

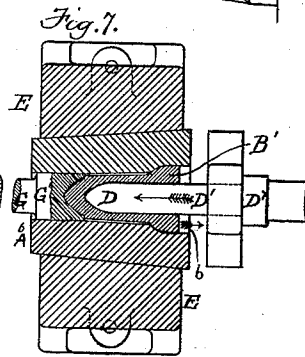
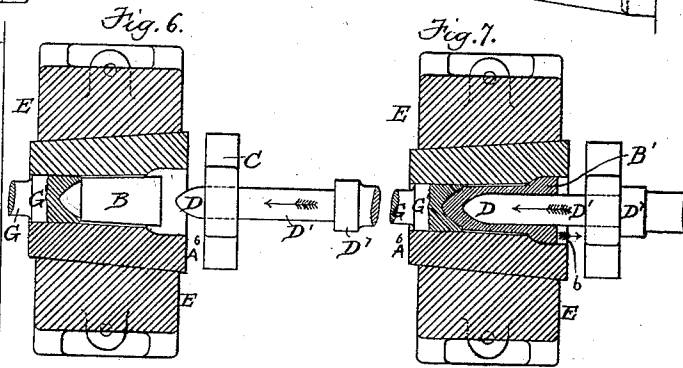
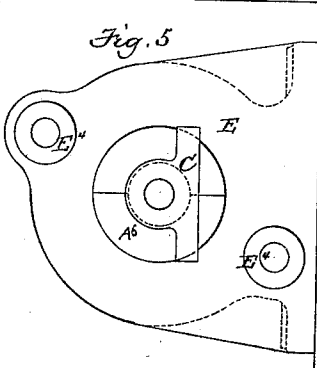
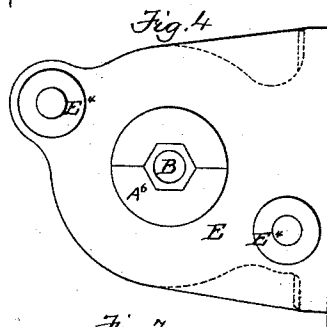
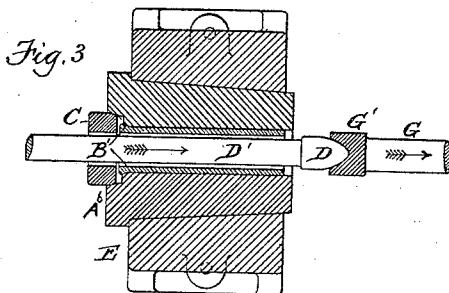
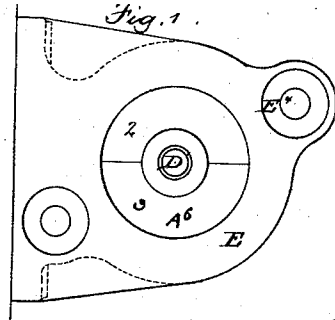
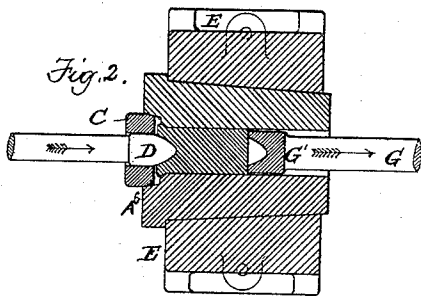
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4 Sheets—Sheet 1.

J. ROBERTSON.
MANUFACTURE OF TUBES.

No. 416,077.

Patented Nov. 26, 1889.



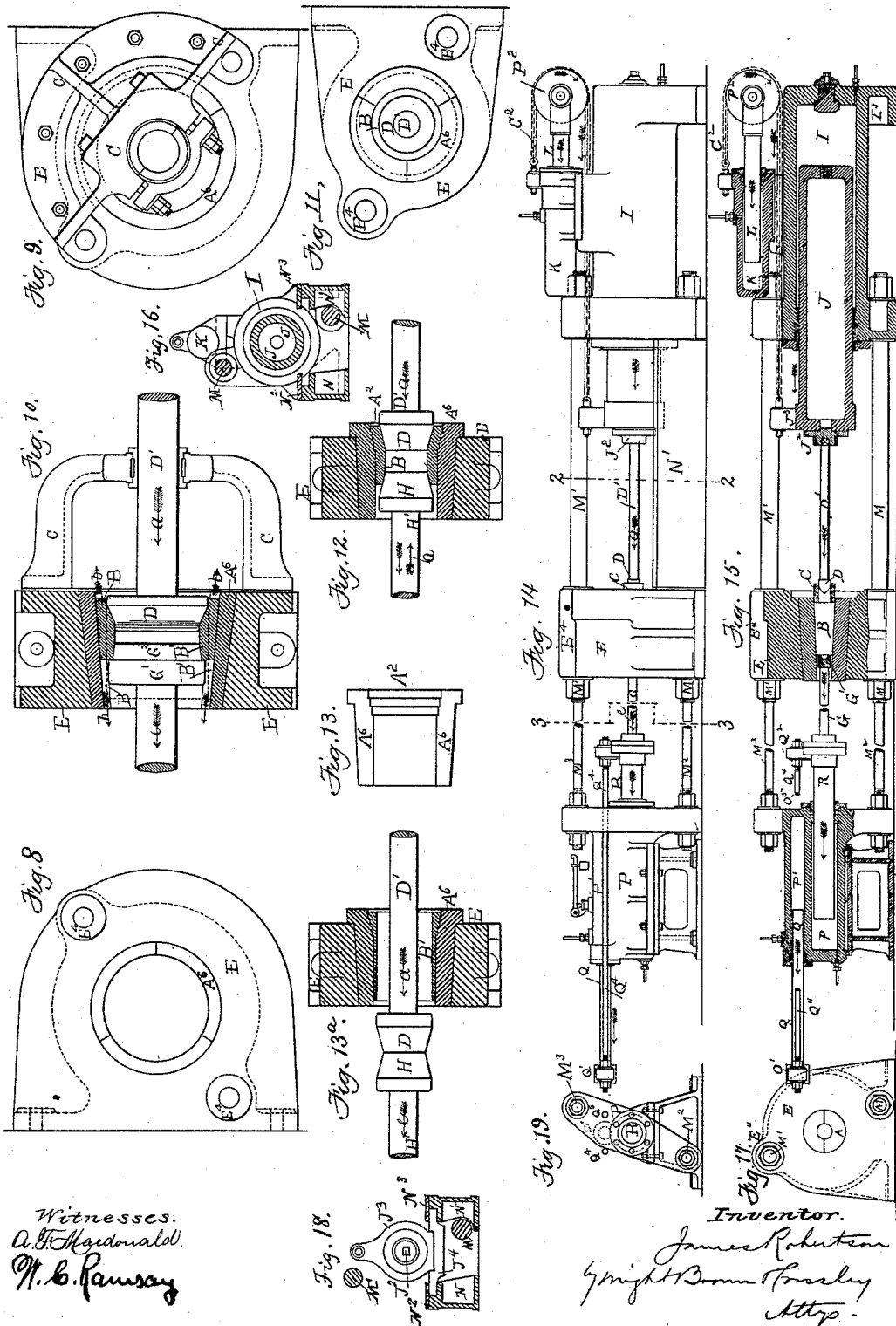
Witnesses.
O. F. McDonald.
W. B. Ramsay.

