

Sept. 14, 1937.

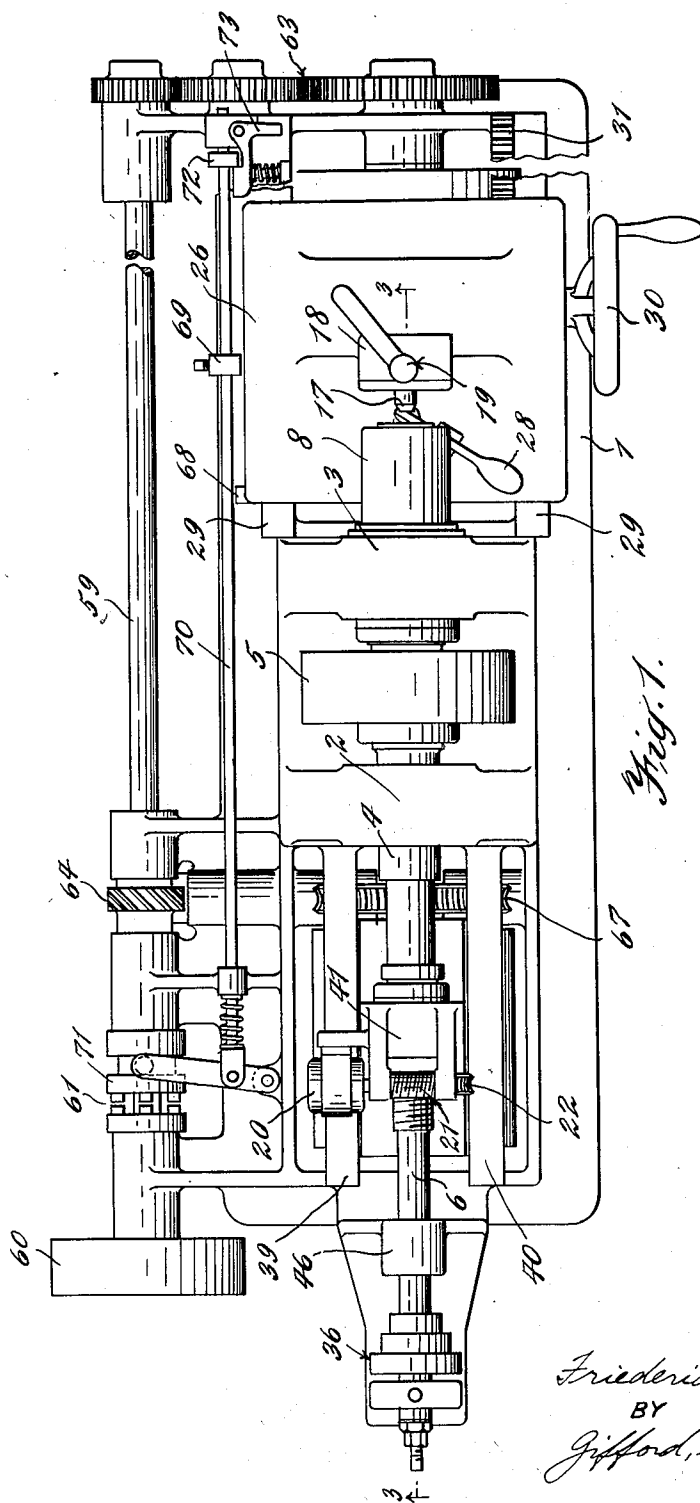
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2,093,155

