide a tapered roll 48 which cooperates with disk roll 49 to roll the outer edge of a ribbon so that it has less thickness at its tip than at its heel. It will be appreciated that roll 48 has a diameter only a fraction of the diameter of disk roll 49, preferably less than one-half the diameter of the disk roll as shown in FIG. 9.

A backing roll 50 of greater diameter than forming roll 48 provides line contact with the upper end of shaft 47 adjacent the forming roll 48 thereon and provides backing-up support for the shaft during the finning operation. Since roll 48 is of very small diameter to permit a spiral having an extremely small diameter to be formed, it is necessary to provide roll 50 to assure the necessary strength. If roll 50 were not provided, roll 48 could not provide adequate pressure to form a spiral of extremely small diameter. Roll 50 is held in fixed position axially of the machine by a pin 51, but is free to rotate about pin 51 by its contact with shaft 47. As stated above, roll 50 permits the application of the necessary pressure by roll 48 to the metal ribbon to roll in the ribbon about the tube to form a fin of desired contour.

Disk roll 49 terminates in a flange 52 adjacent the tapered roll 48. The end of disk roll 49 is plane and is in contact with the ribbon, as hereinafter described.

A shaft 53 aligned with shaft 40, extends from the opposite end of gear box 46 and has attached thereto a relatively small sprocket 54 which is connected by a chain 55 to a relatively large upper sprocket 56 mounted on shaft 57 which supports disk roll 49, thus rotating disk roll 49 at reduced speeds. It is desirable to rotate the disk roll 49 at start-up to aid in feeding ribbon into the nip formed between rolls 48 and 49.

Shaft 53 also has attached thereto a pulley 58 connected by belting 59 to a pulley 60 attached to the hydraulic clutch member 61 which cooperates with a similar clutch member 62, driven by electric motor 63. The motor 63 and clutch members 61 and 62 are contained in a housing 64 which has a partition 65 separating the motor and the clutch members for isolating the motor from the fluid in which the clutch members operate.

The geared-down motor 33 is used for rotating the rotary mechanism described in the foregoing at low speed, for starting up, and motor 63 is provided for driving the assembly at high speed after the start of the fin winding operation.

In FIGURES 1, 3, and 4 there is shown a ribbon 70 which is fed between roller bearings 71 supported by a horizontal guide plate 72. The upper and lower edges of ribbon 70 are in contact with rollers 73 which are journalled in the vertical guide plate 74. The ribbon 70 then passes under rolls 75 journalled in plate 74, adjacent vertical guide 75', and passes between the forming roll 48 and disk roll 49, as illustrated also in FIGURE 9.

It will be understood one or more rolls 75 may be employed to guide the ribbon into the nip of rolls 48 and 49.

The means for rotating and advancing the tube 24 on which a fin is to be formed will now be described with reference to FIGURES 6, 7 and 8 of the drawings. The head member 27 on the inner end of the shaft 26 has attached thereto the supports 123 in the inner ends of which are journalled the inner ends of the shafts 76 and 77, the outer ends of which are journalled in the head member 27. On the inner ends of the shafts 76 and 77 are attached the gears 78 and 79 respectively, which intermesh with the inner gear 80, which is held against rotation with respect to the cover plate 120 by the pins 120'. The shafts 76 and 77 have attached thereto between their ends the worm gears 81 and 82 respectively.

The two oppositely positioned counter-weights 91 have the shafts 84 and 87 journalled for rotation therein adjacent their inner ends. The counter-weights are pivoted for rotation about the two pivot shafts 90 which extend through the two oppositely positioned supports 121 which are secured at their outer ends to the face plate 27.

The gear 83 meshing with the worm gear 82 is attached to the shaft 84 adjacent one end thereof, the tube feed roll 85 being attached to the shaft 84 adjacent the other end thereof. The collar 84' is attached to the end of the shaft 84 adjacent to roll 85. The gear 86 meshing with the worm gear 81 is attached to the shaft 87 adjacent one end thereof. The collar 87' is attached to the end of the shaft 87 adjacent to roll 88.

