Jan. 3, 1928. 1,654,585

W. M. FULTON

METHOD AND APPARATUS FOR DRAWING TUBES

Filed Aug. 8, 1924 4 Sheets-Sheet 1

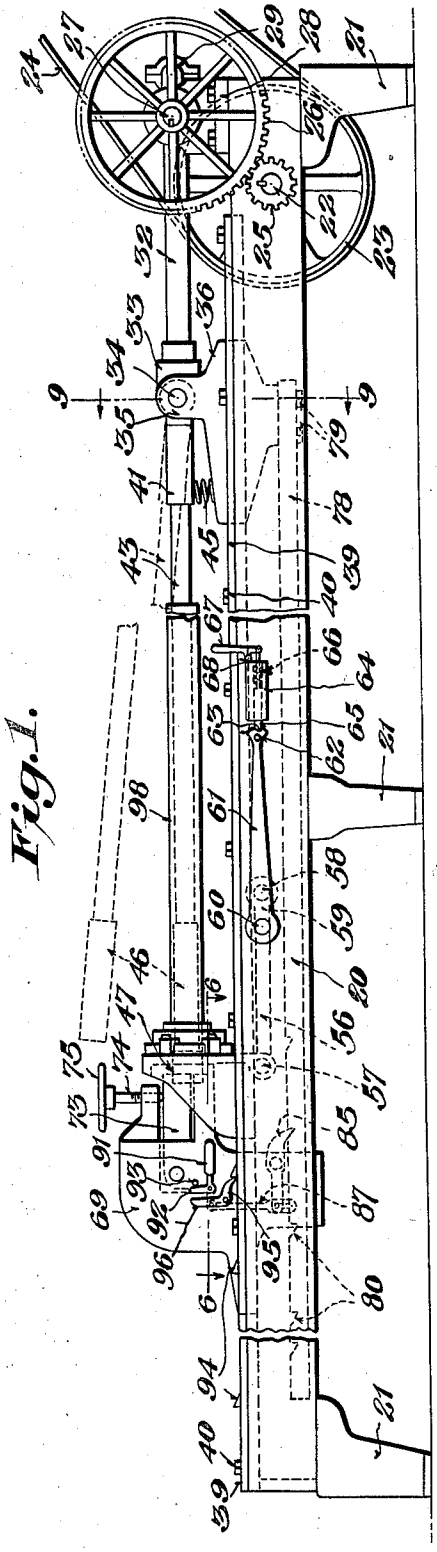


Fig. 1.

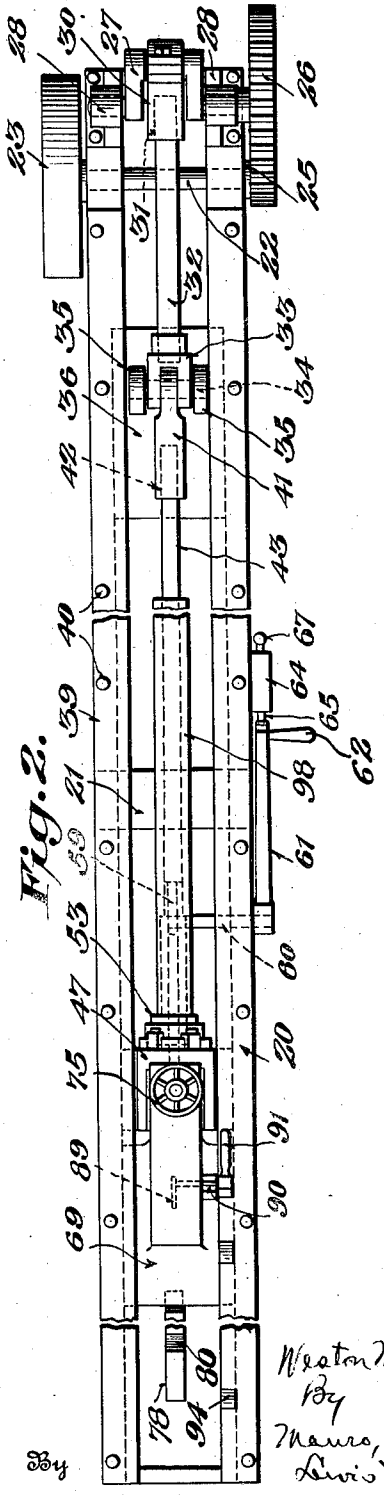


Fig. 2.

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Filed Aug. 8, 1924 4 Sheets-Sheet 2

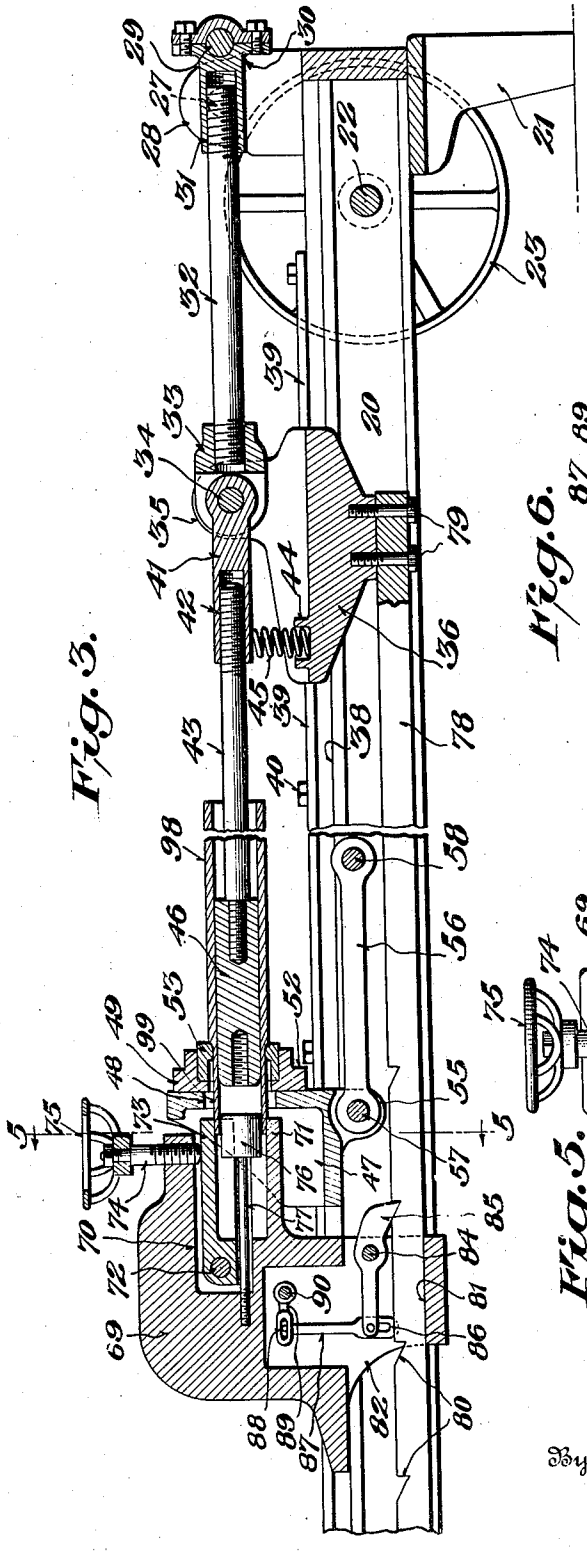


Fig. 3.

