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No. 524,504. Patented Aug. 14, 1894.

FIG. 4.

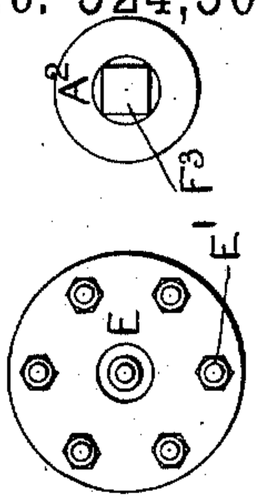


FIG. 5.

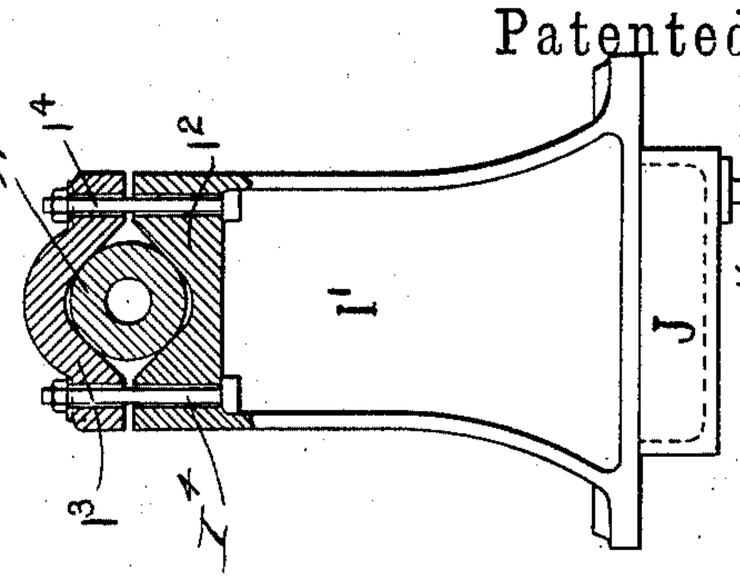


FIG. 10.

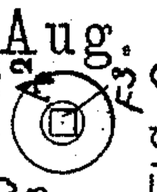
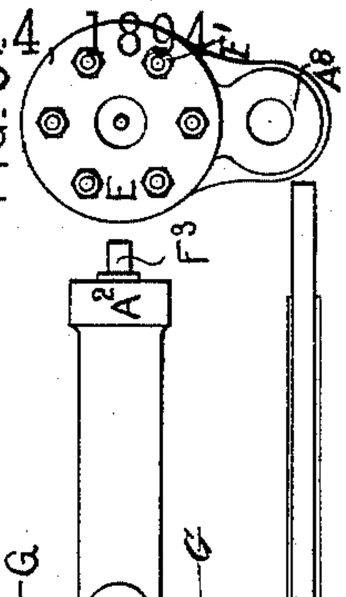


FIG. 9.



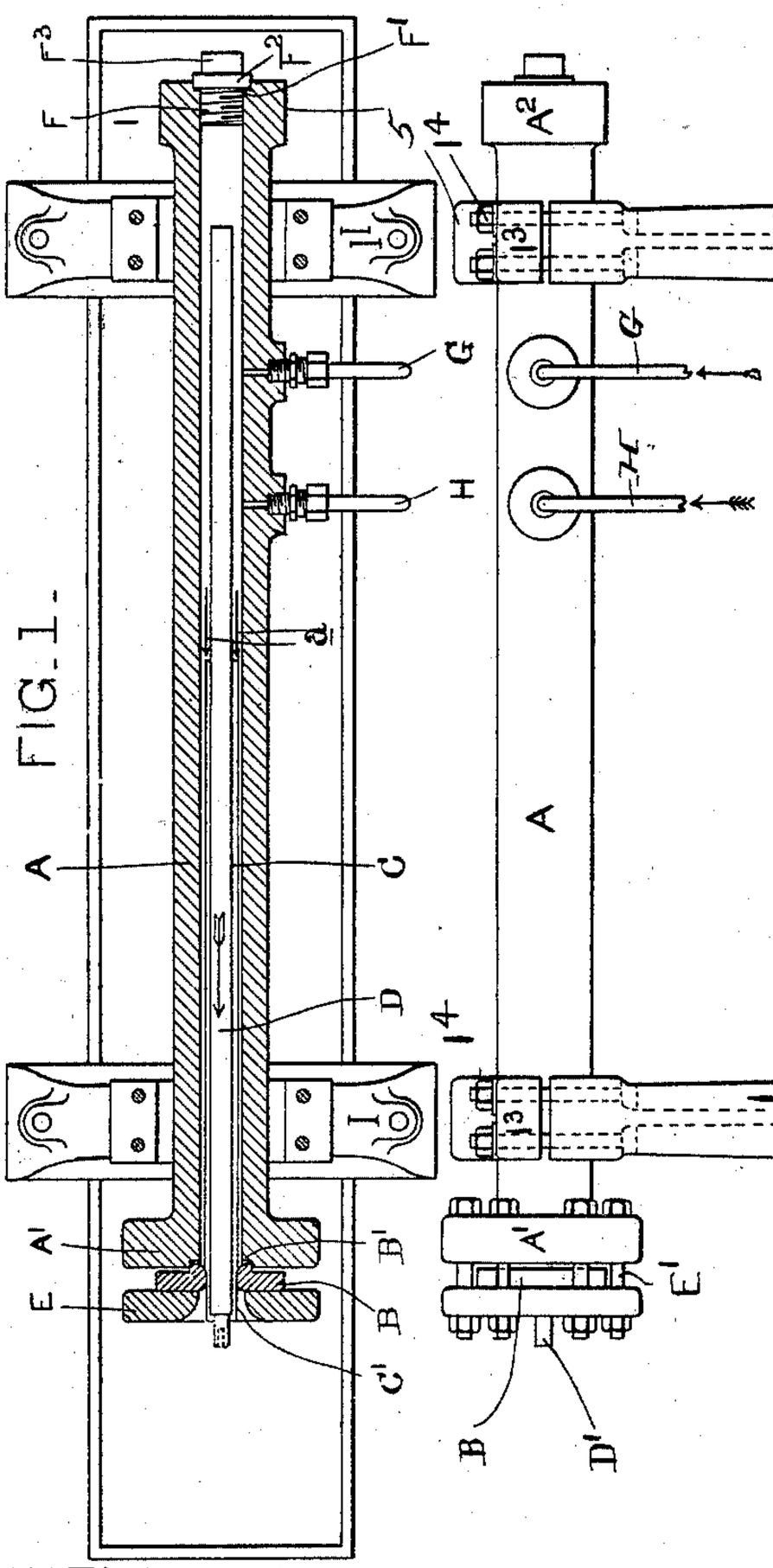


FIG. 1.

FIG. 2.

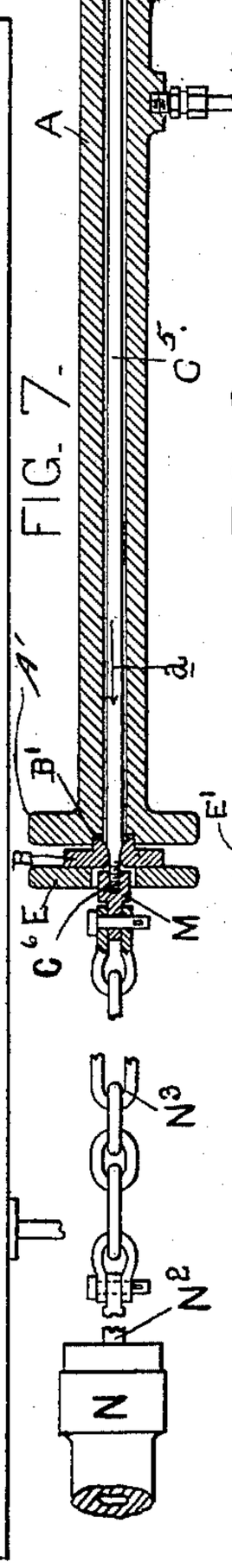


FIG. 7.

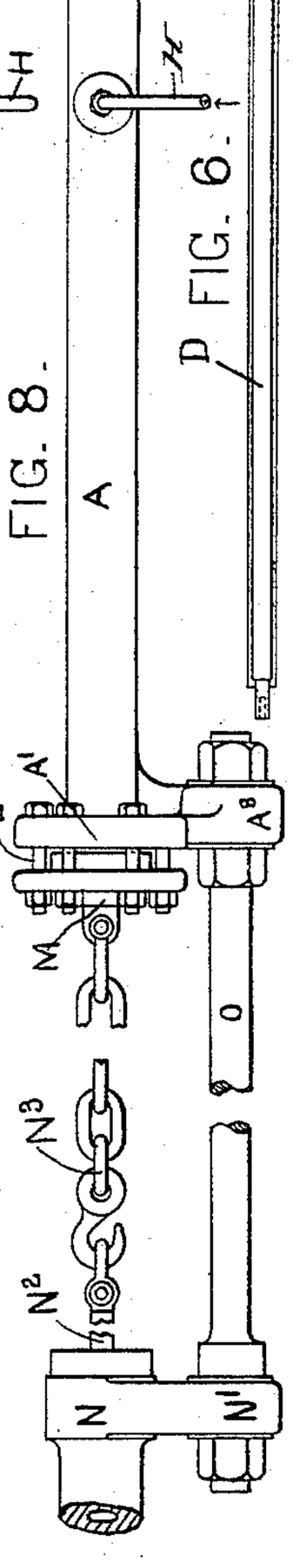


FIG. 8.

FIG. 6.

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No. 524,504. Patented Aug. 14, 1894.

FIG. 11.

