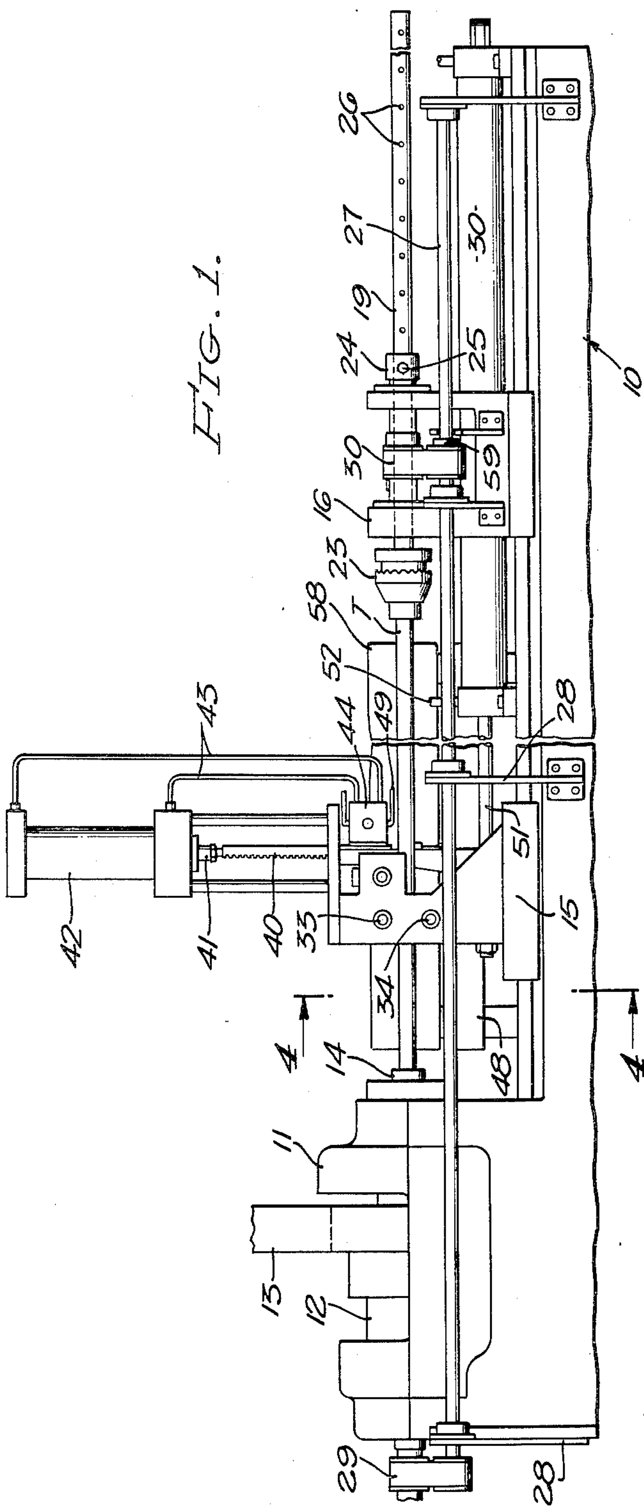
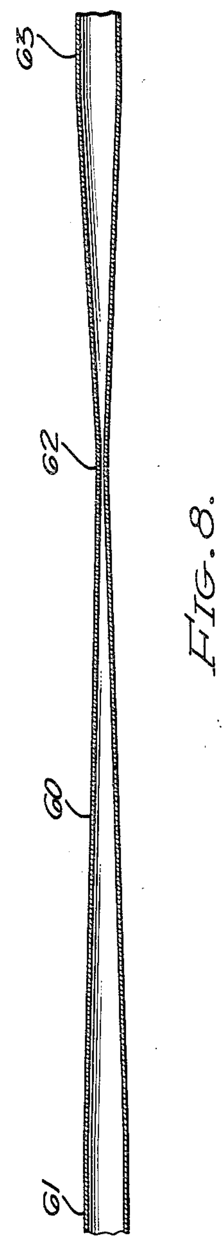
Feb. 6, 1962 C. K. LE FIELL 3,019,678