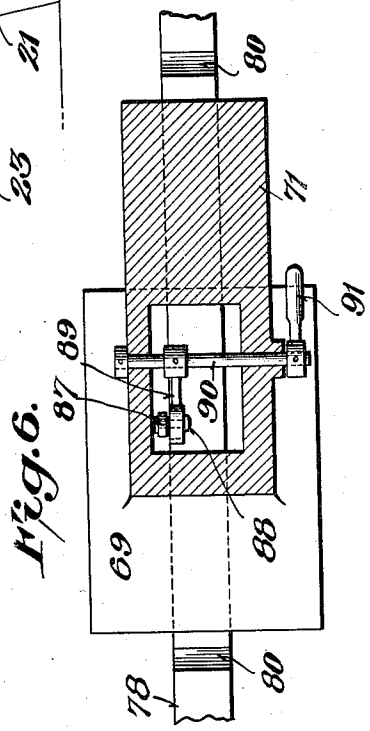


Fig. 6.

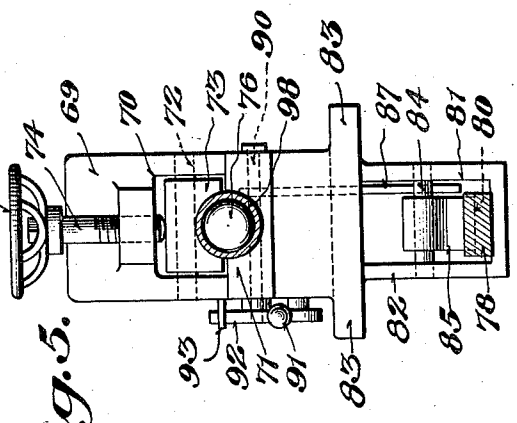


Fig. 5.

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METHOD AND APPARATUS FOR DRAWING TUBES

Filed Aug. 8, 1924 4 Sheets-Sheet 3

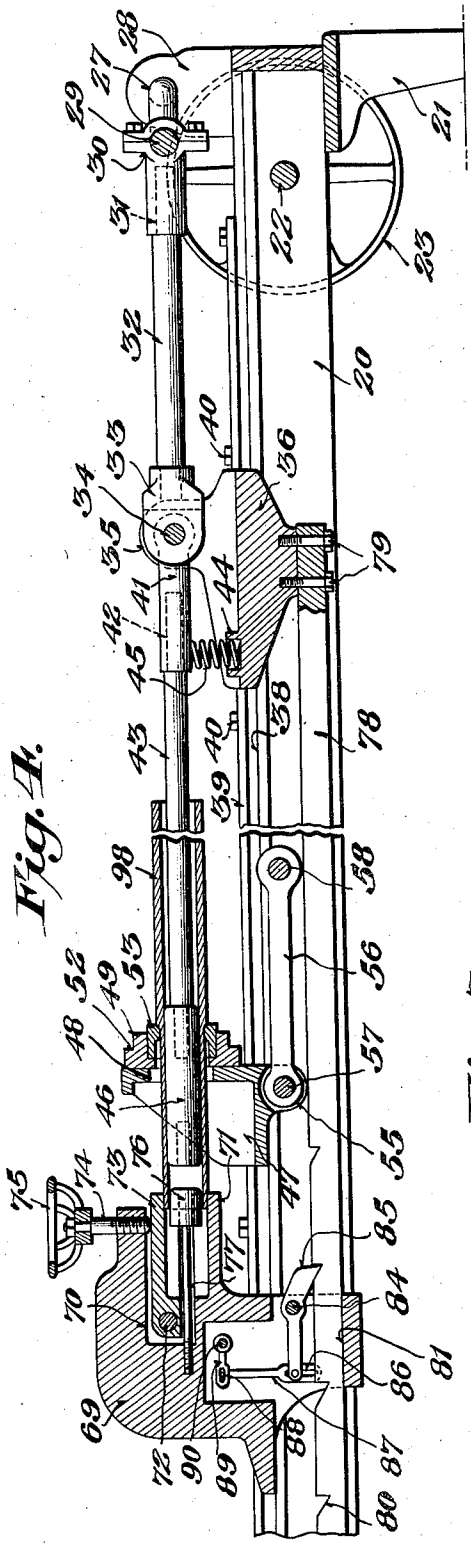


Fig. 4.

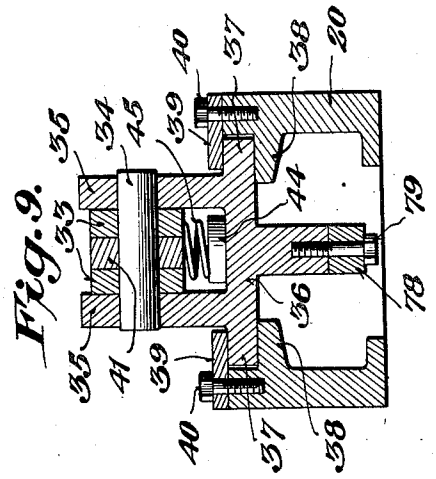


Fig. 9.

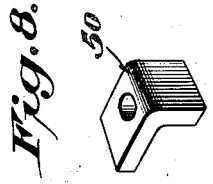


Fig. 8.

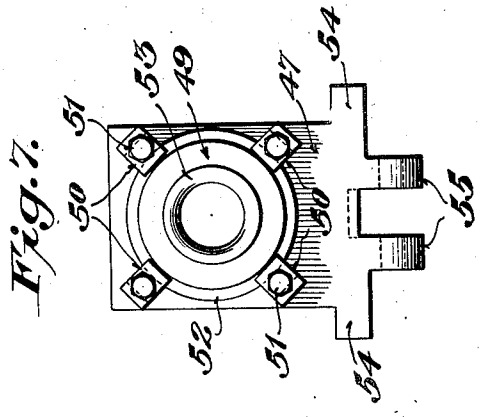


Fig. 7.

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METHOD AND APPARATUS FOR DRAWING TUBES