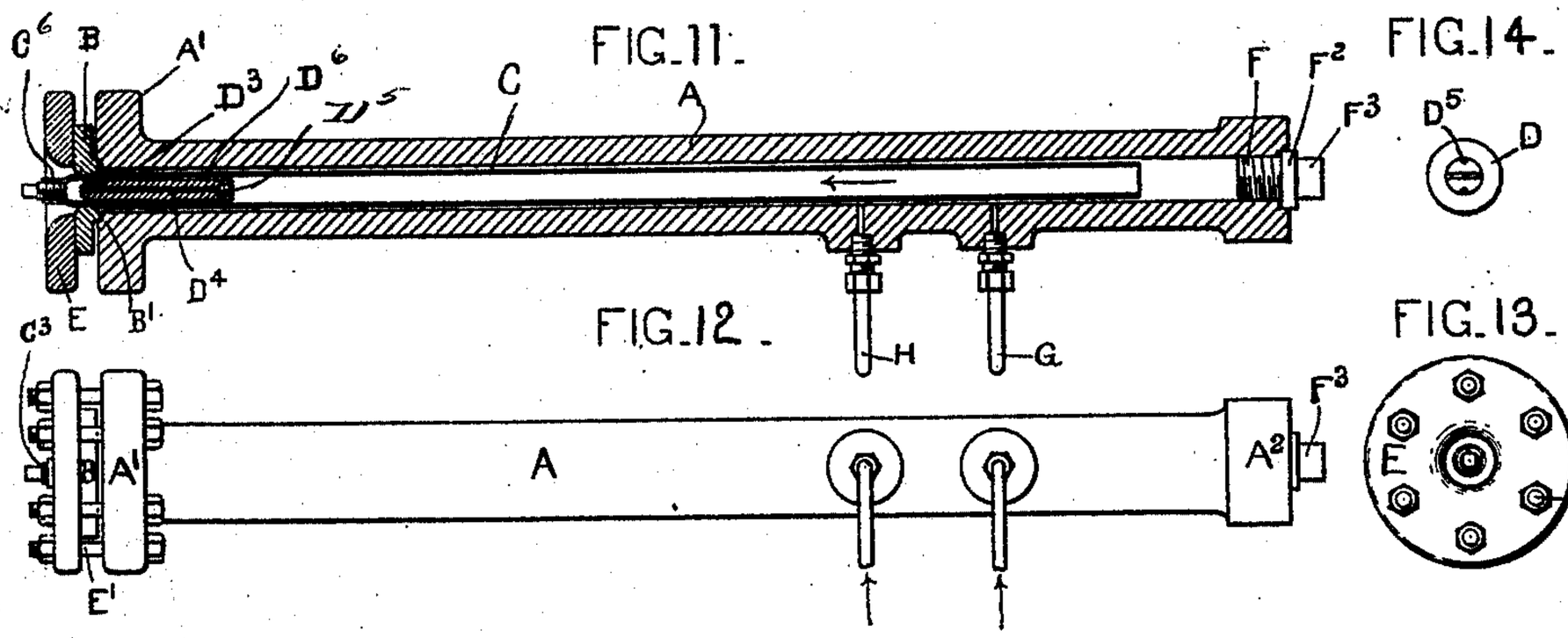


FIG. 14.

FIG. 12.

FIG. 13.

FIG. 15.

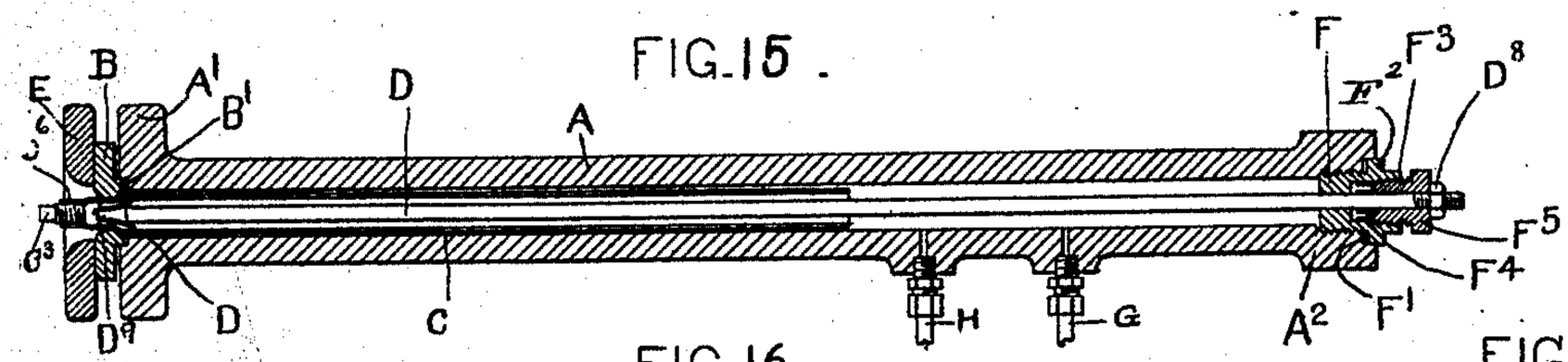


FIG. 16.

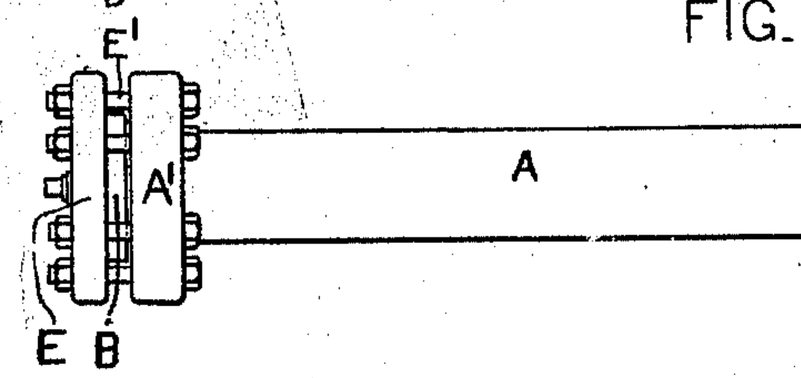
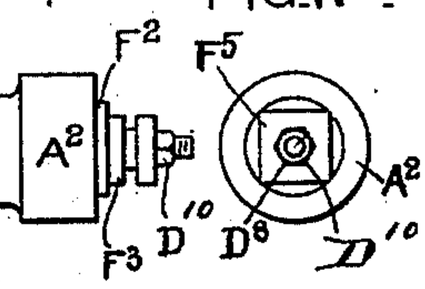


FIG. 17.



WITNESSES.
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METHOD OF AND APPARATUS FOR FORMING METAL ARTICLES.

No. 524,504. Patented Aug. 14, 1894.

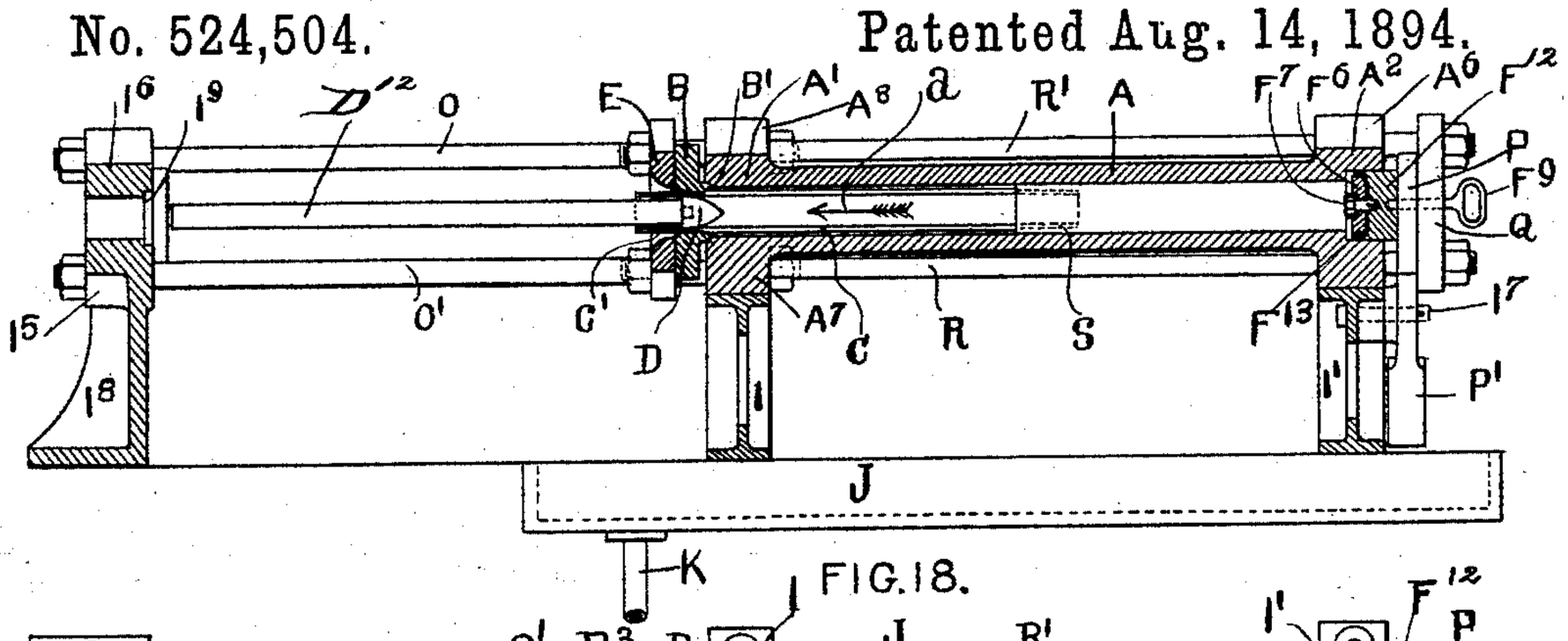

FIG. 18.

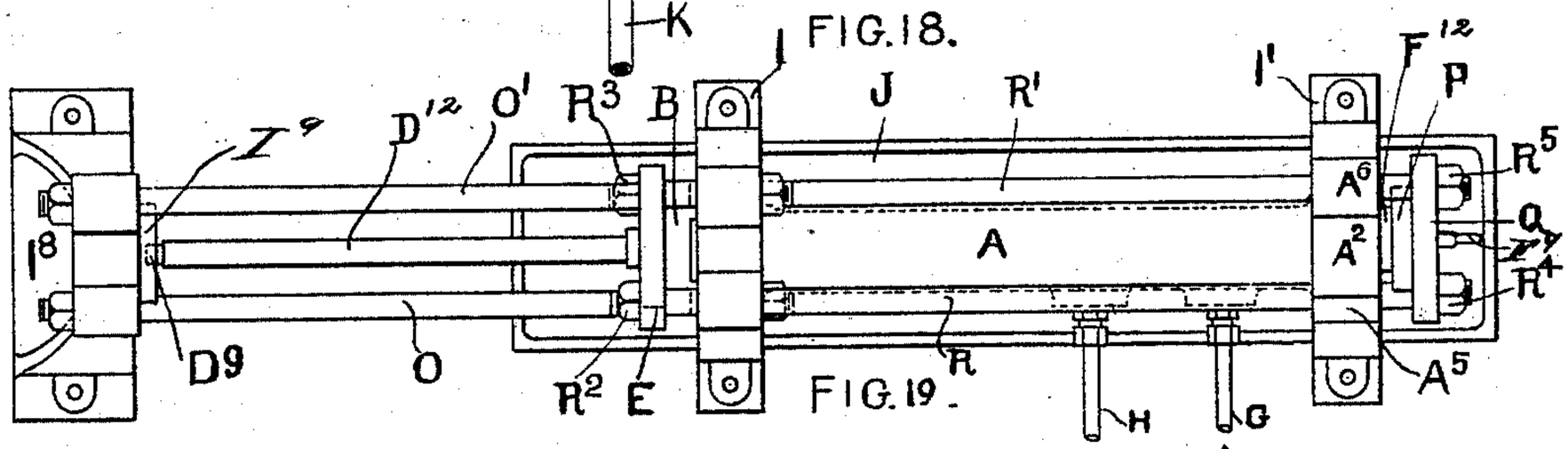

FIG. 19.

