May 1, 1934. J. L. CASSADY 1,957,387

MACHINE FOR MAKING TAPERED TUBES

Filed March 28, 1929 6 Sheets-Sheet 1

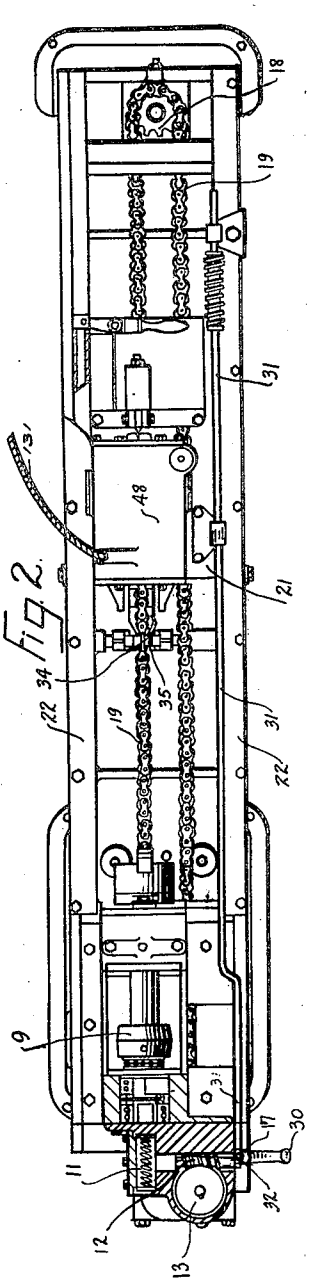


Fig. 2

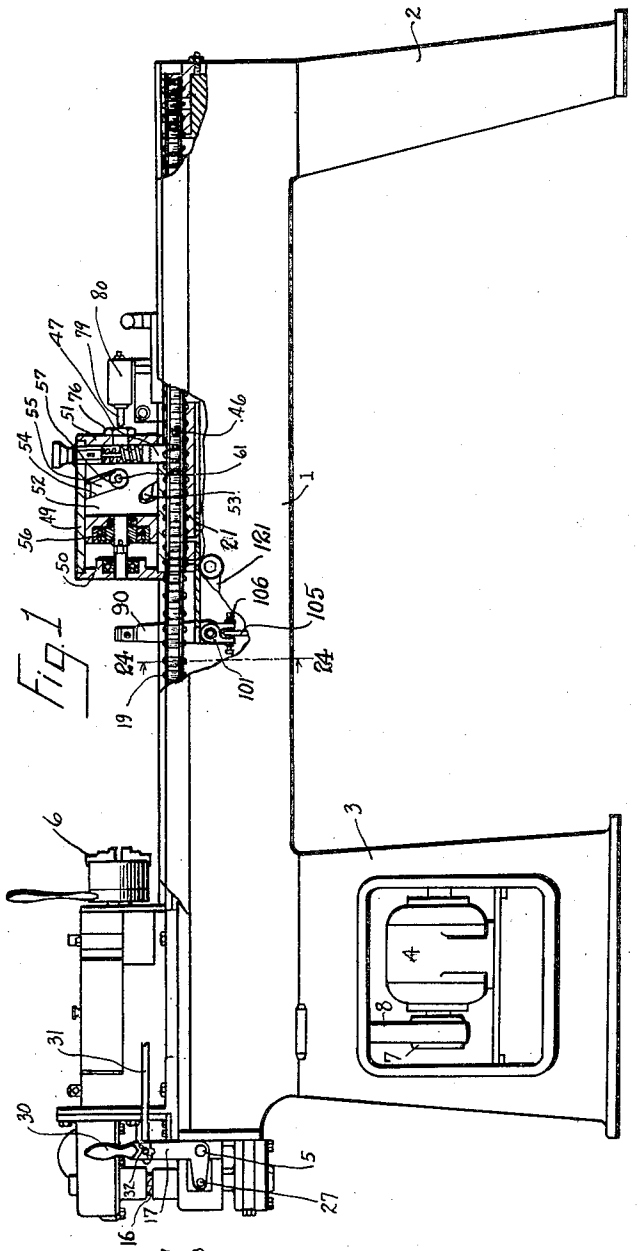


Fig. 1

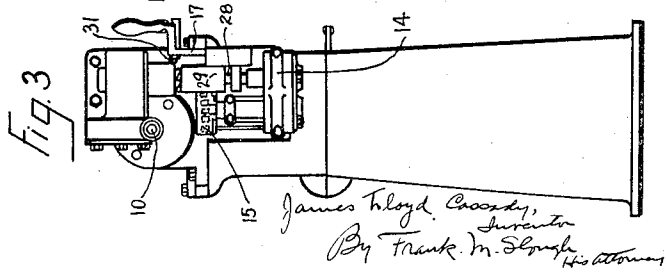


Fig. 3

James Floyd Cassady, Inventor
By Frank M. Slough His attorney

May 1, 1934. J. L. CASSADY 1,957,387

MACHINE FOR MAKING TAPERED TUBES

Filed March 28, 1929 6 Sheets-Sheet 2

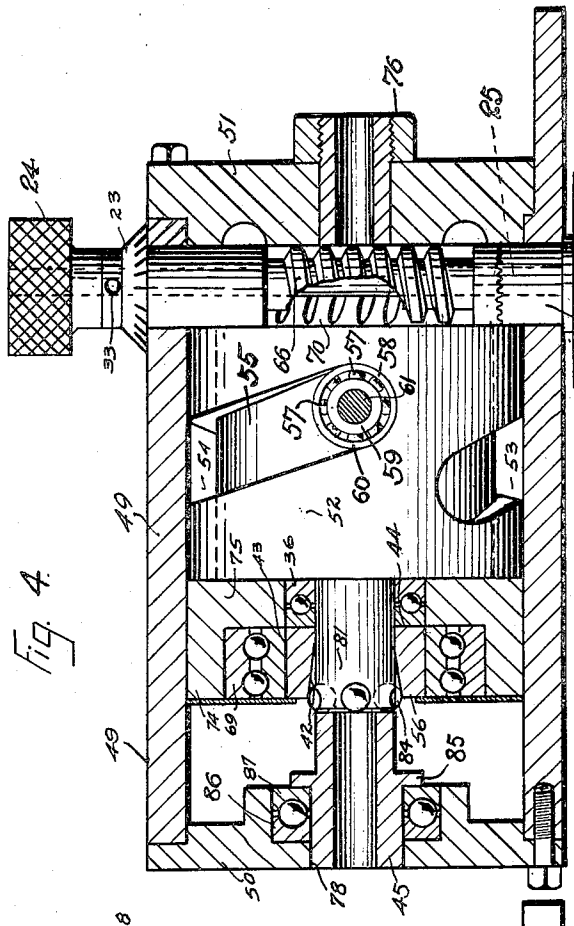


Fig. 4

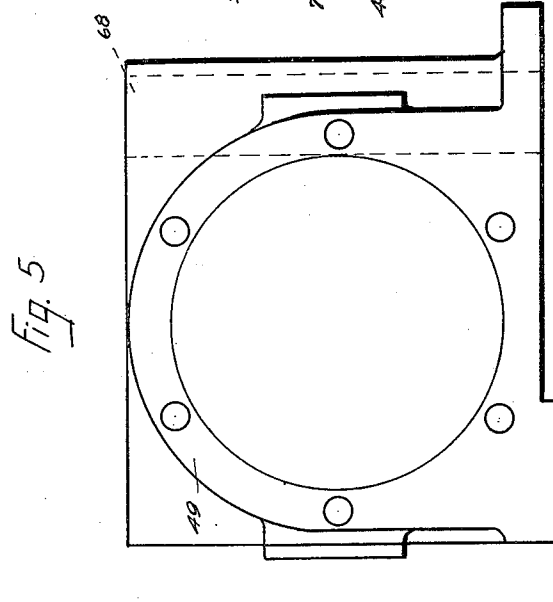


Fig. 5

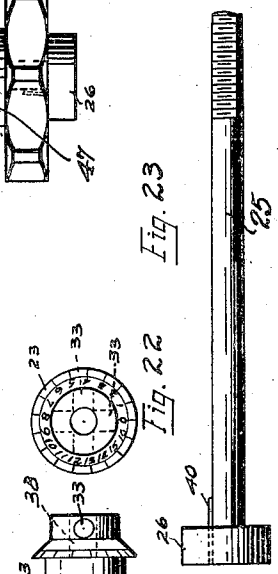