TUBE FORMING APPARATUS

Filed Dec. 5, 1934

3 Sheets-Sheet 1



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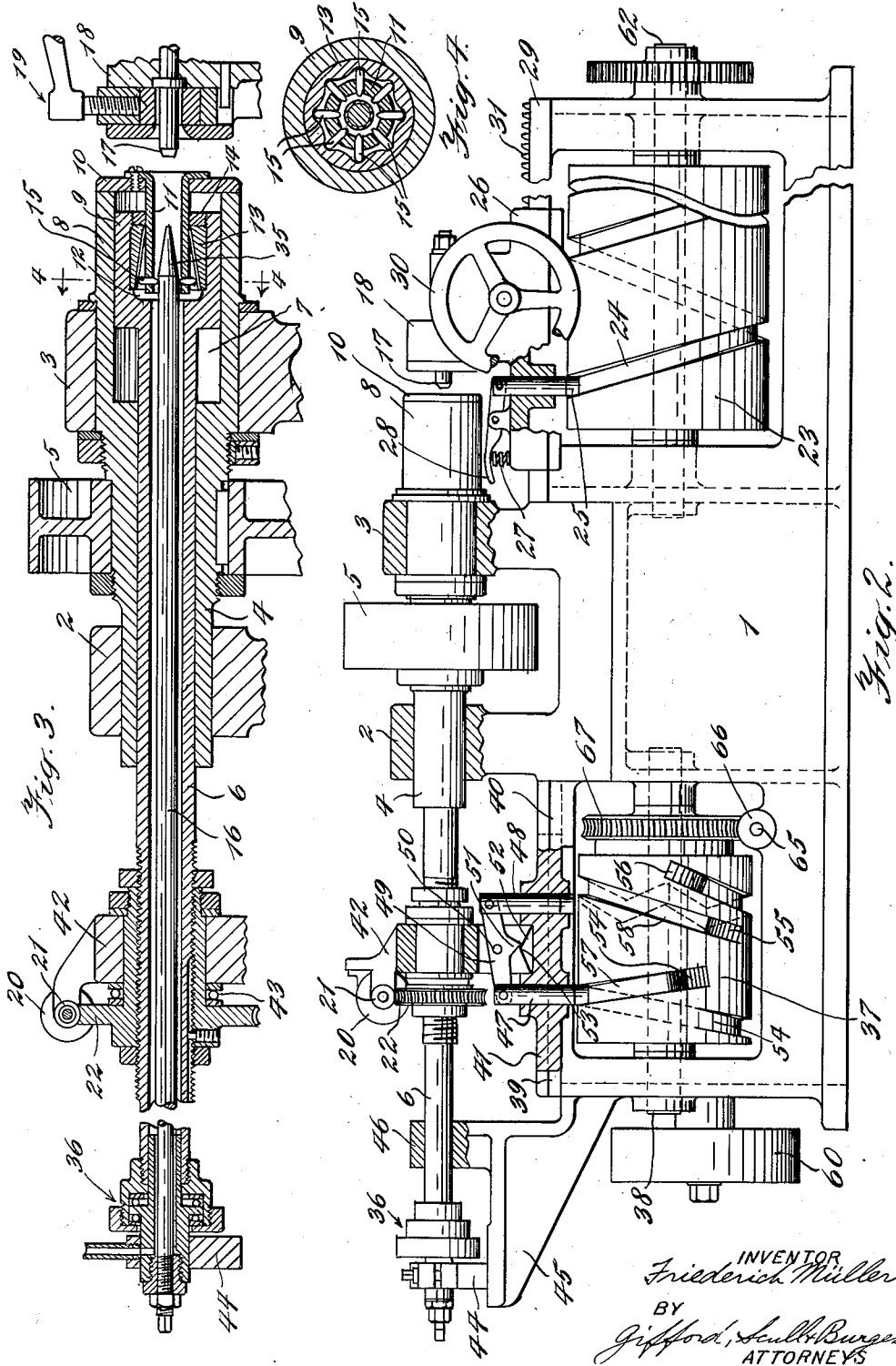
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TUBE FORMING APPARATUS

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3 Sheets-Sheet 3

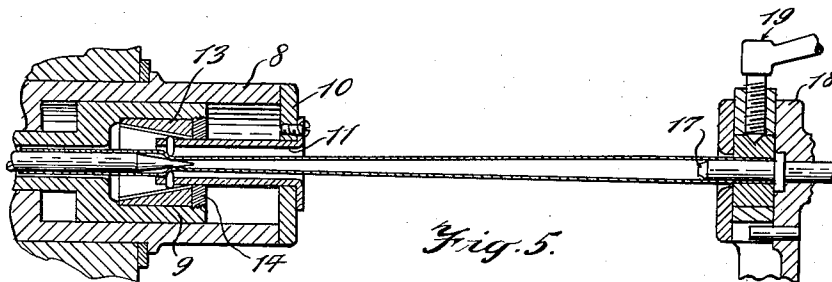


Fig. 5.

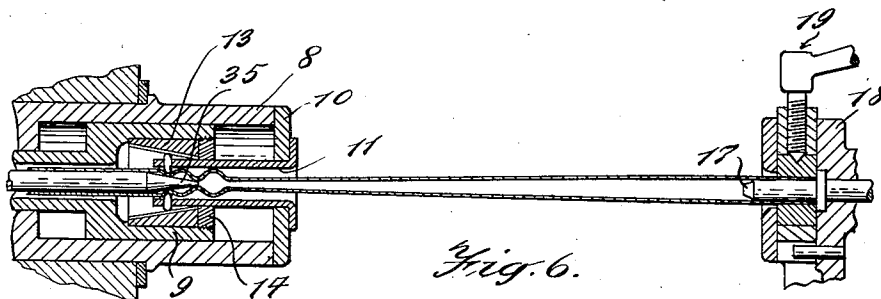


Fig. 6.

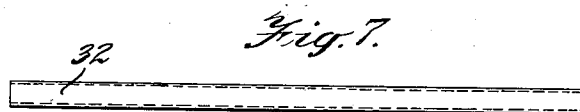


Fig. 7.

