(No Model.) 5 Sheets—Sheet 1.

J. ROBERTSON.

SHAPING METAL TUBES.

No. 481,060. Patented Aug. 16, 1892.

FIG. 2.

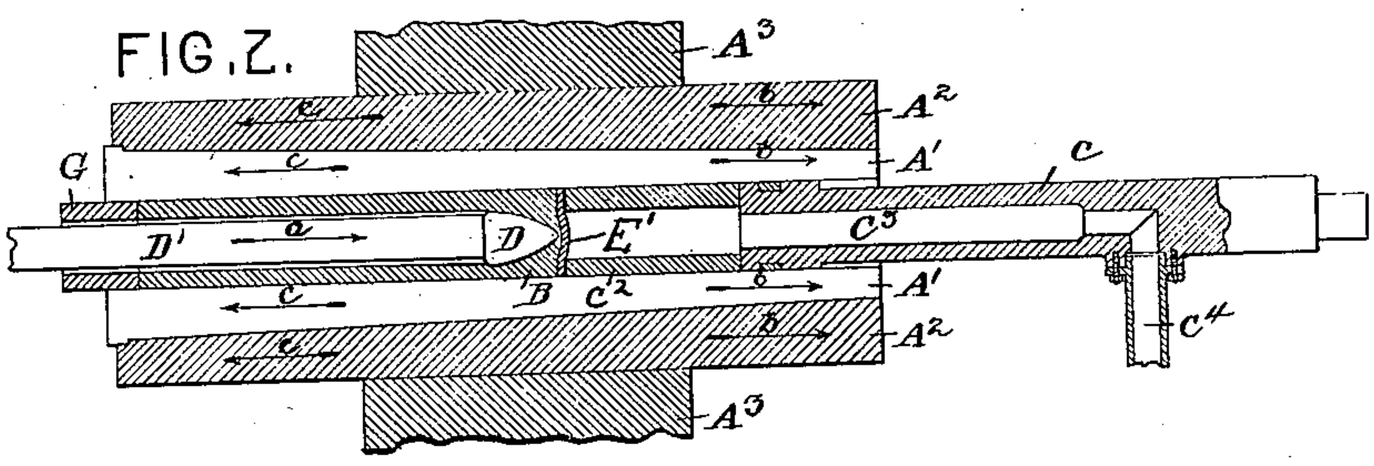


FIG. 1.

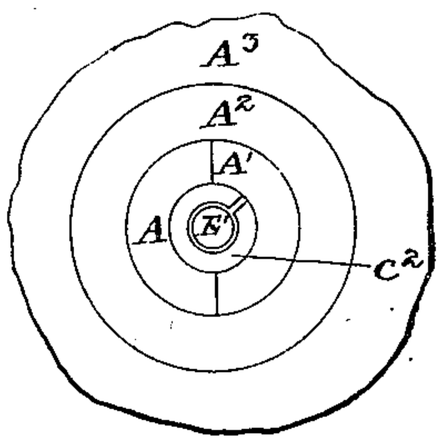


FIG. 3.

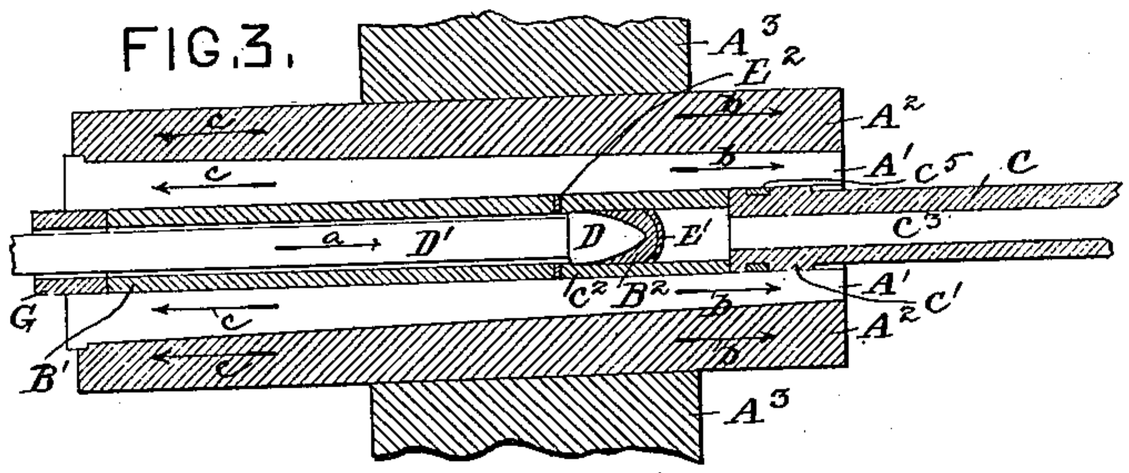


FIG. 5.

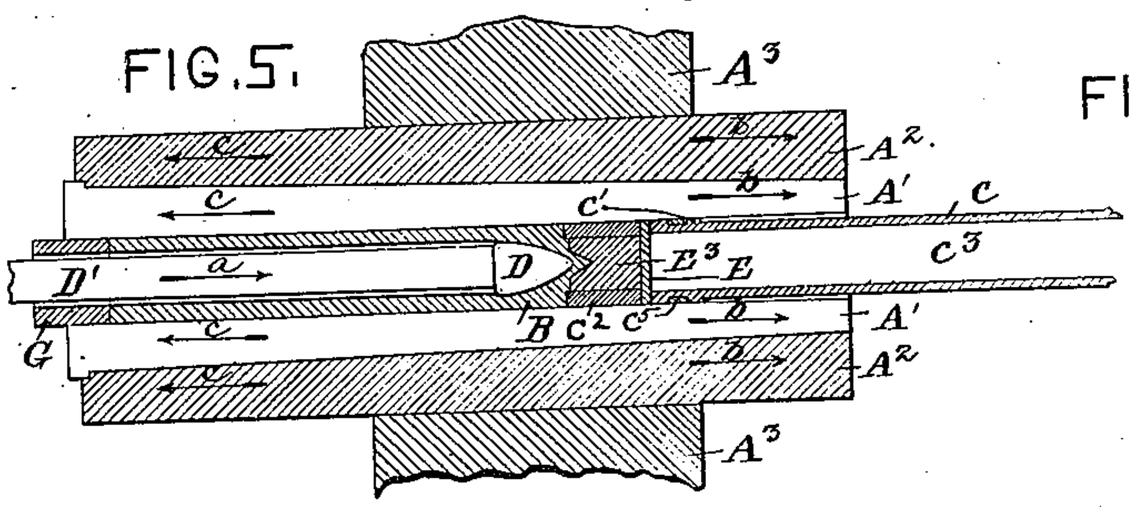


FIG. 4.

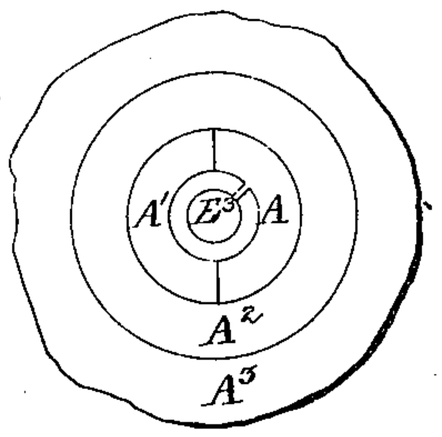


FIG. 7.

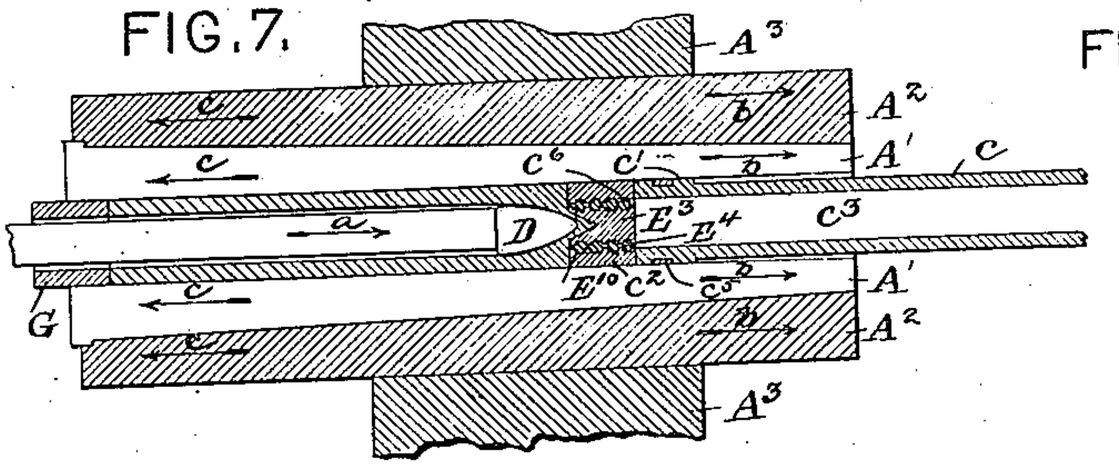


FIG. 6.

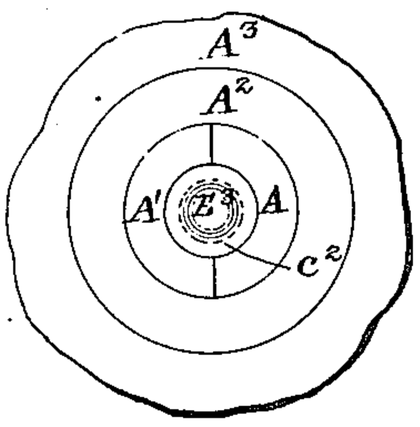


FIG. 9.