TUBE TAPERING MACHINE

Filed July 21, 1958 4 Sheets-Sheet 1





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TUBE TAPERING MACHINE

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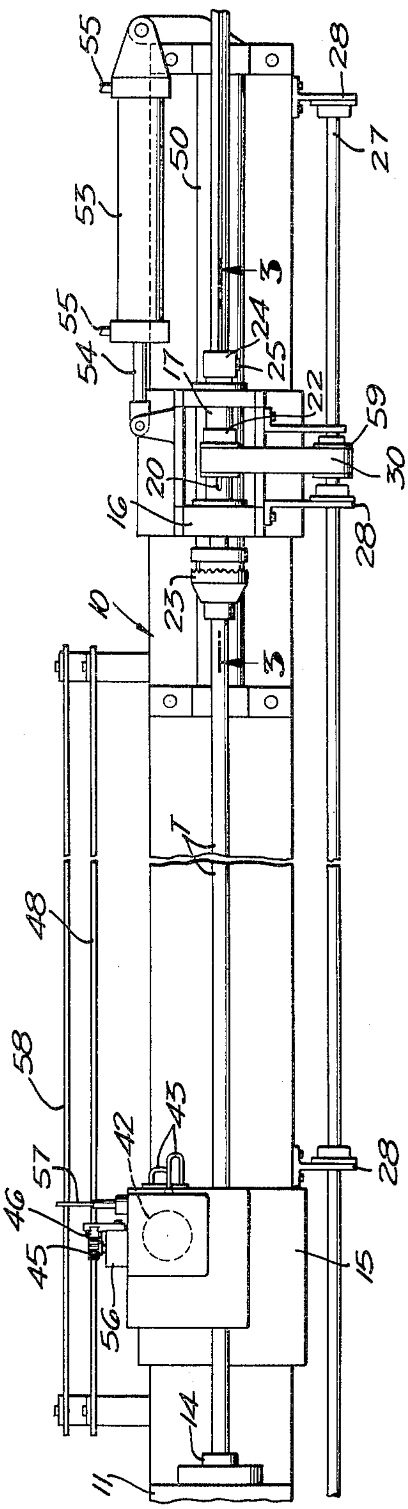

FIG. 2.

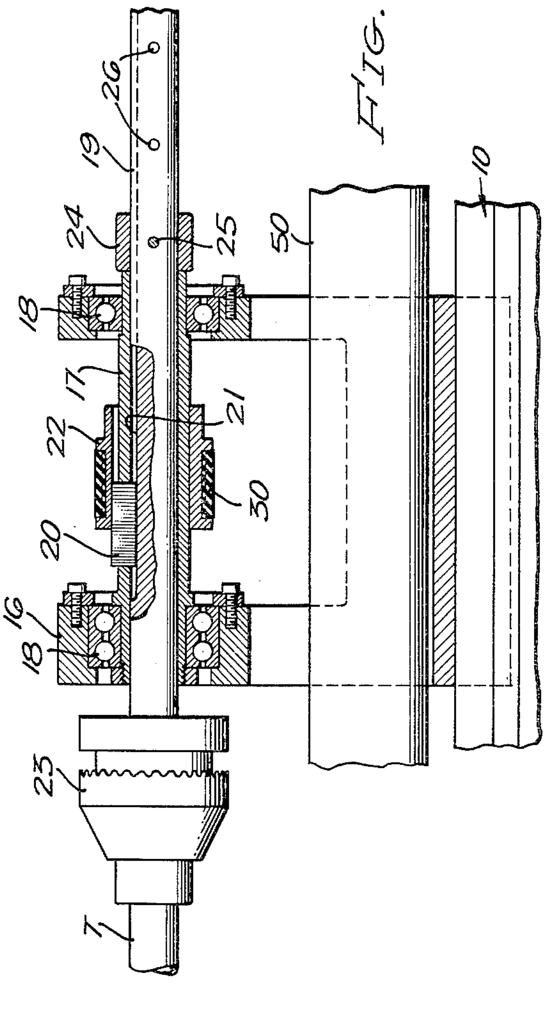

FIG. 3.