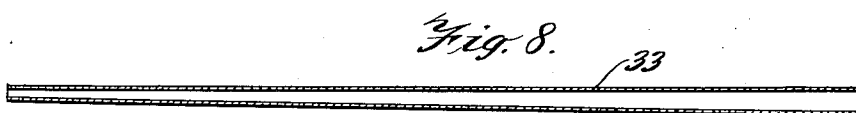


Fig. 8.



Fig. 9.

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UNITED STATES PATENT OFFICE

2,093,155

TUBE FORMING APPARATUS

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Application December 5, 1934, Serial No. 756,028

20 Claims. (Cl. 78—14)

This invention relates to a novel and improved tube-forming apparatus of the general type shown in my prior Patents 1,783,384 and 1,819,376. The novel features will be best understood from the following description and the annexed drawings, in which I have shown a selected embodiment of the invention and in which:

Fig. 1 is a plan view of the apparatus selected for the illustrative embodiment;

Fig. 2 is a side elevation of the structure appearing in Fig. 1;

Fig. 3 is a vertical sectional view taken approximately on the line 3—3 of Fig. 1;

Fig. 4 is a partial section on an enlarged scale taken approximately on the line 4—4 of Fig. 3, but showing the hammers withdrawn;

Fig. 5 is a fragmentary view taken on the same plane as Fig. 3, and showing the parts at the right-hand end of that figure in positions which they may occupy when performing work upon a tube;

Fig. 6 is a view similar to Fig. 5 but showing the parts in still another relation, and showing a different formation of tube being made by the swaging head;

Fig. 7 is a view of a section of tube before having the work performed thereon by my novel apparatus;

Fig. 8 shows a longitudinal section of the same tube after having been operated upon by my novel apparatus;

Fig. 9 shows a longitudinal section of another form which the tube of Fig. 7 may be made to take and illustrating the variety of forms which may be achieved by my novel apparatus.

The apparatus is shown as mounted on a base 1, which may be made of any suitable form and which comprises bearings 2 and 3 rotatably supporting a hollow spindle 4 which may be rotated by any suitable driving means, here shown as a pulley 5.

Rotatably mounted within the spindle and concentric therewith is a hollow shaft 6. The spindle is enlarged at one end to form a chamber 7 surrounded by a cylindrical wall 8. The shaft 6 extends within the chamber 7, where it is likewise enlarged to form a head 9 slidably contacting with the wall 8.

The wall 8 and head 9 form part of the swaging head, the rest of which is composed of a plate 10 rigidly secured to the wall 8 and having secured thereto a hammer carrier 11 disposed coaxially with the hollow shaft 6. The head 9 has a recess 12 therein, likewise coaxial with the hollow shaft 6 and consequently with the carrier 11. Mounted

within this recess is a cam 13, which may be secured in place by a collar 14 so as to move with the head 9.

The cam 13 is shown as being wedge-shaped, as seen in Fig. 3, and as having an undulating surface, as viewed in Fig. 4. The carrier 11 has slidably mounted in the walls thereof a plurality of individually operable pin-like hammers 15 capable of radial movement through the wall of the carrier. Each of these hammers has a small work engaging point adapted to operate upon the work disposed within the carrier 11, as will appear presently.

The work will normally be in the form of a tube, which has been omitted from Fig. 3 but which is shown in Figs. 5 and 6. Such a tube will be placed within the bore of the hollow shaft 6 and surrounding the mandrel 16 within that bore. The end of the tube will then be disposed upon the stud 17 in the draw-head 18, where it may be secured by means of the chuck shown generally at 19. The details of this chuck may be the same as those shown in my aforesaid Patent 1,783,384, or of any other suitable form.

Suitable mechanism to be more fully described presently is provided for moving the draw-head away from the swaging head and thus moving the tube along the mandrel and through the swaging head. At the same time, the spindle may be rotated with respect to the hollow shaft, thus carrying with it the hammer carrier and the hammers while holding the cam relatively stationary so that the action of the cam upon the hammers is to cause a series of rapidly repeated blows of the hammers upon the tube as it is being drawn past the hammers. A relatively slow rotation of the cam itself is provided so that any one hammer will move circumferentially of the tube between blows, thus avoiding a concentrated hammering upon a narrow area extending lengthwise of the tube.

The rotation of the cam may be accomplished by an electric motor 20 having a worm 21 engaging a worm gear 22 secured to the hollow shaft which, as noted above, has the cam rigidly secured thereto. The motor and gearing may be so arranged as to cause the proper speed of rotation of the shaft and cam which, of course, is much slower than the speed of rotation of the spindle carrying the hammers. If desired, the tube may be rotated instead of the cam, for example in some such manner as described and shown in my aforesaid Patent 1,819,376.