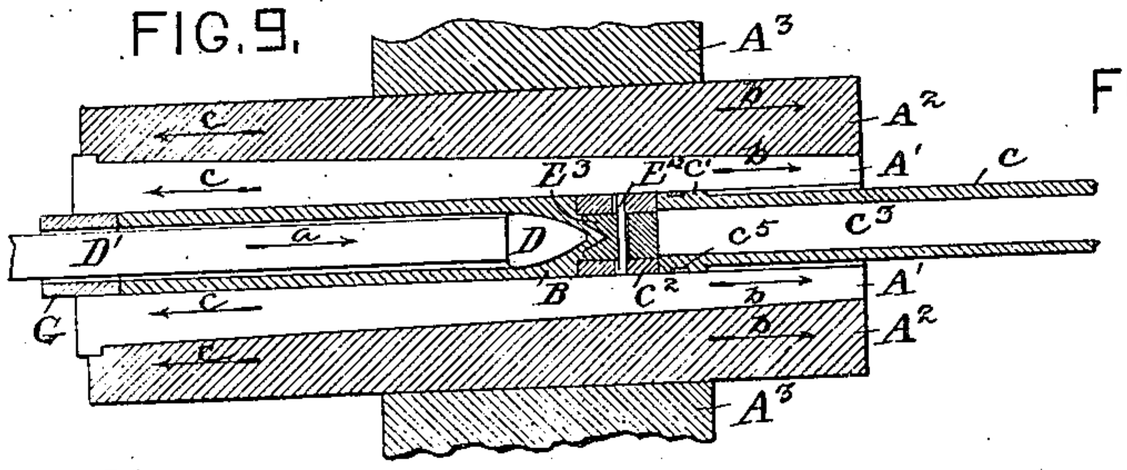
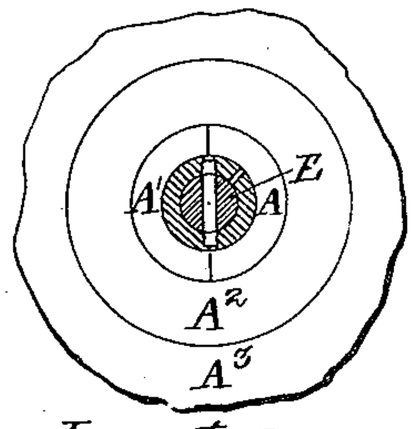


FIG. 8.



Witnesses;
A. D. Harriam
P. A. McSharé.

Inventor
James Robertson
By Wright Brown Quinby
Attorneys.

(No Model.)

5 Sheets—Sheet 2.

J. ROBERTSON.

SHAPING METAL TUBES.

No. 481,060. Patented Aug. 16, 1892.

FIG. 11.

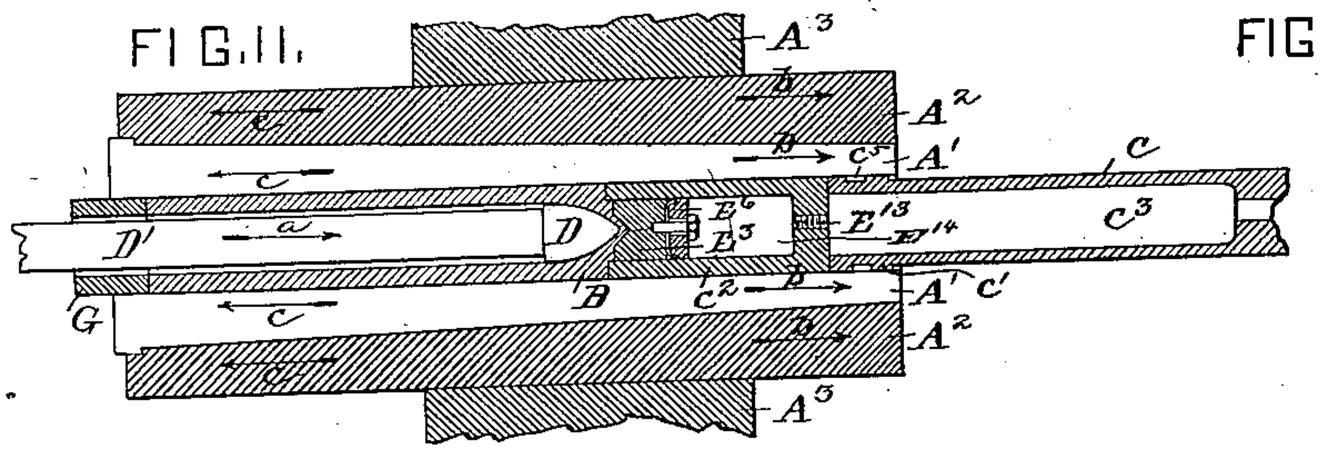


FIG. 10.

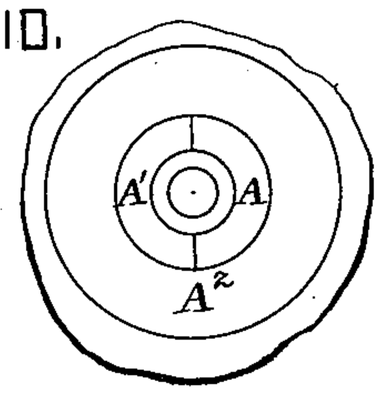
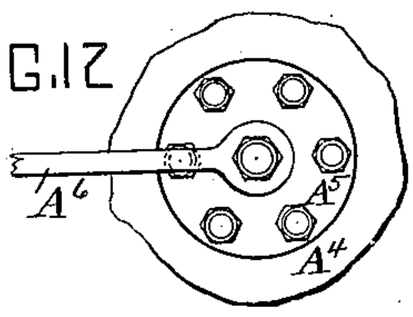


FIG. 12.



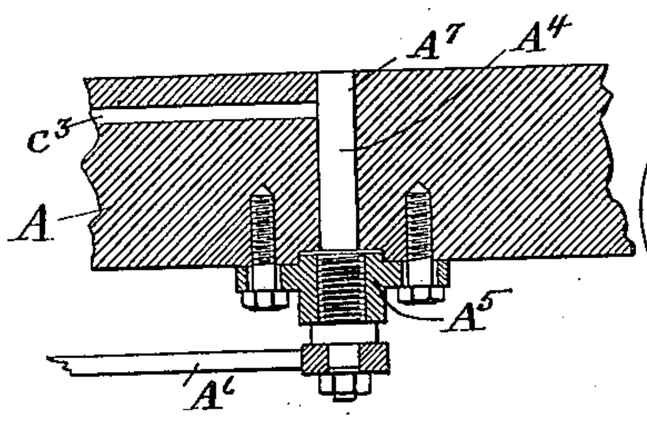


FIG. 13.

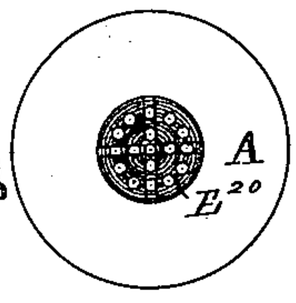
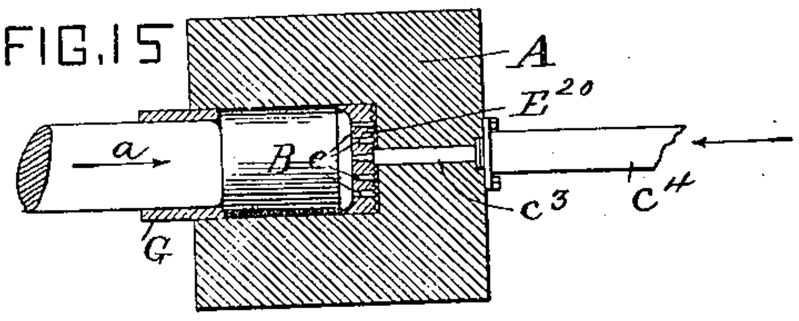


FIG. 14.

FIG. 15.



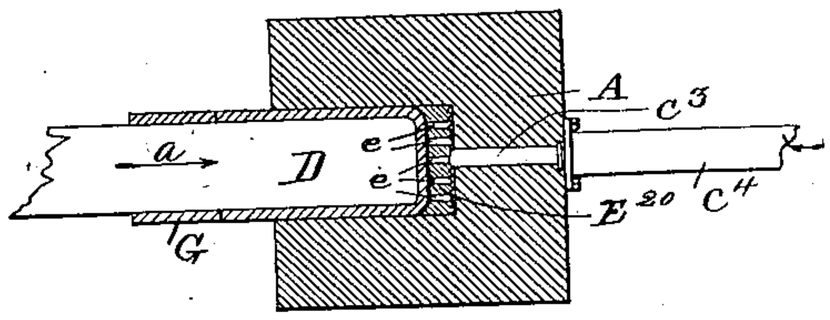
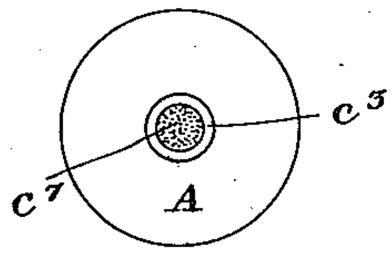


FIG. 16.

FIG. 17.



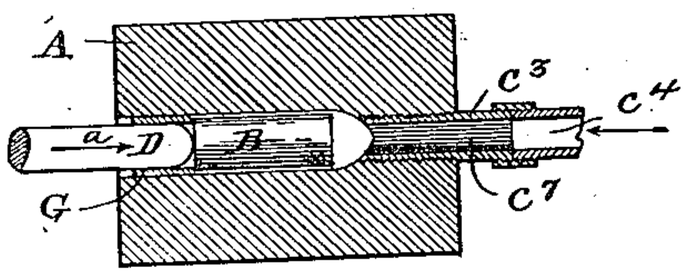


FIG. 18.