Inventor.
James Robertson
G. Wright Brown & Co.
Atty's

J. ROBERTSON.
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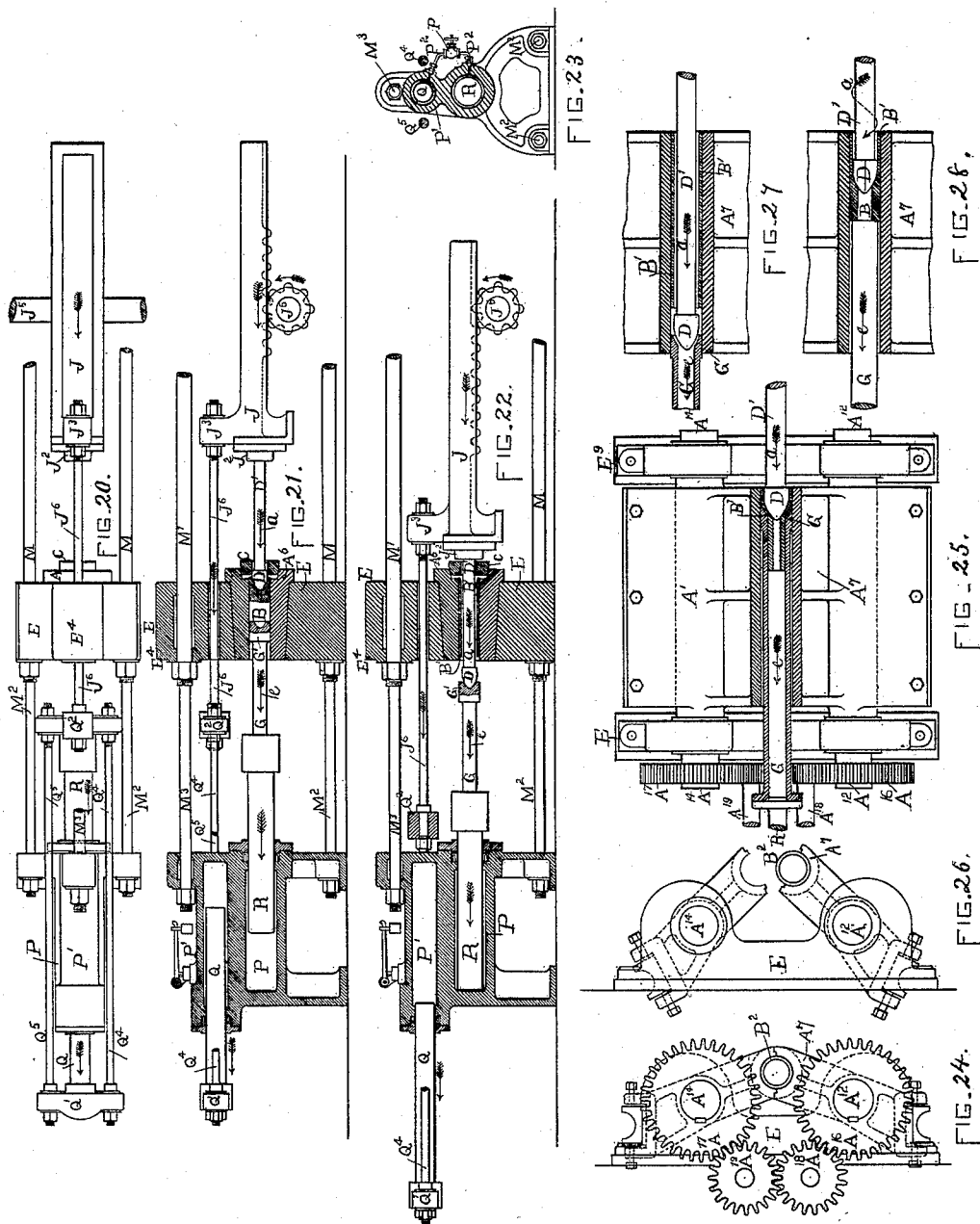
(No Model.)

4 Sheets—Sheet 3.

J. ROBERTSON.
MANUFACTURE OF TUBES.

No. 416,077.

Patented Nov. 26, 1889.



Witnesses.
A. K. Macdonald.
W. E. Ramsay.

Inventor.
James Robertson
by Wright & Brown, Counsel
Atty.

(No Model.)

4 Sheets—Sheet 4.

J. ROBERTSON.
MANUFACTURE OF TUBES.

No. 416,077.

Patented Nov. 26, 1889.

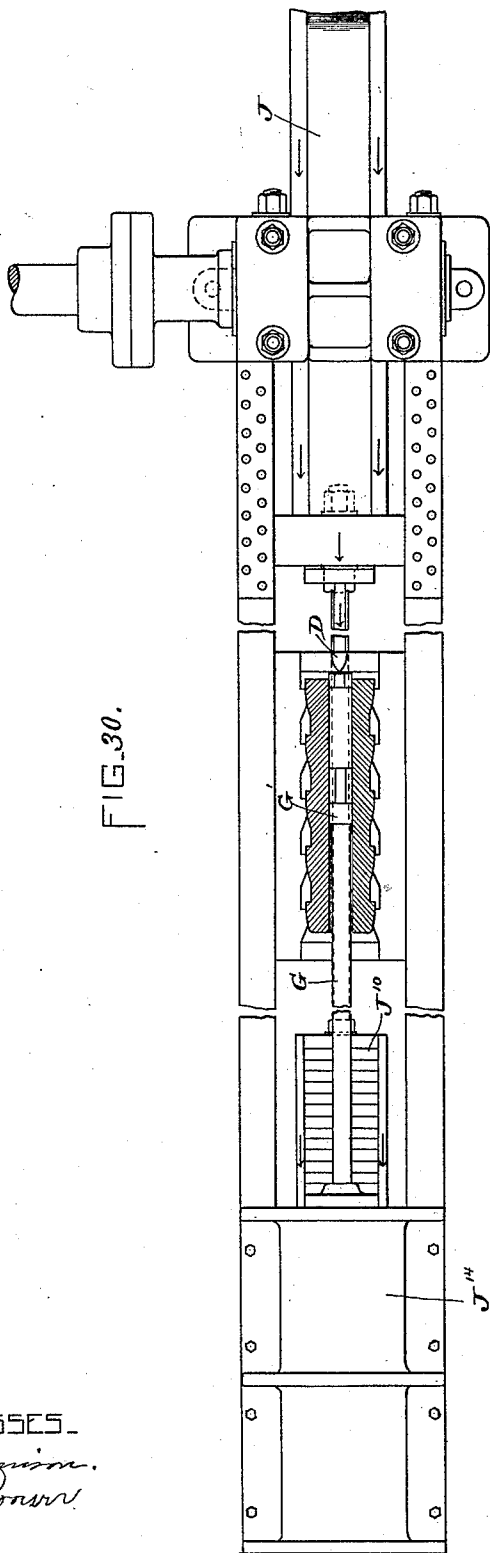


FIG. 30.