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TUBE TAPERING MACHINE

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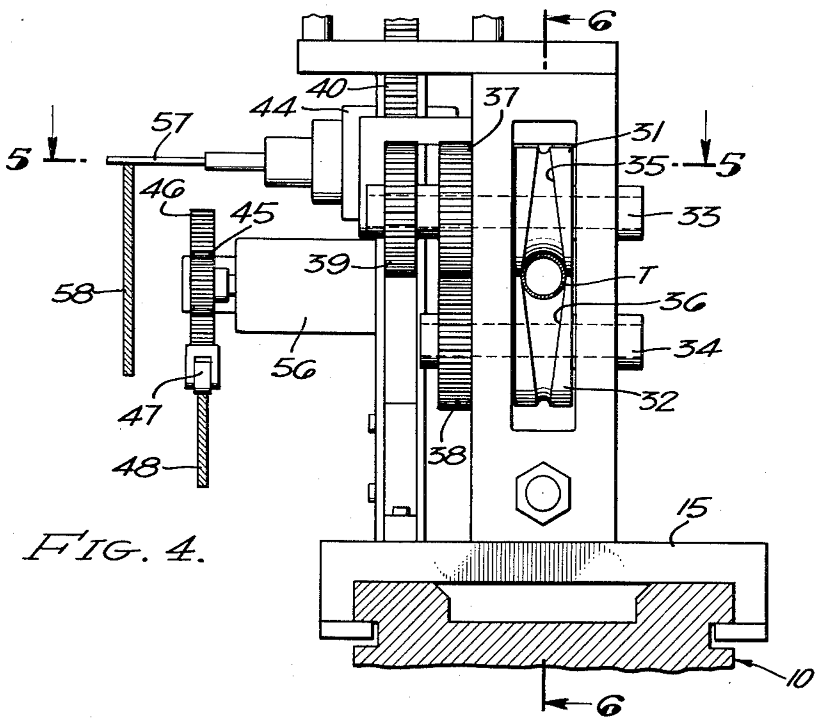

FIG. 4.

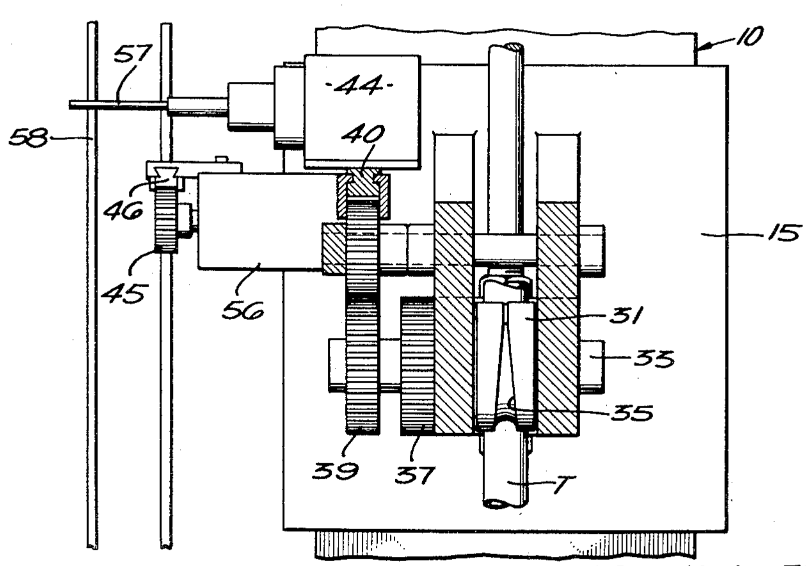

FIG. 5.

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TUBE TAPERING MACHINE

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4 Sheets-Sheet 4

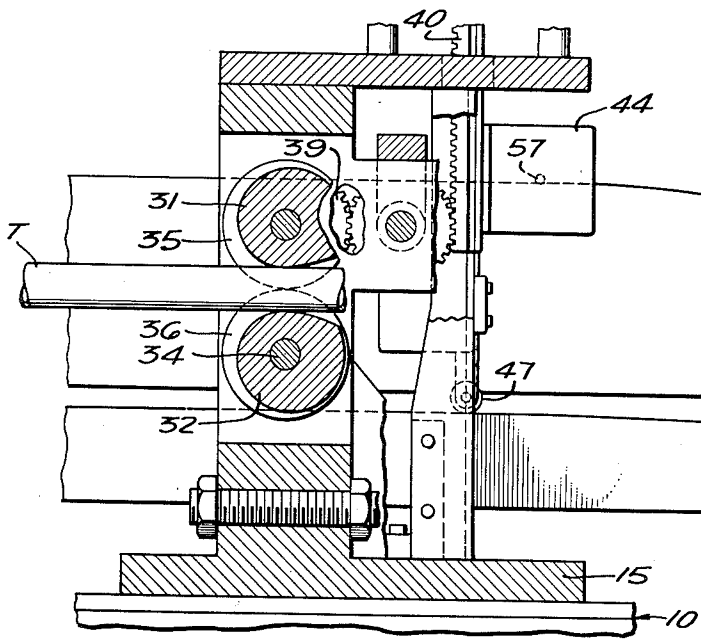

FIG.6.