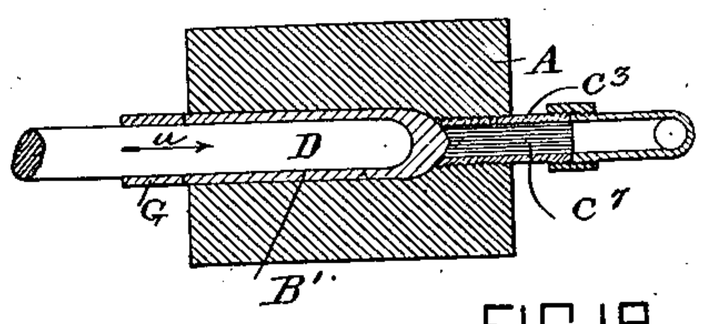


FIG. 19.

Witnesses;
J. D. Harrison
P. A. McShane.

Inventor,
James Robertson
By Wright Brown Quinby
Attorneys.

(No Model.)

5 Sheets—Sheet 3.

J. ROBERTSON.

SHAPING METAL TUBES.

No. 481,060. Patented Aug. 16, 1892.

FIG. 38

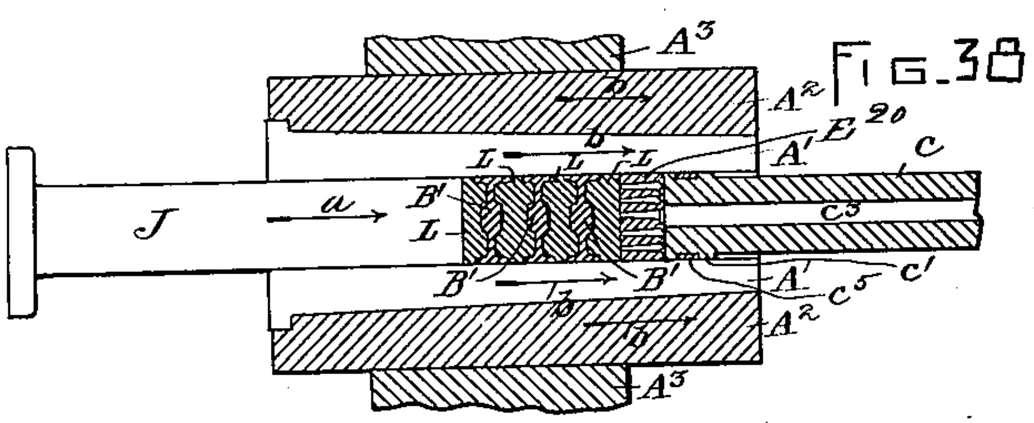


FIG. 36.

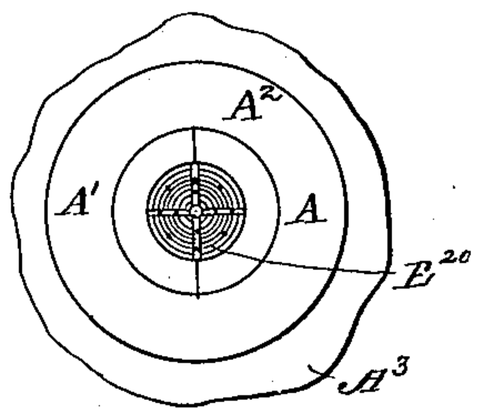


FIG. 37.

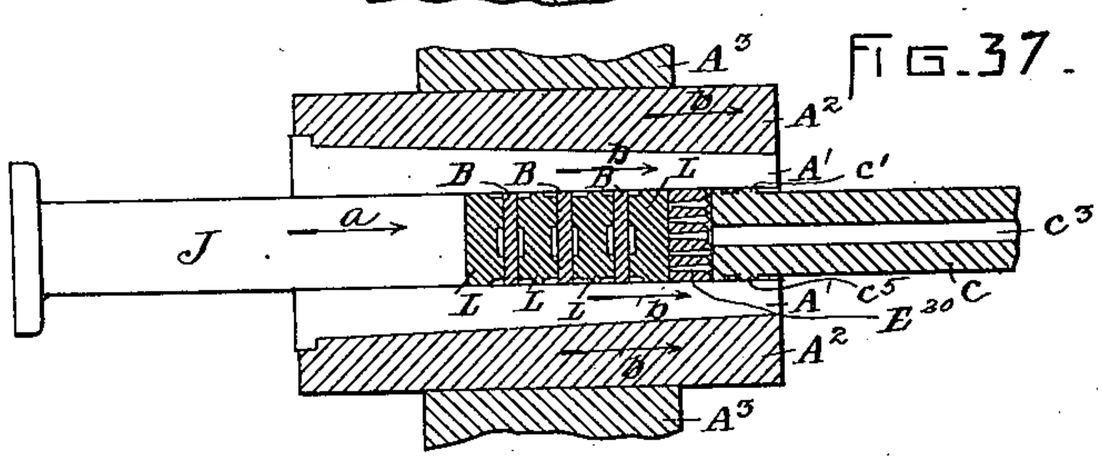


FIG. 34.

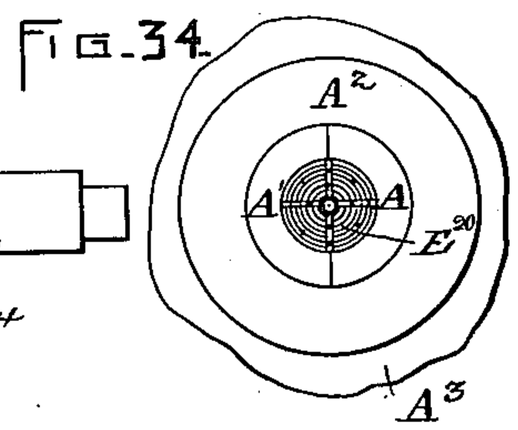


FIG. 35.

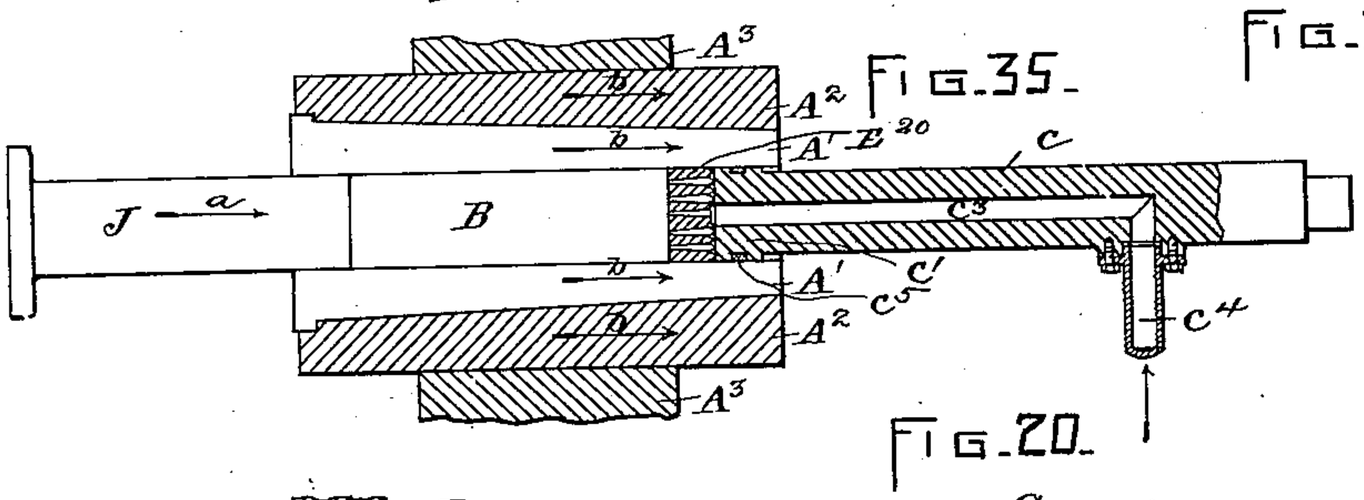
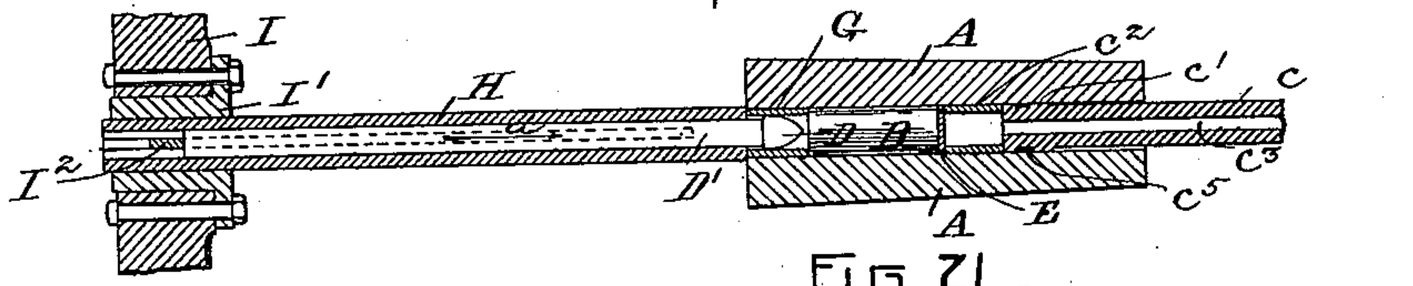


FIG. 20.

FIG. 21.