The draw-head, instead of being operated by a feeding screw as described in my aforesaid

patents, is operated by a cam, here shown as a drum 23 having a cam groove 24 engaging a roller on a cam follower 25 slidably mounted in the frame 26 of the draw-head. The cam follower is shown as being urged into engagement with the cam groove by a spring 27 acting against a handle 28 which may be used to actuate the follower to remove it from the groove. The follower is preferably provided with a roller engaging the groove, as indicated.

The frame 26 is slidably mounted upon tracks 29, and, if desired, may be manually moved along the tracks by a hand-wheel 30. This hand-wheel may operate a drive similar to that described in my Patent 1,783,384, and which will cause movement of the frame 26 along the tracks 29. In said patent, such an arrangement is shown in connection with a screw, whereas in the present instance I replace the screw by a rack 31 which may engage a pinion operated by the hand-wheel 30. Since such arrangements are so well known in the art, no further detail description or illustration thereof is deemed necessary.

The tube may be formed into various shapes as it is drawn through the swaging head. As set forth in my said Patent 1,783,384, by drawing the tube through the swaging head at a uniform speed, a tube, such as shown at 32 in Fig. 7 and which is of the usual cylindrical form, may be drawn out into a uniformly tapered tube, such as shown at 33 in Fig. 8. In Fig. 9, at 34, I have shown the same tube 32 formed into such a shape as may be adapted for part of a piece of furniture. The various peculiar formations seen in Fig. 9 may be obtained in part by varying the speed at which the tube is drawn and also by causing an additional movement of the mandrel and cam 13 lengthwise of the tube. The resultant of the speed of the draw-head on the one hand and of the mandrel and cam 13 on the other hand will determine the shape which the tube is to take. The mandrel is cylindrical through the major portion of its length, to conform with the shape of the tube which surrounds it, but at its end within the swaging head it is provided with a conical-shaped point 35, the surface of which preferably has its longitudinal elements exactly parallel to the longitudinal elements of the undulating surface of the cam 13, so that the thickness of the tube is maintained uniform.

The head 9 and the mandrel 16 are secured together through a connection 36 at the left-hand end of the shaft 6, for example in the manner described in my aforesaid Patent 1,783,384, and which is plainly shown in Fig. 3 and therefore will not be repeated here in detail. It is enough to say that movement of the head 9 and consequently of the cam 13 towards the left will be accompanied by a movement of the mandrel in the same direction and to the same extent, and the result, as plainly shown in Figs. 5 and 6, will be that the further these parts are moved towards the left, the further may the hammers 15 be moved radially inwardly towards the center of the tube. This in turn means that the tube may be reduced to a smaller diameter and, as noted above, the speed at which this reduction takes place, and consequently the taper of the tube, is dependent upon the relative speeds at which the draw-head on the one hand, and the cam and mandrel on the other hand, are moved.

Similarly, movement of the cam and mandrel towards the right will cause the tube to be formed of larger diameter, and here again the speed at which this takes place, and consequently the

taper of the tube, will depend upon the relative speed of movement of the draw-head on the one hand and the cam and mandrel on the other hand. In either case it will be seen that the hammers remain in the same position as measured lengthwise of the tube, and the cam and mandrel are moved lengthwise with relation to the hammers while the tube is drawn past the hammers. Of course, it is to be understood that the tube may for short intervals of time be held stationary while the hammers act thereon, this depending upon the shape of the cam groove 24.

To provide the longitudinal movement of the cam and mandrel, I have provided a novel device which makes possible the formation of a wide variety of shapes. This device comprises a cam drum 37 which is independent of the drum 23 and which is mounted on a shaft 38 in fixed bearings in the base, so as not to have any lengthwise movement on the base. Slidably mounted on tracks 39 and 40 is a slide 41 having a pedestal 42 carrying the motor 20 and having a bearing in which the hollow shaft 6 may rotate. At the same time, the pedestal 42 is held against movement lengthwise of the shaft 6 by any suitable means, such as that illustrated in Fig. 3, and comprising a ball bearing 43 between the gear 22 and the pedestal. The shaft 6 may also be provided with a block 44 slidably mounted upon a bracket 45 of the base, and the shaft may likewise be slidably received in a bearing 46.

The slide has slidably mounted thereon a plurality of cam followers, each adapted to be received in a cam groove in the drum 37. In the present instance, these cam followers, which are designated 47 and 48, are pivotally connected to a rocking arm 49 which is pivoted at 50 upon the pedestal 42 and has a lug 51 engaging a spring 52 received in a recess in the slide.

The arrangement is such that when the lug 51 is on one side of the point 53 of the spring, the arm 49 will be cammed on its pivot so as to bring one of the followers into a cam groove in the drum 37. These cam grooves correspond in number to the number of followers, and the engagement and disengagement of the followers is made automatic.