Filed Aug. 8, 1924 4 Sheets-Sheet 4

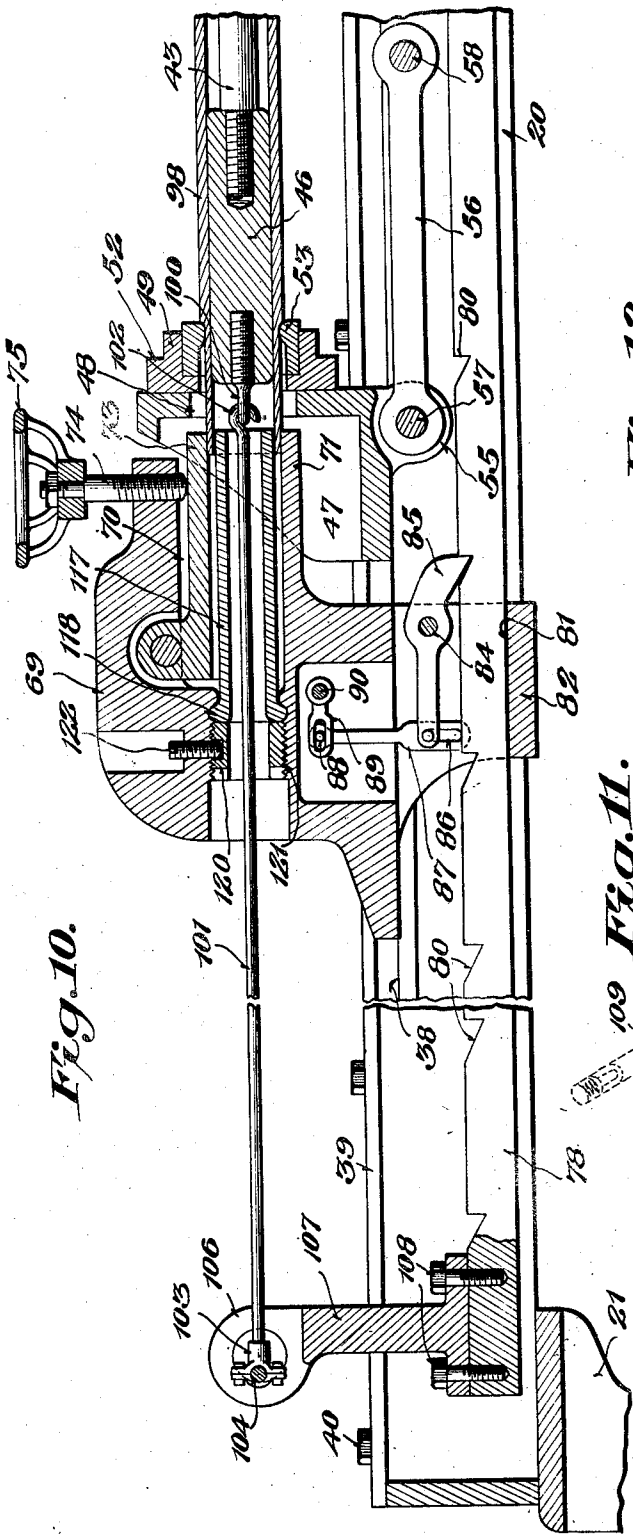


Fig. 10.

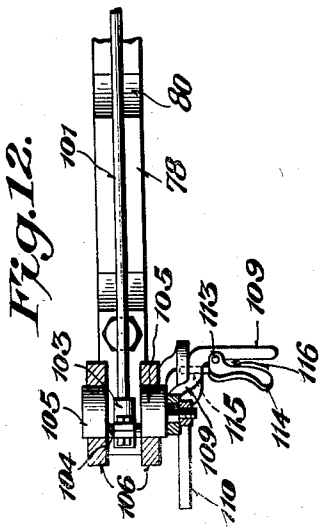


Fig. 12.

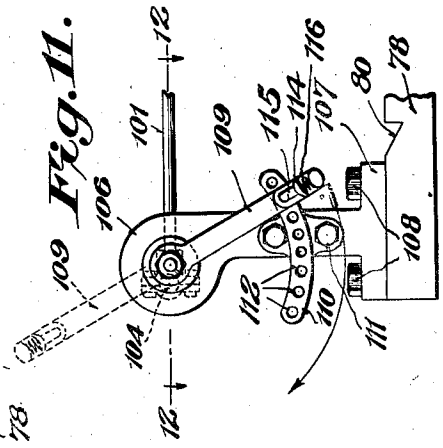


Fig. 11.

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UNITED STATES PATENT OFFICE.

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METHOD AND APPARATUS FOR DRAWING TUBES.

Application filed August 8, 1924. Serial No. 730,962.

This invention relates to a method and apparatus for making drawn tubing, and particularly drawn tubing having relatively thin walls, such as is used in the manufacture of flexible corrugated tubular walls.

As pointed out in my prior Patent No. 1,192,412, granted July 25, 1916, it is highly desirable in the manufacture of flexible corrugated tubular walls to reduce the thickness of the wall which is to be corrugated until the physical properties of the metal are practically uniform throughout the thickness of the wall, and to effect this result and also obtain a wall which is sufficiently thin to give to the resultant corrugated wall the requisite degree of flexibility, it is customary to make these flexible tubular corrugated walls from metal tubes which are on the order of .010 to .005 of an inch in thickness.

In order to produce seamless tubing of this thinness, it has heretofore been the practice to stamp circular disks from sheet metal, cup these disks, and then reduce the diameter of the blanks and the thickness of the metal by successive drawing operations until the desired thickness of wall and dimension of tube has been obtained. This method of procedure, while practical and extensively used, possesses certain disadvantages among which may be mentioned the following:—

As the tubular wall becomes thin and increases in length, it adheres very tightly to the punch owing to the friction between the punch and the wall, this friction being proportional to the length of the tube and the diameter of the tube. Hence considerable difficulty has been experienced in extracting the punch from the tube after the drawing operation, and this difficulty increases very rapidly with the decrease in the thickness of the tube wall owing to the inability of the tube to withstand the stress exerted by a stripper. Hence, many walls are destroyed in withdrawing the same from the punch, and this number rapidly increases as the thickness of the wall is decreased. In order to facilitate withdrawal of the punch from the tube, it has accordingly been the practice to give the punch a small amount of taper, and while the absolute amount of taper given to the punch is relatively small, it necessarily produces a very material variation in the thickness of the tubular wall from one end of the tube to the other in walls of the degree of thinness under discussion. This difference in the thickness of the tubular wall from one end to the other becomes of relatively great moment when the wall is subsequently provided with corrugations, inasmuch as the corrugations formed at the thicker end of the tube are of necessity thicker and therefore stiffer than those formed at the thinner end of the tube, with the consequence that the flexibility of the tube as a whole is not uniform and the greater strain is thrown on the metal in the thinner corrugations, so that walls of this character usually rupture at the end where the metal is thinner.

Again, this method of manufacture is more or less wasteful even though no tubes be destroyed in stripping the same from the punch. In the first place, the cutting of circular disks from sheet metal of necessity leaves considerable scrap which has to be shipped back to the foundry for remelting; in the second place, this method of drawing tubes frequently causes the tubes to become ragged at their open ends, and these ragged portions have to be trimmed off with a consequent waste; in the third place, for most purposes the closed ends of the resultant tubes have to be trimmed off to meet the requirements of the service to which the flexible tubular walls are to be put, and these ends are mere scrap and have to be returned to the foundry for remelting.

Again, the above process of producing drawn tubing limits the possibility of making flexible, tubular corrugated walls of any very great length, because there is a very definite limit to the tubular blank that can be drawn within practical limits of manufacturing operations, since there is a very definite limit to the length of tube of given thickness which can be withdrawn from the punch without resorting to such complicated constructions or operations as to be prohibitive from a manufacturing standpoint.

It has also been proposed heretofore to make seamless drawn tubing by forcing a tube between a relatively stationary die and punch, and this process is used extensively in

the manufacture of "commercial seamless drawn tubing", which may be had in convenient lengths up to twelve to fifteen feet. Experience has demonstrated, however, that this method of producing seamless drawn tubing is inapplicable to the production of seamless drawn tubing of the thickness required in the manufacture of flexible corrugated tubular walls because, as the tubular wall is reduced in thickness, there is a very definite limit beyond which this method of procedure is inapplicable, because the force required to draw the tube between the punch and die exceeds the longitudinal strength of the drawn portion and the metal is ruptured. Hence, the thinnest tubing which is now commercially available by this method of manufacture is about .020 of an inch in thickness—two or more times the thickness needed for the manufacture of flexible tubular corrugated walls. Moreover, this method of manufacturing drawn tubular walls requires a relatively large number of operations as the thickness of the walls is decreased because, as the tubular wall becomes thinner, its tensile strength very narrowly limits the force which can be applied thereto, and therefore the extent to which the wall can be reduced in thickness during a single passage of the tube through the die and punch is likewise limited, with the consequence a large number of operations are required to bring the metal down by small decrements to a final thickness of even .020 of an inch.