Fig. 23

Fig. 22

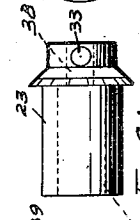


Fig. 21

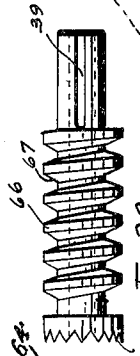


Fig. 20

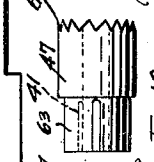


Fig. 19

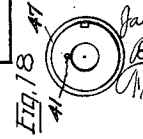


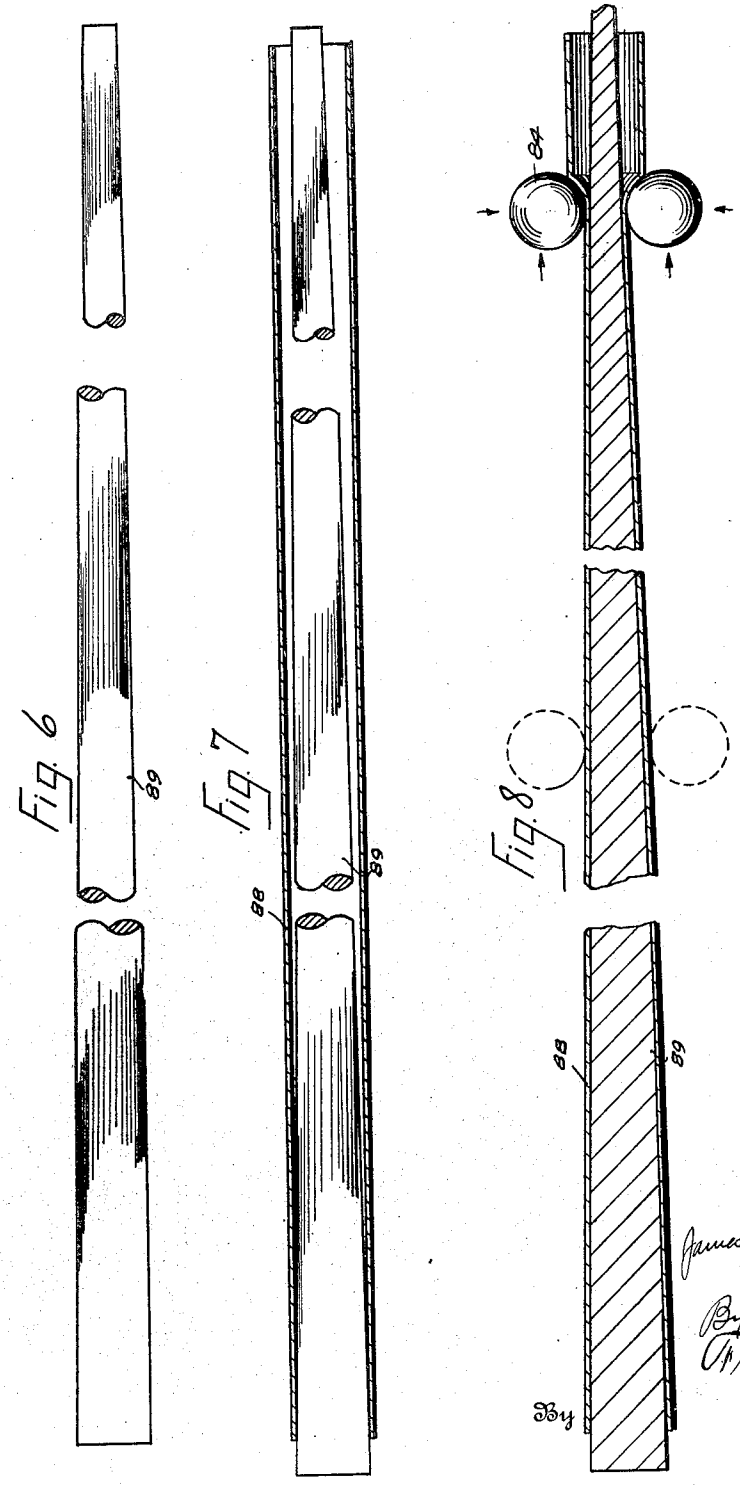
Fig. 18

James Floyd Cassady
Inventor
By Frank McSlough
His Attorney

May 1, 1934. J. L. CASSADY 1,957,387

MACHINE FOR MAKING TAPERED TUBES

Filed March 28, 1929 6 Sheets-Sheet 3



James Tilloyd Cassady,
Inventor
By Frank M. Slough
By
Attorney

May 1, 1934. J. L. CASSADY 1,957,387

MACHINE FOR MAKING TAPERED TUBES