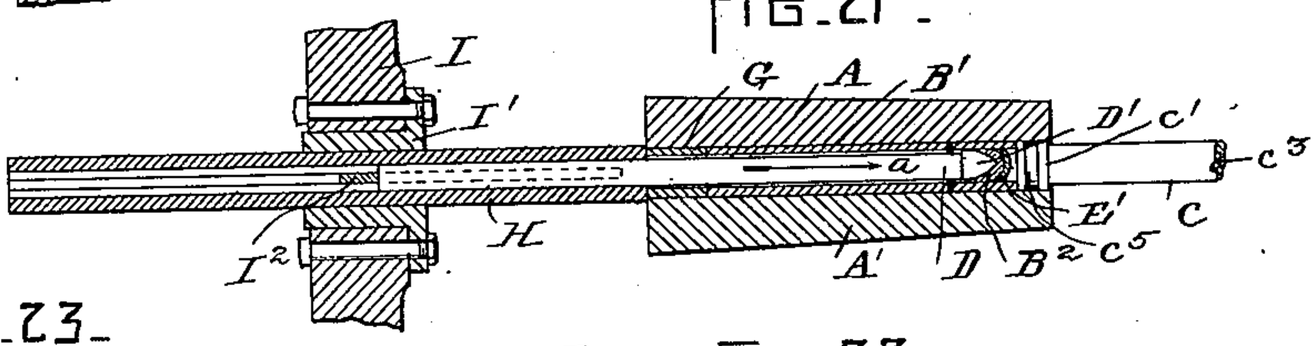


FIG. 23.

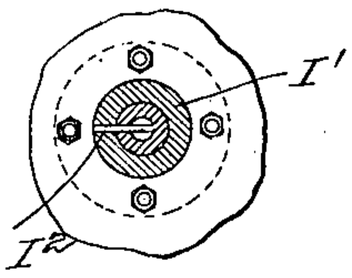
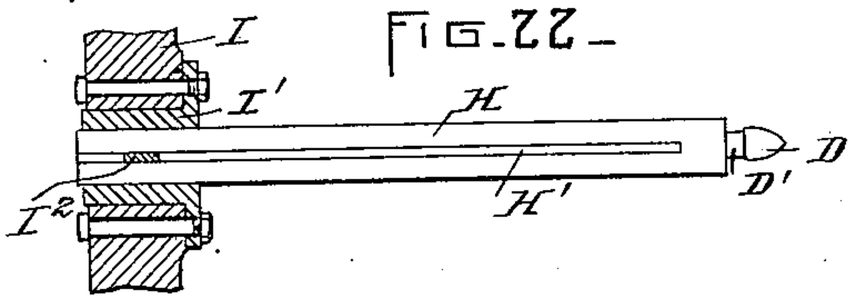


FIG. 22.



WITNESSES:
A. D. Harrison.
B. A. McShane.

INVENTOR:
James Robertson
by Wright Brown Quinby & Atty's.

(No Model.) 5 Sheets—Sheet 4.

J. ROBERTSON.

SHAPING METAL TUBES.

No. 481,060. Patented Aug. 16, 1892.

FIG. 25.

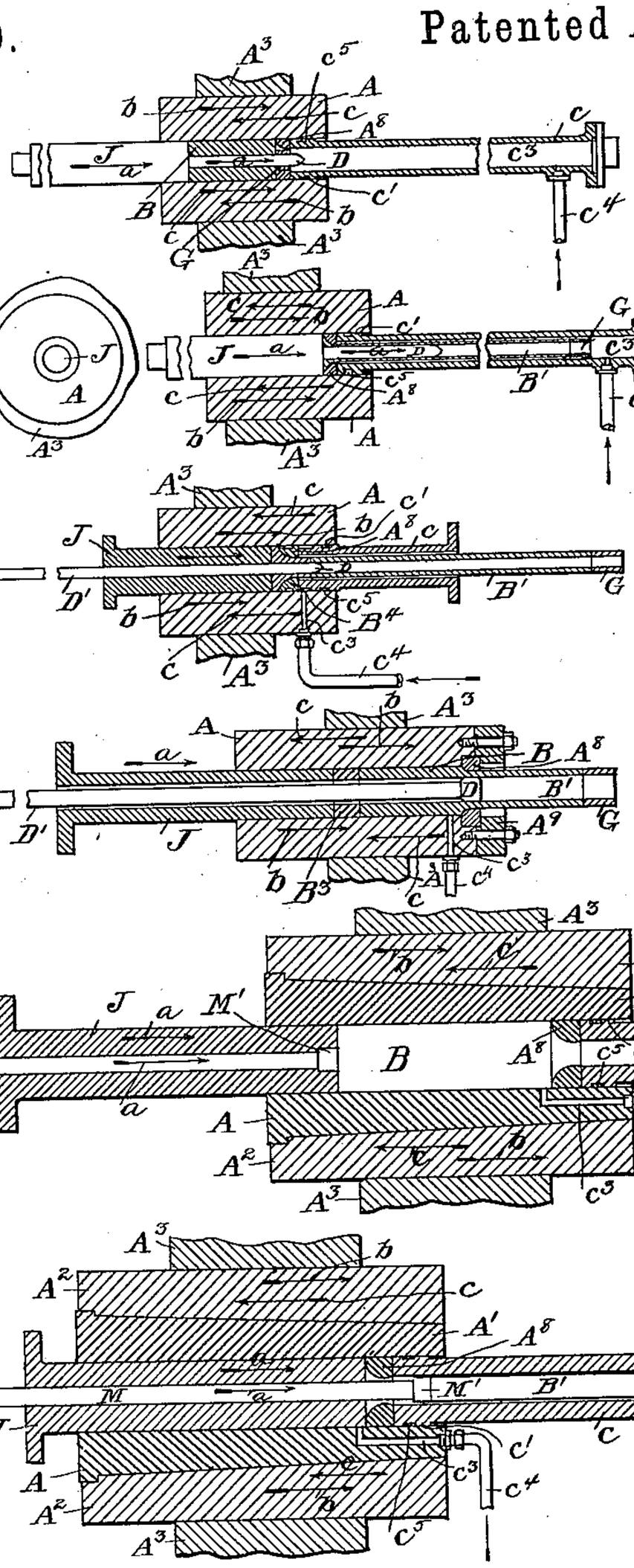


FIG. 26.

FIG. 24

FIG. 27.

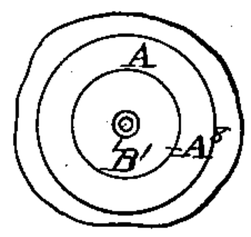


FIG. 28.

FIG. 29.

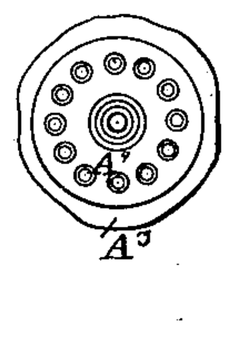
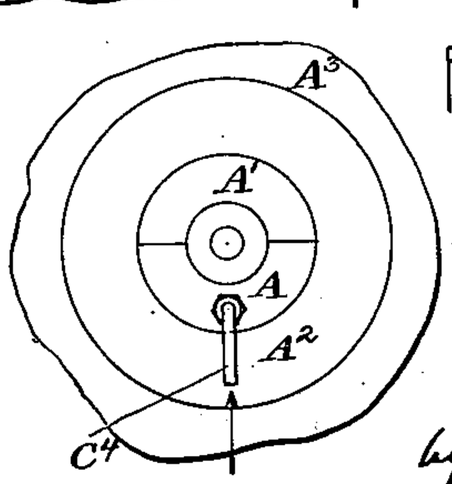


FIG. 30.

FIG. 43.

FIG. 44.

FIG. 42.



WITNESSES:
A. D. Harrison.
P. A. McShane.

INVENTOR:
James Robertson
by Wright Brown Quinby & Otty
Attys

(No Model.) 5 Sheets—Sheet 5.

J. ROBERTSON.

SHAPING METAL TUBES.

No. 481,060. Patented Aug. 16, 1892.

FIG. 31.

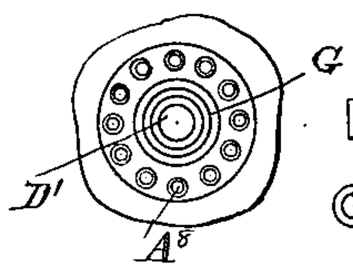


FIG. 32.

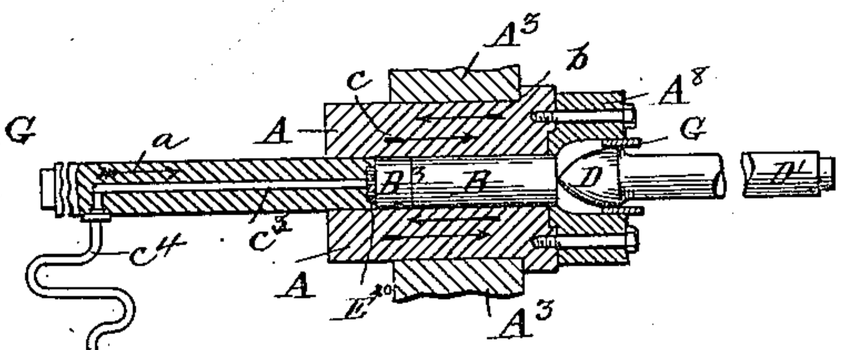


FIG. 33.

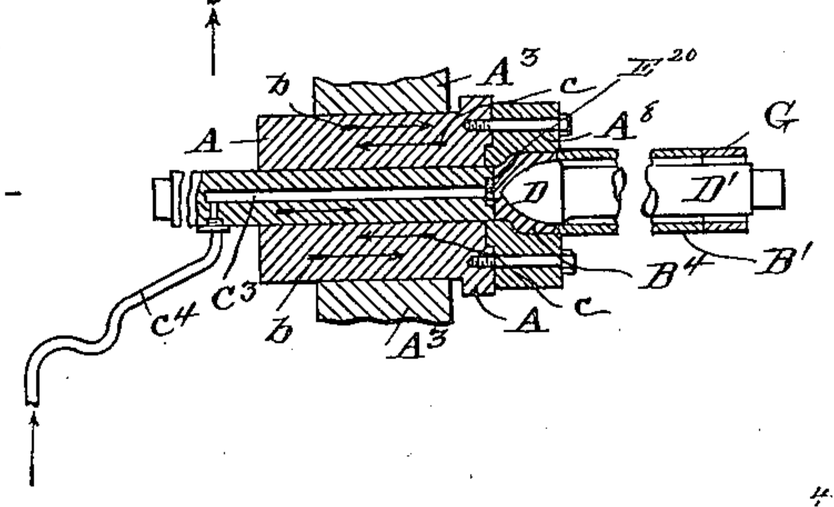


FIG. 40.