It is an object of this invention to provide a method and apparatus for manufacturing drawn tubing available for use in the manufacture of flexible corrugated tubular walls which overcome each and all of the disadvantages above discussed.

Another object of this invention is to provide a method and apparatus for making drawn tubing by which the metal is reduced to the proper thickness so that its physical properties are substantially uniform throughout its thickness and so that proper flexibility will be obtained when corrugated, and by which at the same time tubing of substantially uniform thickness throughout its length may be obtained so that when corrugated all of the corrugations may be of substantially equal thickness of metal.

Another object of this invention is to provide a method and apparatus for making drawn tubing which will avoid the waste incident to the cutting of disks from sheet metal, the production of ragged ends that require trimming, the production of closed ends which have to be cut off, and the destruction of tubes by stripping from the punch.

Another object of this invention is to provide a method and apparatus for making drawn tubing for use in the manufacture of flexible corrugated tubular walls whereby flexible tubular corrugated walls of any desired length may be obtained.

Another object of this invention is to provide a method and apparatus for making drawn tubing of the thickness required in the manufacture of flexible corrugated tubular walls from commercial seamless drawn tubing now available on the market.

Another object of this invention is to provide a method and apparatus for making drawn tubing on the order of .005 to .010 of an inch in thickness or more and of any suitable length.

Another object of this invention is to provide a method and apparatus for making drawn tubing in long lengths and of the desired thinness without the necessity of employing a large number of operations as has heretofore been required, even though the final thickness of the wall is within the limits heretofore obtained by methods of manufacture heretofore in use.

Another object of this invention is to provide a method and apparatus for making drawn tubing of the thickness required in the manufacture of flexible tubular corrugated walls which reduce the labor and expense heretofore incident to the handling of a large number of tubes of short length subjected to a number of successive drawing operations.

Another object of this invention is to provide a method and apparatus for making drawn tubing whereby the desired physical properties may be imparted to the metal and the desired thickness and length of wall be obtained in an economical and efficient manner without undue complexity of procedure, or costliness or complexity of apparatus employed.

Another object of this invention is to provide an apparatus for drawing tubing which is strong and durable, simple in operation, and capable of producing tubing of any suitable length and wall thickness by automatic operations which do not require the use of highly skilled labor.

Other objects of this invention will appear as the description of the invention proceeds.

Stated broadly, the invention includes a method and apparatus for making drawn tubing by which successive portions of a tube are intermittently forced between relatively moving punch and die elements, the tube being restrained against movement during the alternating periods when the punch or die is being moved into cooperative relation with a succeeding portion of the tube.

The invention is capable of being carried out in a variety of ways, and of receiving a variety of mechanical expressions, two being shown on the accompanying drawings for purposes of illustration, but it is to be

expressly understood that the drawings are for purposes of illustration only, and are not to be construed as a definition of the limits of the invention, reference being had to the appended claims for that purpose.

In the drawings, wherein the same reference characters are employed to designate corresponding parts in the several figures,

Fig. 1 is an elevation of an apparatus embodying the present invention and by which the method of the present invention can be carried out;

Fig. 2 is a plan view of the apparatus shown in Fig. 1;

Fig. 3 is an axial section on an enlarged scale of the apparatus shown in Fig. 1, with the central portion of the machine broken away, the parts being shown in the position assumed at the beginning of the drawing operation;

Fig. 4 is a view corresponding to Fig. 3 showing the relation of the parts after the first drawing operation;

Fig. 5 is an enlarged sectional view on the line 5—5 of Fig. 3;

Fig. 6 is an enlarged sectional view on the line 6—6 of Fig. 1;

Fig. 7 is an enlarged face view of the die and its holder;

Fig. 8 is a perspective view of a die holding clamp;

Fig. 9 is an enlarged section on the line 9—9 of Fig. 1;

Fig. 10 is an axial section on an enlarged scale illustrating another embodiment of the present invention;

Fig. 11 is an elevation of the rod tightening device employed in the embodiment of Fig. 10; and

Fig. 12 is a section on the line 12—12 of Fig. 11.

In conformity with the method of the present invention, a tube of any suitable metal, and of any suitable length and thickness, is first formed in any suitable way. This tube may conveniently be standard seamless tubing such as can be obtained on the market. This tube is then subjected to one or more drawing operations, during which the thickness of the tube is reduced to the desired extent, one or more, but preferably all, of said drawing operations being carried out by intermittently subjecting successive portions of the tube to the drawing action of relatively moving die and punch elements of suitable dimensions. The drawing action is thus effected with the aid of the frictional grip of the relatively movable drawing element on the tube, and not wholly by the pull of the drawing head on the tube. After each successive portion of the tube is thus subjected to the drawing action of the relatively moving punch and die elements, the movable of these elements is returned to an initial position to cooperate with a succeeding portion of the tube, and during this return of the movable element to initial position the tube is restrained from moving therewith, this restraint of the tube being aided by the frictional action on the tube of the stationary of said two elements. In carrying out this method, either the die or the punch may be the movable element, but as will hereinafter appear, the die is preferably made the stationary element and the punch is made the movable element, in which event the drawing operation is effected during movement of the punch through the die in one direction, after which the tube is restrained against movement as the punch moves back to initial position to cooperate with a succeeding portion of the tube preparatory to a repetition of the drawing operation.

This method of procedure may be carried out with the use of any suitable apparatus, and it is to be expressly understood that this invention, in so far as the method is concerned, is not to be limited to the use of any particular apparatus. In order to facilitate carrying out this method, however, novel apparatus has been invented, and the accompanying drawings illustrate two different constructions within the present invention and which are particularly adapted for carrying out the method of this invention as heretofore described.

In the form shown in Figs. 1–9, inclusive, the machine for drawing tubes in conformity with the method above disclosed includes a bed or frame 20 of any suitable size, material and construction, this bed being shown as mounted on a plurality of suitably spaced legs 21. Mounted on said bed or frame 20 adjacent one end thereof is a countershaft 22 which carries at one end thereof any suitable driving element, such as a belt pulley 23 driven through belt 24 from any suitable source of power. The opposite end of said shaft 22 carries a pinion 25 which meshes with a gear 26 on a crank shaft 27 suitably journaled in bearing blocks 28 mounted on the bed of the machine. Journaled on the crank pin 29 is a suitable bearing block 30 which is elongated at one side of the crank pin and provided with a recess 31 in which is secured in any suitable way a driving rod 32. The opposite end of said driving rod 32 is provided with a bifurcated bearing block 33 which is journaled on a pin 34 mounted in a pair of upstanding lugs 35 on a cross-head 36. Cross-head 36 is provided with lateral flanges 37 (see Fig. 9) which slide on ways 38 provided on and extending longitudinally of the bed or frame 20. Said flanges 37 may be maintained in cooperative relation with the ways 38 by plates 39 fastened to the bed or frame of the machine in any suitable way, as by screws 40. Also journaled on the pin 34 of said cross-head

36, between the bifurcations of the bearing block 33, is a punch rod holder 41 provided with a recess 42 in which the punch rod 43 is secured in any suitable way. The cross-head 36 is extended in the direction of the punch rod holder 41 so as to underlie the same, and is provided immediately beneath said holder with a socket 44 which centers a coiled spring 45 that at its upper end is engaged with and normally compressed by said holder 41. The opposite end of the punch rod 43 carries the punch 46 which may be of any suitable construction and dimensions and secured to the rod 43 in any suitable way. Punch 46 is selected of such diameter as to fit tightly the interior of the tube to be drawn.