Filed March 28, 1929 6 Sheets-Sheet 4

Fig. 10

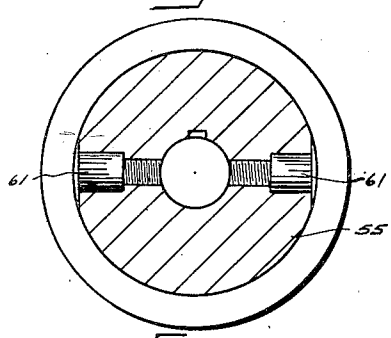


Fig. 9

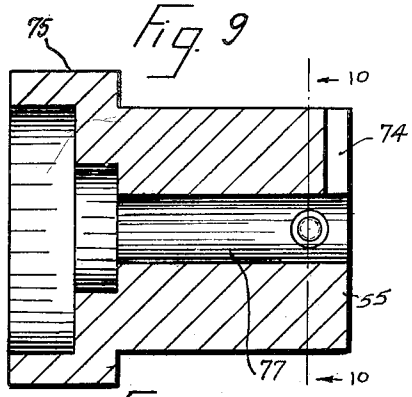


Fig. 11

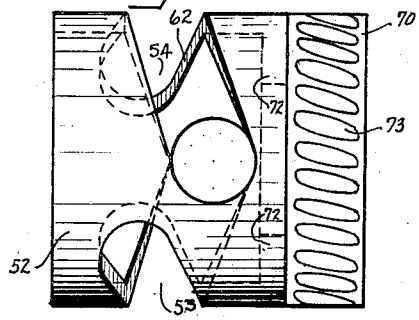


Fig. 12

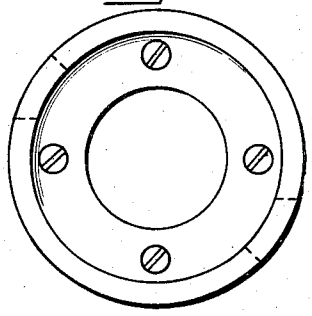


Fig. 13

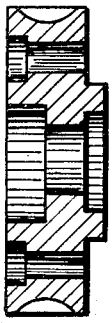


Fig. 14

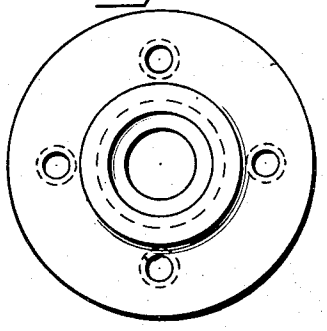


Fig. 17

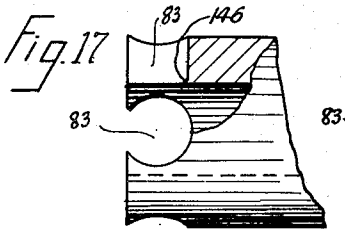


Fig. 15

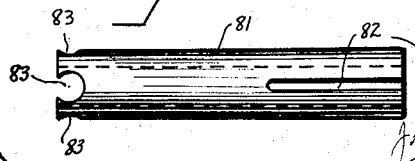
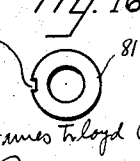


Fig. 16



Inventor

James Lloyd Cassady,

By Frank M. Slough.