This automatic engagement and disengagement may be achieved by providing at the end of each cam groove an inclined surface, such as those indicated by the numerals 54, 54', 55, and 56 at the ends of the cam grooves 57 and 58, respectively, from which it will be seen that as, for example, the follower 47 reaches the incline 54, the follower will be raised out of the groove and the follower 48 will be lowered into the groove 58. While this action is taking place, a slight pause may be arranged in the cam groove 24 of the drum 23.

The above arrangement is one which makes it possible to provide any desired number of backward and forward movements of the cam 13 and the mandrel, in spite of the fact that the length of the travel of these parts is limited. For example, the cam groove 57 may be shaped so as to provide a uniform taper of the tube upon which work is being done, and the groove 58 may be so shaped as to cause a gradual increase of size of the tube together with any peculiar or distinctive shapes which may be desired. The two cam drums 23 and 37 are operated independently, this being so that their speeds may be varied as desired and so that by variation of the speeds and shapes of cam grooves, any desired configuration of tube can be obtained.

As one revolution of the drum 37 is completed and thus the possibilities of one cam groove on that drum, such as the groove 57, are exhausted, the cam follower which has been engaging in that groove will automatically be removed from that groove and a second cam follower will be caused to engage within another groove. In this way, the usefulness of the cam drum 37 is not limited to one revolution, nor is it limited by the length of travel of the cam 13.

When the machine is started, the follower 47 will be substantially in engagement with the inclined surface 54 so that, as the cam drum 37 is rotated, the follower will engage in the groove 57 until such time as it is forced out of that groove by the inclined surface 54'. The parts are so geared that the cam drum 37 completes one revolution during this time while the follower is in the groove 57. As noted previously, as the follower 47 leaves the groove 57, that action causes the follower 48 to enter the groove 58 at the inclined surface 56. Then continued rotation of the drum 37 will cause the follower 48 to follow the groove 58 back to the end where the inclined surface 55 is located. This surface will cause the follower to leave the groove, and the follower 47 to be kicked back into the groove 57 at the inclined surface 54.

Thus it will be seen that a complete cycle of operations has been completed and the parts are back at their initial positions. At the same time, the movement of the draw-head will be completed. This movement takes place while two revolutions of the drum 37 take place. In other words, while the travel of the draw-head takes place, the drum 37 makes as many revolutions as there are cam grooves on it. Then the drive operating the draw-head will be automatically or otherwise disconnected in a manner to be described presently, and the follower 25 may be manually removed from the groove 24 and the entire draw-head returned to its initial position, as by the hand wheel and rack 30 and 31.

The drive may be obtained from a drive shaft 59 which may be operated by a pulley 60 through a clutch 61. This drive shaft may operate the shaft 62 on which the cam drum 23 is mounted through a train of gearing indicated generally at 63, whereas the shaft 38 of the cam drum 37 may be operated through a worm gear 64 engaging a worm on a shaft 65, which, in turn, has a worm 66 engaging a worm gear 67 upon the shaft 38. The clutch 61 may be automatically disconnected when a lug 68 on the frame 26 engages a block 69 secured to a rod 70 which is operatively connected to a clutch collar 71, as plainly shown in Fig. 1. The rod 70 may be held in clutch disengaging position by means of a second block 72 engaging a hand-operated latch 73. The block 69 may be adjusted in position on the rod 70 so that the travel of the draw-head may be stopped at any desired point. This should always be after the cam grooves 57 and 58 have completed their work.

In operation, the mandrel may be removed and a pattern may be placed within the bore of the shaft and extending into engagement with the draw-head to which it may be secured. Then the machine may be turned slowly, as by hand, and when the hammers reach a special configuration on the pattern other than the uniform taper, that fact can be readily felt by the operator. In this way, the cam grooves on the two drums 23 and 37 may be readily marked on blank drums.

When a tube is to be formed, it is secured to

the draw-head in the usual way, and then the cam grooves, the form of which has been previously determined, will thus reproduce the pattern in the tube.

While I have shown the invention as embodied in a specific form, it is to be understood that various changes in details may be made without departing from the scope of the invention, as defined by the appended claims.

I claim:

1. Tube-forming apparatus comprising a swaging head, a mandrel centrally disposed in said head, a tubular hammer holder, having a plurality of apertures, surrounding said mandrel but spaced therefrom a sufficient distance to permit a tube wall to pass between the mandrel and the holder, means to draw a tube over said mandrel and through said head, a plurality of pin-like hammers, each having a work-engaging point, radially movable in the apertures in said holder and adapted to engage a tube and force it against said mandrel, a cylindrical member having internal tapered cam surfaces adapted to engage said hammers to force them against the tube, means to cause relative rotation between said holder and cylindrical member to force the hammers against the tube, and means to vary the relative positions of said cylindrical member and hammers longitudinally of the tube.