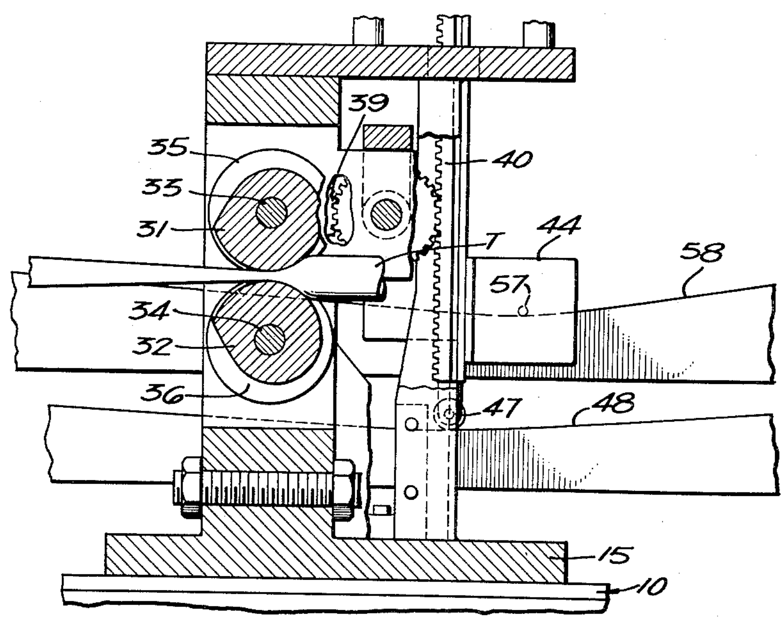

FIG.7.

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United States Patent Office

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TUBE TAPERING MACHINE

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Filed July 21, 1958, Ser. No. 749,678
2 Claims. (Cl. 80—14)

This invention relates to improvements in tube tapering machines. This application may be regarded as a continuation-in-part of the subject matter disclosed in my copending application Serial No. 497,095, filed March 28, 1955, now abandoned.

In its broader aspect, an object of the invention is to provide a method and apparatus for tapering or otherwise altering the shape of a cylindrical metal tube which usually has initially a uniform wall thickness. In accordance with the invention, tubular stock that initially is of uniform external diameter and internal diameter is continuously rotated between adjustable dies that are progressively moved in an axial direction with respect to the tube. These dies apply radially inward pressure to the exterior of the tube at localized portions thereof as the dies progressively move along the length of the tube. The dies present opposed, matched, semi-circular tapered grooves which on rotation of the dies in one direction will tend to cause the effective orifice between dies to be reduced and thus reduce external diameter of the tube. Conversely, if the dies are caused to rotate in the opposite direction they will open with respect to the tube. In this manner, by rotating the dies the tube can be caused to taper from its initial large diameter to a small diameter, and if the dies are then opened the tube can be caused to taper from its small diameter back to a larger diameter. The action of the dies on the tube may be regarded as somewhat in the nature of a combined spinning and drawing action.

In accordance with the present invention, although the tube is continually rotated while it is being worked on by the dies, a force can be applied to the tube axially thereof. Usually, this force is in the nature of a tensile force tending to stretch the tube while it is being reduced in diameter. The stretching of the tube tends to keep the tube straight while it is being reduced in diameter. The stretching of the tube tends to keep the tube straight while it is being acted upon which is one important advantage, and in addition thereto, considerable control is afforded with respect to the wall thickness of the finished tapered tube. As the dies tend to compress the wall of the tube circumferentially during the tapering operation from a large diameter to a smaller diameter, the metal of the tube may tend to increase in wall thickness. If it is desired to not only taper the tube but to retain a uniform or decreasing wall thickness despite the tapering, a sufficient axial force may be applied to stretch the tube and thus obtain a uniform or decreasing wall thickness despite the fact that the tube has had its external diameter reduced. In other instances, it may be desired to have the wall thickness increase so as to be materially thicker at the smallest portion of the taper, and when this is desired the tensile force applied to the end of the tube can either be reduced, or in certain instances, even changed to compressive force.