His Attorney

May 1, 1934. J. L. CASSADY 1,957,387

MACHINE FOR MAKING TAPERED TUBES

Filed March 28, 1929 6 Sheets-Sheet 5

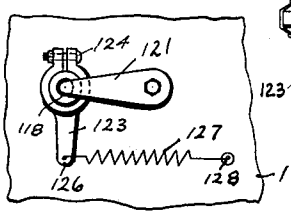


Fig. 30

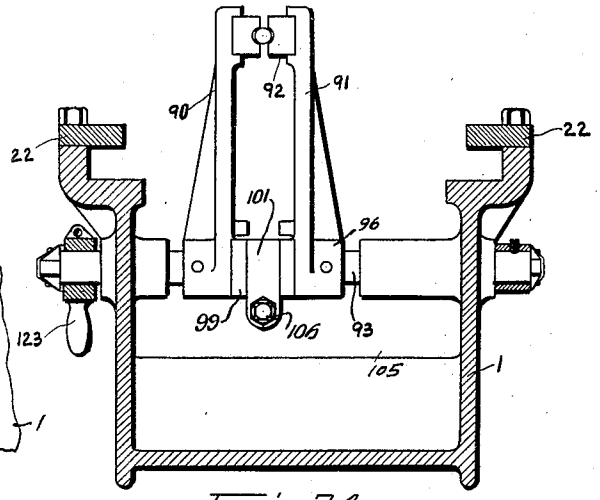


Fig. 24

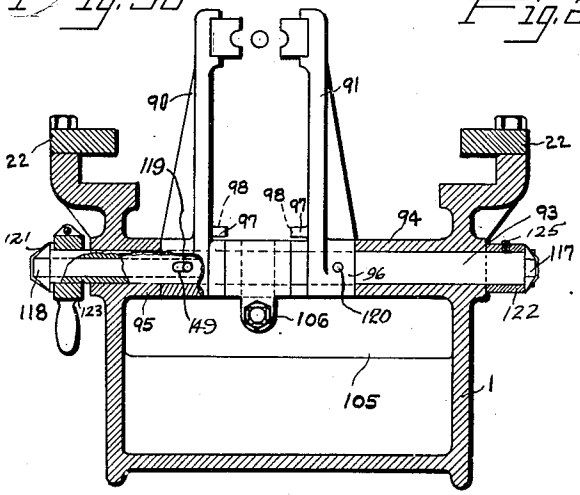


Fig. 25

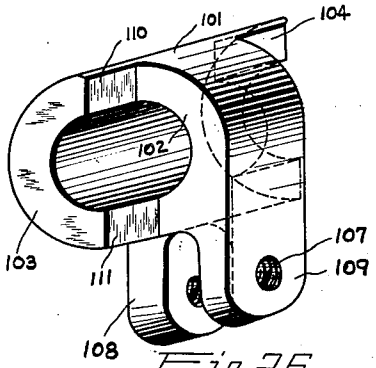


Fig. 26

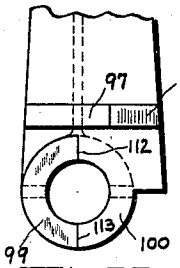


Fig. 27

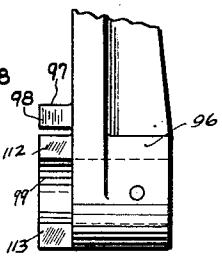


Fig. 28

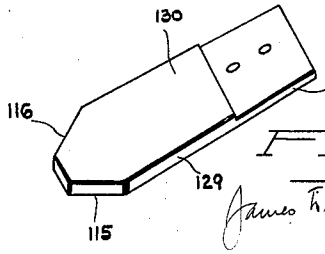


Fig. 29

Inventor
James Floyd Cassady

By

By Frank M. Slough
His Attorney.

May 1, 1934. J. L. CASSADY 1,957,387

MACHINE FOR MAKING TAPERED TUBES

Filed March 28, 1929. 6 Sheets-Sheet 6

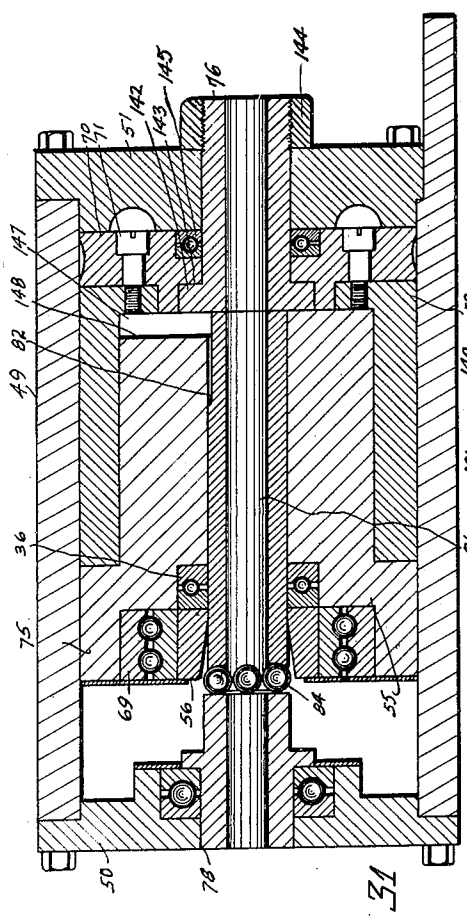


Fig. 31

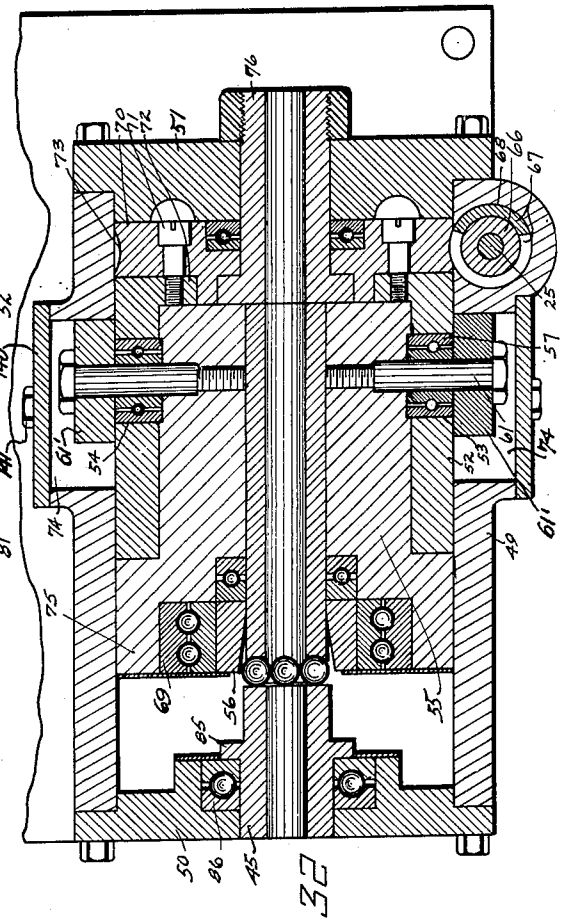


Fig. 32

James Lloyd Cassady Inventor

By Frank M. Lough

His Attorney

Patented May 1, 1934 1,957,387

UNITED STATES PATENT OFFICE

1,957,387

MACHINE FOR MAKING TAPERED TUBES

James Lloyd Cassady, Geneva, Ohio, assignor to The American Fork & Hoe Company, Cleveland, Ohio, a corporation of Ohio

Application March 28, 1929, Serial No. 350,620

11 Claims. (Cl. 80—12)

This invention relates to the drawing of rods or tubes by means of roller dies, such as ball dies, and relates especially to such drawing wherein the diameter of the work is varied in different portions of its length.

An object of the present invention is to provide for the drawing of tubes and rods in such a way as to accomplish a variation in effective diameter of the die-pass according to a predetermined relation to the relative longitudinal movement of the die and work.

Another object of my invention is to effect variations in the form of thin-walled tubes by the action of a roller die, in such a way as not to fracture or otherwise unduly weaken the walls of the tubes during the drawing process.