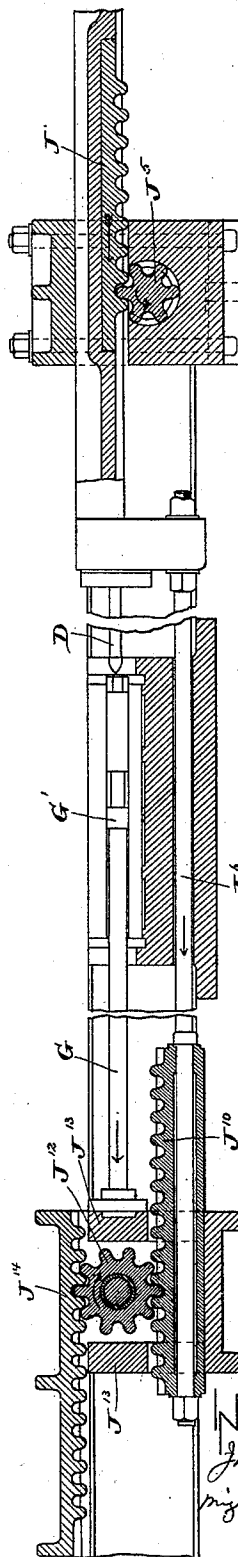


FIG. 29.

WITNESSES.
A. J. Harrison.
L. G. Brown.

INVENTOR.
James Robertson
by
Hight, Brown &
Conley
Atty's.

UNITED STATES PATENT OFFICE.

JAMES ROBERTSON; OF BIRMINGHAM, COUNTY OF WARWICK, ENGLAND.

MANUFACTURE OF TUBES.

SPECIFICATION forming part of Letters Patent No. 416,077, dated November 26, 1889.

Application filed February 26, 1889. Serial No. 301,286. (No model.) Patented in England April 4, 1888, No. 5,018.

To all whom it may concern:

Be it known that I, JAMES ROBERTSON, of Birmingham, in the county of Warwick, England, have invented a certain new and useful Improved Method of and Means for Making Seamless Tubes, Tube-Blanks, and Like Seamless Tubular Articles, (for which I have obtained a patent in Great Britain and Ireland, No. 5,018, dated April 4, 1888,) of which the following is a specification.

My invention relates, mainly, to the manufacture of seamless metal tube-blanks and tubes and like seamless metal tubular hollow articles—such as boiler-flues, pipe-coupling rings or sockets, broad rims of pulleys or rolls, and parallel and tapering articles, such as for shot and shell; and it consists in certain improved means for manufacturing the same. It is no part of my invention to use any of these new and improved means or apparatus for making tubes out of what is usually designated "soft metals"—such as lead and tin—that have the distinguishing feature from other metals of not hardening by compression or by being hammered in a cold state.

My invention consists, mainly, in the combination, in an apparatus for making and drawing out tube-blanks, tubes, tubular articles, and hollow articles or shells, of a die having a forming bore or seat, a fixed holder for said die, a mandrel formed to enter said die and act upon a billet or on a tube-blank therein, a motor connected with the stem of the mandrel, whereby the latter is impelled forward in the die, a head or support formed to support the inner end of the billet or blank while it is being acted on by the mandrel, and means for giving said head or support a movement which is synchronous with but slower than that of the mandrel, the mandrel and head moving in the same direction, so that the mandrel recedes as the head advances, the receding movement of the head being regulated according to the nature of the material being treated, so that the holding-up pressure of said head allows the inner end of the billet to recede before the mandrel at about the speed of the displacement of the metal by the mandrel, and at the same time prevents bodily endwise movement or displacement of the entire billet or blank, including that portion which may have been

formed or laid up to the walls of the die, so that the tube cannot slip endwise while it is being formed. The said synchronous and relatively-slow receding movement of the supporting-head may be produced by various means, several of which are hereinafter described.

The invention also consists in certain improvements in the construction of the die in which the billets or blanks are formed, and, finally, in the improved method of making tubes from billets of metal and drawing out tube-blanks, tubular articles, &c., by placing the metal billet or tube-blank in a long die, causing the mandrel to move forward through the billet or tube-blank, and at the same time holding up the billet or tube-blank by a supporting-head which recedes synchronously with the advancing movement of the mandrel, but at a slower rate.

Throughout my explanation I designate a solid piece of metal, or one with a small central hole in it, to be operated upon, as also a thick cast or hammered ring of metal to be operated upon, a "billet;" a piece of metal partially formed into a tube and open at both ends a "tube-blank;" a finished hollow article of a length double that of its diameter or longer and open at both ends I designate a "tube;" a hollow article open at both ends and of a length more than once and less than twice its diameter I designate a "tubular article," and a hollow article with a closed end a "shell."

Referring to the accompanying drawings, forming a part of this specification, Figure 1 is a front end elevation of a die which I use in carrying out my invention. Fig. 2 represents a sectional view of the same, showing the position of the parts at the commencement of the tube-forming operation. Fig. 3 represents a section similar to Fig. 2, showing the parts at the end of the operation. Fig. 4 is a rear elevation of a die having a hexagonal form internally. Fig. 5 is a front elevation, and Figs. 6 and 7 sectional plans, of a modification of the die. Fig. 8 is a front elevation, Fig. 9 is a rear elevation, and Fig. 10 a sectional plan, of a die made in three sections. Fig. 11 is a front elevation, and Fig. 12 a sectional plan, of another die made in three sections. Fig. 13 is a side view of one section of

a die of slightly-different form. Fig. 13^a represents a sectional view of the die shown in Fig. 13 placed in its container. Fig. 14 is a side external elevation, and Fig. 15 also a side elevation, partly in section, of the operating hydraulic cylinders and rams. Fig. 16 is an end elevation of the hydraulic cylinders, parts being in section. Fig. 17 is an after end elevation of the die-container. Fig. 18 is an end elevation of the ram cross-head, taken on the line 2 2, Fig. 14. Fig. 19 is a view on the line 3 3, Fig. 14. Fig. 20 represents a top view of a modified form of the machine shown in Figs. 14 and 15. Figs. 21 and 22 are longitudinal sectional views thereof. Fig. 23 is a transverse sectional view of this machine. Fig. 24 is an end elevation of the die-containing frame and housing with its gearing. Fig. 26 is a similar view with the latter removed, and showing the parts open. Fig. 25 is a sectional plan view of a die made in independently hinged or pivoted sections. Figs. 27 and 28 are detail views thereof. Fig. 29 is a sectional elevation, and Fig. 30 a plan view, of an arrangement of mechanism for actuating the mandrel.