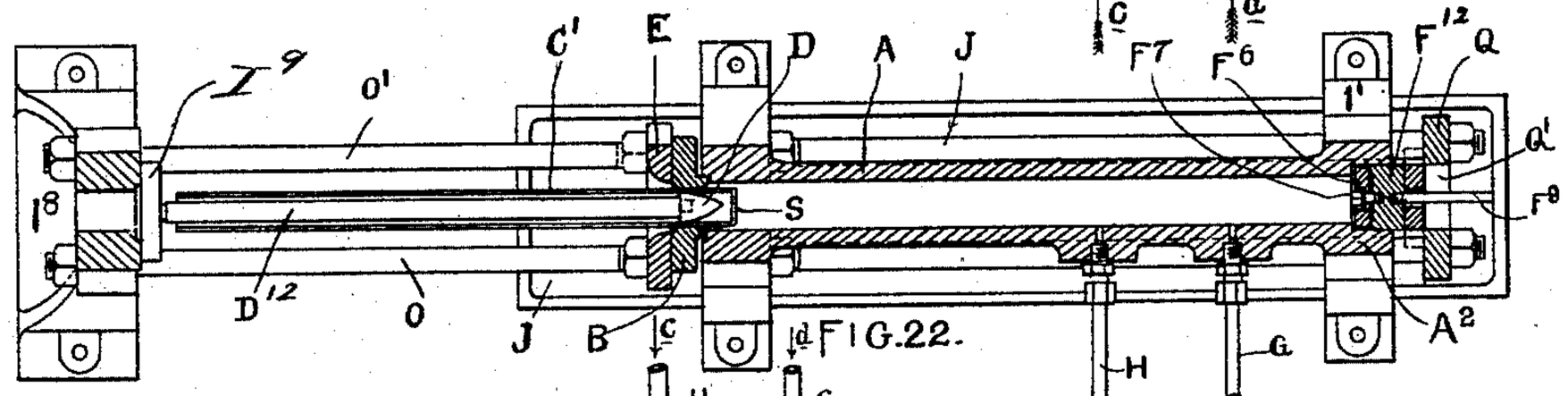

FIG. 22.

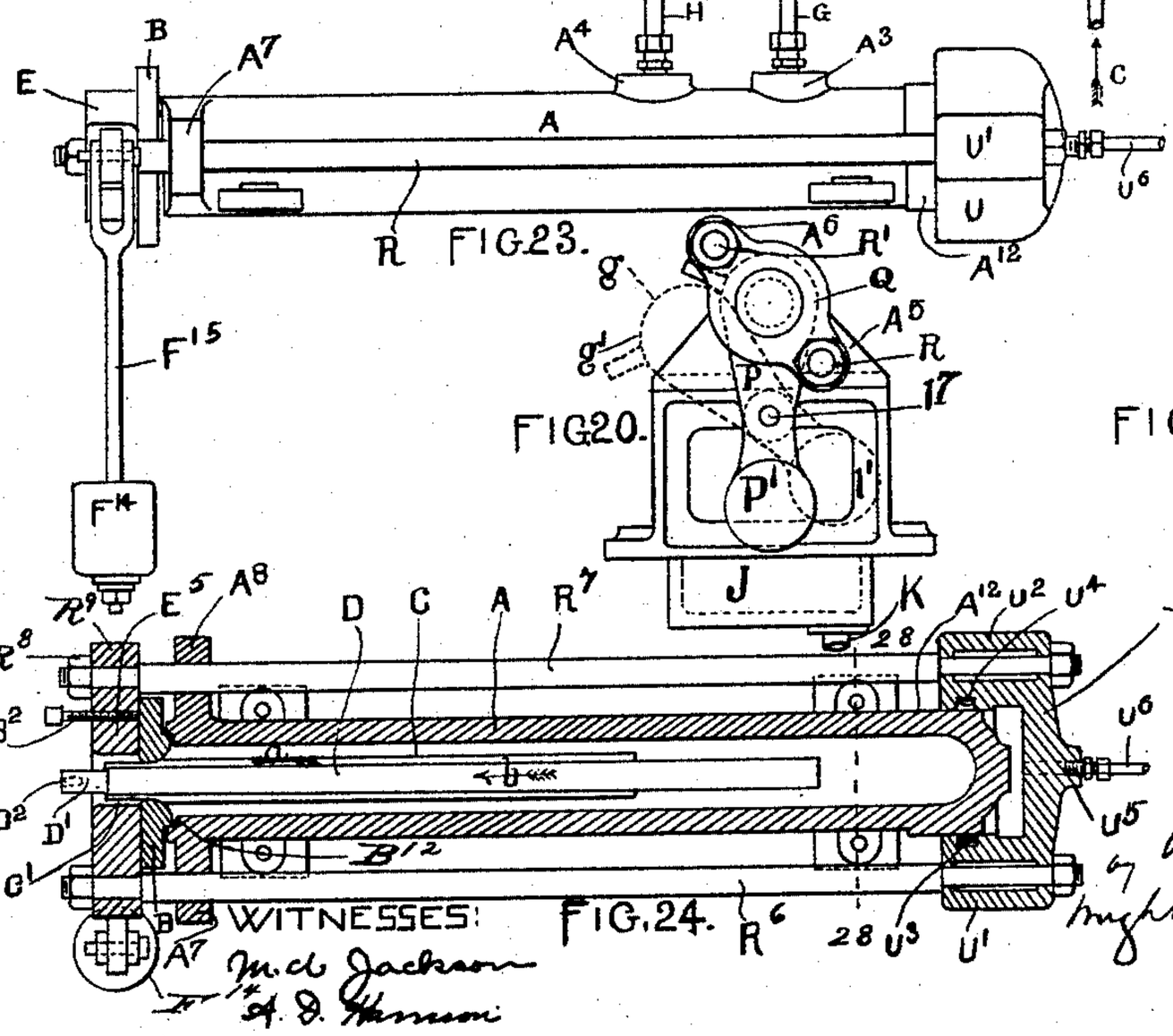

FIG. 23.

FIG. 20.

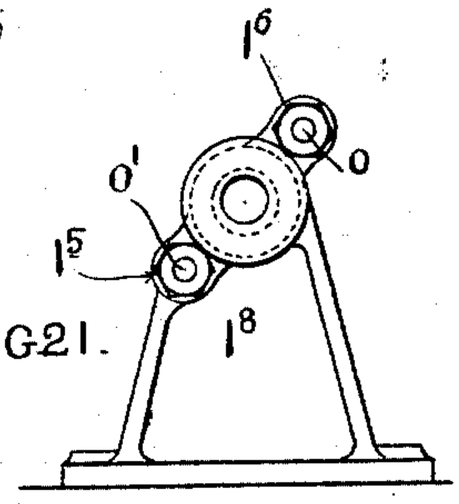

FIG. 21.

FIG. 24.

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METHOD OF AND APPARATUS FOR FORMING METAL ARTICLES.

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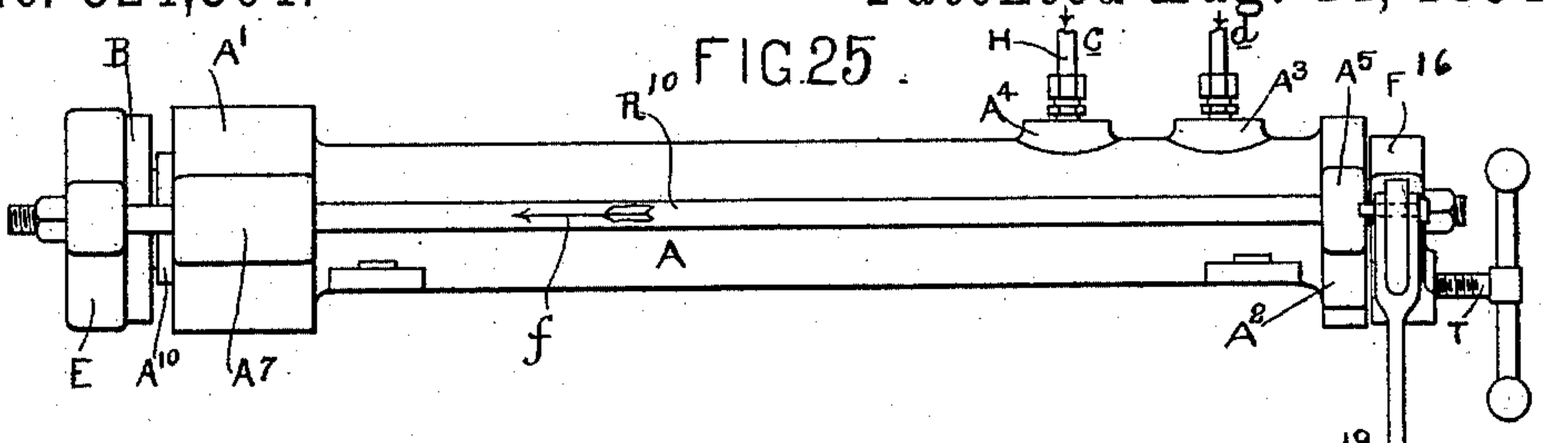


FIG. 25.