2. Tube-forming apparatus comprising a swaging head, a mandrel centrally disposed in said head, a hammer holder surrounding said mandrel but spaced therefrom a sufficient distance to permit a tube wall to pass between the mandrel and the holder, means to draw a tube over said mandrel and through said head, a plurality of pin-like hammers, each having a relatively small work-engaging point, radially movable on said holder and adapted to engage a tube and force it against said mandrel, a cylindrical member having internal tapered cam surfaces adapted to engage said hammers to force them against the tube, means to cause relative rotation between said holder and cylindrical member to force the hammers against the tube, and means to vary the relative positions of said cylindrical member and hammers longitudinally of the tube, said cylindrical member having alternating high and low spots on its inner surface operating a hammer, to cause said hammer to strike repeated blows on the tube wall.

3. Tube-forming apparatus comprising a swaging head, a mandrel centrally disposed in said head, a hammer holder surrounding said mandrel but spaced therefrom a sufficient distance to permit a tube wall to pass between the mandrel and the holder, means to draw a tube over said mandrel and through said head, a plurality of pin-like hammers, each having a work-engaging point, radially movable on said holder and adapted to engage a tube and force it against said mandrel, a cylindrical member having internal tapered cam surfaces adapted to engage said hammers to force them against the tube, means to cause relative rotation between said holder and cylindrical member to force the hammers against the tube, means to vary the relative positions of said cylindrical member and hammers longitudinally of the tube, and means to cause a slow relative rotative movement between said tube and cylindrical member.

4. Tube-forming apparatus comprising a swaging head, a mandrel centrally disposed in said head, a hammer holder surrounding said mandrel but spaced therefrom a sufficient distance to

permit a tube wall to pass between the mandrel and the holder, means to draw a tube over said mandrel and through said head, a plurality of pin-like hammers, each having a work-engaging point, radially movable on said holder and adapted to engage a tube and force it against said mandrel, a cylindrical member having internal tapered cam surfaces adapted to engage said hammers to force them against the tube, means to cause relative rotation between said holder and cylindrical member to force the hammers against the tube, means to vary the relative positions of said cylindrical member and hammers longitudinally of the tube, and means to cause a slow relative rotative movement between said tube and cylindrical member.

5. Tube-forming apparatus comprising a swaging head, a mandrel centrally disposed in said head, a hammer holder surrounding said mandrel but spaced therefrom a sufficient distance to permit a tube wall to pass between the mandrel and the holder, means to draw a tube over said mandrel and through said head, a plurality of pin-like hammers, each having a work-engaging point, radially movable on said holder and adapted to engage a tube and force it against said mandrel, a cylindrical member having internal tapered cam surfaces adapted to engage said hammers to force them against the tube, means to cause relative rotation between said holder and cylindrical member to force the hammers against the tube, said cylindrical member being tapered lengthwise of the tube, and means for moving said cylindrical member lengthwise of the tube in either direction and to a predetermined amount.

6. Tube-forming apparatus comprising a swaging head, a mandrel centrally disposed in said head, a hammer holder surrounding said mandrel but spaced therefrom a sufficient distance to permit a tube wall to pass between the mandrel and the holder, means to draw a tube over said mandrel and through said head, a plurality of pin-like hammers, each having a small work-engaging point, radially movable on said holder and adapted to engage a tube and force it against said mandrel, a cam adapted to engage said hammers to force them against the tube, means to cause relative rotation between said holder and cam to force the hammers against the tube, said cam having alternating high and low spots on its surface operating a hammer, to cause said hammer to strike repeated blows on the tube wall and being tapered lengthwise of the tube, and means for moving said cam lengthwise of the tube in either direction and to a predetermined amount.

7. Tube-forming apparatus comprising a swaging head, a mandrel centrally disposed in said head, a hammer holder surrounding said mandrel but spaced therefrom a sufficient distance to permit a tube wall to pass between the mandrel and the holder, means to draw a tube over said mandrel and through said head, a plurality of pin-like hammers, each having a small work-engaging point, radially movable on said holder and adapted to engage a tube and force it against said mandrel, a cam adapted to engage said hammers to force them against the tube, said cam having alternating high and low spots on its surface operating a hammer, to cause said hammer to strike repeated blows on the tube wall and being tapered lengthwise of the tube, means to cause relative rotation between said holder and cam to force the hammers against the tube, means for moving said cam lengthwise of the tube in either

direction and to a predetermined amount, and means to cause a slow relative rotative movement between said tube and cam.

8. Tube-forming apparatus comprising a swaging head, a mandrel centrally disposed in said head, a hammer holder surrounding said mandrel but spaced therefrom a sufficient distance to permit a tube wall to pass between the mandrel and the holder, means to draw a tube over said mandrel and through said head, a plurality of pin-like hammers, each having a small work-engaging point, radially movable on said holder and adapted to engage a tube and force it against said mandrel, a cylindrical member having internal tapered cam surfaces adapted to engage said hammers to force them against the tube, means to cause relative rotation between said holder and cylindrical member to force the hammers against the tube, said mandrel having a longitudinally tapered surface within said head and said cylindrical member having a longitudinally tapered surface surrounding said tapered surface of the mandrel, and means for moving said cylindrical member and mandrel together lengthwise of the tube in either direction and to a predetermined amount.