It is a part of my invention to employ two operating-mandrels, stem-rods, or operating-bars, to be actuated mechanically or by pistons at each end of the dies. In carrying out this arrangement by hydraulic means I connect both hydraulic cylinders by stays to the die-container, and use the second ram or stem-rod from it, with a suitable head, to abut against the smaller end of the billet, which stem-rod may be variously formed, and under one form made internally conical or cup-shaped to abut against and conically shape the end of the billet against the action of the mandrel for shaping up the closed ends of tubular articles—such as shot and shell—for holding up the end of the billet partly against the tube-mandrel to prevent the metal at the center breaking off as the mandrel comes through it, and for exerting and regulating a degree of pressure on the after end of the billet to help solidify the metal and protect it against being overstrained tensely, particularly in parallel long-tube dies. The said second ram or stem-rod may also be used as a return motion for pushing back the ram of the main cylinder and obviating the use of a return-motion cylinder and ram.

Fig. 1 is a front end elevation on its side, and Fig. 2 a sectional plan, of a long die A⁶, also formed in halves 2 and 3, in which I show applied my new and improved means of forming parallel tube-blanks B' out of solid billets of steel, or out of billets formed with an initiatory small guiding-hole in them, also suited for forming tube-blanks out of steel heated to a soft state. If the billets are used with a small hole in them, this may be filled with asbestos, graphite, or other heat-resisting and lubricating materials to lubricate the mandrels and tend to keep the same in a central position.

Referring to Figs. 1 and 2, G represents an after abutting and holding-up stem-rod for supporting the after end of the billet B or of a tube-blank or shell when operated upon. This rod is preferably operated by an after hydraulic ram, and has, by preference, a conical hollow or cup-shaped stem-rod G' formed in it or socketed onto it, and forming, as shown, an easy-working fit on its external diameter for the internal bore of the die A⁶. On the stem-rod head G', I exert such a lesser degree of force than is exerted by the mandrel D on the billet B, so as to allow said stem-rod head to recede as it is stretched out by the passage of the mandrel D through it, so that by this partial receding and holding-up action of the stem-rod head G', combined with the frictional hold of the metal of the billet B on the inner surface of the die A⁶, and by the die being made slightly conical at its forward end, as shown, the metal of the billet B is prevented from being moved backward in the die bodily by the force of the mandrel. The abutting, resisting, or holding-up action of the stem-rod G and its head G' is regulated to such a degree as to prevent the metal from being squirted out at the front end of the die, and at the same time to allow the billet to stretch out into the tube-blank or tube B' by a receding action on the stem-rod head G' under such a degree of resisting pressure as to cause the mandrel to pierce it, but not to break the walls of the tube-blank crosswise, and thus allow the passage of the mandrel to properly stretch out the billet B to its after end into a tube-blank B', as shown in Fig. 3. For this action I prefer to use a hydraulic cylinder to operate this billet-holding-up stem-rod head G', and by loading a safety escape-water valve or other water-escape equivalent connected to the water-cylinder I provide a handy means of regulating the degree of resisting pressure on the holding-up stem-rod G and its head G', which degree of pressure will vary to a considerable extent, according to the kind, quality, or condition of the metal being operated upon. The resisting pressure exercised on the stem-rod head G' must always be less than that exercised on the mandrel D, and may be regulated automatically. If, for example, a mandrel in piercing a heated soft steel billet from the solid by this modification of die exerts a force of twenty tons to the square inch of surface on its cross-area, as hereinbefore referred to, a resisting pressure of about one-half of this pressure, or ten tons to the square inch of the cross-area of the die, has to be exercised on the after abutting receding stem-rod head G' to allow it to recede and at the same time to effect the piercing of the billet B.

Although the mode of operation necessarily varies under different working conditions, I prefer generally the following mode: The holding-up stem-rod and its piston-shaped stem-rod head G' are brought forward to the position shown in the die A⁶ in Fig.

2 by the operating hydraulic cylinder, the head G' thus holding the front end of the billet B about flush with the mouth of the die A⁶. The escape-valve of the said cylinder should be of a large area to allow the contained water in the hydraulic cylinder to escape quickly and exert a pressure on the end of the billet of metal of, say, ten tons to the square inch. The entering-guide C for the mandrel being in its position, the mandrel D is then pushed into the metal of the billet and pushes out the after stem-rod G in part of its course forward by the intervening mass of metal of the billet B. Then after all the metal is formed into the tube-blank B' and pressed up to the walls of the die A⁶ the mandrel enters the cup-shaped stem-rod head G' and pushes the latter out of the die. The altered position of the mandrel D and after stem-rod head G', as also the in part altered position of the mass of material now shown in this way formed into a tube-blank B', are shown in Fig. 3, the motions of the mandrel D, after mass of the tube-blank, and of the after stem-rod G being as indicated by the arrows on said figure.

The regulation of the receding motion of the after or holding-up stem-rod G by the outflow of water from an operating hydraulic cylinder, either by a safety-valve loaded to a certain degree of resistance, as described, or by regulating the outflow of the water by widening or narrowing the outflow of the water from its operating hydraulic cylinder, (the arrangement of which is to be hereinafter shown,) may be regarded as a resisting frictional means of so regulating the receding action of the rod G, and which can be effected by the frictional hold of hard bodies, either by clamping the rod G itself by a brake in rectilinear brake form, or by the intervention of cog-wheel or other gear by a brake-wheel and brake, which can be carried out in many ways. The backward motion of the rod G before the after end of the billet can also be regulated in the exact degree required relatively to the inward motion of the mandrel by cog-wheel or other positive gear to suit the proportions of the billet being operated upon and the cross-area of the mandrel used. Thus in a billet of double the cross-sectional area of the mandrel D the rod G requires to be moved backward before the end of the billet at half the speed of the inward motion of the mandrel D, and this also can be effected in many ways, one of which ways is shown in Figs. 20 to 23, and another in Figs. 29 and 30, all hereinafter referred to. Instead of the internal acting surface of the tube-die A⁶ being of a round form, it may be of a hexagonal or any other form that can be readily given to either the die or mandrel.