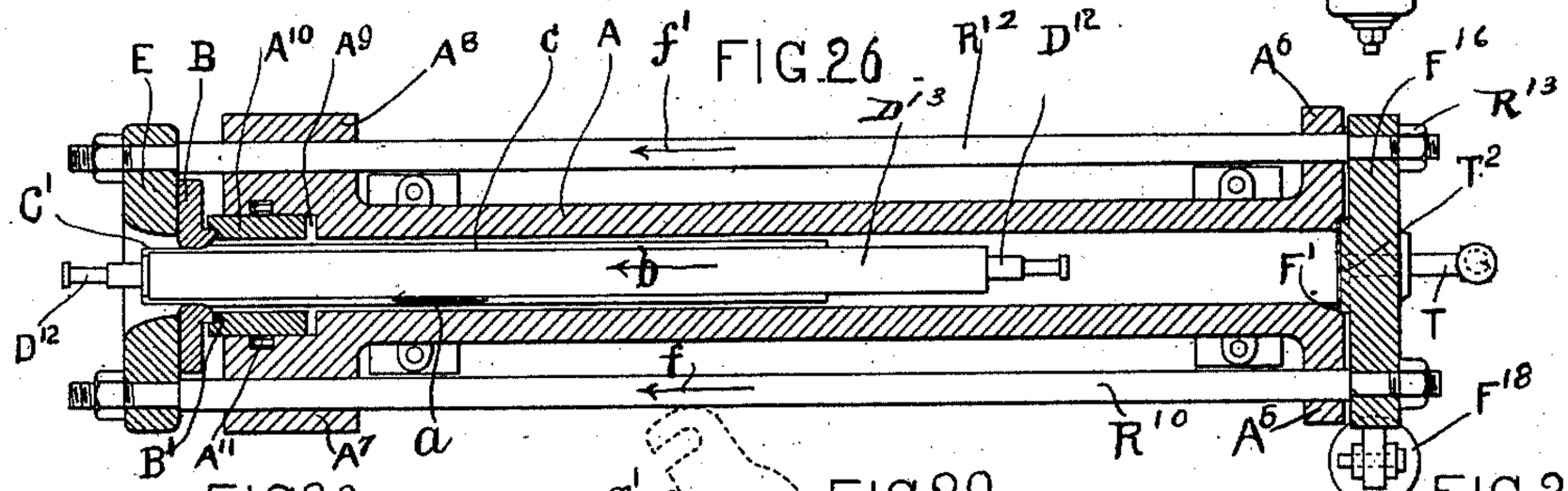


FIG. 26.

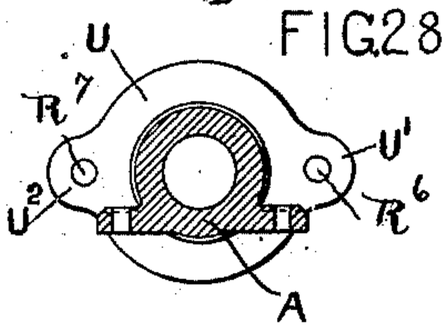


FIG. 28.

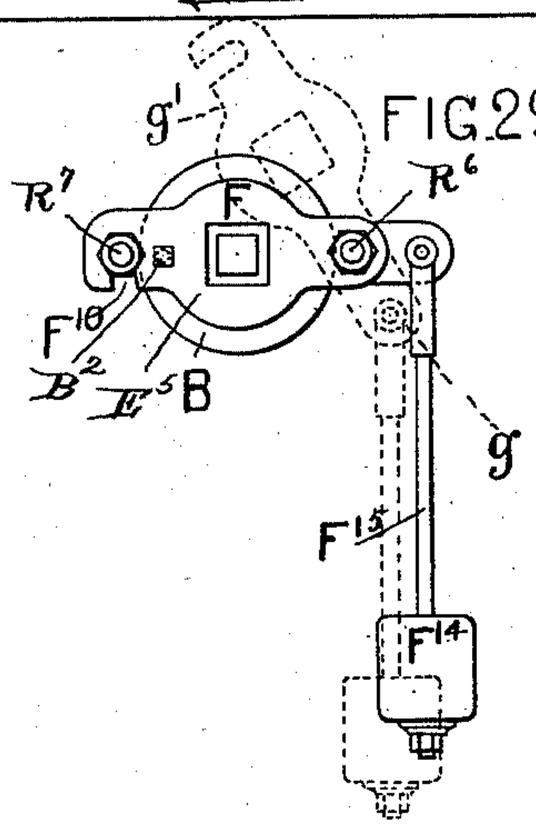


FIG. 29.

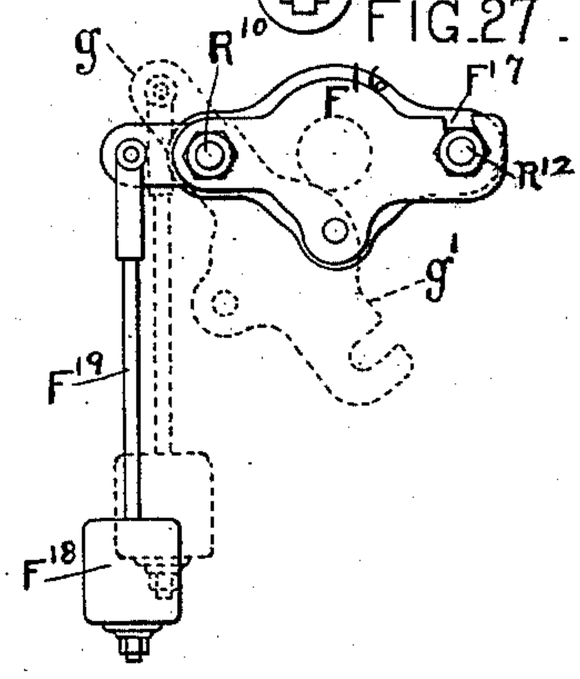


FIG. 27.

FIG. 30.

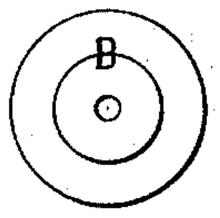


FIG. 31.

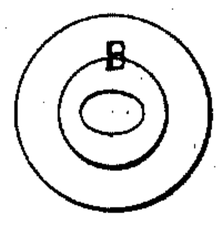


FIG. 32.

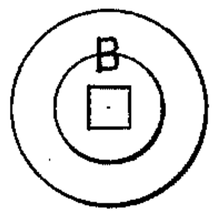
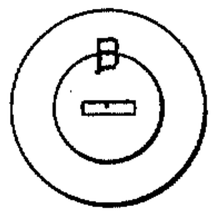


FIG. 33.



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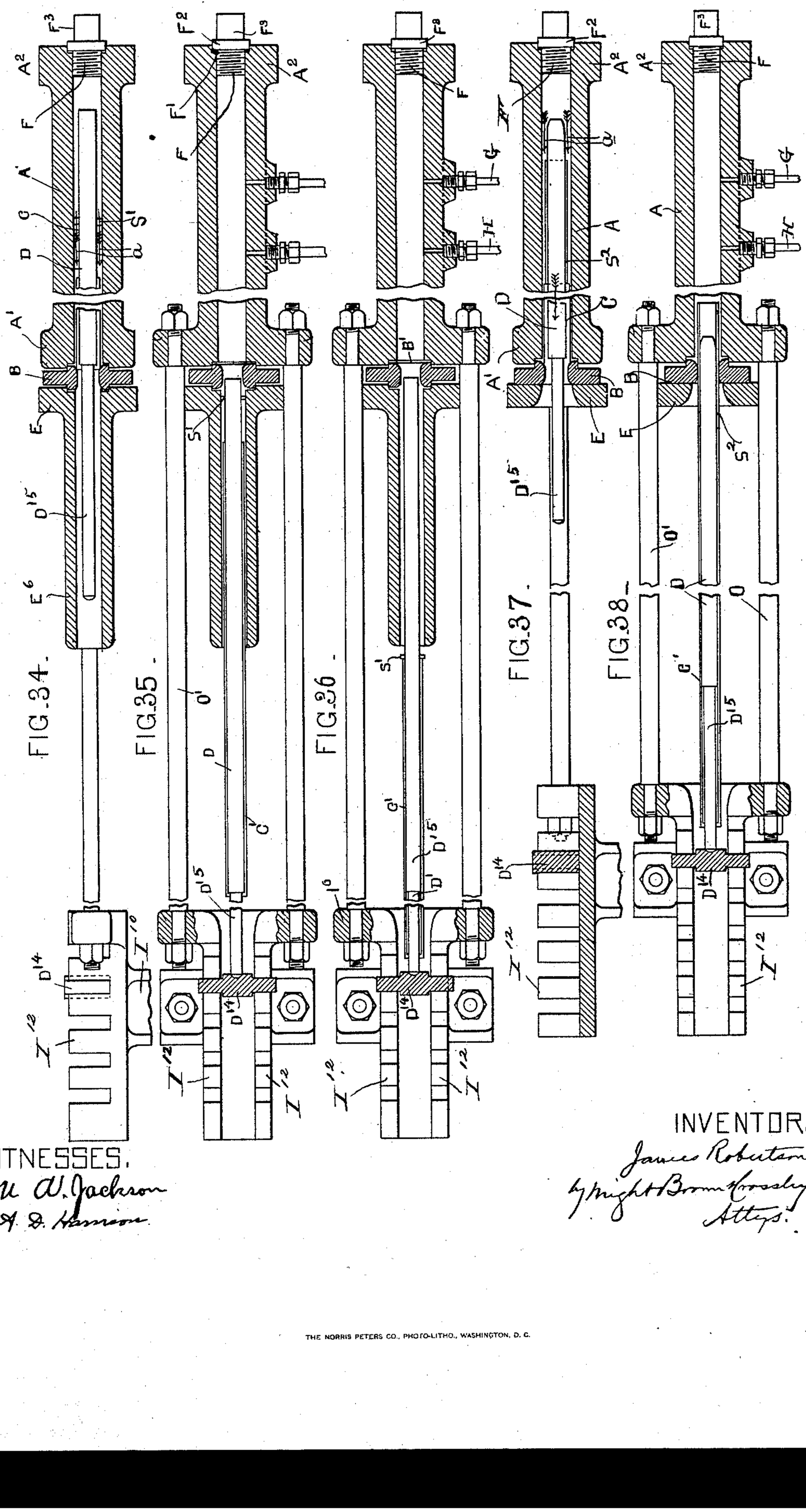
METHOD OF AND APPARATUS FOR FORMING METAL ARTICLES.

No. 524,504. Patented Aug. 14, 1894.



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(No Model.) 7 Sheets—Sheet 6.