Also mounted for a limited reciprocating movement on the bed or frame 20 of the machine is a relatively stationary die element for cooperation with the relatively movable punch element heretofore described. In the form shown, a die block 47 is provided with an aperture 48 and carries in any suitable way the die holder 49. Said die holder is clamped to the face of the die block in any suitable way as by a plurality of right-angle clamp members 50 (see Fig. 8) which are retained on the die block by bolts or screws 51 and the overhanging flanges of which engage a shoulder 52 on the die holder. Suitably retained within the die holder is a die 53 provided with an aperture of suitable dimensions for the particular operation to be performed. Die block 47 is provided with lateral flanges 54 (see Fig. 7) for cooperation with the ways 38. and depending from said block are a pair of apertured lugs 55 between which a link 56 is pivoted on a pin 57. The opposite end of link 56 is pivotally connected, by means of pin 58, to the free end of a crank-arm 59 carried by a stub shaft 60 journaled on the bed or frame of the machine. The opposite end of said stub shaft 60 carries an operating crank-arm 61 which at its free end is provided with a hand grasp 62 and a notch 63.

Mounted on the side of the bed or frame of the machine, adjacent the free end of said operating arm 61, is a housing 64 in which is reciprocably mounted a latch pin 65 which is normally pressed forwardly by spring 66 to engage its free end in the notch 63 of said operating arm 61. The opposite end of latch pin 65 is pivotally connected to a lever 67 fulcrumed at 68 on the end of the housing 64. By moving lever 67 to the left, as viewed in Fig. 1, latch pin 65 may be withdrawn from operating arm 61, which may thereupon be rotated upwardly as viewed in Fig. 1, to correspondingly rotate the crank-arm 59 and slide the link 56 and die holder 47 to the left as viewed in said figure.

Also mounted on the ways 38 of the machine is a draw-head or draw-block 69 which is provided with means of any suitable construction for centering and clamping the end of a tube to be drawn with the cooperation of the punch element 46 and the die element 53. In the form shown, said head is provided with a recess 70 the lower wall of which is suitably shaped to provide a clamping element 71. Pivoted in said recess at 72 is a second clamping element 73 which may be forced into cooperative relation with the clamping element 71 by a clamping screw 74 operated by a hand wheel 75. Also mounted within said recess 70 is a centering block 76 of generally cylindrical formation and of suitable size to prevent collapse of the tube between clamping elements 71 and 73. Said centering block 76 is preferably flexibly mounted so that it may be brought into proper cooperative relation with the tube and clamping elements 71 and 73 when the latter is depressed by the action of the clamping screw 74. In the form shown, centering block 76 is mounted on the rod 77 which is possessed of the requisite degree of flexibility and which is suitably mounted, as by screw-thereaded engagement, in the end wall of the recess 70.

Suitable means are provided to cause the draw-head or draw-block 69 to move with the cross-head 36 when the latter reciprocates toward the left as viewed in Fig. 1 and to restrain said head or block against movement when said cross-head 36 reciprocates in the opposite direction. In the form shown, a long bar 78 is suitably attached to the cross-head 36, as by screws 79, and is provided with a plurality of notches 80, spaced apart by a distance equal to the movement of the cross-head 36 during 180° of revolution of the crank 27. This bar 78 preferably extends throughout the length of the machine, and projects through an aperture 81 provided in an extension 82 depending beneath the flanges 83 by which the head or block 69 slides on the ways 38. Pivoted in said aperture 81 on a pin 84 is a pawl 85 for engagement in the notches 80. The opposite end of pawl 85 has a pin and slot connection 86 with a link 87 that at its opposite end has a pin and slot connection 88 with a crank arm 89 extending from a stub shaft 90. Said stub shaft 90 extends to the outside of the head 69 and carries an operating arm 91. When arm 91 is thrown upwardly, as viewed in Fig. 1, crank-arm 89 is depressed to actuate pawl 85 through link 87 and lift the pointed end of said pawl out of the notch 80 in which it may be engaged. Operating handle 90 is prevented from dropping below a horizontal position by engagement of an arm 92 thereon with a stop pin 93 projecting from the side of the head 69.

To prevent the head 69 from moving back with the cross-head 36 during the 180° of

revolution of the crank 27 when said cross-head is moving toward the right as viewed in Fig. 1, a second pawl and ratchet mechanism is provided as follows:—The upper surface of the bed or frame of the machine is provided with a plurality of notches or lugs 94 which are spaced by the same distances as the notches 80. Pivoted on the side of the head 69 is a pawl 95 which may move in an anti-clockwise direction from the position shown in Fig. 1 to ride over the lugs 94, but which is normally maintained in the upright position shown in this figure. When the nose of pawl 95 drops behind one of the lugs 94, as shown in Fig. 1, head 69 cannot be moved to the right, as viewed in said figure. To release said pawl 95 from engagement with the lugs 94 when it is desired to return the head 69 to starting position, i. e. into adjacency with the die block 47, the pawl 95 is provided with an upstanding arm 96, as shown in Fig. 1, which projects into adjacency to the arm 92 on the operating handle 91. When operating handle 91 is thrown upwardly as viewed in Fig. 1, its arm 92 engages the upstanding arm 96 on pawl 95 and releases it from the corresponding lug 94 at the same time that the pawl 85 is moved out of engagement with the corresponding notch 80.

In operation, the machine is prepared to receive a tube as follows:—Assuming that the draw-head or block 69 is toward the left of the machine as viewed in Fig. 1, lever 67 is moved to the left as viewed in Fig. 1 to withdraw latch pin 65 from the notch at the free end of operating arm 61, whereupon arm 61 may be thrown upwardly by hand grasp 62. This rotation of arm 61 rotates stub shaft 60 and crank-arm 59, which carries link 56 upwardly and to the left as viewed in Fig. 1, exerting a thrust toward the left on die block 47, and thereby moving the latter to the left on the ways 38 until said die block, with the die holder and die carried thereby, are withdrawn from over the punch 46. Punch 46 being thus released, the coiled spring 45 raises the punch 46 and punch rod 43 to the position shown in dotted lines in Fig. 1, said punch and rod pivoting about the pin 34 as an axis. The punch is now free to receive a tube 98, one end 99 of which has previously been reduced in thickness in any suitable way, as by swaging, so as to be capable of passing through the die 53 into clamping relation with the clamping elements 71 and 73 and the centering block 76. The coiled spring 45 may be selected of such strength as to certainly raise the punch and punch rod when no tube is positioned on the punch, and yet be such that the added weight of the tube will move the punch down into alignment with the die element 53. Operating handle 61 is then returned to initial position where it is locked by the latch pin 65, and the reverse rotation of crank 59 by this movement of the operating arm 61 causes the link 56 to move downwardly and to the right as viewed in Fig. 1, drawing the die block 47 to the right as viewed in said figure, so that it passes over the free reduced end of the tube 98 and into the position shown in Fig. 3. During the subsequent operation of the machine the die block 47 with its associated die element 53 is stationary and locked in position by the latch pin 65.