Fig. 4 is a rear end elevation of a die A⁶, internally of a hexagonal form, with a billet B in it, shown as pierced with a round hole, the die being in halves and suited to fit the

container E to facilitate ready interchange of the same.

Fig. 5 is a front elevation, and Fig. 6 a sectional plan, of a modification of a form of my taper die A⁶ in halves, in which I show an after abutting stem-rod G and its head G' for holding up the metal billet B to the operation of the mandrel D, as described in connection with Figs. 1, 2, 3, and 4. It is also part of my invention to use this rod G and its head G' for making tubes and tubular articles in conjunction with my improved taper dies. In this example I show it used for a purpose other than making ordinary tube-blanks or tubes—namely, tubular close-ended articles or shells—which application of this abutting or billet-holding-up ram is also part of my invention. The close-ended tubular article it is here shown as applied to is a steel blank for forming a shell-blank or military shell. I am aware that without this after abutting and shaping adjustable stem-rod and stem-rod head G' (in part) similar dies of a parallel form, and also dies with a tapering or rounded mouth end at which the mandrel enters, have been used for making articles with one closed end and military-shell blanks and shells out of plates and flat round blanks with closed ends variously shaped, and for making military hollow shot also out of solid billets of hot soft metal by successive punching operations; but this part of my invention is designed to effect and form shell-blanks or military shells and like close-ended articles out to its full internal diameter required from solid billets out of hot metal at one operation, which is a great advantage. The taper die A⁶, Figs. 5 and 6, placed in a container E, has a taper billet B of metal inserted into it, which is to be understood as a hot billet of steel to be shaped into a military-shell blank. The mandrel D is formed in one piece with its stem-rod D', requiring for this to be formed on its acting point-piece slightly tapered, as shown, and hardened. The mandrel-guide C is separated from the front of the die A⁶ a short distance to allow the billet B to be inserted freely. The after stem-rod G and head G' are not allowed to recede in this example. Their use is to provide a bottom holding-up contrivance for the hollow conical rod-head, to forge or shape the point of the shell-blank B' into a suitable conical form, and to push the shell out of the die quickly after it is formed. The mandrel stem-rod is shown provided with a stop-collar D', which arrests the progress of the mandrel inward at the proper distance by coming up against the guide-bush C. The motions of the mandrels and of the flow of the metal on the front end of the shell are as indicated by the arrows placed on the same, the position and shape of the shell-blank B' being, when the shaping action to the shell is accomplished, as shown in Fig. 7. The rod G and its head G' serve also for setting out the length the shell B'

is required in the die A^6 to be formed, and is applied also for pushing back the mandrel D. In case, also, of operating on like hollow articles with enlarged after ends, the after stem-rod and its shaping-head G' are used for pressing and shaping purposes, and it is part of my invention to use these rods to operate mandrels also for shaping tubular articles.

There are practicable limits to the diameter of tubes, shells, tube-blanks, and other tubular articles producible in this way at one operation, as hereinbefore referred to, which may be generally from about one inch to eighteen inches in diameter, and such articles as boiler-flues or boiler-flue shells of, say, about three feet external diameter should be produced from annular billets or rings of, say, for this size of boiler-flue, about eighteen inches long, three feet diameter, and four inches thick, the size of a mass to produce, say, a boiler-flue of about seven feet long and half an inch thick. The die for this purpose may be also of a conical internal form and of the same general form as just described, but is used with two operating hydraulic rams, the mandrel to be provided with a parallel or tapering tongue-point somewhat shorter than the length of the blank-ring to be operated upon and of about the diameter of or somewhat smaller than the internal diameter of the blank or billet ring into which this round cylindrical tongue-point is made to enter and fill up the space inside the billet-ring before the conical and operating part of the mandrel reaches the billet, this tongue-point of the mandrel being made into a fitting annular supporting or abutting holding-up head fitted onto the stem-rod of the after hydraulic cylinder, thus securing the mass of the ring against being pressed inward by the mandrel, while the stem-rod head used to assist the binding action of the inwardly-tapering surface of the die can be so regulated by water-pressure valves to give way and recede before the mandrel while the annular billet is being forced out into a flue-tube blank or tube. The after stem-rod may be also modified to enter the ring-billet to prevent it from being pressed inward.

Fig. 8 is a front end elevation, Fig. 9 an after end elevation, and Fig. 10 a sectional plan, of a large-size taper die in three sections, A^6 , Fig. 10 showing, also, the container E, partly in section; also the billet B and mandrel D in section, and also a mode of fixing the mandrel-stem-rod guide C to the container E to guide the mandrel in centrally to the metal billets B of large diameters. This modification is suited for cast or otherwise formed ring-billets of steel or other metal suited for making tube-blanks for forming large diameters of tubes, which by this means is also a part of my invention adapted in this example for a cast billet-ring of steel B to be operated upon in a hot state, which is shown placed in the taper die A^6 , which is in this

example shown in three sections, with the mandrel D shown in its position ready to be forced through the billet and with its stem-rod D' and guide C, showing, as heretofore referred to, how these are secured to the die-container E for large sizes, and some exceptional forms of dies for tubular articles of some forms. A rod-head G' is also shown with an after stem-rod having a tapered point G^2 formed on it to keep the ring-formed billet B from being crushed inward by the action of the mandrel D. The billet B indicates the size and form of this heated cast-steel billet-ring as it is entered into the die A^6 , and the dotted lines B' indicate its increased length and diminished thickness after the mandrel is forced through it, which thereafter takes its tube-blank form B' . The motions when the tube-blank is being formed are all as indicated by the arrows placed on the mandrel-stem rod D' and on the after stem-rod G' and on the tube-blank B' . In these large sizes the fore part of the billet flows outward, and the after end of the same, to some extent, flows inward, as indicated by the arrows. In the preparation of these large-diameter tube-blanks an important use of this process is to get the tube-blank round and to the right size internally for the after drawing-out process, and also to get the metal solidified at same time, for which purpose alone the steel ring-billets B in a cast state would otherwise require to be hammered. In another and somewhat modified form of this arrangement for making tube-blanks or tubes the die A^6 may be beveled in from both ends, and the holding-up annular after stem-rod head formed into a conical or bulbous mandrel at its working-surface, the same as the main mandrel, and the soft metal of the billet B in this way made to flow or squirt out at both ends of the die, and the tube removed from the die by taking out the die from its seat in the container E, the die being formed in three parts, and when opened out allows the tube-blank B' thus formed to be removed from it. This arrangement has the advantage of making the tube about alike in thickness and diameter at both ends, and although left somewhat thicker in the center, this is more easily dealt with by ordinary after-finishing processes than when the thickest portion is at one end of the blank.