Another object of my invention is to provide for the operation upon tubes of a given diameter and wall thickness, to vary the diameter and/or wall thickness in at least certain portions of the length of the thin-walled tube, in such a way that the resulting exterior surface of the tube will be relatively smooth throughout its length.

Another object of my invention is to provide for the drawing of relatively high carbon steel tubes, to a predetermined tapered form and with such a resulting wall thickness as to make them applicable for use as shafts of golf clubs.

Another object of my invention is to effect the drawing of tubes and rods to a predetermined form from a rod or tube varying in form therefrom in an economical manner.

Another object of my invention is to provide for the forming from substantially non-tapered tubes to relatively strong highly resilient tapered tubes which may be of any desired wall thickness in different portions of their length.

Another object of my invention is to provide against scoring of rods or tubes processed in a roller tube die.

A further object of my invention is to provide an improved structure of an adjustable roller ball die.

Other objects of my invention and the invention itself will become apparent from the following description of an embodiment of my invention, and in which description reference will be had to the accompanying drawings illustrating the said embodiment and forming a part of this specification.

Referring to the drawings:

Fig. 1 illustrates mostly in side elevation, a machine embodying the principles of my invention, certain parts, however, being shown in longitudinal sectional view;

Fig. 2 is a plan view of the machine shown in Fig. 1, except that certain parts are shown in transverse section;

Fig. 3 is an end elevational view of the machine;

Fig. 4 is a longitudinal medial sectional view of the roller die head, of said embodiment;

Fig. 5 is an end elevation of the casing for the roller die head shown in Fig. 4;

Fig. 6 is a view in fragmentary elevation of a typical mandrel over which, for instance, a tubular golf shaft may be formed by the machine;

Fig. 7 is a view in longitudinal medial section of a tube before being processed by the machine of my invention, the mandrel being shown in elevation as telescoped therein;

Fig. 8 is a view in longitudinal medial section showing the tube telescoped upon the mandrel and in the process of being formed;

Fig. 9 is a view in longitudinal medial section, of a piston for the roller die head of the said machine;

Fig. 10 is a view taken on the line 10—10 of Fig. 9;

Fig. 11 is a side elevational view of a specially formed cam element adapted to effect a longitudinal thrusting effort on the piston of Fig. 9, a driving gear being shown as affixed thereto;

Fig. 12 is an end elevational view of the cam of Fig. 11;

Fig. 13 is a longitudinal medial sectional view of the worm gear in the driving connections for the piston and cam of Figs. 10 and 12 inclusive.

Fig. 14 is an end elevational view of the worm gear of Fig. 13;

Fig. 15 is a side elevational view of a die ball retaining tube for the roller die head;

Fig. 16 is an end elevational view of said tube;

Fig. 17 is an enlarged view of a portion of the tube of Fig. 16, a fragment being shown in section;

Figs. 18 and 19 are end and side elevational views of a clutch element formed with a jaw clutch end face;

Fig. 20 is a side elevational view of a worm pinion having clutch jaws adapted to cooperate with the clutch element of Fig. 19;

Figs. 21 and 22 are side and end elevational views of an adjustment element for the worm pinion of Fig. 20;

Fig. 23 shows a pin employed in connection with said mechanisms;

Figs. 24 and 25 are views taken on the line 24—24 of Fig. 1, certain parts being shown in different operative positions, and parts being broken away and shown in section;

Fig. 26 is a perspective view of a stop used to position the arms of Figs. 24 and 25;

Figs. 27 and 28 are fragmentary side and front elevational views of one of a pair of tube supporting arms used in the machine of my invention;

Fig. 29 is a perspective view of a wedge which operates the arms of Figs. 24 and 25;

Fig. 30 is a fragmentary side view of the bed showing part of the mechanism associated with that of Figs. 24 to 28.

Fig. 31 is a vertical medial sectional of the die head, and

Fig. 32 is a horizontal medial sectional view of the die head.

Referring now to the different figures of drawings in all of which like parts are designated by like reference characters, a bed 1 is supported by a pair of legs 2 at one end and by a hollow stand 3 at its other end. The hollow stand 3 houses a reversible electric motor 4 for rotating a chuck 6 at varying speeds, depending upon the ratio of the driving connections intermediate the motor and the chuck, and comprising a pulley 7 on the motor shaft and a belt 8 communicating motion from the pulley 7 to a pulley 9 to effect driving of the work holding chuck 6 through the shaft supporting the pulley 9; the chuck 6 and a worm pinion 10 being disposed at the two ends of the shaft.

The train of gears 11, 12 and 13 are driven from the worm pinion 10 and motion is communicated from the gear 13 through the jaw clutch 16 to the gears contained in the housing 14, and which are effective to drive the sprocket 15, as shown by dotted lines, by motion communicated through the jaw clutch 16, as above described. Whenever the bell crank lever 17 is rocked to its ultimate angular position, clockwise on its fulcrum joint 5, as viewed in Fig. 1, to lift its bifurcated horizontal arm by pin projections 27 standing within an annular recess 28 of the rotary jaw clutch element 29 of the clutch 16, the element 29 of the clutch 16 engages by its teeth of the upper driven element and motion is thereupon communicated from the driving gear 13 to drive the sprocket 15.

The vertical arm of the bell crank lever 17 terminates in a handle 30 whereby manual operation of the clutch may be accomplished. In addition, a rod 31 is swivelably joined at 32 to the bell crank lever and extends longitudinally of the bed 1 above one side of the head and is adapted to be engaged by the reciprocable carriage 21, which is journalled for reciprocation longitudinally of the bed, upon extreme predetermined longitudinal movement of the carriage, as later described.

The carriage 21 rests upon and is guided in its longitudinal movements by a pair of parallel trackways 22 which are provided on the upper part of the bed 1, extending from the adjacent chuck 6 to the foot of the lathe, which is supported by the legs 2. At the foot of the lathe, an idler sprocket 18 is journalled for horizontal rotation and a roller link chain 19 is passed around the driving sprocket 15 and the idler sprocket 18.