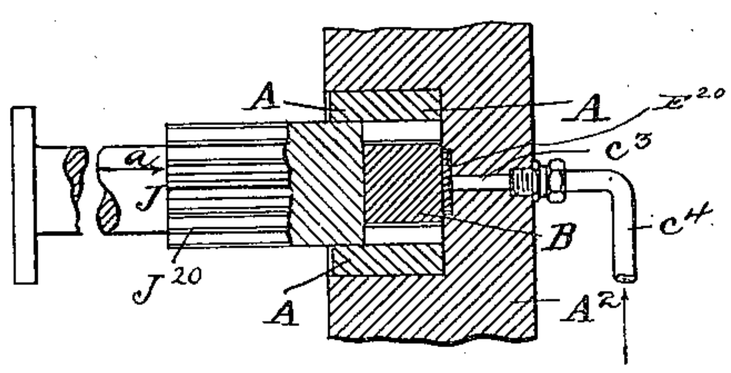


FIG. 39.

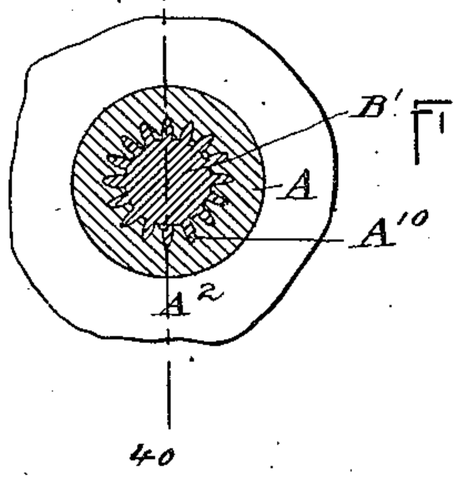
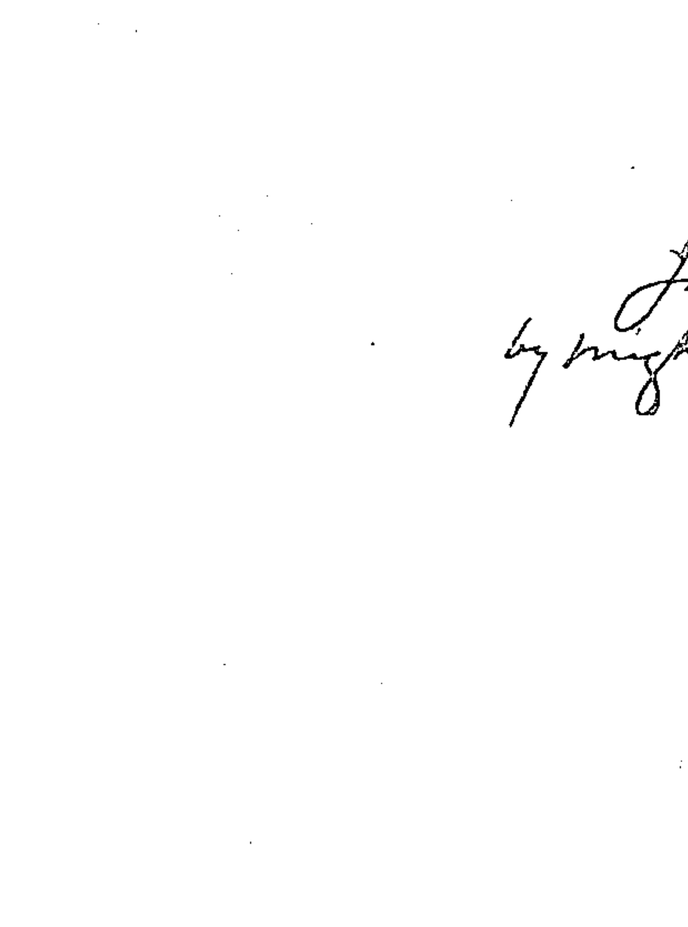


FIG. 41.



WITNESSES:
H. D. Harrison.
B. A. McShane.

INVENTOR:
James Robertson
by Wright Brown Quinby & Otty.
Attys.

UNITED STATES PATENT OFFICE.

JAMES ROBERTSON, OF BIRMINGHAM, ENGLAND.

SHAPING METAL TUBES.

SPECIFICATION forming part of Letters Patent No. 481,060, dated August 16, 1892.

Application filed March 18, 1892. Serial No. 425,429. (No model.) Patented in England July 6, 1891, No. 11,436.

To all whom it may concern:

Be it known that I, JAMES ROBERTSON, of Birmingham, England, have invented an Improvement in the Compressing, Shaping, and Drawing of Metal Tubes, &c., of which the following is a specification.

This invention relates, mainly, to compressing and shaping metals—such as iron, steel, and copper—made soft by heat and to shaping or forming billets or masses of metal in this soft state into tubes or tubular, hollow, and solid articles by pressing, piercing, or expanding such billets or masses, by the application of great force, into or through shaping-dies, by piercing-mandrels for the manufacture of tubes or tubular and hollow articles, and by rams or shaping-heads for solid articles and bars.

The invention consists, first, in certain improvements in the art of making metal articles, which consists in giving a blank of metal rendered soft by heat the desired form in a hollow die by pressure suitably applied and then introducing a fluid—such as water, preferably in a cold state, under high pressure into the interior of the die, thereby ejecting the formed article from the die, the fluid when cold acting, also, to contract the formed article and thus release the hold of the die upon it, so as to facilitate the ejection of the formed article, as well as cooling the die and preparing it for a subsequent operation.

The invention also consists in the combination of a hollow die, a mandrel or pressure device movable lengthwise in the die and adapted to co-operate with the die in forming a mass or billet of metal heated to softness and placed within the die, and means for introducing water under pressure into the interior of the die to eject from the latter the formed article and the mandrel or pressure device and incidentally to cool the die and the formed article.

The invention also consists in certain other improvements in apparatus for forming masses or billets of metal softened by heat in a die and ejecting the formed article and the pressure device that co-operates with the die in forming it from the die.

The invention also consists in an improvement in the art of forming masses or billets of metal heated to softness in a die by the conjoint action of a piercing-mandrel and the die, whereby the piercing-pressure of the mandrel in penetrating a billet is prevented from breaking the billet crosswise before the greater part of its mass has been formed into a tube, said improvement consisting in placing a blank or billet softened by heat in a die, forcing the piercing-mandrel lengthwise into and through the billet, thereby causing the metal of the billet to exude in tube form between the die and mandrel in the direction opposite the movement of the mandrel and supporting the rear end of the billet against the piercing-pressure of the mandrel by a rigid abutment adapted to stand the pressure of the mandrel when said pressure is relieved by the exudation of the metal from between the support and mandrel, whereby the mandrel is prevented from breaking the billet during the piercing operation, said support being further adapted to give way to the direct or unrelieved pressure of the mandrel when the latter has passed through the metal of the billet or a greater part thereof, so that when the mandrel emerges from the metal of the billet it will not be injured by contact with a rigid or unyielding surface, the said abutment yielding and permitting the unopposed movement of the mandrel out of the rear end of the tube.

The invention also consists in the combination of a die, a piercing-mandrel movable lengthwise in the die, and an abutment for the rear end of the billet engaged with a support at the rear end of the die and adapted to sustain the billet rigidly against the pressure of the mandrel while the same is relieved by the exudation of the metal and to give way to the direct or unrelieved pressure of the mandrel.

The invention also consists in certain additional improvements involving the employment of an abutment for the rear end of the billet, adapted to sustain the billet against the relieved pressure and to give way to the direct pressure of the mandrel.

In the accompanying drawings, forming part of this specification, Figure 1 represents an end elevation of a die and its containing and supporting devices and certain parts, hereinafter described, co-operating with the die. Fig. 2 represents a longitudinal section of the devices shown in Fig. 1, the parts being