It is, therefore, an object of the present invention to provide a method and apparatus for tapering or altering cylindrical tube stock of uniform wall thickness wherein provision is made for adjustably applying an axial force to the tube while it is being continuously rotated and acted upon by the adjustable dies that progressively move along the length of the tube.

With the foregoing and other objects in view, which will be made manifest in the following detailed description and specifically pointed out in the appended claims, reference is had to the accompanying drawings for an illustrative embodiment of the invention, wherein:

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FIGURE 1 is a view in side elevation of a tube tapering machine embodying the present invention;

FIG. 2 is a top plan view of the same;

FIG. 3 is a view in vertical section taken substantially upon the line 3—3 upon FIG. 2, in the direction indicated;

FIG. 4 is a sectional view taken substantially upon the line 4—4 upon FIG. 1 in the direction indicated;

FIG. 5 is a horizontal section taken substantially upon the line 5—5 upon FIG. 4 in the direction indicated;

FIG. 6 is a vertical section taken substantially upon the line 6—6 upon FIG. 4 in the direction indicated, the dies being shown in that position wherein they are about to commence their tapering operation on the tube;

FIG. 7 is a view similar to FIG. 6, but illustrating the dies in a position wherein the tapering operation on the tube is substantially completed; and

FIG. 8 is a sectional view through a tube that has been typically tapered by use of the present method and apparatus.

Referring to the accompanying drawings wherein similar reference characters designate similar parts throughout, the machine embodying the present invention consists of a frame or bed generally indicated at **10**, at one end of which there is a stationary headstock **11** within which there is a rotary spindle **12** that can be rotated at various speeds, such as by a belt **13**. In this spindle there is a chuck **14** in which one end of a metal tubing T may be chucked so that it can be rotated thereby.

The frame or bed **10** provides longitudinally extending ways on which a die carrier **15** and a tailstock **16** are movable. The tailstock has a hollow spindle **17** rotatably mounted thereon such as by anti-friction bearings **18**. A mandrel **19** extends longitudinally through the spindle **17** and is slidable with respect thereto. This mandrel is keyed to the spindle **17** such as by a key **20** that slides in a keyway **21** that extends the entire length of the mandrel. The key **20** also serves to key a pulley **22** to the spindle. At the forward end of the mandrel there is a chuck **23** in which the other end of the tube T is chucked, the chuck **23** being arranged in axial alignment with the chuck **14**.

On the mandrel **19** there is a collar **24** that is positioned against the end of spindle **17**. This collar can be selectively positioned at any position along the length of the mandrel **19** by means of a bolt or pin **25** that is selectively receivable in any one of apertures **26** that extend diametrically through the mandrel.

A shaft **27** is rotatably mounted in shaft supports **28** mounted on the bed or frame **10**. This shaft is arranged parallel to the length of the bed and is driven off of the spindle **12** such as by a belt **29**. A belt **30**, in turn, drives the spindle **17** on the tailstock off of the shaft **27**. Preferably, the belts **29** and **30** are in the nature of toothed belts so that the spindle **12** and **17** will rotate in perfect unison or in synchronism to rotate forcibly both ends of the tubing T. This could also be done by chains and sprockets or gear trains.

The adjustable dies which act upon the exterior of the tubing T are illustrated at **31** and **32**. These dies are rotatably mounted on die carrier **15** for rotation about transverse axes indicated at **33** and **34**, respectively. These dies have opposed matching semi-circular tapered grooves **35** and **36** formed on the peripheral surfaces thereof which semi-circular grooves taper from one end to the other. Thus, at one end of each groove the radius of the curve is substantially equal to the radius of the exterior of the largest tube within the machine's capacity. The other end of each groove has a radius equal to the radius of the smallest diameter within the capacity of the machine.

Tubes of any diameter within the range of the dies may be tapered. It is not necessary to have different dies for various sizes or tapers.