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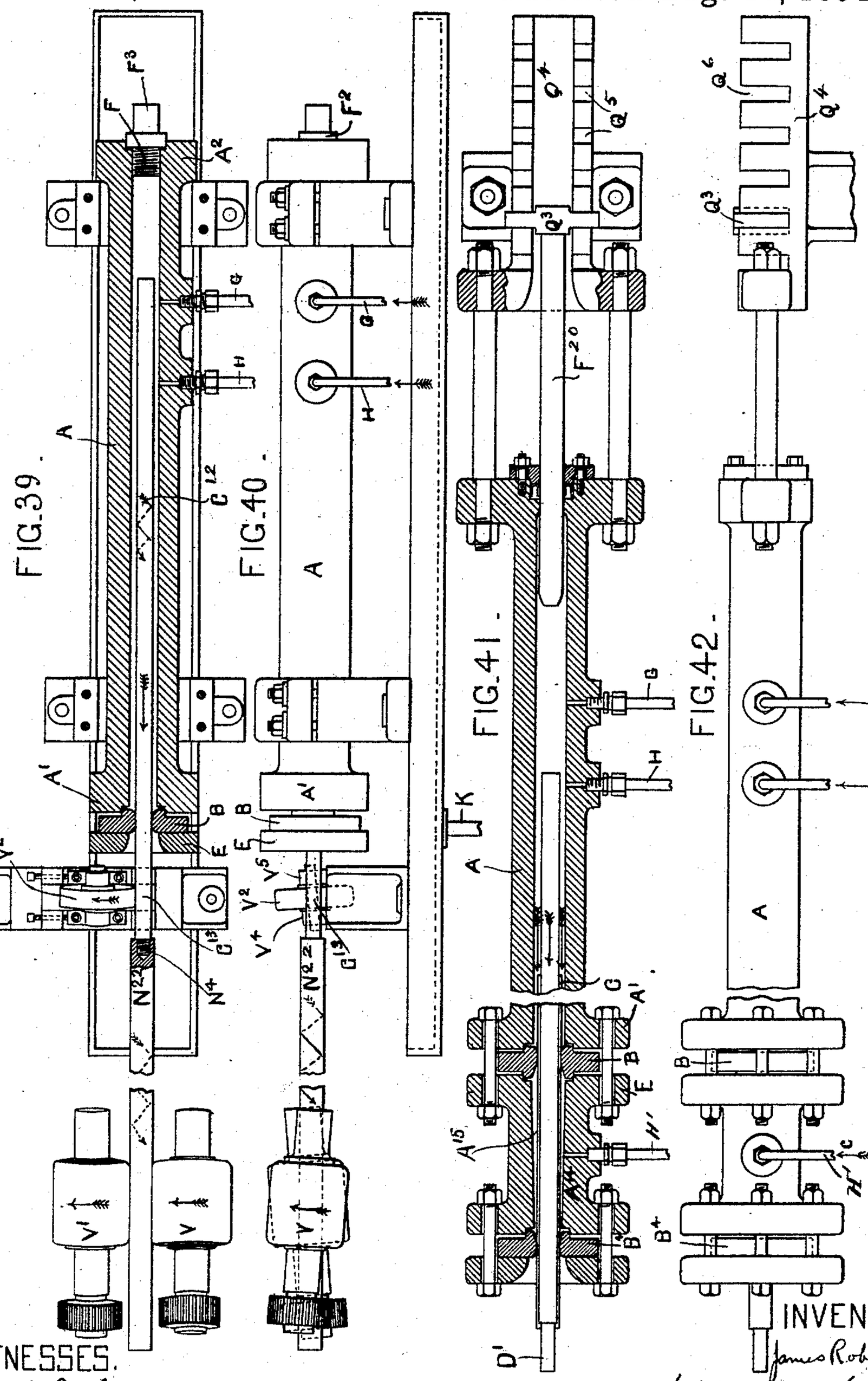
METHOD OF AND APPARATUS FOR FORMING METAL ARTICLES.

No. 524,504. Patented Aug. 14, 1894.



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METHOD OF AND APPARATUS FOR FORMING METAL ARTICLES.

No. 524,504. Patented Aug. 14, 1894.

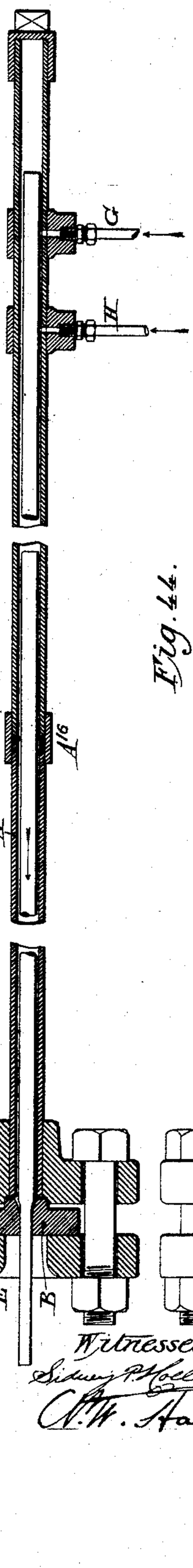

Fig. 43.

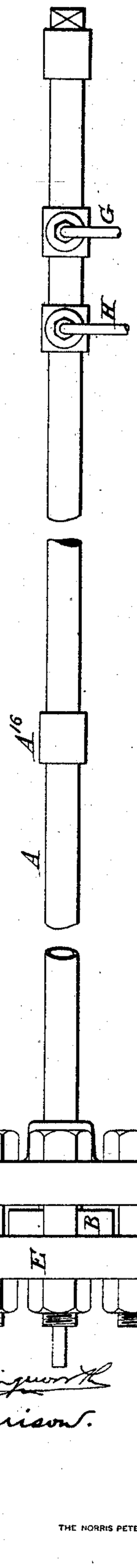

Fig. 44.

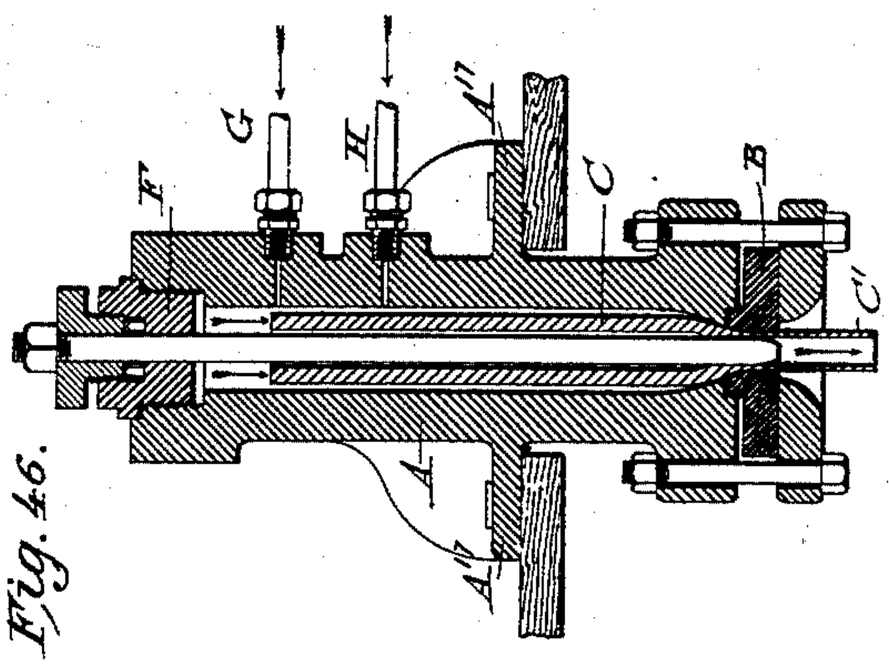

Fig. 46.

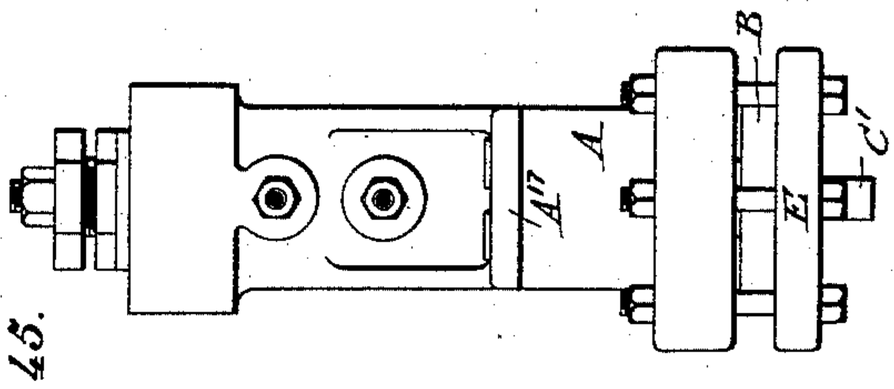

Fig. 45.

Witnesses
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C. W. Harrison.

Inventor;
JAMES ROBERTSON,
by his attorneys,
Wright, Brown & Quinby

UNITED STATES PATENT OFFICE.

JAMES ROBERTSON, OF MANCHESTER, ENGLAND.

METHOD OF AND APPARATUS FOR FORMING METAL ARTICLES.

SPECIFICATION forming part of Letters Patent No. 524,504, dated August 14, 1894.

Application filed September 30, 1893. Serial No. 486,869. (No model.) Patented in England October 14, 1893, No. 19,356.

To all whom it may concern:

Be it known that I, JAMES ROBERTSON, a subject of the Queen of Great Britain and Ireland, residing at Manchester, Lancashire, England, have invented certain new and useful Improvements in Methods of and Apparatus for Forming Metal Tubes, Tubular and Hollow Articles, Rods, Bars, Wires, and Plates, (for which I have obtained British Letters Patent No. 19,356, dated October 14, 1893,) of which the following is a specification.

This invention relates to the manufacture of metal rods, bars, tubes, tubular articles, plates and wires, by a drawing operation involving the movement of the mass of metal from which the finished article is to be made through a die of smaller cross-sectional area than the blank or mass of metal, the die compressing and forming the metal as the latter moves through it.

The invention has for its object to form metal articles by a drawing operation, without injury to the article being formed or to any part thereof by the pressure against it of the appliance used to impart the motion which carries it through the die, and without the employment of complicated and expensive mechanism.

The invention also has for its object to form metal articles by a drawing process, and at the same time prevent the drawing die and other appliances used in connection therewith from becoming unduly heated, and to keep said die and the metal acted on thereby constantly lubricated during the drawing operation.

The invention also has for its object to enable tubular articles to be formed by a drawing operation, in such manner as to obviate liability of breaking the tube crosswise during the forming operation.

The invention consists, first, in compressing and forming a metal article by confining the blank or partially-formed mass of metal at the entrance to a drawing-die, and forcing a liquid against and around the length of said metal under sufficient continuously supplied pressure to push it through the die and thus impart to the cross-section of the metal the form of a die, the liquid pressure acting to force the metal forward without involving any injury to the completed article or any part thereof by the force used in driving the metal through the die.