9. Tube-forming apparatus comprising a swaging head, a mandrel centrally disposed in said head, a hammer holder surrounding said mandrel but spaced therefrom a sufficient distance to permit a tube wall to pass between the mandrel and the holder, means to draw a tube over said mandrel and through said head, a plurality of pin-like hammers, each having a relatively small work-engaging point, radially movable on said holder and adapted to engage a tube and force it against said mandrel, a cylindrical member having internal tapered cam surfaces adapted to engage said hammers to force them against the tube, means to cause relative rotation between said holder and cylindrical member to force the hammers against the tube, said mandrel having a longitudinally tapered surface within said head and said cylindrical member having a longitudinally tapered surface surrounding said tapered surface of the mandrel and generally parallel thereto, and means for moving said cylindrical member and mandrel together lengthwise of the tube in either direction and to a predetermined amount.

10. Tube-forming apparatus comprising a swaging head, a mandrel centrally disposed in said head, a hammer holder surrounding said mandrel but spaced therefrom a sufficient distance to permit a tube wall to pass between the mandrel and the holder, means to draw a tube over said mandrel and through said head, a plurality of pin-like hammers, each having a relatively small work-engaging point, radially movable on said holder and adapted to engage a tube and force it against said mandrel, a cam adapted to engage said hammers to force them against the tube, means to cause relative rotation between said holder and cam to force the hammers against the tube, said cam having alternating high and low spots on its inner surface operating a hammer, to cause said hammer to strike repeated blows on the tube wall, said mandrel having a longitudinally tapered surface within said head and said cam having a longitudinally tapered surface surrounding said tapered surface of the mandrel, and means for moving said cam and mandrel together lengthwise of the tube in either direction and to a predetermined amount.

11. Tube-forming apparatus comprising a swaging head, a mandrel centrally disposed in said head, a hammer holder surrounding said mandrel but spaced therefrom a sufficient distance to permit a tube wall to pass between the mandrel and the holder, means to draw a tube over said mandrel and through said head, a plurality of pin-like hammers, each having a relatively small work-engaging point radially movable on said holder and adapted to engage a tube and force it against said mandrel, a cam adapted to engage said hammers to force them against the tube, means to cause relative rotation between said holder and cam to force the hammers against the tube, said cam having alternating high and low spots on its inner surface operating a hammer, to cause said hammer to strike repeated blows on the tube wall, said mandrel having a longitudinally tapered surface within said head and said cam having a longitudinally tapered surface surrounding said tapered surface of the mandrel and generally parallel thereto, and means for moving said cam and mandrel together lengthwise of the tube in either direction and to a predetermined amount.

12. Tube-forming apparatus comprising a swaging head, a mandrel centrally disposed in said head, a hammer holder surrounding said mandrel but spaced therefrom a sufficient distance to permit a tube wall to pass between the mandrel and the holder, means to draw a tube over said mandrel and through said head, a plurality of pin-like hammers, each having a relatively small work-engaging point, radially movable on said holder and adapted to engage a tube and force it against said mandrel, a cam adapted to engage said hammers to force them against the tube, means to cause relative rotation between said holder and cam to force the hammers against the tube, means to cause a slow relative rotative movement between said tube and cam, said mandrel having a longitudinally tapered surface within said head and said cam having a longitudinally tapered inner surface surrounding said tapered surface of the mandrel, and means for moving said cam and mandrel together lengthwise of the tube in either direction and to a predetermined amount.

13. Tube-forming apparatus comprising a swaging head, a mandrel centrally disposed in said head, a hammer holder surrounding said mandrel but spaced therefrom a sufficient distance to permit a tube wall to pass between the mandrel and the holder, means to draw a tube over said mandrel and through said head, a plurality of pin-like hammers each having a relatively small work engaging point radially movable on said holder and adapted to engage a tube and force it against said mandrel, a cam adapted to engage said hammers to force them against the tube, means to cause relative rotation between said holder and cam to force the hammers against the tube, means to cause a slow relative rotative movement between said tube and cam, said mandrel having a longitudinally tapered surface within said head and said cam having a longitudinally tapered surface surrounding said tapered surface of the mandrel and generally parallel thereto, and means for moving said cam and mandrel together lengthwise of the tube in either direction and to a predetermined amount.

14. Tube-forming apparatus comprising a swaging head, a draw-head disposed in line with said swaging head, means to secure a tube to said draw-head to be drawn thereby through said

swaging head, swaging means on said swaging head adapted to act upon said tube while being drawn through said swaging head, a rotating drum having a plurality of cam grooves therein, means connected with said swaging heads and adapted successively to engage said cam grooves to move said swaging means longitudinally of said tube, a cam controlling said draw-head and causing it to move lengthwise of said tube, and means to operate said cams independently of each other.