It will, therefore, be understood that during operation of the machine, the motor 4 simultaneously drives the sprocket 15 to drive the chain 19, which extends from end to end of the machine and round the idler sprocket 18, drives the rotatable chuck 6 and drives a die head sprocket 46, which is carried on a stem 47, the stem being journalled in the die head housing 49.

The die head is of special construction, and comprises a housing 49, which has a substantially cylindrical longitudinal bore and is provided with end plates 50 and 51 and contains a cylindrical gear driven cam 52 within which a piston or ram 55 is telescoped, adapted for longitudinal reciprocation to thrust an annular die block 56 axially. The cam element 52 has a pair of preferably spiral oppositely disposed cam slots 53 and 54, extending through its lateral walls, each of which snugly receives a ball bearing 57, illustrated best in Figs. 4, 11 and 32.

The ball bearing element comprises an outer annular ball race 58, an inner annular race 59, and interposed bearing balls 60. Each of the inner race elements 59 is tightly fitted onto a piston pin 61, the piston pins being screw threaded into opposite radially disposed apertures in the supporting piston 55. The pins and piston are thus guided by the walls of the slots 53 and 54 in engagement with the outer surfaces of the race elements.

The sprocket supporting stem 47 is illustrated in Figs. 18 and 19, and comprises a reduced sprocket supporting end 63 and an annular radially serrated jaw clutch face 64, which is adapted for engagement with a similar jaw clutch face 65 of a worm pinion element 66 having worm threads 67 on its intermediate portion.

The worm pinion element is journalled within the die head spaced portion 68 and is adapted to be driven through the interlocking clutch faces 64 and 65 when the sprocket 46 is rotated by relative movement of the engaged chain links and the die head, longitudinally of the bed 1.

The sprocket 46, supporting stem 47, worm pinion 66 and adjusting element 23 are held, as shown in Fig. 4, upon a center bolt 25, and are locked in an adjusted position by the knurled nut 24. The end of the worm pinion 66 is adapted to be slidably journalled in the enlarged portion 37 of a bore 38 in the adjusting element, and is held against rotation therein by a suitable key disposed in a keyway 39 of the pinion and a corresponding keyway in the bore of the adjusting element.

The center bolt 25 is provided with a head 26 at one end and is threaded at the other end. A pin 40 is secured in the head and extends parallel to the axis of the bolt stem adjacent thereto and is adapted to be seated in a cylindrical aperture 41 in the sprocket supporting element stem, to prevent relative rotation of the center bolt and the supporting stem.

The pinion 66 may be rotated relative to the sprocket, for adjustment, by loosening the nut 24, which holds the elements in operative relation to each other and inserting a suitable pin in one of the radial apertures 33 in the adjusting element 23 and rotating the element; which rotation also rotates the pinion 66. The sprocket 46, however, will not move, being held against rotation by the links of the chain, and the serrated clutch faces 64 and 65 will slide over each other. Tightening the nut 24 brings the faces 64 and 65 into close contact with each other preventing further relative movement. The adjusting element may be provided with suitable indicia in its flange as shown to indicate the adjusted position of the worm pinion.

The worm pinion 66 is disposed laterally of a worm gear element 70, which is affixed by screws 71 projecting into an end wall of the gear through an inwardly extending annular flange 72 com-

prising a partial end wall for the cylindrical cam element 52. Therefore, the gear 70 having spiral teeth 73 engaged by the spiral teeth 67 of the worm gear element 66, will be driven to rotatively drive the affixed cam element 52.

The piston 55 is telescoped within the cylindrical cam element and is held against rotative movement by the pins 61 which have rollers 61' rotatably journalled thereon and adapted to reciprocate in oppositely disposed longitudinal slots 74 in the housing. A plate 140 is provided to cover the slots being held in place by screws 141. Said piston comprises the die supporting portion 75 which is suitably recessed to provide successive mounting surfaces for the camming annulus supporting bearing 69 and a camming annulus thrust bearing 36. The camming annulus 56 comprises an annular ring, the inner wall 42 slanting outward substantially as shown. The annulus is supported by its outer wall 43 within bearing 69 and its wide side 44 is adapted to contact with the thrust bearing 36.

An axially bored center bolt 76 is provided and has a head 142 adapted to be disposed in a recess 143 in the gear 70. The bolt is secured by the nut 144 and prevents longitudinal movement of the gear to the left as viewed in Figs. 31 and 32. A suitable thrust bearing 145 is disposed in a recess in the gear 70 opposite to the recess 143 and is adapted to take the thrust between the gear 70 and end plate 51. The bolt is in axial alignment with an axial opening 78 through the end wall 50 also with the die-pass later to be described, and the axis of the chuck 6.

A center 79 is carried on a tail-stock 80, which is adapted to be moved longitudinally on the tracks 22 of the bed 1, and secured tightly thereon in any desired longitudinally adjusted position. The center 79 is adapted to receive the end of the mandrel to hold it and the tube telescoped thereon in desired axial alignment with the die-pass opening and the chuck 6. Although the drawings show this center in one adjusted position, it will be understood that it is susceptible of being placed near the end of the bed 1, which carries the sprocket 18 when a tube is to be operated upon.

The die pass mechanism comprises a tubular die ball holder 81, having a longitudinally key groove 82 adjacent one end. A key 147 is secured in a keyway 148 in the piston and extends into the keyway 82, being adapted to slide longitudinally thereof with the piston and prevents rotation of the die ball holder relative to the piston. A plurality of radial passages 83 extend from the opposite end of the tube, and are particircular in form with preferably parti-cylindrical walls, comprising preferably three-fourths of a cylinder, a one-fourth segment thereof being omitted, and are adapted to carry die balls 84. The innermost portion of the passages are slightly restricted at 146 to restrain the die balls from dropping into the bore of the cylinder.

A rotatable thrust element 45, having a radial flange 85 is centrally disposed in the opening 73 of the die head end wall 50, being loosely journalled therein and within the bearing race element 86 supported thereby, the opposing bearing race element 87 being rigidly carried by the tubular thrust element 45. Bearing balls are interposed between the races to take the thrust. The end of the thrust element is adapted to contact with the die pass balls 84 to prevent further axial movement towards the thrust element; the other end of the die ball holder contacts with the bolt 76 to prevent further longitudinal movement thereof.