The invention also consists in certain improvements in apparatus for compressing and forming metal articles, comprising a container, having a liquid-inlet, and an outlet formed as a drawing-die adapted to compress and form a mass of metal forced into it from the container, the arrangement being such that a blank or mass of metal placed in the container with one end presented to the die will be forced through the die by the pressure of a liquid introduced into the container through said inlet.

The invention also consists in certain other improvements employed in connection with the said container and drawing-die, all of which I will now proceed to describe and claim.

Of the accompanying drawings, forming part of this specification: Figure 1 represents a horizontal section, showing a container provided with an outlet formed as a drawing-die, and with a liquid-inlet, in accordance with my invention. Fig. 2 represents a side elevation of the construction shown in Fig. 1. Fig. 3 represents an end elevation, showing the plate or head that secures the die to the container. Fig. 4 represents a rear end elevation of the container. Fig. 5 represents a section on line 5—5 of Fig. 2. Fig. 6 represents a side view of the mandrel shown in Fig. 1, after the completion of the forming operation, the completed tube being shown in section on said mandrel. Fig. 7 represents a sectional view and Fig. 8 a side elevation, showing the container, and means for supplementing the action of the liquid and aiding the same in moving the metal through the drawing-die. Figs. 9 and 10 represent respectively front and rear end elevations of the construction shown in Figs. 7 and 8. Fig. 11 represents a sectional view and Fig. 12 a side elevation, the former showing a blank closed at its forward end, and a mandrel having a liquid-channel to permit access of the liquid to the closed end of the blank. Fig. 13 represents an elevation of the forward end of the construction shown in Figs. 11 and 12. Fig. 14 represents an end view of the mandrel shown in Fig. 11. Fig. 15 represents a sectional view and Fig. 16 an elevation, the former showing the container

provided with a fixed mandrel adjustable from the rear end of the container. Fig. 17 represents an elevation of the rear end of the container shown in Fig. 16. Fig. 18 represents a vertical section and Fig. 19 a top plan view, showing a container, and a mandrel which is rigidly supported outside of the container. Figs. 20 and 21 represent respectively rear and front end elevations of the construction shown in Figs. 18 and 19. Fig. 22 represents a horizontal section, illustrating the construction shown in Figs. 18 and 19, and showing the position of the parts at the completion of the drawing operation. Fig. 23 represents an elevation and Fig. 24 a sectional view, showing a different arrangement of parts from that shown in the preceding figures. Fig. 25 represents an elevation and Fig. 26 a sectional view, showing another modification. Fig. 27 represents a rear end elevation of the construction shown in Figs. 25 and 26. Fig. 28 represents a section on line 28—28 of Fig. 24. Fig. 29 represents a front end elevation of the construction shown in Fig. 23. Figs. 30, 31, 32 and 33 represent side views of dies having differently-shaped forming orifices. Figs. 34, 35 and 36 represent sectional views, showing means for effecting the removal or disengagement of a tubular article from the mandrel over which it is formed by the liquid pressure. Figs. 37 and 38 represent a modification of the matter shown in Figs. 34, 35, and 36. Fig. 39 represents a top view, partly in section, and Fig. 40 a side view, showing means for rotating the article being formed and the mandrel during the forming operation. Fig. 41 represents a sectional plan view and Fig. 42 a side view, showing a different form of breech-plug and a different construction of die. Fig. 43 represents a sectional view, showing principally certain modifications in the form and construction of the container. Fig. 44 represents a plan view of the construction shown in Fig. 43. Fig. 45 represents a side view and Fig. 46 a sectional view, showing certain modifications in the form and arrangement of the container.

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

In the drawings: A represents a container or receptacle, of strong construction, adapted to sustain the high pressure of a liquid introduced into it, as hereinafter described. The container is of elongated form, and its interior cavity or chamber is formed to correspond to the general shape of the blank or mass of metal to be drawn. The container has at one end a discharge opening, through which the metal passes. At said opening is located a drawing-die B, which is or may be a plate of suitable metal, such as hardened steel, having an orifice, the walls of which are shaped to give the desired form to a mass of metal forced through the die, as usual in the operation of drawing-dies. The die constitutes, in effect, the outlet of the container, it being secured to the container in such manner that when liquid pressure is maintained within the container, the only outlet will be through the die. In the simplest form of apparatus embodying my invention, the die is or may be secured to the container by means of a head or plate E, which is secured by bolts E′ to a flange A′ formed on one end of the container. The plate E is thus removably attached, so that the die may be at any time removed and another one substituted for it, the die being placed loosely between the flange A′ and plate E. A water-tight joint may be maintained between the die and the container, by means of a packing-ring or washer B′ (Fig. 1) of leather or other suitable material.

G represents a pipe, communicating with the interior of the container, and adapted to conduct a liquid into the same. Said pipe is preferably connected with a hydraulic accumulator, loaded to give a sufficiently high degree of pressure to the liquid to cause the latter to push a blank or mass of metal inserted in the container through the die B.

In drawing tubular articles in accordance with my invention, I employ a tubular blank C, which is placed upon a mandrel D, the latter being arranged to co-operate with the die in compressing and shaping the blank into a tube of the desired form. The blank may be inserted loosely in the container and adapted to be moved through the die by the liquid-pressure, as shown, for example, in Fig. 1; or it may be fixed or rigidly supported, as shown, for example, in Figs. 15 and 18. When the blank is movable, as shown in Fig. 1, the pressure of the liquid in the container is exerted both on the mandrel and on the blank C, and both are forced together through the die, the mandrel moving somewhat more rapidly than the metal blank and supporting the metal within the die, the result being that the metal is drawn and elongated into a tube C′, which at the end of the operation is disposed upon the mandrel as shown in Fig. 6. The blank may be engaged with the forward end of the mandrel by means of an internal shoulder, formed originally on the forward end of the blank, and engaged with an external shoulder on the forward end of the mandrel, as shown in Figs. 1 and 6.

It will be seen that, if the die has an internal diameter of three and one-quarter inches ($3\frac{1}{4}''$), its cross-sectional area will be about eight (8) square inches. Assuming this to be the case, and assuming further that the internal diameter of the container is four and one-half inches ($4\frac{1}{2}''$), and that the external diameter of the mandrel is three inches ($3''$), and that the external diameter of the blank is three and one-half inches ($3\frac{1}{2}''$), it will be seen that a propelling liquid at a pressure of about five (5) tons to the square inch will exert a propelling force of forty (40) tons on the mandrel and blank, and will move both forward through the die, causing the blank to be drawn into the desired form and expelled in

the form of a completed tube from the container.

In Figs. 7 and 8, I show an adaptation of my invention to the drawing of a solid rod of iron from a blank C^5, the container and die being of smaller diameter than in the figures before described, no mandrel being employed. In this case, if the die have an internal diameter of one and one-eighth inch ($1\frac{1}{8}''$), its cross-sectional area will be about one (1) square inch. The internal diameter of the container being one and one-half inch ($1\frac{1}{2}''$), and the diameter of the blank one and three-sixteenths inch ($1\frac{3}{16}''$), liquid pressure of about sixteen (16) tons to the square inch would be suitable, it being preferable to employ a pressure which will not exert a crushing force upon the metal. As the crushing resistance of wrought iron is about eighteen (18) tons to the square inch, a pressure of sixteen (16) tons would be suitable. It will be seen that the liquid surrounds the blank in the container, and is in direct contact with the blank up to the point where the latter touches the die, hence the liquid lubricates the die and the metal passing through it, and thus facilitates the passage and formation of the metal. If desired, the die and blank, in this modification as well as in other forms described in this application, may be greased before the operation. For more complete lubrication than can be furnished by the preliminary greasing and by the action of a liquid which is not oleaginous, the impelling liquid introduced through the pipe G may be oil, in which case the great pressure employed would cause the oil to penetrate the metal to some extent, thereby insuring very complete lubrication.

In the modification shown in Figs. 7 and 8, the force of the liquid may be supplemented by an external pulling force, which may be exerted by means of a hydraulic piston-rod N^2, connected by a chain N^3 with the forward end of the rod C^5, said forward end being screw-threaded, as at C^6 (Fig. 7) and engaged with an internally-threaded socket M, connected to the chain N^3. The hydraulic piston-rod works in a hydraulic cylinder, and may be actuated in the usual way to exert a pulling force upon the metal passing through the die. In this modification, the hydraulic cylinder N is connected to the container by means of a stay-rod O, engaged with lugs N′ and A^8, formed respectively on the cylinder N and container A.

The figures above described constitute embodiments of all the fundamental features of my invention, the constructions hereinafter described showing various adaptations of my invention to special uses, and various alternative constructions that may be employed for the uses already described.

It will be seen that, among the advantages resulting from the drawing of metal articles by pushing the same through a drawing-die by the pressure of a liquid in direct contact with the metal, are the following:

First. The work is continuously lubricated.

Second. No mechanism is required to effect a return-motion, as in the ordinary forms of draw-benches, it being necessary only to shut off the impelling liquid after the drawing operation has been completed, thus preparing the container for a fresh operation.

Third. There is no possibility of injury to the finished article by the contact therewith of appliances used to impart motion to the metal. Heretofore it has been necessary to subject some part of the completed metal article to contact with some rigid appliance used to impart motion thereto, such contact changing the form of that portion of the metal with which it comes in contact, thus to some extent damaging and distorting the article. The pressure being in this case wholly effected by means of a liquid, there can be no distortion or change of form of the article excepting that resulting from the action of the die.

Fourth. The forward pushing pressure of the liquid upon the metal supports the metal, and obviates any liability of breaking the completed article transversely in the die, a liability that exists in the operation of ordinary draw-benches, particularly in drawing tubular articles.

Fifth. Great rapidity of action is attained, in consequence of the lubricating, cooling and supporting action of the liquid.

I prefer to provide the container with two liquid-inlets, one being the inlet G already described, for liquid under the high working pressure; the other being a pipe H, which is connected with a source of liquid supply at a relatively low pressure, sufficient only to properly fill the container and the interstices between the container and the blank, and between the blank and the mandrel in case the blank is slightly larger than the mandrel, which I consider preferable. The pipe H may be connected with any suitable source of water-supply, such as a cistern. In the operation of the apparatus, liquid is first introduced under low pressure through the pipe H, and afterward the high pressure liquid is introduced through the pipe G, one object of the employment of the pipe H being to insure the filling of all parts of the container with a liquid before motion is imparted to the blank through the die.