The ends of the counter-weight 91 are interconnected by the coiled springs 89 which pull the rolls 85 and 88 towards each other in frictional contact with the tube 24. The feed rolls 85 and 88 have surfaces curbed to fit the exterior surface of the tube 24.

The pivoted counter-weights 91 oppose the action of centrifugal force in tending to cause the rolls 85 and 88 and the gears 83 and 86 to move outwardly. This may be understood by reference to FIGURE 7 where it will be seen that centrifugal force will cause the larger, vertically extending portions of the counter-weights to tend to move outwardly and to rotate about the pivots 90 towards the rolls 85 and 88, thus tending to cause the rolls 85 and 88 and the gears 83 and 86 to move inwardly in opposition to the action of centrifugal force acting on such rolls and gears. The pivoted counter-weights permit the advancing and turning rolls 85 and 88 to move inwardly or outwardly against the tension of the springs 89 as the tube 24 varies in size.

In the operation of the tube rotating and advancing mechanism the rotation of shaft 26, as described above, causes rotation of the head member 27. The gears 78 and 79 carried by shafts 76 and 77 are caused to rotate though being meshed with the fixed gear 80 attached to the head 23. This causes rotation of shafts 76 and 77 and rotation of the worms 81 and 82. Rotation of the worms 81 and 82 rotates worm gears 83 and 86 which rotate the shafts 84 and 87 respectively. Tube feed rolls 85 and 88, mounted on shafts 84 and 86 are rotated in a direction to advance the tube 24 toward the fin forming rolls, to the left considering FIGURE 7 of the drawing. At the same time since the head member 27 is rotated, the rolls 85 and 88 are rotated bodily about the axis of the tube 24 causing the tube to rotate.

Springs 89 are tensioned so that under operating conditions the friction between the rolls 85 and 88 is sufficient to cause about 10% slippage between the tube and the rolls 85 and 88 under normal ribbon tension. If the ribbon tension increases above normal, the tube will be held back a corresponding amount through its connection thereto so that increased slippage will occur. If the ribbon tension decreases below normal, its pull on the tube will decrease a corresponding amount so that decreased slippage will occur. It will be appreciated that the amount of slippage is empirically determined; slippage

within a wide range may occur. I have found that as much as 50% slippage may occur, if desired.

As the tube **24** is rotated and advanced as described, and the ribbon **70** is fed between the rolls **48** and **49** as described, the outer edge of the ribbon is squeezed between the rolls so that its width is less than the width of the inner edge. This causes the ribbon to curl around the tube so that its inner edge or heel grips the tube tightly, forming a spiral fin thereon, as illustrated in FIGURES 3, 4, and 9 of the drawings. The flange **52** of roll **49** passes between adjacent turns of the fin as it is formed and supports and aids in spacing the fins. It will be appreciated the thickness of the flange of roll **49** is material in my invention. Such thickness preferably is in the order of the desired spacing between fins, or may be smaller. It will be appreciated such thickness may be slightly greater than the spacing between adjacent fins, provided such thickness is not so great as to loosen the fin upon the tube. Any slight distortion of the fin caused by such thickness will be eliminated by passage through the straightening device **45**.

It will be appreciated that rotation of rolls **48** and **49** draws the ribbon from supply and rolls it in about tube **24**, frictionally securing the ribbon to the tube without substantial deformation at the heel and elongating the tip longitudinally of the ribbon to wind or curl the ribbon about the tube spirally to form the fin. The pressure exerted by the small forming roll **48** in rolling and forming the fin about the disk roll **49** is taken by backing roll **50**. In other words, roll **48** in itself need not exert the pressure required to shape and wrap the ribbon so that it may be small enough to roll the ribbon and not exert a pressure in excess of the strength of the disk.