The dies **31** and **32** are gearedly connected together such as by gears **37** and **38** so as to cause them to rotate in unison and in opposite directions. One of the dies has associated therein a pinion **39** which meshes with a rack **40** that is vertically slidable on the die carrier. The rack **40** is connected to the piston rod **41** of a ram, the cylinder of which is indicated at **42**. The ends of the cylinder are connected by tubing **43** to a tracer control valve **44** equipped with a finger or follower **57** that is engageable with the top edge of a template or cam **58**. The control valve **44** is actuated by the finger **57** and controls the supply of fluid pressure from the pump or other source of fluid pressure, not shown, to the ends of the cylinder **42**. Control valve **44** is fixedly mounted on rack **40** thereby acting as a tracer control. (These tracer control valves are in common use in other machinery.)

When fluid pressure is supplied to one end of the cylinder **42** the rack **40** is actuated in one direction to rotate both dies **31** and **32** in unison in one direction. Conversely, if fluid pressure is supplied to the other end of cylinder **42** a reverse rotation of the dies **31** and **32** is accomplished. The rotation of these dies governs the size of the tapered grooves **35** and **36** that is bearing upon the exterior of the tubing T at any particular location along the length of the tubing. Tracer control valve **44** is so constructed that pressure from the pump normally goes through to the upper end of cylinder **42**. When resultant travel carries it down (with rack **40**) until finger **57** contacts template **58** a slight deflection of finger **57** cuts off further flow. As traverse of carrier **15** (and finger **57**) brings a change in template height, flow to one end or other of cylinder **42** is automatically modified or changed to maintain neutral position contact of finger **57** with template **58**.

The die carrier **15** is caused to move steadily or at a uniform rate along the length of the bed **10** by means of a ram **50**, the piston rod of which indicated at **51**, is connected to the die carrier. The cylinder of the ram may be supplied with fluid pressure through tubings **52** so as to cause the die carrier to move axially with respect to the tubing T at a uniform rate, or at least at a rate to cause the dies to apply a constant even pressure to the exterior of the tubing T that is being worked upon. A four-way valve, not shown, reverses direction of travel as required.

The tailstock **16** is also urged to move lengthwise of the bed **10** by means of a ram **53** which has a piston rod **54** connected to the tailstock. This ram has its cylinder connected by tubings **55** to a pressure control valve **56**, that is actuated by a pinion **45** that meshes with a rack **46** that is vertically slidable thereon and which carries a roller **47** that rolls on a template or cam **48** that is replaceably mounted on the frame **10**. The shape of the top edge of the template or cam **48** governs vertical movements of the rack **46**. Vertical movements of the rack **46** actuate the pinion **45** and cause the control valve **56** to regulate fluid pressure to the ends of the cylinder **53** as required. This fluid pressure is supplied to the machine through tubing **49** from any suitable source of fluid pressure such as a hydraulic pump, not shown. A four-way valve, not shown, reverses the direction of travel of tailstock by reversing pressure to the other end of cylinder **53** when required.

As the tailstock **16** moves lengthwise of the bed the pulley for the belt **30** that is on the shaft **27** must likewise move lengthwise of the bed. This pulley indicated at **59** is consequently keyed to the shaft and may move lengthwise of the shaft along with the tailstock. The ram **53** when actuated, may cause the tailstock to move away from the headstock to impose a tension on the tubing T. This tension assists in keeping the tubing T straight while the tubing T is being acted upon by the adjustable dies **31** and **32**, and also takes up resulting lengthening of tube. The dies **31** and **32** in all positions of adjustment present surfaces or lines of contact with the tubing T that slidingly engage the tubing as it rotates. These surfaces or lines of contact do not completely surround the tubing due to the fact that some clearance must be left at the sides of the grooves in the dies due to the fact that the grooves themselves taper. Usually, the surface or line of contact that slidingly engages the rotating tubing on each dies is approximately 150° and is concave. Due to the concave line or surface of engagement between each die and the tubing as opposed to a convex deforming tool excessive working and work-hardening of the metal is avoided.