Fig. 11 is a front elevation, and Fig. 12 a sectional plan, of a somewhat similar large die A^6 to that just described, also shown in three sections. A parallel ring-billet B is shown in Fig. 12 ready to be drawn out into a tube-blank or tube; but in this example there are two mandrels D and H. The mandrel D is shown entering the front end of the die, and the mandrel H is entering the rear end of the die, the two mandrels being of substantially the same form and diameter. The internal surface of the die is shown of a slightly-tapering form, largest at the front end, and has formed in it the step-grooves A^2 ,

to fix the fore end of the mass of the shell B' from flowing out in either direction. The two mandrels are pushed into the ring-billet B simultaneously to thin down its ends, the mandrel H effecting the purpose of an abutting stem-rod head G', at the same time acting in the billet B as a mandrel, as well as to hold up the billet against the action of the front mandrel D, and when the points of the two mandrels D and H meet, as shown, the pressure of the after hydraulic ram operating the mandrel H is released, and the front mandrel D thereafter is caused by its forward movement to push the after mandrel H back and draws out the ring-billet into a tube-blank B', as indicated in Fig. 13^a, with the main part of its length, as shown, nearly parallel, the motions of both the mandrels D and H until they meet, as described, being indicated by arrows *a*, placed on their stem-rods D' and H', the after motion of the mandrel H and its stem-rod H' being indicated by the arrows *e*. Fig. 13 shows a section of one half of the die A⁶ detached.

Fig. 14 is a side external elevation, and Fig. 15 also a side elevation, partly in section, of my new and improved combination of hydraulic cylinders and rams for operating these new and improved long-tube dies, hereinbefore referred to, which arrangement of hydraulic cylinders and rams and combination with a forward and after ram J and R are part of my said invention. The form of the internal die A and its mandrel D and stem-rod D' is tapering, the die being placed in a container E; but either of the dies above described may be used as a part of the organized machine shown in Figs. 14 and 15. There is nothing new or peculiar in the hydraulic cylinders of themselves, and they require no detailed description. The main hydraulic cylinder I is shown with its ram J connected to the mandrel-holder J², into which the mandrel stem-rod D' is inserted, and which, with its bulb mandrel end D, is shown ready to form a tube-blank. This main cylinder I has fixed on its top side the small hydraulic cylinder K, fitted with a ram L, shown with a suitable arrangement of gear for pulling back the main hydraulic ram J—viz., a chain C², connecting the cylinder K and ram J and passing over a pulley D², carried by the ram L. The end elevation, Fig. 16, of these cylinders further illustrates their arrangement, as also of the stays M M', which are shown binding the main-cylinder ram and the die-container E together.

Fig. 17 is an after end elevation of the die-container E, showing the positions of its main stays M and M' and the snugs E⁴ for the same.

Fig. 18 is an end elevation of the ram cross-head J³, showing the cylinder and container-stays M and M' and slide-bars N and N' of the cross-head in section, with its covers N² and N³ through the line 2 2 in Fig. 14, show-

ing, also, the saddle slide-piece of the ram cross-head J⁴ placed in the slide-bars N and N'. An after hydraulic cylinder P is shown connected to the die-container E and main hydraulic cylinder I by the main stays M² and M³, which are continuations of the main stays M and M', so that this after hydraulic cylinder P P' is bound in one machine along with main hydraulic cylinder I and the die-container E. The after hydraulic cylinder P has cast with it a small pulling-back hydraulic cylinder P', which is fitted with a direct pulling-back ram Q, the cross-head Q' of which is shown connected with side pulling-back stays Q² in an ordinary way to the cross-head of the main after ram cross-head R', the whole constituting a new and improved arrangement of hydraulic machines capable of performing the operations above described in connection with Figs. 1 to 13^a.

The position of the rod G and head G' (or mandrel stem-rod H', as the case may be, when used in this machine) is shown by Fig. 15. Instead of regulating the backward or receding motion of the stem-rod G by frictional retarding means—such as a retarding-brake—or by throttling the escape of water from a hydraulic cylinder, as described mainly in connection with Figs. 1, 2, 3, and 4, and Figs. 14 to 19 of my drawings, said motion can with great advantage be regulated in its backward movement automatically by devices connecting said rod to the mandrel D or its motor, and it is part of my invention to operate the stem-rod G in this way. The motion backward of the stem-rod G is generally slower than the inward motion of the mandrel and should have the same relation to the motion of the mandrel that the cross-area of the mandrel bears to that of the die. For example, if the cross-area of the mandrel is one-half of the cross-area of the die, which is the best proportion for making a tube-blank or tube which is double the length of the billet B, the stem-rod should recede or move backward one-half as far as the mandrel moves forward. It will be seen, therefore, that a saving of power is effected by so coupling the stem-rod G to the operating-mandrel D. In carrying out this movement a new and improved and still more important advantage is obtained by this means of making the motion backward of the rod G slightly greater than the exact degree required for the proportion of the cross-area of the tube-blank B' to the mandrel, as thereby, after the fore part of the tube-blank gets fixed on the walls of the die, as it immediately does (more or less) after the mandrel enters it, a degree of drawing action to the tube-blank B' being formed is thereby imparted to it, which tends to relieve the mandrel from being so hard packed in the metal of the tube-blank at its greatest diameter as it otherwise would be if only the exact proportion of traverse were communicated to the stem-rod G, or was so operated

backward by resisting friction or pressure on it. In this way a saving of wear on the mandrel is effected, and at the part where it ordinarily wears most, as also a saving of wear effected by this means on the internal surface of the die.