Operating member 91 having been thrown upwardly so as to release pawl 95 from engagement with the lugs 94 and pawl 85 from engagement with the notches 80, head 69 is moved to the right as viewed in Fig. 1 until the free end of the tube passes over the centering block 76 and enters between the opposed clamping elements 71 and 73 to a position where the pawl 85 may drop into a notch 80. The free end of the tube is then clamped between the clamping elements 71 and 73 by rotating the clamp screw 74 through handle 75 to force the clamping element 73 downwardly onto said centering block 76, and centering block 76 downwardly onto clamping element 71. The centering block 76 prevents the collapse of the tube under the clamping pressure, and the tube is thus securely clamped to the draw-head 69 between said centering block and the clamping elements 71 and 73. Operating member 91 having been returned to the position shown in Fig. 1, the parts are now in the relation shown in Fig. 3, and the machine is ready to start.

Assuming that the crank 27 is in the position shown in Figs. 2 and 3, the first 180° of revolution of the crank 27 causes the drive rod 32 to move to the left as shown in Fig. 3, moving the cross-head 36 correspondingly to the left. During this movement of the cross-head, the punch rod 43 and punch element 46 are also moved to the left by the same amount, and hence the punch is advanced through the die element 53, and the draw-head 69 is also moved to the left by the same amount, owing to the action of the bar 78 on the pawl 85 in engagement with a notch 80. Inasmuch as the end of the tube is clamped to said draw-head 69, said draw-head insures the forward travel of the end of the tube and aids in drawing the latter through the die element 53. At the same time, the punch element 46, which fits the interior of the tube so as to frictionally advance the tube therewith, aids in forcing the tube through the die, thinning and elongating the tube. At the end of this movement of the draw-head 69 toward the left, pawl 95, which has moved over a lug 94, drops behind said lug and locks said head against movement toward the right, as viewed in Fig. 1.

The parts are now in the relative position shown in Fig. 4.

During the next 180° of revolution of the crank 27, the cross-head 36, punch element 46 and rod 78 are moved to the right as viewed in Figs. 1 and 4. The punch 46 is thus withdrawn relatively to the die element 53 into cooperative relation with the next succeeding portion of the tube. During this rearward movement of the punch 46, however, the head 69 is not moved to the right as viewed in Figs. 1 and 4 because of the lock provided by the pawl 95 and lug 94. The bar 78, however, moves rearwardly with the cross-head and relatively to the pawl 85 which slides freely on the upper surface of said bar until it drops into the next notch 80. At the conclusion of this 180° of revolution of the crank 27, the parts are back in their initial or starting position, and during the next 180° of revolution of the crank, the punch element 46 is again advanced, and the head 69 is correspondingly advanced with the tube 98 clamped thereto, and accordingly the next succeeding portion of the tube is thinned and elongated by being forced through the die element 53. This operation is continued, the punch being intermittently advanced through the die with the advance of the draw-head 69 to draw successive portions of the tube, and the draw-head being alternately restrained against rearward movement with the punch element during the return of said element to initial position. This operation is continued until the tube is drawn its entire length and carried out of the die element 53. If the tube is to be further reduced in thickness, the die holder 49 may be removed from the die block 47 by releasing the clamps 50 and a new die element of suitable size mounted on the die block, and the tube again drawn in the manner heretofore described—or a second machine provided with a suitable die element may be used.

In the embodiment of the invention so far described, the punch element 46 is forced forwardly with the tube by the exertion of thrust on the punch rod 43. Where tubes of relatively small diameter are to be drawn, however, the punch rod 43 may become of such small diameter as to be incapable of receiving the thrust pressure necessary to effect the drawing operation without buckling of said rod. In such an event, it is desirable to pull the punch element 46 through the die rather than push it through the die. In the embodiment shown in Figs. 10–12, a construction is shown whereby the punch is pulled through the die instead of being pushed therethrough, but while this construction is especially designed for drawing tubes of small diameter, it is to be understood that it is equally applicable to drawing tubes of any suitable diameter, and may be used in place of the construction heretofore described—although I prefer to push the punch through the die where the size of the tube permits of the use of a punch rod of sufficient diameter to avoid buckling.

In the form shown in Figs. 10–12, the punch element 46 is provided with an eye 100 which, for convenience, may be mounted on a threaded stem screwed into a threaded recess in the end of the punch element. In the embodiment of the invention shown in Figs. 1–9 inclusive, I have shown the punch element 46 as provided with a threaded recess at each end so that the punch element may be reversed on its punch rod and thereby evenly distribute the wear and the recess at the free end of the punch may be utilized for receiving the eye 100 when the punch element is to be pulled through the die in the manner now to be described.

Cooperating with the eye 100 is a pull rod 101 having a hook 102 for engagement in the eye 100. The opposite end of pull rod 101 is suitably attached to a head 103 journaled on an eccentric pin 104 which in turn is journaled at 105 in a pair of upstanding arms 106 carried by a vertical post 107 suitably secured, as by screws 108, to the end of the notched bar 78 heretofore described. In order to rotate the eccentric pin 104, the outer end of one of the bearing portions 105 carries in any suitable way an operating crank-arm 109. When crank-arm 109 is thrown to the position shown in dotted lines in Fig. 11, the pull rod 101 is moved to the right as viewed in Fig. 10 so that hook 102 may be readily withdrawn from eye 100. When operating crank-arm 109 is moved to the full line position in Fig. 11, the eccentric pin 104 causes the pull rod 101 to move to the left as viewed in Fig. 10, so as to pull the hook 102 into tight engagement with the eye 100. Crank-arm 109 may be locked in this latter position in any suitable way. In the form shown, a segmental bar 110 is suitably mounted as by screws 111 on the post 107 and is provided with a plurality of apertures 112. Pivotally mounted on the crank-arm 109 at 113 is a latch lever 114 which operates a latch pin 115, said latch pin being normally pressed into latching position by a spring 116 interposed between said lever 114 and the crank-arm 109. When the crank-arm 109 is in the position shown in full lines in Fig. 11, the latch pin 115 enters the opposed aperture 112 and locks said crank-arm in its adjusted position. To release the crank-arm 109 the handle 114 is moved toward the crank-arm, thereby withdrawing the latch pin 115 from the aperture 112 and permitting the crank-arm 109 to be thrown to the position shown in dotted lines in Fig. 11.

To provide for the use of the pull rod

101, the recess in the draw-head 69 is extended throughout the length of said head as shown in Fig. 10. The centering member 117 now takes the form of a sleeve which at its inner end is shaped to constitute one member of a ball and socket joint 118, the adjacent surface of the recess 70 being shaped to cooperate with the curved end of said sleeve 117 and permit a limited degree of universal movement so that said sleeve may properly cooperate with the end of the tube 98 when the latter is clamped between said sleeve and the clamping elements 71 and 73. To retain the sleeve 117 in position, a ring nut 120 is screwed into a threaded portion 121 of the recess 70 extending through the head 69, and is locked in position by a lock-screw 122. The pull rod 101 therefore extends through the axial space of the sleeve 117 and ring nut 120. Otherwise the machine of Figs. 10–12 is or may be of the same construction as heretofore described in connection with the embodiment of Figs. 1–9 inclusive.