A tube 88, to be processed, is telescoped upon a tapered mandrel 89 and secured in the chuck 6, the opposite end of the mandrel being supported by the tail stock center 79. At the beginning of the tube processing operation the die head with the enclosed die pass mechanism will be adjacent the chuck, to the left as viewed in Fig. 1. When the motor 4 is energized, the chain 19 will travel as previously described pulling the die head with its associated mechanism to the right. The sprocket 46 will also be rotated by the links of the chain 19, communicating motion to the pinion 66, which rotates the barrel cam 52 by the gear 70. The slanting camming slots 53 and 54 will force the piston by the bearings and pins axially to the left carrying with it the camming annulus 56 and forcing the die pass balls, which are held against longitudinal movement, inward making the die pass smaller.

The chuck rotates the mandrel and tube at a relatively high speed between the die balls, and they are gradually pressed inward by the camming action of the camming annulus 56, reducing the tube in diameter towards the right as best illustrated in Fig. 8.

A suitable lubricant may be supplied through a flexible tube 131 into an aperture in the top of the die head flooding the die pass mechanism.

As the die head travels over the bed to the right the unsupported span of the drawn tube is prevented from "whipping" or vibration by a pair of arms 90 and 91 which support fiber blocks 92, the blocks being grooved to allow the shaft to rotate freely therebetween.

As best shown in Figs. 24 to 30 inclusive, the arms are slidably supported upon a tube 93, which is rotatably journalled in the bed 1 in suitable oppositely disposed axially aligned bored bosses 94 and 95, by the enlarged bored ends 96. The arms are right and left hand respectively and each is provided with a transverse lug 97 disposed adjacent the enlarged end, which has a slanting face 98 at one end. The bored ends of the arms are cut away at 100 leaving a semi-cylindrical shaped portion 99.

Intermediate the two arms and also loosely fitting the tube 93 is a stop lug 101, best shown in Fig. 26, which comprises a central bored portion 102 and a pair of outer semi-cylindrical portions 103 and 104, formed in a manner similar to the portion 99 of the arms. The lug, telescoped on the tube, is secured to a web 105, which extends transversely across the bed 1, by a pair of screws and lock nuts 106 disposed in threaded apertures 107 in the depending portions 108 and 109 of the lug, which holds the lug in a non-rotative position.

The semi-cylindrical portions of the arms 90 and 91 are adapted to engage with the like portions of the lug 101 and when in such interlocking engagement, the arms will be held in an upright position due to the contact of the faces 110 and 111 of the lug with the faces 112 and 113 of the arms; such a position being illustrated in Fig. 24. The arms may, however, be placed in a position where they will be free to oscillate by sliding them along the tube 93 until the cooperating faces of the lug and arms are out of engagement with each other. This may be accomplished by means of a wedge shaped extension 114, Fig. 29, secured to the die head which is secured to the bottom thereof. The slanting faces 115 and 116 are adapted to contact with the slanting faces 98

on the lugs 97 and by a camming action, as the wedge 114 passes between the arms, forces the arms apart sliding them along the tubes 93 out of contact with the lug 101.

The arms 90 and 91 which are telescoped on the tube 93 are also pinned to short rods 117 and 118, telescoped within the tube, by transverse pins 119 and 120 which extend through elongated slots 149 in the tube into the arms. The arms thus secured to the rods may be reciprocated axially upon the tube thereby, the amount of reciprocating being limited by the slots 149. Both of the rods extend beyond the end of the tubes and are adapted to be spring pressed inwardly by a spring 121 which exerts pressure upon the ends of the rods, thus tending at all times to slide the arms toward each other.

The ends of the tube extend beyond the bosses 94 and 95 and the tube is prevented from longitudinal reciprocation by a collar 122 on the one end and lever 123 on the other end. The collar being secured to the tube by a set screw 125, and the lever being split and secured to the tube by a clamping bolt 124. The collar may, however, be replaced by a lever similar to that at 123. A helical spring 127 is secured to the end 126 of the lever 123 and has the other end 128 secured to the bed 1, and exerts a steady pull upon the lever tending to rotate the tube 93 and the arms 90 and 91 therewith.

When the head is adjacent the chuck at the start of the tube processing operation, the arms, having been previously displaced from contact with the lug 101 by the wedge 114, are held in a spread recumbent position underneath the head, the ends 99 of the cylindrical portions of the arms contacting with the ends 103 and 104 of the lug; as the head travels along the bed to the right, it will allow the arms to spring up due to the retractive efforts of the helical spring 127 wherein the lugs 97 will contact with the sides 129 and 130 of the wedge 114 and as the wedge is gradually withdrawn will allow the arms secured to the rods 117 and 118 to be spring pressed, by the springs 121, inward until the cooperating faces of the lug and arms are in engagement, and further rotation of the arms and assembly is prevented and wherein the fiber or blocks 92 will loosely support the tube to prevent undue vibration or whipping of the mandrel and tube telescoped thereon.

When the tube has been completely processed, and reduced to its smallest diameter, the motor 4 is reversed and the die head repassed to its original position adjacent the chuck where the motor may be stopped and another tube placed in position for processing.

Having thus described my invention in an embodiment thereof, I am aware that numerous and extensive departures may be made therefrom but without departing from the spirit of my invention.

I claim:

1. In a ball die, a die pass comprising a series of balls adapted to act compressively on a work piece relatively rotated in the pass and having relative longitudinal movement therein, a fixed ball cage for disposing the balls in a circular series and a ball raceway including a ring having an inner tapered bore outwardly flaring in the direction of longitudinal movement of the work piece encircling the balls, means to effect relative longitudinal movement of the ring and balls, a thrust raceway for restraining the balls from longitudinal movement the tapered ring and the thrust raceway being supported on rotational bearings and freely rotatable thereon by movement communicated thereto through the balls from the rotatable work.