A convenient means for supporting the container A is shown in Figs 2 and 5, the same comprising stands or brackets I I′, having angular seats or recesses I^2 in their upper portions, and correspondingly-shaped blocks I^3 secured to said brackets by bolts I^4, the seats I^2 and blocks I^3 being formed to bear upon the cylindrical surface of the container at four points, as shown in Fig. 5. The bolts I^4 permit the blocks I^3 to be adjusted and thus adapted to containers of different diameters, so that the supporting-means will suit various

containers within a considerable range of external diameters, it being desirable to provide several sizes of containers, adapted for as many sizes or varieties of work and readily interchangeable, each container, particularly in the smaller sizes, being of but small expense.

In Fig. 11, I show the blank C closed at its forward end by means of a screw-threaded plug C^3, inserted in an internally-threaded socket C^6 formed by slightly reducing and tapping the forward end of the blank. The head thus formed receives the pressure of the liquid in the container. I employ in this case a mandrel D^6, which has a greater cross-sectional area than the die, so that it cannot pass through the latter, and is placed loosely in the container, its forward end D^3 being suitably hardened and beveled, so that it can partially enter the die, as shown in Fig. 11. The mandrel D^6 is self-adjusting, and finds its proper place in the die, and serves to co-operate with the die in gripping and drawing the walls of a tubular blank, without being held in position by any means except the blank and the liquid pressure which is exerted upon the rear end of the mandrel. The mandrel has a channel D^4 passing through it, to permit the water to gain ready access to the head C^3. The strain or pressure of the liquid exerted on the head C^3 may be regulated by means of a throttling or adjusting valve D^5, as shown on a larger scale in Fig. 14, said valve being in substance a screw, having slots or channels in the periphery of its tapered head, and arranged so that when turned in one direction it will contract the flow of water to the channel D^4, and when turned in the opposite direction will increase said flow.

In Figs. 15 and 16, I show a mandrel D^7, affixed to an elongated stem-rod D^8, the rear end of which is engaged with a breech-plug F hereinafter described, affixed to the rear end of the container, so that the mandrel is rigidly secured relatively to the die during the drawing operation. The blank has the head C^3 described in connection with Figs. 11 and 12, the liquid having access to said head through orifices D^9 in the mandrel. The breech-plug F forms part of a stuffing-box F^4, which includes a stuffing-nut F^5 through which the mandrel-rod D^8 passes, the rod being secured to the stuffing-nut by means of a nut D^{10}, engaged with the threaded rear end of the rod D^8. By adjusting the nut D^{10}, the mandrel may be adjusted as to its projection into the die. This provision for adjusting the mandrel enables the thickness of the tube to be varied within certain limits, using the same die and mandrel.

The container is provided in every case with a supply-opening, which is preferably located at the end of the container opposite the die B, said opening being of sufficient size to receive the blank and the mandrel when the mandrel is employed. A removable water-tight closing-piece or plug is employed to close the supply-opening during the drawing operation, the plug being removed to permit the insertion of the blank or the blank and mandrel.

In the figures already described, the closing-piece for the supply-opening is shown as a screw-threaded breech-plug F, engaged with an internal thread formed in a seat or enlargement A^2 at the rear portion of the container, said plug being also shown as provided with an enlargement F^2 and a shank F^3 to be engaged by a wrench or turning-key, whereby the plug may be screwed into and out of its operative position. A packing-ring or washer F′ may be placed against the inner side of the enlargement F^2 to insure a tight joint when the plug is screwed to place.

Figs. 18 to 22 inclusive show an embodiment of my invention, in which different means are employed for detachably securing the breech-plug, and in which the mandrel is supported by a stem-rod D^{12}, located outside of the container, and arranged so that the completed tube when ejected from the container will rest upon the said stem-rod D^{12}. The said stem-rod rests against an abutment-plate I^9, which is supported by a bracket I^8, the latter having sockets I^5 I^6, which receive stay-rods O′ O, said rods being also engaged with sockets A^7 A^8 formed on the container A. The abutment I^9 is removable from the bracket I^8, a seat being provided on said bracket for the abutment, so that abutments for different stem-rods may be used interchangeably. In this case, F^{12} represents the breech-plug which is not screw-threaded, and is formed to slide in a socket or seat formed to receive it in the rear portion of the container, the plug being therefore adapted to be pressed backwardly or outwardly by the liquid-pressure in the container. The plug is provided with a cup-leather packing F^{13} secured to it by a plate F^6 and screw F^7, said packing being arranged to be expanded against the seat in which the plug is movable by the liquid-pressure, so that said pressure maintains a tight joint around the plug. The plug is held in position by means of a cross-head or holder Q, which is secured to the container by means presently described, and a movable abutment P interposed between said holder and the plug. The holder or cross-head Q has an opening Q′ (Fig. 22) slightly larger than the plug, so that the latter may be removed through said opening by means of a handle F^9 when the abutment P is not in place. The abutment P is in this case pivoted to oscillate on a stud I^7, affixed to one of the supporting brackets of the container, and is provided with a weighted portion P′, which is arranged to normally hold the abutment in its operative position between the breech-plug and the holder or cross-head Q. When the abutment is in said position and the liquid pressure is exerted in the container, the plug is forced backward slightly, thus causing a

similar backward movement of the abutment and of the cross-head or holder Q. Said cross-head is connected by means of sliding stay-rods R R′ with the die-holding plate E, said stay-rods passing through and being adapted to slide in sockets formed on the supporting brackets I I′. The die B is in this case separable from the container, and adapted to move slightly toward and from the seat B′ formed at the discharge end of the container. The backward movement of the plug caused by the liquid pressure therefore moves the die B backward sufficiently to tighten the joint at B′. When the liquid-pressure is removed, the plug is free to move forward sufficiently to release the pressure on the abutment Q and permit the latter to be readily swung aside to permit the removal of the breech-piece, prior to the insertion of a new blank. When the blank has been inserted, the abutment is returned to place and the operation above described is repeated.

The liquid introduced through the pipe H at a low pressure fills the container, and has sufficient pressure to move the plug backwardly, thus tightening the parts, as above described.

The main advantage of the described means for supporting the breech-plug, in connection with the liquid-pressure for effecting the drawing operation, is the practical release of the breech-plug so that it can be readily removed when the liquid-pressure is discontinued, and the immediate rigid support of the breech-plug when the pressure is applied. The movability of the die B, and the tightening of the joint between it and the container by the backward movement of the breech-plug are incidental to the object above mentioned, the die constituting a convenient means for limiting the backward movement of the plug-supporting holder or cross-head.

I also show in Figs. 18 and 22 a removable piston S, which is placed in the container against the rear end of the blank, and is of a diameter preferably about equal to that of the blank, the rear end of said piston being closed, and constituting a head of considerable area against which the pressure of the liquid is exerted. The piston-piece S enables the drawing operation to be performed with the propelling liquid at a much lower pressure than would otherwise be possible, there being no movable mandrel. This arrangement is particularly adapted to the production of lap-welded iron tubes in a cold state. The cross-sectional area of an ordinary lap-welded iron boiler-tube three and one-half inches ($3\frac{1}{2}''$) in diameter is usually equal to two (2) square inches. By using the propelling liquid at a pressure of sixteen (16) tons to the square inch, a drawing force or pressure is exerted on the blank of thirty-two (32) tons, which, with the forced lubrication caused by the impelling-liquid, is sufficient to cold-draw lap-welded iron tubes, a result which I believe has not been accomplished heretofore.

In Figs. 23 and 24, I show a modification, in which the supply-opening of the container is at the forward end, namely, the end where the die is located, the die being in this case affixed to a holder E^5, which is pivotally mounted upon a stay-rod R^6, so that it can swing to and from its operative position, as shown in full and dotted lines in Fig. 29. The holder E^5 is provided at one end with a segmental slot F^{10}, which, when the holder is in its operative position, receives a stay-rod R^7, the holder being interposed between a shoulder R^9 and a nut R^8 on said rod, as shown in Fig. 24. The rods R^6 and R^7 are fitted to slide in sockets formed in ears A^7 A^8 on the container A, the rear ends of said rods being connected with a cap-piece U, which is fitted to slide upon a seat A^{12} formed on the rear end of the container. The die B, its holder E^5, the rods R^6 R^7 and the cap-piece U have an endwise sliding motion upon the container, of sufficient extent to permit the die to enter and leave a socketed seat or bearing B^{12} at the forward end of the container. The cap-piece U has an inlet-pipe U^6, screwed into a socket U^5 in said cap, through which the liquid under pressure may be introduced into the space between the cap-piece and the rear end of the container, said liquid being confined in said space by a packing-ring U^4 (Fig. 24). Preparatory to the drawing operation, liquid is admitted into the cap-piece U, and its pressure moves the cap-piece, die-holder and die inwardly, thus bringing the die to a water-tight bearing upon the forward end of the container. After the drawing operation, which is effected in the manner already described by the introduction of the liquid into the container, the liquid-pressure may be removed from the cap-piece U, leaving said piece and the die-holder and die free to move in the opposite direction, the cap-piece separating the die from its bearing and permitting the die and die-holder to swing away from the discharge end of the container, as indicated in dotted lines in Fig. 29, thus enabling the container to receive a blank and mandrel. It will be seen, therefore, that the supply-opening of the container may be at either end thereof, said opening being shown in the rear end in the figures previously described, and at the forward end in Figs. 23 and 24. In the construction last described, the die forms a part of the closing-piece for said supply-opening.

The pivoted die-holder E^5 may be partially counterbalanced by means of a weight F^{14}, suspended from said holder by a rod F^{15} (see Fig. 29).

The die, the die-holder E^5 and cap-piece U may be moved forward by means of a screw B^2, inserted in a tapped orifice in the holder E^5 and bearing at its inner end against the forward end of the container (see Fig. 24). When this screw is turned inwardly, it forces the holder E^5 and die B forward, thus disengaging the die from the forward end of the

container and permitting it to be swung aside with its holder.

In Figs. 25, 26 and 27, I show a construction adapted for heavier work, in which the breech-piece is too heavy to be conveniently handled in the manner set forth in connection with Figs. 18, 19 and 20. In this case, the breech-piece is an enlarged plate F^{16}, pivoted upon a stay-rod R^{10}, and having at its swinging end a segmental slot F^{17}, which, when the breech-piece is in place, engages a a stay-rod R^{12} and a nut R^{13} thereon. The breech-piece is partially counter-balanced by a weight F^{18}, suspended from said breech-piece by a rod F^{19}. The stay-rods R^{10} and R^{12} are fitted to slide in ears formed on the container, and are secured at their forward ends to the die-holder E, the breech-piece, stay-rods, die-holder and die being movable together endwise of the container, so that a projection T^2 on the inner side of the breech-piece may move into and out of a corresponding socket or seat in the rear end of the container (see Fig. 26), a packing-ring F′ being interposed between said projection and seat to insure a tight joint.