In operation, the tube is prepared and mounted in cooperative relation with the die element, punch element and draw-head in the same manner as heretofore described in connection with the embodiment of Figs. 1–9. When the cross-head 36 is moved to the left as viewed in Fig. 1, carrying the notched bar 78 to the left as viewed in said figure and also in Fig. 10, the punch element 46 is pulled by pull rod 101 through the die element 53, instead of being pushed therethrough as in the embodiment of Figs. 1–9. During the succeeding movement of the cross-head 36 to the right as viewed in Fig. 1, the draw-head 69 is locked against movement in this direction as heretofore described, and punch element 46 is drawn to the right by the pull exerted thereon through the punch rod 43. It will be perceived that in this embodiment of the invention the punch is not pushed in either direction, being pulled through the die by pull rod 101 in one direction and being pulled to initial position by punch rod 43 in the opposite direction. Otherwise the manner of using this apparatus is the same as that of using the apparatus, illustrated in Figs. 1–9 inclusive.

It will therefore be perceived that a novel method and apparatus for drawing tubes has been provided whereby tubes of any suitable length and thickness may be drawn by the intermittent action on successive portions of the tube of relatively movable punch and die elements. The punch element may be made as short as desirable so that the friction between the tube and punch will not unduly resist the withdrawal of the punch, and hence any destructive force on the tube may be avoided when extracting the punch. At the same time the thinning and elongating, i. e. the drawing, of the tube is effected by the combined action of the draw-head and the movable punch, so that a tube can be drawn down until its wall is very thin without exerting any force of tension or compression on the tube that will rupture or injure it. This method of procedure results in a tube which has substantially the same thickness from end to end as the punch needs no taper, and the thickness of the final wall may be on the order of .005 to .010 of an inch,—or as much larger as may be desired. The entire tube so drawn is available for use in manufacturing flexible corrugated walls, and thereby corrugated tubes of a length heretofore unobtainable can be manufactured, or the tubes so drawn may be cut up into suitable lengths for manufacturing shorter commercial sizes of flexible corrugated tubular walls.

It will also be perceived that this method of procedure eliminates the wastage heretofore unavoidably incident to the cutting of disks from sheet metal to be drawn into tubes, the cutting off of the closed ends of the resulting tubes, and the trimming of ragged ends, as well as the wastage arising from the destruction to tubes during stripping from the punch incident to the methods heretofore used in drawing thin-walled tubes. This method also enables the use of commercial seamless drawn tubing in the manufacture of very thin walled tubes, such as required in the manufacture of flexible corrugated tubular walls.

Additionally, this method of procedure enables tubes of desired thickness to be produced by fewer operations than has heretofore been required where the tube has been forced between relatively stationary punch and die elements, because the passage of the tube between said elements does not depend upon the exertion of a drawing force which is less than the tensile or crushing strength of the tube, and hence a greater reduction in the thickness of the tube can be obtained during each passage of the tube through the machine than has been possible heretofore where the tube has been drawn between relatively stationary punch and die elements. Therefore, the present invention involves a very considerable saving in time and labor in the manufacture of seamless drawn tubing of thicknesses that were obtainable with the methods heretofore in use, while at the same time it possesses the further advantage that long tubes of much thinner wall can be manufactured by this method than were heretofore obtainable by the methods now in use. Additionally, the labor and expense incident to the handling of a large number of short tubes during a number of successive drawing operations has been avoided. Moreover, the apparatus of this invention is strong and durable, and simple in operation, and is therefore easily understandable and oper-

able by relatively unskilled labor, so that it possesses the advantage that it is not unduly expensive in installation and operation.

While the method of this invention has been described with considerable particularity and the embodiments of the invention shown on the drawings have been described in considerable detail, it is to be expressly understood that the invention is not to be restricted to the particular forms shown and described, as the invention is capable of being carried out in a variety of ways and receiving a variety of expressions, some of which will now readily suggest themselves to those skilled in the art. Changes may also be made in the details of construction, arrangement and proportion of parts, and certain features used without other features, without departing from the spirit of the invention. Reference is therefore to be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. The method of drawing tubes which includes intermittently exerting a drawing force on the tube to advance successive portions thereof between punch and die elements, aiding the passage of the tube between said elements during the successive exertions of drawing force by relatively reciprocating said elements, and moving one of said elements relatively to the tube into cooperative relation with successive portions of the tube during the interims between exertions of drawing force.

2. The method of drawing tubes which includes exerting a drawing force on a tube to advance the tube in a step-by-step motion between punch and die elements and reciprocating one of said elements relatively to the other and to the tube through a distance equal to each step-by-step advance of the tube.

3. The method of drawing tubes which includes intermittently advancing successive portions of a tube between relatively moving punch and die elements, and restraining the tube against movement during the movement of the movable element into cooperative relation with the next succeeding portion of the tube.

4. The method of drawing tubes which includes advancing the tube in a step-by-step motion to bring successive portions of the tube into cooperative relation with relatively movable punch and die elements and relatively reciprocating said elements with respect to the tube after each advance to bring the movable element into cooperative relation with succeeding portions of the tube.

5. The method of drawing tubes which includes intermittently advancing successive portions of a tube between punch and die elements, reciprocating one of said elements relatively to the other through a stroke which is short as compared with the length of the tube and restraining said tube against movement during each movement of the movable element to engage a succeeding portion of the tube.

6. The method of drawing tubes which includes intermittently advancing successive portions of a tube by and between relatively moving punch and die elements, and between advances restraining said tube against movement while returning the movable element to initial position.

7. The method of drawing tubes which includes intermittently exerting a drawing force to draw successive portions of a tube while aiding the drawing by the frictional action of relatively moving punch and die elements, and intermittently restraining said tube against movement while moving the movable element into engagement with each succeeding portion of the tube.

8. The method of drawing tubes which includes advancing successive portions of a tube between punch and die elements while reciprocating said elements relatively and with respect to the tube to engage successive portions of the tube and effect the passage of the same between said elements.

9. The method of drawing tubes which includes reciprocating a punch with respect to a die, advancing successive portions of a tube between said punch and die while drawing said successive portions with the aid of the frictional action thereon of said punch, and restraining said tube against movement while said punch moves into cooperative relation with each of the successive portions of the tube.

10. The method of drawing tubes which includes advancing successive portions of a tube between punch and die elements while reciprocating one of said elements relatively to the other and to the tube through a stroke which is short as compared with the length of the tube.

11. The method of drawing tubes which includes intermittently exerting a drawing force on the tube to advance successive portions of a tube between punch and die elements by strokes which are short as compared with the length of the tube and reciprocating one of said elements relative to the tube to assist the passage of the tube between said elements.

12. The method of drawing tubes which includes intermittently exerting a drawing force to advance successive portions of a tube in one direction between punch and die elements, moving one of said elements during the exertion of said drawing force to assist the passage of the tube between said elements, and restraining said tube against movement when said element moves in the opposite direction.

13. The method of drawing tubes which

includes thinning the wall of a tube by intermittently advancing successive portions of the tube between punch and die elements and reciprocating said punch with and relatively to the tube in synchronism with said intermittent advances in forcing each successive portion of the tube between said elements.

14. The method of drawing tubes which includes reciprocating a punch with respect to a die, advancing each of a plurality of successive portions of a tube between said punch and die with the aid of the punch, and restraining said tube between advances with the aid of the frictional action of the die on said tube while said punch is returned to initial position.

15. The method of drawing tubes which includes intermittently exerting a drawing force to draw successive portions of a tube between punch and die elements, reciprocating the punch in the direction of said force during each exertion thereof to aid the passage of the tube through the die, and restraining the tube while withdrawing the punch.

16. The method of drawing tubes which includes producing relative reciprocation of short strokes between punch and die elements, and drawing the tube in successive sections while exerting a drawing force on the tube during each movement of the movable element in a drawing direction and restraining the tube against movement during each movement of the movable element in the opposite direction.