Fig. 20 is an external plan, and Fig. 21 a sectional side elevation, of an arrangement of gear suited to obtain this result in one way, and in this proportion of equal cross-area in the mandrel D shown used to that of the tube-blank B' shown made. I show in this example, in place of a hydraulic ram for operating the mandrel D, a strong cast-metal rack J, operated by a pinion J⁵, the die and its container E, mandrel D, billet B, and rod-head G' shown being the same as described with reference to Figs. 1 to 4. The after-operating hydraulic cylinders P and P' and their respective rams R and Q are of the same general form as described in connection with Figs. 14 to 19. In this example, however, the cross-area of the top hydraulic cylinder-ram Q, as referred to, is made slightly over one-half of that of the main after ram R, and the connecting arrangement of said ram with the motor (here shown as the rack J) is a rod J⁶, passed from said motor through an aperture formed in the die-container E, and connected by the cross-head Q² and the connecting-rods Q⁴ and Q⁵ to the ram cross-head Q'. The backward motion of the ram Q is therefore at the same speed as the forward motion of the mandrel D into the die. The water in the after cylinder P, as it is pressed out by the motion of its ram R, (which is moved backwardly by the advancing end of the billet,) is thus caused to flow out into the top hydraulic cylinder P' through the connecting-pipe P², (shown in Fig. 23,) and thus regulates back the speed of the stem-rod G at slightly over one-half of the distance in the same time traversed inward by the mandrel D. The position of the billet B relatively to the tube-blank B' after it is formed is as shown in Fig. 21, and the motions of the several parts all as indicated by arrows, as also the direction of the flow of the water from the lower to the upper after hydraulic cylinder P through the pipe P². By relatively proportioning the mandrel to the die and the operating speeds of the mandrel D and rod G any required degree of "draw" on any required proportion of tube-blank can readily be given to the tube-blank in this way. A safety-valve P³ is shown connected with the hydraulic cylinder P', which, by means of the pipe P², also serves as a safety-valve to the cylinder P.

All the hydraulic cylinders of this machine are designed to be operated by pumps, by preference, through the intervention of a hydraulic accumulator to produce quick movement to the mandrels and stem-rod heads G', the hydraulic cylinders, as shown, being suited for a pressure of two thousand pounds to the

square inch of area of the same. A converse mode of effecting the same purposes would be by holding the mandrel stationary and moving the die, with the billet contained in it, over the mandrel by very similar arrangements of hydraulic cylinders to those described. This converse mode of working by imparting rectilinear movement to the die by hydraulic cylinders or by rams or pistons actuated by steam or other elastic fluid, or so actuated mechanically, is not, however, so generally convenient, and is not shown in the drawings. Pistons in a single form, or by two or more successive tandem pistons on the same rod, actuated by steam, air, or other fluid, can be used in much the same way as this hydraulic arrangement of cylinders, hereinbefore shown and described, and by using steam in a way to require no accumulator other than a boiler. Any good mechanical means of transmitting rectilinear motion to either the mandrels or dies—such as by screws or by toothed pinion and rack—may have force stored by the momentum of a fly-wheel, and in this way is quite available for operating these new and improved dies in an effective manner, although not shown in the drawings.

In Fig. 29 I show a sectional elevation, and in Fig. 30 a plan view, of an arrangement of mechanism for actuating the mandrel D and the holding-up stem-rod G, in which the receding movement of the rod G is entirely positive, all hydraulic mechanism being dispensed with. The mandrel is connected with a rack J, which is operated by a pinion J⁵, as in Figs. 20, 21, and 22. A rod J⁶ connects the rack J not with a hydraulic ram, but with another rack J¹⁰, which meshes with a pinion J¹², mounted to rotate on a bearing in a frame J¹³, affixed to and moving with the rod G. Said pinion meshes with a fixed rack J¹⁴, attached to the supporting-frame of the machine. The movement imparted to the rack J¹⁰ by the forward motion of the rack J causes the rack J¹⁰ to rotate the pinion J¹², the latter being thus caused to travel along the fixed rack J¹⁴ and move the rod G with it in the same direction that the mandrel moves. The pinion J⁵ is so proportioned relatively to the pinion J¹² that the rod G is moved backwardly at half the speed of the forward movement of the mandrel. The mandrel D and the after holding-up head G', moving synchronously but at different speeds, as hereinbefore described, may also be used in making pipes of non-metallic plastic material, such as clay, paper-pulp, &c.

For converting thick tube-blanks into thin tubes of larger diameter, a new and improved arrangement of parallel long die suited for being used with mandrels having rectilinear motion only, as described mainly in connection with Figs. 14 to 19 of my drawings, and with Figs. 20 to 23, as also suited to be used in conjunction with revolving mandrels which may be operated by my modifications of fric-

tional driving skew-rolls for giving quick spiral motion to the mandrels for this purpose, or to be operated by my hydraulic revolving-mandrel machine, (to be hereinafter described,) consists, mainly, in revolving these long dies on axis as a quick means of closing them over the tube-blanks, and of the use of an inside die for converting tube-blanks of smaller external diameter into thin tubes of larger external diameter by means of a hollow stem-rod used as an internal die, as also of new and improved combinations with my holding-up and regulating after stem-rod, as hereinbefore described.

Fig. 24 is an end elevation, and Fig. 25 a sectional plan, of a new and improved long die A⁷ of this kind in two halves, which are adapted to close on the tube-blank B' by each half of the die being revolved or partially revolved together on their turned trunnions A¹² A¹³ on one half of the die A⁷ and on the trunnions A¹⁴ A¹⁵ on the other half, and these trunnions are shown placed in the two die-containing frames E and E', the internal form of the die when closed and form of the hollow stem-rod G and of the tube-blank B' being shown operated upon in sectional plan by Fig. 25, the out end of the tube-blank B' shown being operated upon before being inserted into the die being expanded out a short distance at its out end to the internal diameter of the main die 7 before closed into it, the out end of the tube-blank B' being thus roughly made out this shape to allow the mandrel D to enter into it, (shown with its stem-rod D' broken off.) The die containing frames or housings 9 have bush-bearings shown bored in them, an easy-working fit for these trunnions of the die and into which the trunnions A¹² of one of the halves of the die A⁷ are shown placed, and similarly shown placed in same container-frames the trunnions A¹⁴ of the other half of said die, which halves are shown in end elevation in a closed position in Fig. 24 and in an open position in Fig. 26, and their actuating parts for the widening out of a tube-blank or tube shown in section with the hollow after stem-rod G bored out to be used as an inside die and the tube-blank B' shown placed in it, its stem-rod head G' being shown turned in an internal conical form and the direction of its motion as indicated by the arrows placed upon it. The hollow stem-rod G is moved back automatically along with the inward motion of the mandrel D in an analogous way to that described in connection with Figs. 20 to 23, and at the same speed, thereby keeping always an equal distance between the internal conical surface of the rod-head G' and the forward surface of the mandrel D, so that the rod-head G' holds up in a regular way onto the passing part of the tube-blank B', between it and the mandrel D, and when the tube is thus expanded and finished the po-

sition of the mandrel D and of the after stem-rod G and its acting-head G', as also of the finished tube B², being as indicated in the plan section of the bored-out part of the halves of the die A⁷, (shown by Fig. 27,) and the motion of the mandrel and after hollow stem-rod, as indicated by the arrows. It is part of my invention to use this arrangement of die and after stem-rod along with a revolving mandrel. The halves of the die A⁷ are easily retained closed in a secure way by having the tube-blank seat in same brought round to nearly the dead-centers in each half between their trunnion-axis A¹² and A¹⁴, as shown by Fig. 26. The halves of the die are moved to and from said positions, and when closed are retained by the cog-wheels A¹⁶ and A¹⁷, keyed on the trunnions A¹² and A¹⁴ of the halves of the die, and geared together by the cog-wheels A¹⁸ and A¹⁹, and by this gear are held closed or opened out, as shown by Fig. 26, in which position the tube B² is removed and a fresh tube-blank B' inserted for a fresh operation. This new and improved long die A⁷, from its quick and effective closing action and free access when open for the insertion of asbestos or other lubricant into it for the tube-blank moving along the die, is very suitable, and without or with the after stem-rod G, as shown, for widening and drawing out hot steel tube-blanks with a revolving mandrel D from tube-blanks of about the same external diameter as that of the die, by using the main die only.