As the fin passes from between rolls **48** and **49**, it may have a wave therein which for some duties would be undesirable so that the straightening disk assembly **45** is provided for removing this wave.

At the start of a fin winding operation, the straightening disk assembly **45** is pivoted out of position; after the advancing end of a ribbon has been placed by hand at the ribbon entering edges of the forming rolls, the motor **33** is started. This rotates the tube advancing and rotating mechanism and the forming rolls at slow speed for enabling any necessary adjustment to be made. At this time motor **63** is not energized. When a few turns of the fin have been properly formed, the straightening disk mechanism is rotated to its operating position, and the motor **63** is started. It starts at high speed and for preventing any sudden strain on the fin forming mechanism, the fluid clutch comprising members **61** and **62**, is provided. Since the clutch **36** is over-running, the motor **33** provides no drag at this time and may be shut down.

It may be desired to employ the machine of the present invention to form a fin with a crimp or other indentation in the tip rather than to form a smooth fin. In such circumstances the straightener assembly **45** may be omitted or operated at the same peripheral speed as the fin so that the escalloped disk will form crimps in the outer edge of the fin. Any suitable device may be substituted for the straightening disk to form the desired contour.

It will be appreciated, as shown in FIGURES 1 and 2, the straightening assembly **45** is adjustable axially by means of threaded shaft **124** of the tube **24** as well as being rotatable to and from tube **24**. Under some circumstances, it may be possible to operate the machine satisfactorily without employing the straightening assembly **45**. This is generally undesirable, however, since very delicate adjustment of the machine is required. For commercial operation, it is generally preferable to employ the straightening assembly.

If desired, the metal ribbon **70** may be lubricated prior to its supply to the forming roll. In most cases, however,

such lubrication is not necessary. While the fin is frictionally secured to the tube, under some circumstances, it may be desirable to solder the fin to the tube. In such case, any suitable soldering arrangement may be employed.

The present invention provides a speedy, economical device for forming a smooth surface fin about a metal tube. Preferably, in most cases a separate head is provided for each diameter of tube to be provided with extended heat exchange surface since the expense of such heads is not great.

The present machine permits a fin having any desired thickness to be formed on a tube even a tip thickness as low as three thousandths of an inch. Commercially, the finned tube may have a tipped thickness of four or five thousandths of an inch. By so forming the tip of the fin, large amounts of material can be saved in the outer edge of the fin. The possible saving may be 20% or more of the cost of the material required to form a fin.

While I have described a preferred embodiment of the invention, it will be understood the invention is not limited thereto since it may be otherwise embodied within the scope of the following claims.

What is claimed is:

1. In a machine for forming a spirally wound fin about a tube, means for feeding and rotating a tube through the machine, means for feeding sheet metal stock under tension to an assembly of fin fabricating rolls, said assembly forming a succession of spirally wound fins about the tube as it advances through the machine, said assembly including a disc roll with a plane surface and an outer flange which extends between the fin being formed and the adjacent previously formed fin, a beveled forming roll cooperating with said disc roll and between which the sheet metal stock is engaged, said forming roll having a diameter less than half that of the diameter of the disc roll, a back roll rotating against the forming roll on a side thereof opposed to the disc roll, the pressure exerted by the beveled forming roll being resisted by said back roll so that the disc roll will not be injured despite great pressures exerted thereon by the beveled forming roll, said means for advancing and rotating the tube upon which the ribbon is formed being operative responsive to the tension of the ribbon as it is placed upon the tube so that said means continuously slips, with respect to the tube.

2. In a machine according to claim **1**, said forming roll having, a beveled nose end, the sheet metal stock being formed between the nose end and the disc roll, the disc roll having a peripheral flange slightly less in thickness than the desired spacing between adjacent fins, said back roll being in pressure contact with the forming roll.

3. In a machine according to claim **1**, the axis of the forming roll being perpendicular to the axis of the disc roll.

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