17. In a machine for drawing tubes, the combination of a die element, a punch element, means for reciprocating one of said elements with respect to the other and with respect to the tube through a stroke which is short as compared with the length of the tube, and means for intermittently advancing successive portions of the tube into cooperative relation with said relatively movable punch and die elements.

18. In a machine for drawing tubes, the combination of a die element, a punch element, means for reciprocating one of said elements with respect to the other and with respect to the tube, and means for intermittently exerting a drawing force on the tube to draw the same between said punch and die elements.

19. In a machine for drawing tubes, the combination of a die element, a punch element, means for producing relative reciprocation between said punch and die elements, means for advancing successive portions of said tube between said punch and die elements, and means for restraining said tube against movement during the movement of the movable element into cooperative relation with the next succeeding portion of the tube.

20. In a machine for drawing tubes, the combination of a die element, a punch element, means for reciprocating one of said elements with respect to the other, a head separate from and movable with the reciprocating element in one direction, means carried by said head for clamping a tube, and means for restraining said head against movement during movement of said element in the opposite direction.

21. In a machine for drawing tubes, the combination of a stationary die, a punch, means for reciprocating said punch with respect to said die, a separate head provided with means for clamping a tube, means whereby said head advances with said punch as said punch moves in one direction, and means for restraining movement of said head as said punch moves in the opposite direction.

22. In a machine for drawing tubes, the combination of a die, a punch, means for reciprocating one of said elements with respect to the other, a pivotal mounting for said punch whereby said punch may be moved to receive a tube, a separate movable head provided with means for clamping a tube, and means whereby said head moves with the reciprocating element in one direction but not in the other direction.

23. In a machine for drawing tubes, the combination of a die, a punch, means for reciprocating one of said elements with respect to the other, a head provided with means for clamping a tube, and means including pawl and ratchet mechanism between said head and reciprocating element whereby said head advances with said element in one direction but is held against movement with said element in the opposite direction.

24. In a machine for drawing tubes, the combination of a die, a punch, means for reciprocating one of said elements with respect to the other, a head provided with means for clamping a tube, pawl and ratchet mechanism between said head and last-named means whereby said head is advanced with said element in one direction, and pawl and ratchet mechanism whereby said head is prevented from returning with said element in the opposite direction.

25. In a machine for drawing tubes, the combination of a die, a punch, means for reciprocating one of said elements with respect to the other, a head provided with means for clamping the tube, pawl and ratchet mechanism between said head and last-named means whereby said head is advanced with said element in one direction, pawl and ratchet mechanism whereby said head is prevented from returning with said element in the opposite direction, and means for simultaneously throwing both of said pawl and ratchet mechanisms out of operation.

26. In a machine for drawing tubes, the combination of a die element, a punch element, means for moving said die element into and out of operative position with respect to said punch element, means for producing relative movement between said punch and die elements, and a head provided with means for clamping a tube and movable with the movable element intermittently in only one direction.

27. In a machine for drawing tubes, the combination of a die, a punch, means for moving said die into and out of operative position with respect to said punch, means for locking said die in said operative position, means for moving said punch with respect to said die, and a head provided with means for clamping a tube and movable with said punch intermittently in only one direction.

28. In a machine for drawing tubes, the combination of a die element, a punch element, means for reciprocating one of said elements with respect to the other, a drawing-head provided with means for clamping the tube, and means for alternately moving said head to exert successive applications of drawing force in the same direction on the tube as said movable element reciprocates in one direction and restraining said head and tube against movement as said movable element reciprocates in the opposite direction.

29. In a machine for drawing tubes, the combination of relatively movable punch and die elements, means for reciprocating the movable of said elements with respect to the stationary of said elements, a head provided with means for clamping a tube, and means whereby said head alternately moves with and is restrained against movement with said movable element.

30. In a machine for drawing tubes, the combination of relatively movable punch and die elements, means for reciprocating the movable of said elements with respect to the stationary of said elements, a head provided with means for clamping the tube and flexibly supported means for centering the same, and means whereby said head alternately moves with and is restrained against movement with the movable element.

31. In a machine for drawing tubes, the combination of a die, intermittently acting means for advancing successive short portions of a tube relatively to said die, and a punch reciprocating relatively to said die and in alternation moving relatively to the tube to engage a succeeding section thereof and frictionally aiding the passage through said die of the succeeding tube section.

32. In a machine for drawing tubes, the combination of a die, a head provided with means for clamping a tube, intermittently acting means for exerting a drawing force on said head, and a punch reciprocating relatively to said die in synchronism with the intermittent applications of drawing force on said head and alternately engaging succeeding sections of the tube and aiding the passage of the same through said die.

33. In a machine for drawing tubes, the combination of a die, means for intermittently drawing successive portions of a tube through said die, means for frictionally aiding the passage of each successive portion of the tube through the die, and means for restraining the tube against movement as said last-named means moves into cooperative relation with successive portions of the tube.

34. In a machine for drawing tubes, the combination of a punch, a die, means for intermittently exerting a drawing force on the tube, and means for reciprocating said punch with and relatively to the tube to aid the passage of the tube between the punch and die during the exertion of said drawing force.

35. In a machine for drawing tubes, the combination of a punch, a die, means for alternately exerting a drawing force on the tube and holding the tube stationary, and means for reciprocating said punch to aid said drawing force in passing the tube between the punch and die.

36. In a machine for drawing tubes, the combination of a die, a draw-head, means for intermittently advancing said draw-head to advance successive portions of the tube with respect to the die, a punch, and means for reciprocating said punch in timed relation to the movement of the draw-head to aid the passage of the tube between said punch and die.

37. The method of drawing tubes which includes intermittently exerting a drawing force on a tube to draw successive portions thereof through a die, at each exertion of drawing force reciprocating a punch relatively to said die and in frictional contact with the tube and between exertions of drawing force moving said punch relatively to the tube into cooperative relation with a succeeding portion of the tube.

38. The method of drawing tubes which includes intermittently exerting a drawing force on a tube to draw successive portions thereof through a die and at each exertion of drawing force reciprocating a punch relatively to said die and in frictional contact with the tube, and restraining said tube against movement while said punch moves into frictional contact with a succeeding portion of the tube.

39. The method of drawing tubes which includes intermittently exerting a drawing force on the tube to advance short lengths of tube between punch and die elements, and relatively reciprocating said elements through corresponding short lengths of movement to aid the passage of said tube

therebetween and to move relatively to the tube into cooperative relation with succeeding portions thereof.

40. The method of drawing tubes which includes intermittently advancing successive short lengths of the tube through a die by a drawing force while aiding the passage of the tube through the die by the relative movement of a punch which reciprocates back and forth with and with respect to the tube through strokes equal to each of the short lengths to be acted upon.

41. The method of drawing tubes which includes intermittently advancing successive short lengths of the tube through a die by a drawing force, aiding the passage of each short length of the tube through the die by relative movement of a punch and said die, and restraining the tube from movement while said movable element moves into engagement with a succeeding portion of the tube.

42. The method of drawing tubes which includes intermittently drawing successive short lengths of the tube through a die by a drawing force, aiding the passage of each short length of the tube through the die by a movable punch, and restraining the tube from movement while said punch moves into frictional engagement with succeeding portions of the tube.

In testimony whereof I have signed this specification.

WESTON M. FULTON.