If the tubing T is to have a straight taper thereon such as the tapers **60** that taper uniformly from the large initial diameter of the tubing indicated at **61** to a small diameter indicated at **62**, then the top edge of the template or cam **48** may be merely an inclined straight edge, causing the adjustable dies **31** and **32** to rotate in unison and at a substantially uniform rate as the die carrier proceeds along the length of the bed **10**. On the other hand, if the tubing T is to be tapered from the end **61** to a point of minimum diameter **62**, and then be tapered reversely back to the maximum diameter as indicated at **63**, then the tamplate or cam **48** is given a corresponding shape to cause the dies **31** and **32** to first be rotated in one direction to taper the tubing from **61** to **62**, and then to be rotated in the opposite direction to reversely taper the tubing T from **62** to **63**.

The decrease in external diameter of the tubing T between **61** and **62** usually causes the wall thickness of the tubing T to increase from **61** to **62**. It sometimes is desirable, however, that the wall thickness of the tubing remain uniform or even decrease despite the fact that the tubing is tapered. If this is the case the template or cam **48** is so shaped as to actuate the pressure regulator **56** and vary the pressure supplied to the ram **53**. Thus, as the dies proceed from **61** to **62** the pressure regulator **56** may be so actuated as to cause the ram **53** to progressively increase the pressure supplied to the ram **53** and thus progressively increase the tension applied to the tubing T to stretch the tubing and thus compensate for the tendency of the dies to increase the wall thickness. Conversely, in proceeding from **62** to **63**, the pressure supplied to the ram **53** may be gradually decreased to compensate for the decreasing effect of the dies to increase wall thickness as they proceed from point **62** to point **63**.

It will be appreciated that by merely changing the shapes of the two templates or cams **48** and **58** virtually any combination of tapers and wall thicknesses can be secured. In some instances, uniform wall thickness throughout the tapered tube is desired. In other instances, it is desirable that the wall thickness increase at or near the point of minimum diameter **62**. In still other instances, a thinning of the wall thickness may be desired at the point **62** of minimum diameter. All of these variations are possible by merely designing a properly shaped cam or template **48**.

Various combinations of tapers are possible, the nature of the taper being governed entirely by the top edge of the template or cam **58** causing the dies to rotate in one direction or the other as required by the shape of the taper. The tubing is, of course, continuously rotated and the die carrier moves progressively along the length of the bed. The traverse speed which the die carrier moves its dies axially of the tubing is governed by a flow control valve, not shown, to ram **50**. As tension which may be variable as above explained, can be continuously applied to the tubing while it is being rotated and squeezed by the dies, the tubing not only tends to remain straight but a fine finish on the exterior of the tubing is also possible. Usually, a lubricant is fed between the dies and the exterior of the tubing. By reason of the fact that the mandrel 19 is adjustably mounted with respect to the hollow spindle 17 on the tailstock the position of the chuck 23 with relation to the head stock can be varied to accommodate tubings of various lengths.

In cases where the amount of reduction of diameter is greater than strength of tube can tolerate without failure (torsionally or otherwise) reductions may be made in a series of passes or stages to progressively reduce the diameter with or without annealing operations inbetween.

Various changes may be made in the details of construction without departing from the spirit and scope of the invention as defined by the appended claims.

I claim:

1. A tube tapering machine comprising a headstock and a tailstock both of which have rotary chucks therein in which the ends of a tube may be chucked, means for rotating the chucks, a die carrier between the chucks having opposed rotary adjustable dies mounted thereon rotatable about axes transverse to the axis of rotation of the tube and presenting opposed tapered peripheral grooves which slidingly engage the tube with concave lines of contact in all positions of adjustment of the dies, means for moving the die carrier axially of the tube as it rotates, a template, means engageable with the template for rotating the dies about their respective axis oppositely but in unison as the die carrier moves between the chucks, a second template, means for moving one of the chucks relatively to the other axially of the tube, and means engageable with the second template for regulating the movement of the axially movable chuck.

2. A tube tapering machine comprising adjustable opposed dies engageable with the exterior of a tube on opposite sides thereof for altering its shape, said adjustable dies being rotatable about parallel axes transverse to the axis of the tube and presenting opposed tapered peripheral grooves which present opposed transversely concave surfaces engageable with the tube in all positions of adjustment, means for rotating the tube in sliding contact with said concave surfaces, means for axially stressing the tube while rotating it in contact with said surfaces, means for moving the dies axially of the tube as the tube rotates in contact therewith, and means for rotating the dies about their axes of rotation independently of their movements axially of the tube to adjust the dies.

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