Fig. 28 is a sectional plan of the working portions of the halves of the die A⁷, as shown, with a cam-shaped revolving mandrel D entered into same, and with a plain after stem-rod G shown in it suited to be retarded by a frictional contact-breaking retarding action. With a heavy stem-rod G its inertia at starting on its backward motion and the resistance caused by its own weight resting on the lower surface of the die are sufficient means for regulating the action of the drawing-out hot steel tube-blanks into light tubes.

I do not claim in this application the invention shown in my British patent, No. 15,752 of 1884, nor in my pending application for Letters Patent of the United States, filed July 7, 1887, Serial No. 243,617, said United States application showing the invention for which the last-named British patent was granted.

I claim—

1. As an improvement in apparatus for making and drawing out tube-blanks, tubes, tubular articles, and hollow articles or shells, the combination of a die having a forming bore or seat, a mandrel formed to enter said die and elongate a billet or blank therein, means for forcing the mandrel into the die, and a movable head or support moving synchronously with the mandrel, but at a slower rate, and arranged to support the inner end of the billet or blank, whereby bodily move-

ment of the billet or blank by the die is prevented, as set forth.

2. As an improvement in apparatus for making and drawing out tube-blanks, tubes, tubular articles, and hollow articles or shells, the combination of a die having a forming bore or seat, a holder for said die, a mandrel formed to enter said die and act on a billet or blank therein, a motor connected with the stem of said mandrel, whereby the latter is impelled forward, a movable or yielding head or support formed to enter the die and bear against the inner end of a billet or blank, and means for resisting or retarding the receding motion of the said head or support, as set forth.

3. As an improvement in apparatus for making and drawing out tube-blanks, tubes, tubular articles, and hollow articles or shells, the combination of a die having a forming bore or seat, a holder for said die, a mandrel formed to enter said die, a motor for said mandrel, a movable or yielding head or support formed to bear on the inner end of a billet or blank therein, and a hydraulic cylinder containing a ram which is connected with said head and provided with an outlet for the escape of water, as set forth.

4. As an improvement in apparatus for making and drawing out tube-blanks, tubes, tubular articles, and hollow articles or shells, the combination of a die having a forming bore or seat, a holder for said die, a mandrel formed to enter said die, a motor for said mandrel, a movable or yielding head or support formed to bear on the inner end of a billet or blank therein, a hydraulic cylinder containing a ram which is connected with said head, a water-outlet for said cylinder, and means for regulating or adjusting the escape of water through said outlet, as set forth.

5. As an improvement in apparatus for making and drawing out tube-blanks, tubes, tubular articles, and hollow articles or shells, the combination of a die having a forming bore or seat, a holder for said die, a mandrel formed to enter said die and act on a billet or blank therein, a motor connected with the stem of said mandrel, whereby the latter is impelled forward, a movable head or support formed to enter the die and bear against the inner end of the billet or blank, and a connection between the said support and the mandrel, whereby the support is caused to recede synchronously with the advance of the mandrel, but at a slower rate, as set forth.

6. As an improvement in apparatus for making and drawing out tubes, tubular articles, tube-blanks, and hollow articles or shells, the combination of a die having a forming bore or seat, a holder for said die, a mandrel formed to enter said die, a motor for said mandrel, a movable or yielding head or support formed to bear on the inner end of a billet

or blank therein, a primary hydraulic cylinder containing a ram which is connected with said head, a secondary hydraulic cylinder connected with the primary cylinder to receive the water from the latter, a ram or plunger in the secondary cylinder, whereby the admission of water thereto is regulated, and a connection between said ram or plunger and the mandrel, whereby the ram is moved synchronously with the mandrel, as set forth.

7. As an improvement in apparatus for making and drawing out tube-blanks, tubes, tubular articles, and hollow articles or shells, the combination of a die having a forming bore or seat, a holder for said die, a mandrel formed to enter said die, a second hydraulic cylinder K, having a ram L, and a connection, substantially as described, between the rams J and L, whereby the ram J and the mandrel are retracted by the operation of the ram L, as set forth.

8. As an improvement in apparatus for making and drawing out tube-blanks, tubes, tubular articles, and hollow articles or shells, a die having a forming bore or seat and composed of separable longitudinal sections mounted on independent centers and capable of swinging on said centers to open and close the die, combined with a mandrel formed to enter the die, a motor for said mandrel, and a yielding support or head formed to enter the die and bear on the inner end of a billet or blank therein, as set forth.

9. As an improvement in apparatus for making and drawing out tube-blanks, tubes, tubular articles, and hollow articles or shells, a die having a forming bore or seat composed of separable longitudinal sections, each having trunnions, combined with fixed bearings or frames supporting said trunnions and permitting the said die-sections to oscillate, as set forth.

10. As an improvement in apparatus for making and drawing out tube-blanks, tubes, tubular articles, and hollow articles or shells, a die having a forming bore or seat composed of separable longitudinal sections, each having trunnions, combined with fixed bearings or frames supporting the trunnions and permitting the said die-sections to oscillate, gears affixed to said trunnions, and intermediate gears connecting said trunnion-gears, whereby the latter may be simultaneously rotated, as set forth.

11. The improved method hereinbefore described of making tubes from billets and of drawing out tube-blanks and tubular articles, &c., the same consisting in placing the billet in a long die, forcing a mandrel into or through the billet or tube-blank while in said die, and at the same time holding up the inner end of the billet or tube-blank by a support which recedes synchronously with the advancing mandrel, but at a slower rate,

whereby the unformed end or mass of the
billet or blank is allowed to recede before
the mandrel at about the speed of the dis-
placement of the material by the mandrel
5 and the drawn or formed portion of the tube
is laid up to the walls of the die without end-
wise-slipping motion thereon.

In testimony whereof I have signed my name

to this specification, in the presence of two sub-
scribing witnesses, this 28th day of January, 1889.

JAMES ROBERTSON.

Witnesses:

WILLIAM ROBERTSON,
WILLIAM LINDSAY.