15. Tube-forming apparatus comprising a swaging head, a mandrel centrally disposed in said head, a tubular hammer holder surrounding said mandrel but spaced therefrom a sufficient distance to permit a tube wall to pass between the mandrel and the holder, means to draw a tube over said mandrel and through said head, a plurality of short pin-like hammers mounted in openings in said tubular holder and radially movable with respect to said mandrel, each hammer having a work-engaging point adapted to operate upon a tube engaging the mandrel and having a head disposed a short distance outside of said holder, a longitudinally inclined cam disposed outside said holder and closely adjacent thereto and adapted to engage said hammers to force them against the tubes, said cam having alternate high and low spots on its inner surface circumferentially thereof, and means to cause relative rotation between said holder and cam to cause vibration of said hammers against a tube on the mandrel.

16. Tube-forming apparatus comprising a swaging head, a mandrel centrally disposed in said head, a tubular hammer holder surrounding said mandrel but spaced therefrom a sufficient distance to permit a tube wall to pass between the mandrel and the holder, means to draw a tube over said mandrel and through said head, a plurality of short pin-like hammers mounted in openings in said tubular holder and radially movable with respect to said mandrel, each hammer having a work-engaging point adapted to operate upon a tube engaging the mandrel and having a head disposed a short distance outside of said holder, a longitudinally inclined cam disposed outside said holder and closely adjacent thereto and adapted to engage said hammers to force them against the tubes, said cam having alternate high and low spots on its inner surface circumferentially thereof, means to cause relative rotation between said holder and cam to cause vibration of said hammers against a tube on the mandrel, and means to vary the relative positions of the cam and hammers longitudinally of the tube.

17. In a tube swaging machine, the combination of a swaging head, a work-drawing head co-operating therewith, and swaging means carried by said swaging head, a portion of said swaging head being shiftable longitudinally to cause said swaging means to vary the diameter of the tube therein; with means for shifting said portion of the swaging head comprising a slide, means connecting said slide with said shiftable portion, a rotating cam drum having in its periphery a plurality of cam grooves, a plurality of cam followers carried by said slide, each adapted to co-operate with one of said cam grooves to shift said slide and swaging head longitudinally, and automatic means for successively shifting said followers into and out of said cam grooves to give to the shiftable portion of the swaging head a predetermined cycle of axial movement while the work is drawn therethrough.

18. Tube-forming apparatus combining a swaging head, a draw-head disposed in line with said swaging head, means to secure a tube to said draw-head to be drawn thereby through said swaging head, swaging means on said swaging head adapted to act upon said tube while it is being drawn through said swaging head, a plurality of unlike cams and a corresponding number of cooperating elements connected with said swaging head to shift a portion of said swaging head back and forth longitudinally of said tube, means actuated by the shifting movements of said portion to vary the diameter of said tube, automatic means for successively rendering effective said cams and their cooperating elements, means to move said draw-head lengthwise of said tube, and means for simultaneously actuating said draw-head moving means and said swaging head shifting cams.

19. Tube-forming apparatus combining a swaging head, a draw-head disposed in line with said swaging head, means to secure a tube in said draw-head to be drawn thereby through said swaging head, swaging means on said swaging head adapted to act upon said tube while being drawn through said swaging head, a rotatable cam drum having, in its outer periphery, a plurality of cam grooves, one of which has a radially inclined surface at one end, a slide operatively connected with said swaging head to move a portion thereof axially of said tube, means actuated by the axial movement of said portion to cause said swaging means to vary the diameter of said tube, a plurality of cam followers carried by said

slide and each adapted to engage one of said cam grooves thereby to cause said slide and the said portion of said swaging head to be shifted thereby, and means for shifting one of said followers into its complemental cam groove as another follower is shifted out of its groove by the radially inclined end thereof.

20. Tube-forming apparatus combining a swaging head, a draw-head disposed in line with said swaging head, means to secure a tube to said draw-head to be drawn thereby through said swaging head, swaging means on said swaging head adapted to act upon said tube while it is being drawn through said swaging head, a portion of said swaging head being shiftable longitudinally to cause said swaging means to vary the diameter of the tube therein, means for giving to said draw-head a single uni-directional movement for one complete operation of the apparatus, and means for giving to the shiftable portion of said swaging head a plurality of oppositely directed longitudinal movements for each uni-directional movement of said draw-head, comprising a rotatable but non-translatable cam drum, means for giving said drum one rotation for each operative movement of said draw-head, a plurality of cam grooves formed in said cam drum, a cam follower for each of said grooves, means connecting said cam followers with the shiftable portion of said swaging head, and automatic means for shifting said cam followers successively into and out of said cam grooves during a uni-directional movement of said draw-head.

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