shown in the position occupied near the close of the operation of forming a tube. Fig. 3 represents a section similar to Fig. 2, showing the position of the parts after the close of the tube-forming operation. Fig. 4 represents an end elevation, and Fig. 5 a longitudinal section, the latter showing certain modifications in the construction and arrangement of the abutment supporting the rear end of the billet. Figs. 6 and 7 represent, respectively, an end elevation and a longitudinal section involving another modification. Figs. 8 and 9 represent, respectively, an end elevation and a longitudinal section showing another modification of the abutment. Figs. 10 and 11 represent, respectively, an end elevation and a longitudinal section showing still another modification of the abutment. Fig. 12 represents an end elevation, and Fig. 13 a sectional view, showing a modification of the means for admitting fluid under pressure to the die. Fig. 14 represents an end elevation, and Figs. 15 and 16 sectional views, showing another modification of the means for admitting fluid under pressure to the interior of a die. Fig. 17 represents an end elevation, and Figs. 18 and 19 sectional views, showing another modification of the means for admitting fluid under pressure to the interior of a die. Figs. 20 and 21 represent sectional views of a die having means for admitting fluid under pressure, a piercing-mandrel, an abutment for the billet, and certain means hereinafter referred to for guiding and supporting the mandrel during its piercing-stroke. Fig. 22 represents a partial sectional view and partial elevation of portions shown in Figs. 20 and 21. Fig. 23 represents an end elevation and partial transverse section of the construction shown in Fig. 22. Fig. 24 represents an end elevation, and Figs. 25 and 26 sectional views, showing modifications of the construction of a die having means for introducing fluid under pressure into its interior. Fig. 27 represents an end elevation, and Fig. 28 a sectional view, showing other modifications relating to a die provided with means for introducing fluid under pressure into its interior. Figs. 29 and 30 represent an end elevation and a sectional view similar to Figs. 27 and 28, with slight additional modifications. Fig. 31 represents an end elevation, and Figs. 32 and 33 sectional views, showing other modifications relating to the form and arrangement of the parts and to the means for introducing fluid under pressure into the die. Figs. 34 and 35 represent an end elevation and a sectional view, the latter showing a shaping head or ram adapted to exert compressing pressure upon a billet of metal in the die, instead of a piercing-mandrel, as shown in the preceding figures, the die being provided with means for the introduction of a fluid under pressure. Figs. 36 and 37 represent, respectively, an end elevation and a sectional view, the latter being similar to Fig. 35, but showing instead of the solid billet a series of billets or blanks and shaping devices between which the billets or blanks are interposed, the die being provided with means for the introduction of a fluid under pressure. Fig. 38 represents a sectional view similar to Fig. 37, showing a different stage of the operation. Fig. 39 represents a transverse section, and Fig. 40 a partial longitudinal section and partial side elevation, showing a die for forming gears by the compression of metal, the die having means for the introduction of fluid under pressure. Fig. 41 represents a view similar to Fig. 40, showing a different stage of the operation. Fig. 42 represents an end elevation, and Figs. 43 and 44 sectional views, showing another modification of a die and co-operating devices, the die having means for the introduction of a fluid under pressure.

The same letters of reference indicate the same parts in all the figures.

In the drawings, A A′ represent the two halves of a long die, which is formed internally to impart the desired form to a billet or blank of metal placed in said die and subjected therein to compressing pressure, the blank or billet being rendered soft and viscid by heat.

In all the figures of the drawings, excepting Figs. 13 to 19, inclusive, and Figs. 20, 21, 22, 23, 39, 40, and 41, I have shown the die as adapted to slide lengthwise in a fixed guide or holder A^3, substantially as set forth in British Letters Patent No. 1,627 of 1890, granted to me, the die being adapted to slide freely in either direction in the said holder, which is affixed in any suitable way to a supporting-bed. This freedom of the die to move endwise enables it to be moved by the movement of the metal, such movement being caused by the shaping device co-operating with the die in giving the desired form to the blank or billet of metal softened by heat placed in the die.

In the production of tubes the device for applying pressure to the billet or blank is a piercing-mandrel D, formed on a stem-rod D′, and said rod is caused to act usually by being forced into the die against the billet, thereby causing the metal of the billet to exude through the annular space between the mandrel and the die in the form of a tube, the exuding metal moving at a slower rate than the mandrel and in the opposite direction and causing the die to move with it, as fully described in my above-mentioned British patent. The rear end of the billet is supported by means of an after holding-up stem-rod C, entering the rear end of the die. In most cases this stem-rod is rigidly supported and the mandrel is movable, although the conditions may be reversed and the mandrel held stationary and the stem-rod moved to cause the shaping action. When the billet or blank is acted upon by a compressing ram or head, as shown particularly in Figs. 35, 37, and 38, the metal does not exude from the die, but is simply compressed therein, and in this case

the die moves in the direction of movement of the metal, which is in the same direction as that of the ram or compressing-head J.

In carrying out that part of my invention which relates to the introduction of a fluid under pressure into the die for the purpose of ejecting the formed article and the mandrel or other pressure device from the die and of cooling the die and the formed article I provide a water inlet or channel, communicating with a source of fluid-supply, such as a water-forcing pump, water-accumulator, or any other means for supplying water at a high pressure, the pressure being preferably about one ton to the square inch.

In all the figures showing the holding-up stem-rod head C, excepting Figs. 28, 30, 43, and 44, I show a water channel or conduit C^3, extending longitudinally through the stem-rod and adapted to introduce water into the interior of the die.

In Figs. 2, 25, 26, and 35 I show a branch pipe C^4 connected to the stem-rod C at a point outside of the die, said pipe conducting water to the passage C^3 in the stem-rod from a suitable water-forcing apparatus.

It will be seen that the introduction of water in a cold state into the die containing a formed article of hot metal exerts a quick cooling action, slightly contracting the article, and releasing the hold of the die upon it, also affording a very steady force for the removal of the article, with the mandrel or pressure device, from the die.

The stem-rod C is preferably provided within the die with a packing-ring C^5 to make a water-tight joint and prevent the water from escaping from the rear end of the die. When water under pressure, as described, is introduced into a die containing a tube and a piercing-mandrel, as shown, for example, in Figs. 2 and 3, the pressure forces back the mandrel-head D into the hot tube B′ just formed (the connection between the mandrel and the internal surface of the tube being substantially water-tight) and at the same time generates steam largely and at a high pressure and cools the tube B′, thus contracting it and releasing it from the die. The contraction of the tube makes for the instant a water-tight connection between the tube and mandrel, so that the water and steam pressure quickly forces out both the tube and mandrel, leaving no time for the hot metal to injure the die, mandrel, or any of the working parts, the die being thus prepared for a fresh operation.

In Figs. 2 to 11, inclusive, and in several succeeding figures the form of the water-conduit in the stem-rod is such that the water admitted bears directly upon an abutment hereinafter referred to, which abutment is rigidly supported within the die during the tube-forming operation and is released and allowed to slide within the die at the close of the tube-forming operation, as hereinafter described, the pressure of the water being directed against the said abutment. In other figures, particularly Figs. 14, 15, and 16, as well as in Figs. 34 and 35, the said abutment is not employed and a loose water-distributing piece or tube E is placed in the die, said piece being of such form as to extend across the die and fill the cross-section thereof and provided with numerous perforations *e*, which are arranged to receive water from the supplying-conduit, which in Figs. 15 and 16 is indicated by c^2 c^4, the said orifices being connected by annular grooves in the rear side of the plate E, so that water can pass freely into all the orifices *e* from the conduit, the water being distributed by the plate so as to act on this water-distributing plate E being adapted particularly for articles of large diameter, such as the hollow shells or casings left closed at one end, as shown in Fig. 16, such shells being suitable for the manufacture of containers for gaseous fluids under pressure.

In Figs. 12 and 13 I show a conduit or passage A^7 extending laterally through the wall of the die in a direction at right angles to the length of the die and another conduit c^3 communicating with the conduit A^7, said conduit c^3 receiving water under pressure and being closed or obstructed by a plug A^4, which is formed to fill the conduit A^7 and has a screw-threaded portion working in a screw-threaded nut A^5, affixed to the wall of the die. A handle A^6 on the outer end of the plug A^4 permits said plug to be turned so as to withdraw it enough to uncover the conduit c^3 and permit the water to pass from the conduit c^3 through A^7 into the die. In Figs. 28, 43, and 44, a similar arrangement of the water-supplying conduit is shown—namely, a conduit c^2 formed in the wall of the die and communicating with the interior thereof, the conduit being connected by a pipe c^4 with the source of water-supply.

In Figs. 17, 18, and 19 I show a fixed die, and as a water-conduit I show a pipe c^3, connected by a pipe c^4 with a source of water-supply and provided with a filling of parallel lengths of wire c^7, closely packed and filling the pipe, excepting the necessary longitudinal interstices between the wires, each wire being preferably round and about one-eighth of an inch in diameter. The wires are so closely compressed or crowded into the tube as to resist endwise movement, and therefore the pressure of the compressed hot metal. The end of the mass of wires may be shaped to conform to the shape of the inside of the die or matrix, the shape of the die and of the end of the mass of wires (shown in Figs. 18 and 19) being suited for the formation of military shells.

The method of and means for introducing fluid under pressure into the interior of the die, for the purposes above described, are not limited to use in connection with apparatus for forming tubular or hollow articles, nor to apparatus in which tubular or hollow articles are formed by the oxudation of the metal be-

tween the wall of the die and the periphery of a mandrel co-operating with the die.

In Figs. 15 and 16 I show a fixed die and a mandrel or plunger adapted to co-operate therewith in forming a hollow article or tube closed at one end.

In Fig. 35 I show a longitudinally-movable die and a ram or compressing-head J closely fitting the interior of the die and adapted to co-operate with the die and with the stem-rod C in imparting equal pressure to both ends or both sides of the article being compressed and shaped, the main difference between the construction shown in Fig. 35 and that shown in Figs. 1, 2, 3, &c., being the substitution of a ram J, closely fitting the interior of the die, for the mandrel D, made smaller than the die, the billet being compressed and given externally the exact shape of the die instead of being pierced. In this case the die may be round, square, or of any other shape in cross-section. Two or more pieces or blanks of hot soft metal may be compressed or shaped in the manner shown in Fig. 35. The sliding motion of the die equalizes the pressure throughout the die, which thus, by diminishing the loss of pressure at the rear end of the die by the friction of the billet of metal on its walls, allows a long die to be used for the purpose described.

In Figs. 37 and 38 I show the same apparatus as in Fig. 35; but instead of one billet in the die there are a series of billets B, which are to be compressed into a web or disk pulley. In the die are placed a series of formers or shaping devices L L L L, between which the billets are interposed, said formers being inserted in a cold state and provided on their sides adjacent to the sides of the billet with suitable recesses and projections adapted to act upon the soft hot-metal billets when the ram J is forced inwardly, as shown in Fig. 38, to convert the billets B into pulleys B', as shown in the last-mentioned figure. Metals—such as iron, steel, and copper and its alloys—can be forged quickly in this way into a great variety of shapes, as the dies and shaping devices may be of square, oblong, or any other shape in cross-section.