2. A ball die comprising a casing, a series of balls disposed in annular relation to define a die pass, through which work to be compressively acted upon by the balls may be relatively longitudinally moved, and relatively rotated, a radially disposed thrust element comprising a ring having an inner tapered bore encircling the balls with the walls of the bore in tangential contact therewith, the ring being journalled in a bearing for free rotational movement in the casing by the work means to adjust relatively longitudinal positions of the balls and the ring to determine the effective diameter of the die pass, and thrust means for restraining the balls from longitudinal movement from said longitudinally adjusted position of the balls relative to the ring journalled in bearings for free rotational movement independently of the rotation of the ring.

3. In a tube and rod tapering mechanism, the combination of a die head having a die pass opening extending longitudinally therethrough, a work holder disposed in axial alignment and longitudinally of the pass opening, means to effect rotational movement of the holder to rotate the work with said work projected through the opening, means to effect relative longitudinal movement of the holder and head to progressively move the work through the opening, an annulus supported by the head coaxially of the opening and having inner walls converging toward an end of the annulus, a series of die rolling balls adapted for annular disposition around the work in engagement therewith and encircled by the engaged converging walls of the annulus, a rotational bearing supporting the annulus for free rotation within the head, means supported by a rotational thrust bearing to restrain movement of the balls longitudinally of the annulus and rotatable independently of the annulus, and means to continuously adjustably vary the relative longitudinal positions of the balls and the annulus to progressively effect progressive engagement between the converging surface of the annulus wall and the balls to continuously progressively restrict the effective die pass opening provided within the balls.

4. A ball die comprising a casing, a series of balls within said casing, a raceway for said balls comprising a ring having an inner tapered bore encircling the balls and longitudinally movable with relation to the remainder of the raceway, means for effecting simultaneous rotation of the work in the pass and longitudinal movement of the work relative to the pass, means for moving said tapered ring longitudinally over the balls, to vary the diameter of the pass commensurably with the relative longitudinal movement of the work and pass, and a bearing for said ring disposed radially thereof, a thrust raceway for restraining the balls from longitudinal movement supported on rotational bearings said ring and thrust element freely rotatable in said bearings about the axis of said pass.

5. A ball die comprising a casing, a series of balls within said casing, a raceway for said balls comprising a ring having an inner tapered bore encircling the balls and longitudinally movable with relation to the remainder of the raceway, means for effecting simultaneous rotation of the work in the pass and longitudinal movement of the work relative to the pass, means for

moving said tapered ring longitudinally to vary the diameter of the pass commensurably with the relative longitudinal movement of the work and pass, and a bearing for said ring disposed radially thereof, said ring freely rotatable in said bearing about the axis of said pass, by movement communicated thereto through the balls from the rotary work, a tubular thrust element for said balls, engageable therewith longitudinally of the pass, and a thrust bearing for said thrust element adapted to permit rotary movement of said thrust element between said balls and said bearing.

6. In a mechanism for tapering thin-walled tubes, the combination of a rotatable work holder, a die or pass through which the work is longitudinally projected, means for moving the die longitudinally of the work means for rotating the work in the die, said die comprising a series of balls encircling the work, and positioning means for said balls, a machine bed for supporting the holder upon which the die is longitudinally moved, a pair of steadying jaws for the work, arms for supporting the jaws carried by the bed, and means actuatable by movement of the die on the bed to position the jaws about the work, only during periods when the die has moved to a substantially remote position relative to the jaws.

7. A ball die comprising a casing, a series of balls within the casing, a raceway for the balls comprising a tubular ball holder having radially extending ball retaining passages at one side of the series of balls and an annular independently rotatably mounted thrust element at the other side of the series of balls, said tubular ball holder and said annular thrust element disposed in relatively longitudinally fixed relation to the casing, a ring having an inner wall longitudinally outwardly tapered in the direction toward the thrust element and encircling and by its tapered wall engaging the balls, and means engaging said ring to adjustably longitudinally move it relative to the balls.

8. A ball die comprising a casing, a series of balls within the casing, a raceway for the balls comprising a tubular ball holder having radially extending ball retaining passages at one side of the series of balls and an annular thrust element at the other side of the series of balls, said tubular ball holder and said annular thrust element disposed in relatively longitudinally fixed relation to the casing, a ring having an inner wall longitudinally outwardly tapered in the direction toward the thrust element and encircling and by its tapered wall engaging the balls, and means engaging said ring to adjustably longitudinally move it relative to the balls, and bearing elements freely rotatably supporting said ring in the casing.

9. A ball die comprising a casing, a die pass comprising a series of balls within said casing, a raceway for said balls comprising a ring having an inner tapered bore encircling the balls and longitudinally movable with relation to the remainder of the raceway, means for effecting simultaneous rotation of the work in the pass and relative longitudinal movement of the work and the pass, means for moving said tapered ring longitudinally over the balls to vary the diameter of the pass commensurably with the relative longitudinal movement of the work and pass, and a bearing for said ring disposed radially thereof, said ring freely rotatable in said bearing about the axis of said pass by movement communicated thereto through the balls from the rotating work, the ball race way comprising also an end thrust bearing mounted for rotation around the axis of said pass, independently of the rotation of the said ring.

10. A ball die comprising a casing, a series of die pass balls within said casing, a raceway for said balls comprising bearing thrust elements rotatably mounted in said casing at each side of the said series of balls and a ring having an inner longitudinally tapered wall encircling said balls with said tapered wall in engagement therewith, and means associated with the ring to adjustably position it longitudinally of the die during rotational and longitudinal relative movement of a work piece through the die pass, said means comprising a pair of thrust elements supported by the casing, one of which is longitudinally movable in the casing and guided against rotation and connected with said ring, and the other of which is rotatable in the casing, and means so interlocking said thrust elements as to effect a camming action between the elements when the said rotatable element is rotated to effect relative longitudinal movement of the two elements.

11. In a mechanism for drawing tubes or the like, a ball die, a die pass comprising a circular series of balls, a stationary ball holder having ball-receiving recesses, a ball raceway including a ring having an inner tapered bore encircling and engaging the balls, a work head for supporting a work piece in the pass, means for relatively rotating the work in the pass, means for relatively longitudinally moving the work in the pass, and means for effecting relative longitudinal movement of the ring and balls, the ring being supported upon bearings to be freely rotated by movement communicated by the balls from the work to the ring.

JAMES LLOYD CASSADY.