I do not claim herein the apparatus nor the method immediately above described and illustrated in Figs. 35, 37, and 38, as the same forms the subject-matter of another application filed by me July 15, 1892, and having Serial No. 440,149.

In Figs. 39 and 40 I show a die and a ram co-operating therewith, adapted to compress and shape heated metals into short articles—such as gear-wheels—where there is no large diminution of pressure by friction, owing to great length of surface of the walls of the die and pressure device. In this case the die A is fixed, the stem-rod being omitted. The interior of the die may be provided with a series of recesses adapted to form teeth on the periphery of a gear B', Fig. 39, the ram J being provided with a follower J^{31}, having teeth adapted to closely fit the tooth-forming recesses of the die, said teeth being longer than the depth of the die.

Fig. 41 shows the position of the ram at the close of the forming operation, the billet having been compressed within the die by the vertical movement of the ram, so that a portion of its metal has been forced outwardly into the tooth-forming recesses of the die. The expelling fluid is admitted into the die through conduit c^3 c^4 and a distributing-tube E. It will be seen that by apparatus similar to that shown in Figs. 39 and 40 articles of various shapes can be formed very solidly and quickly, the water-expelling process being well suited for this apparatus, as well as for all the previously-described forms.

In Figs. 42, 43, and 44 I show apparatus for compressing and shaping or drawing down masses, billets, or bars of hot metal which have round or other cross-section from a larger to a smaller cross-section, the die A A', of the general form hereinbefore described, having a reducing-die A^8, which is supported by the stem-rod C and supports the rear end of the billet. The stem-rod in this case has its central longitudinal aperture made somewhat larger than the diameter of the interior of the die A^8. The billet or bar is placed in the die A A' as before, and a ram J, closely fitting the interior of the die, is introduced into the latter, the pressure of the ram forcing the billet through the die A^8, thus converting the billet into a rod of smaller diameter, which rod passes out into the orifice in the stem-rod C. The ram J in this case is provided with a longitudinal hole slightly enlarged at its inner end, in which is placed a secondary ram M, adapted to slide longitudinally, and having a head M' fitting the enlargement in the hole in the ram, said head and enlargement preventing the metal under pressure from pressing the secondary ram M backward. The object of the ram M is to push the metal out of the die A^8 after the completion of the stroke of the ram J. The cooling and expelling water is then admitted to the die through the conduit c^3 c^4, expelling the bar B', but in this case in the same direction as that in which the bar moved while it was being formed, as indicated by the arrow marked thereon in Fig. 44.

In Figs. 20, 21, 22, and 23 I show means for supporting and imparting rigidity to the elongated stem-rod D' of a piercing-mandrel for forming tubes and tubular and hollow articles of small diameters. The mandrel stem-rod D' is placed in a tubular guide-piece H and adapted to slide freely therein. One end of the guide-piece H is inserted in a bushing I', affixed to a driving-head I, which may be impelled toward the die A A' by means of a hydraulic ram or otherwise. I^2 represents a transverse arm or cotter affixed to the bush-piece I' and passing through a slot H' in the guide-piece H into the interior of the ram, said cotter bearing against the rear end of

the mandrel. In this case the die A A′ and guide-piece H are held stationary, a fixed after-holding-up stem-rod C being employed to support the rear end of the billet, and the mandrel is moved forward, as indicated by the arrows marked thereon. The guide-piece H supports the mandrel stem-rod and prevents its from buckling or bending under the strain imposed upon it.

I do not claim in this application the means above described and illustrated in Figs. 20 to 23, inclusive, the same forming the subject-matter of another application filed by me July 15, 1892, and having Serial No. 440,150.

In Figs. 24, 25, and 26 I show means of shaping and drawing seamless tubes of considerable length from billets of metal—such as steel and copper—and of diminishing the external diameter of the formed tube below that of the blank or billet by pushing the metal out of a long tube-forming die A by means of a ram J, closely fitting the interior of the die and between a mandrel D and a short die A^8 of smaller diameter placed in the die A. In this case the fixed after-holding-up stem-rod C supports the reducing-die A^8, and the mandrel D projects through an orifice previously formed in the center of the billet B and through the die A^8. In this case the ram J and mandrel D move together, the ram compressing the billet and causing it to exude in tube form between the reducing-die A^8 and the mandrel, the ram moving with the formed tube into the stem-rod C, which is made of sufficient length to receive the entire length of the formed tube. At the completion of the operation the tube is ejected by fluid under pressure introduced into the stem-rod C through pipe c^4.

Figs. 27 and 28 show apparatus in which the mandrel is inserted through a hollow billet-forcing ram and through a hollow metal billet held in a die A between the ram J and fixed stem-rod C, the mandrel being held stationary instead of moving along with the metal billet, as in Figs. 25 and 26. A reducing-die A^8 is employed in this modification, as in one last described. In this case the ejecting fluid enters through the conduit c^3 c^4, passing through one of the walls of the die A into an annular cavity formed by reducing the end of the stem-rod C. The fluid thus admitted forces the die A^8 and ram J out of the die A.

In the apparatus shown in Figs. 29 and 30 the action is the same as in Fig. 28; but in this modification the die A^8 is secured to the die A by means of a holder or plate A^9, which takes the place of the after-holding-up stem-rod C, the latter being removed. The mandrel D and its rod D′ are fixed in a stationary mandrel-holder K. The mandrel is arranged within a die A^8 and serves the purpose of the stem-rod C in compacting the metal of the billet B when the said metal is being squirted out in the tube B′.

Figs. 31 and 32 show dies A A^8 of different diameters, adapted to expand a solid billet B of hot metal outwardly into a tube B′ of larger external diameter than the billet from which it was made. In this case a ram J is employed closely fitting the interior of the die, while a piercing-mandrel D, supported by a stem-rod D′, is held stationary within the die A^8, the mandrel D being an equivalent of the fixed stem-rod C. In this case the expelling fluid enters the ram through a flexible tube c^4 and passes into the die through a conduit c^3 in the ram. At the beginning of the operation a short piece of metal B^8, of the same kind as the billet and in a hot state, is interposed between the billet and the ram, as shown in Fig. 32, said piece being converted by the action of the ram and mandrel into a cap B^4, as shown in Fig. 33, enveloping the mandrel at the close of the tube-forming operation. The fluid introduced through the ram ejects the said cap, with the mandrel and tube, leaving the dies A A^8 ready for fresh operation.

I do not claim herein apparatus for forming elongated articles from billets of heated metal, such as described above and illustrated in Figs. 43, 44, 25, 26, 28, 32, and 33, as the same forms the subject-matter of another application filed by me July 15, 1892, and having Serial No. 440,151.

I have shown the various modifications above described to illustrate the applicability of my method of expelling formed articles of hot metal from shaping-dies and of preparing the dies and the co-operating devices for fresh operations to variously-organized apparatuses, my invention not being limited in this respect to any particular form of apparatus, as the fluid under pressure may be introduced into a die which is either fixed or movable lengthwise, and through a fixed stem-rod or through the side or end wall of the die or by means of a flexible connection through a movable ram or presser.

Various other modifications of means for introducing water under pressure into dies for forming hot-metal blanks may be adopted without departing from the spirit of my invention.

Another feature of my invention, which I have used with very satisfactory results in connection with the mode of and means for ejecting the formed articles from the die and for cooling the die and mandrel or pressure device, consists in the provision of an abutment for the rear end of the billet, said abutment being used in connection with apparatus for piercing the billet and converting the same into a tube, the piercing-mandrel passing entirely through the billet and forming a tube, which is open at both ends.

In converting a billet into a tube by the conjoint use of a longitudinally-sliding die and a piercing-mandrel movable in the die it is necessary to support the rear end of the billet against the pressure of the die, in order that the said pressure may be prevented from

breaking the billet crosswise before the material thereof has been fully utilized in the manufacture of the tube. It is desirable that the mandrel pass through substantially all of the metal of the billet, in order that the material may be worked up into tube form without any considerable waste, such as would be caused by failure of the mandrel to pass entirely through the billet, or by the crosswise breaking of the billet before the mandrel has reached the rear end of the same. I find that it is necessary, in order to prevent such crosswise breaking of the billet, to provide a support which will extend across the inner end of the billet, and thus support substantially all of the surface of the end of the billet. It is obvious, however, that if such support be fixed and immovable the mandrel will not only be prevented by it from emerging through the end of the billet, and thus completing the tube, but will also be liable to be injured by contact with the support on approaching the end of its inward stroke, the mandrel being then in a heated condition and easily battered and indented. To afford a sufficient support for the billet during the piercing action of the mandrel and to allow the mandrel to emerge practically unopposed from the end of the billet when the material of the latter has been practically all converted into a tube, I provide an abutment or support within the die, which abutment is adapted to withstand the pressure of the mandrel when said pressure is relieved by the exudation of the metal from between the die and mandrel, and therefore constitutes a practically-rigid support, preventing the breaking away of the rear end of the billet during the tube-forming operation, said support being adapted to yield or give way to the direct or unrelieved pressure of the mandrel after the metal has ceased to exude from between the mandrel and die, so that the abutment is displaced and permits the unobstructed exit of the mandrel from the rear end of the completed tube without injury to the mandrel. The abutment, thus released and permitted to move endwise in the die, permits the described expelling action of the fluid under pressure introduced into the die.

This part of my invention may be carried out in various ways. –

In Fig. 2 I show as the abutment a service-plate E, which may be of copper, iron, steel, or other suitable material, and is so proportioned that it will resist the relieved pressure of the billet against it, while the mandrel is piercing the billet, and will be ruptured or shorn by the direct or unrelieved pressure of the mandrel, so that its central portion will be converted into a loose disk E′, which retreats before the mandrel and the remnant B^2 of the metal billet, which remnant is also shown in Fig. 3 in the form of a barb, retreating with the disk E′ before the mandrel. In this instance the margin of the service-plate E is supported by a tube or ferrule piece C^2, placed in the die and supported by the stem-rod C, the said ferrule-piece C^2 constituting an extension of the stem-rod and having an internal cavity large enough to receive the mandrel, as shown in Fig. 3, said ferrule-piece also permitting the passage of water under pressure from the stem-rod into the die.

In Fig. 5 I show a service-plate E of the same form as in Fig. 2, said plate being, however, clamped between the forward end of the stem-rod C and the rear end of the ferrule-piece C^2, a cylindrical filling-piece E^3 of suitable metal being interposed between the service-plate and the billet, said piece being inclosed in the ferrule-piece C^2. In this case the pressure of the billet is communicated to the service-plate through the filling-piece E^3, and when the pressure of the mandrel becomes positive or unrelieved the filling-piece E^3 and the service-plate yield, the service-plate being shorn away at its central portion, as above described.

In Fig. 7 I show as the abutment the filling-piece E^3, the stem being placed in the ferrule-piece C^2 and engaged with the latter by means of a key or locking device consisting of a sleeve E^{10} of soft metal—such as lead—filling an annular space between the ferrule-piece and the filling-piece, and also filling grooves C^6, formed in the inner surface of the ferrule-piece and the outer surface of the filling-piece. The sleeve E^{10} has sufficient strength to resist the relieved pressure of the billet against the filling-piece E^3, but is ruptured or shorn away by the positive or unrelieved pressure of the mandrel. In this case the ferrule-piece C^2 is directly supported by the forward end of the stem-rod C.

In Figs. 8 and 9 I show the filling-piece E^3 secured in place by a transverse key or locking device E^{12}, which may be of any suitable metal, and is inserted at its ends in orifices in the filling-piece E^3, the said key being proportioned to resist the relieved pressure and to be ruptured by the direct pressure of the mandrel.

In Fig. 11 I show the filling-piece E^3 arranged as the abutment, the key or locking device being a blank E^{13} of soft metal, closing the outlet of a chamber E^{14}, formed in the ferrule-piece C^2, the latter having one end closed and provided with an orifice, which is filled or closed by the plug E^{13}. The filling-piece E^3 is adapted to slide in the chamber E^{14} and has a packed piston E^6 affixed to its rear end, which fits closely in the chamber E^{14}. The space between the piston E^6 and the head or closed end of the ferrule-piece is filled with water or other suitable liquid. So long as the pressure of the billet against the filling-piece E^3 is relieved by the exudation of the metal, the plug E^{13} holds the liquid in place and prevents endwise movement of the filling-piece; but when the filling-piece is subjected to the direct pressure of the mandrel the plug E^{13} is ruptured and ejected, thus permitting the fluid to escape and the pad-

piece to be displaced or moved before the mandrel.

It will be observed that in each of the constructions above described an abutment is provided, which is held in place by a locking device or key which secures the abutment to a fixed support and is adapted to resist the relieved pressure of the mandrel through the billet against the abutment and to be ruptured or shorn by the direct or unrelieved pressure of the mandrel. In the construction shown in Figs. 2, 3, and 5 the key or locking device is the marginal portion of the service-plate, the same being ruptured or shorn at a line coinciding with the inner surface of the ferrule-piece C^2. In Figs. 5, 7, 9, and 11 the key or locking device is made independent of the part which directly supports the rear end of the billet, while in Figs. 2 and 3 the key or locking device is a part of the device which directly supports the billet.

Various other modifications may be made in the construction of this portion of my invention without departing from the spirit or nature thereof.

In several figures of the drawings I show a tubular mandrel-guide G loosely inserted in one end of the die as a means for keeping the mandrel at the center of the die.

I do not claim herein the method of protecting a tube-forming mandrel from injury and of separating it from the formed tube, the same consisting in interposing a landing-piece of hot soft metal between the billet and the head or support which co-operates with the mandrel in compressing the billet, said piece receiving the mandrel at the close of the tube-forming operation.. Nor do I claim the means for carrying out this method, as the said method and means form the subject-matter of another application filed by me July 15, 1892, and having Serial No. 440,152.

Having thus described the nature of my invention and explained a way of constructing and using the same, though without attempting to set forth all of the forms in which it may be made or all of the modes of its employment, I declare that what I claim is—

1. That improvement in the art of making metal articles which consists in giving a blank piece of metal softened by heat the desired form in a die by pressure and then introducing a relatively-cold fluid, such as water, under pressure into the die, said fluid operating to cool and contract the formed article as well as to eject it from the die, as set forth.

2. That improvement in the art of making seamless metal tubes and tubular articles which consists in placing a blank or billet softened by heat in a die, forcing a piercing-mandrel lengthwise into and through the billet, thus converting it into a tube, and then introducing a fluid, such as water, under pressure into the die, and thereby ejecting both the tube and mandrel from the die, as set forth.

3. The combination of a hollow die, a mandrel or pressure device movable lengthwise within the die, and means for introducing water under pressure into the interior of the die, whereby the formed article and the mandrel or pressure device may be ejected from the die, as set forth.

4. The combination of a fixed guide, a die adapted to slide lengthwise therein, a pressure device movable lengthwise within the die, and a fixed stem-rod entering the rear end of the die and provided with a conduit adapted to deliver a fluid, such as water, under pressure to the interior of the die, as set forth.

5. The combination of a fixed guide, a die adapted to slide lengthwise therein, a mandrel adapted to move lengthwise into the die, and a fixed stem-rod entering the rear end of the die as a means for supporting a billet or blank of metal therein against the piercing pressure of the mandrel, said stem-rod having a water channel or conduit adapted to introduce a fluid, such as water, under pressure into the rear portion of the die, as set forth.

6. That improvement in the art of making seamless metal tubes and hollow articles which consists in placing a blank or billet softened by heat in a die, forcing a piercing-mandrel lengthwise into and through the billet, and thereby causing the metal of the billet to exude in tube form between the die and mandrel in a direction opposite the movement of the mandrel, rigidly holding the rear end of the billet against the piercing pressure of the mandrel by a rigid support while the mandrel is piercing the billet, and thereby preventing the mandrel from breaking the billet during the piercing operation, and displacing or removing the rigid support by the direct or unrelieved pressure of the mandrel at the end of the piercing operation, whereby injury to the mandrel is prevented, as set forth.

7. That improvement in the art of making seamless metal tubes and hollow articles which consists in placing a blank or billet softened by heat in a die, rigidly supporting the rear end of the billet, forcing a piercing-mandrel lengthwise into and through the rigidly-supported billet, and thereby causing the metal of the billet to exude in tube form between the die and mandrel in a direction opposite the movement of the mandrel, and displacing the support at the rear end of the billet after the mandrel has passed substantially through the billet, whereby the mandrel is permitted to emerge unobstructed from the rear end of the tube without injury.

8. That improvement in the art of making seamless metal tubes and hollow articles which consists in placing a blank or billet softened by heat in a die, rigidly supporting the rear end of the billet, forcing a piercing-mandrel lengthwise into and through the rigidly-supported billet, displacing the support from its operative position at the rear end of the billet after the mandrel has passed substantially through the billet, and thereby permitting said support to slide in the die, and finally introducing a fluid, such as water, un-

der pressure into the rear end of the die, and thereby ejecting the mandrel, the billet, and the displacing billet-support, as set forth.

9. As a fixed improvement in apparatus for making seamless metal tubes and hollow articles, the combination of a die, a piercing-mandrel movable lengthwise in the die, and an abutment for the rear end of the billet, adapted to sustain the billet rigidly against the relieved pressure of the mandrel and to give way to the direct or unrelieved pressure of the mandrel, whereby the mandrel is permitted to emerge from the rear end of the tube without injury, as set forth.

10. As an improvement in apparatus for making seamless metal tubes and hollow articles, the combination of a die, a piercing-mandrel movable lengthwise in the die, a recessed support at the rear portion of the die, adapted to resist the pressure of the mandrel against the billet, and a fixed abutment for the rear end of the billet, adapted to sustain the billet rigidly against the relieved pressure of the mandrel and to give way to the direct or unrelieved pressure of the mandrel and retreat before the mandrel into the recessed support, as set forth.

11. As an improvement in apparatus for making seamless metal tubes and hollow articles, the combination of a die, a piercing-mandrel movable lengthwise in the die, a recessed support at the rear portion of the die, adapted to resist the pressure of the mandrel against the billet, an abutment for the rear end of the billet, and a locking device or key securing the abutment to the support and adapted to resist the relieved pressure of the mandrel through the billet against the abutment and to be ruptured or shorn by the direct or unrelieved pressure of the mandrel, as set forth.

12. As an improvement in apparatus for making seamless metal tubes and hollow articles, the combination of a die, a piercing-mandrel movable lengthwise in the die, a recessed support at the rear portion of the die, adapted to resist the pressure of the mandrel against the billet, and a service-plate of ruptturable metal covering the forward end of the recessed support, said plate serving as an abutment for the rear end of the billet, while its margin constitutes a locking device or key engaging the abutment with the recessed support and adapted to be ruptured or shorn by the direct pressure of the mandrel, as set forth.

13. The combination of a hollow die, a mandrel or pressure device movable lengthwise within the die, a support or abutment for the rear end of the billet, adapted to sustain the billet rigidly against the pressure of the mandrel when said pressure is relieved by the exudation of the metal between the die and mandrel and to give way or become loosened by the direct pressure of the mandrel, and means for introducing a fluid under pressure, such as water, into the rear end of the die to eject the mandrel, the formed tube, and the loosened support from the die, as set forth.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 23d day of February, A. D. 1892,

JAMES ROBERTSON.

Witnesses:

ARTHUR T. HALL,
ARTHUR H. POPE.
9 *Mount Street, Manchester.*