A^{10} represents a sliding annular piece, movable in a seat A^9 in the forward end of the container, and bearing against the die B. The surface area presented by said piece A^{10} and the surface of the die exposed to contact with the liquid in the container is greater than that of the projection T^2 of the breech-piece, hence, when the liquid-pressure is introduced into the container, said pressure, acting on the sliding piece A^{10} and die B as well as on the mandrel and blank, forces the piece A^{10}, the die, the die-holder, the stay-rods and the breech-piece forward, thus tightly seating the breech-piece upon the rear end of the container. When the pressure is removed, the breech-piece and the parts connected therewith can be moved backwardly in any suitable way until the projection T^2 of the breech-piece is removed from the seat in the container, the breech-piece being then free to be swung upon its pivot to uncover the supply-opening of the container, as indicated in dotted lines in Fig. 27.

The breech-piece and the connected parts may be drawn backwardly by means of a screw T, inserted in a tapped socket in the breech-piece, and arranged to bear on the end of the container below the supply-opening, said screw, when turned inwardly, forcing the breech-piece backwardly.

In Fig. 26, I show, instead of a mandrel, a core or body D^{13}, constituting the body of a printer's roller, the tube C′ formed by the drawing operation being intended to remain as a permanent covering upon said body, the metal used in this case being usually copper.

It will be seen that my invention is well adapted for the overlying and casing of the cores of printers' rollers and other like articles, there being no necessity of providing the tube formed by the drawing operation with any additional length to be laid hold of by drawing-pinchers or tongs or to receive the action of hydraulic rams or other means heretofore used for forcing the metal through drawing-dies. Hence the blank can be so proportioned that it will exactly cover the article or core upon which it is to be laid without requiring the trimming off or removal of any considerable part. Hydraulic rams, pump-plungers, rods and tubes may be readily incased in this way, as also may non-metallic articles made of any moderately rigid material, such as wood.

Figs. 30, 31, 32 and 33 show drawing-dies, having various forms such as may be used in my improved apparatus.

In Figs. 34, 35 and 36, I show means for arresting a movable mandrel after the completion of the drawing operation and holding the mandrel in such position that the continued pressure of the liquid from within the container will act to push off the tubes formed by the drawing operation, or to expand and loosen the tube while on the mandrel, so that the tube can be easily removed by hand. To this end, I provide a stop or abutting-piece D^{14}, located at a suitable distance from the discharge end of the container and adapted to arrest the mandrel just as its rear end is about leaving the die, as shown in Fig. 35. The mandrel D preferably has an extension D^{15}, projecting forward from the forming portion of the mandrel, the stop D^{14} being located at a sufficient distance from the die to accommodate said extension, so that when the mandrel is arrested there will be sufficient room between the forming portion of the mandrel and the stop for the reception of a part if not all of the tube when the latter has been forced from its seat upon the mandrel by the liquid-pressure, as indicated in Fig. 36. I prefer to provide the container with a guide or extension E^6, which extends forward from the die B, its interior being bored out as a continuation of the interior of the container, so that an annular piston-piece or packing-ring S′, placed loosely in the container behind the blank, as shown in Fig. 34, can pass into the guide E^6 and continue to move the completed tube forward after the arrest of the mandrel by the stop D^{14}. In the operation of this embodiment of my invention, the positions of the blank, mandrel and piston at the beginning of the operation are as shown in Fig. 34. The liquid-pressure being exerted in the container, said parts are pushed forward until the tube has been formed and moved out of the die, the piston S′ following the tube. The motion of the mandrel is arrested at this point, but the pressure continues, and is exerted through the piston S′ upon the rear end of the completed tube within the guide E^6, thus forcing the tube forward upon the extension D^{15}, as shown in Fig. 36. In Figs. 37 and 38, I show a similar arrangement, excepting that the guide E^6 is omitted, and, instead of a ring-shaped piston S′, I em-

ploy a piston S^2 of elongated form, which, as here shown, is a cylinder, open throughout its entire length, and presenting a sufficient area of surface to the impelling-liquid to dislodge the tube from the mandrel when the parts reach the position shown in Fig. 28, the piston S^2 being of sufficient length to give the tube an independent forward motion without the piston passing entirely through the die. The stop D^{14}, in each of the instances above described, is shown as detachably secured to a head on a bracket I^{10}, said head being slotted to form a series of ears or projections I^{12}, arranged in pairs, the stop D^{14} having ears adapted to be engaged with either pair of said projections, so that a considerable range of adjustment of the stop is permitted.

In Figs. 39 and 40, I show means for rotating the article or blank C^{12} being formed during the drawing operation, thus reducing the frictional resistance of the die to the passage of the metal, so that the pressure required is not so great as it would be if the blank were not rotated. The means shown for rotating the blank are rolls V V′, mounted on shafts, which are arranged obliquely and at different inclinations, so that their rotation in contact with a rod N^{22} affixed to the forward end of the blank causes the rotation of said rod, and the blank, while it is moving forward, the result being a helical motion of the rod, the blank, C^{12}, and the finished article C^{13}.

V^2 represents a straightening-roll, the axis of which is obliquely arranged, said roll being arranged to bear on the finished article as it emerges from the die and straighten the same.

In Figs. 41 and 42, I show a container having a modified construction of breech-piece, the same being a cylindrical rod F^{20}, which is movable in a stuffing-box F^{21} at the rear end of the container, the rear end of the breech-piece F^{20} being supported by an abutment Q^3, adjustably secured by means of a head Q^4, having slots Q^5, between which are ears adapted to engage ears on the abutment Q^3. The abutment Q^3 is separable from the breech-piece F^{20}, and may be readily lifted out of engagement with the head Q^4 to permit the endwise removal of the breech-piece. Figs. 41 and 42 also show a drawing-die of peculiar construction, which I term a hydraulic die, and which is the subject of a separate application for Letters Patent, filed by me, said die comprising a casing or container, secured to the forward end of the container A, and provided with a liquid-chamber A^{15}, having an inlet-pipe H′, and dies or curbs B B^4 at opposite ends of said chamber, the die B being formed to closely fit the periphery of the blank and preferably to slightly reduce the same, the main object of said die being to prevent the escape of liquid from the chamber A^{15}; while the die B^4 is of smaller diameter, and is formed to tightly fit the metal as shaped or reduced by the compressing action of a liquid in the chamber A^{15}, the main object of the die B^4 being also to prevent the escape of liquid from the chamber A^{15}. The blank is forced from the container, as already described, and in passing through the chamber A^{15} is compressed or crushed inwardly by the liquid-pressure in said chamber, a sufficiently high pressure being there maintained to effect the desired result.

Figs. 43 and 44 show a construction of the container A adapted particularly for use in connection with the said hydraulic die, the latter being particularly adapted to act on rods or small bars of considerable length. In this case, the container is composed of a series of tube-sections, connected by couplings A^{16}, and therefore adapted to be made of any length desired at small expense.

Figs. 45 and 46 show a container vertically arranged, and adapted for drawing soft metals, such as lead and tin into tubes. The container is shown as provided with two ears or brackets A^{17}, adapted to rest on a floor or other support. The general operation of the apparatus is substantially the same as described in connection with several of the preceding figures.

In drawing metals of a comparatively brittle nature, such as aluminum, by the use of my improved process and apparatus, I find that it is very advantageous to heat the impelling liquid, the liquid heating the blank to such an extent as will reduce the liability of the metal breaking or cracking during the drawing operation. The heating of the metal and of the article being formed in this manner constitutes a part of my present invention.

I do not claim herein certain modifications of my invention herein disclosed, the same forming the subjects-matter of five separate applications filed February 19, 1894, and numbered and embracing as follows: Serial No. 500,725 embraces the invention above disclosed in connection with Figs. 18, 19 and 22. Serial No. 500,726 embraces the invention above disclosed in connection with Figs. 2, 11, 14 and 15. Serial No. 500,727 embraces the invention above disclosed in connection with Figs. 7 and 8. Serial No. 500,728 embraces the invention above disclosed in connection with Figs. 39 and 40. Serial No. 500,729 embraces the invention above disclosed in connection with Figs. 41 and 42, said application, however, embracing other features of invention not now disclosed herein but disclosed in my British patent above referred to.

I claim—

1. The improved method of drawing a metal article, the same consisting in confining a body of liquid under continuously supplied high pressure around the entire length of a blank of metal at the entrance to an unobstructed or open drawing die, and preserving a practically uniform pressure of the liquid, thereby pushing the blank through said die and exerting a compressive strain thereon.

2. The improved method of drawing and lubricating metal articles, the same consisting in pushing a blank of metal through an unobstructed or open drawing die by the pressure of a continuously supplied liquid which is in direct contact with and surrounds the blank up to its point of contact with the die, and preserving a practically uniform pressure of the liquid during the movement of the entire blank through the die.

3. The improved method of drawing a metal article, the same consisting in subjecting a blank of metal to direct contact with a heated liquid under a pressure and pushing the blank by such pressure through an unobstructed or open drawing die, said liquid heating the metal and thereby reducing its liability to break or crack during the drawing operation.

4. The method of drawing metal articles, the same consisting in confining a blank at one side of a drawing die of smaller cross sectional area than the blank, pushing the metal through said die by the direct action of a liquid surrounding the length of the metal in the container and under continuously supplied pressure, and aiding the movement of the metal by a pulling force exerted in the same direction, as set forth.

5. The improved method of compressing or drawing a metal article, the same consisting in moving it through a confined body of liquid having a pressure sufficient to overcome the crushing resistance of the metal, the said pressure tending to compress the metal laterally and correspondingly elongate the same.

6. In an apparatus for compressing and forming metal articles, a container having a liquid-inlet, an outlet at one end formed as a drawing-die, a supply-opening at the opposite end, and a removable breech-piece or plug adapted to tightly close said opening.

7. In an apparatus for compressing and forming metal articles, a container having a liquid-inlet, an outlet at one end formed as a drawing-die, a supply-opening at the opposite end, and a removable breech-piece or plug adapted to close said opening, combined with a movable breech-piece abutment adapted to be displaced to permit the removal of the breech-piece, and means for rigidly securing said abutment in its operative position.

8. In an apparatus for compressing and forming metal articles, a container having a liquid-inlet, an outlet at one end formed as a drawing-die, a supply-opening at the opposite end, and a removable breech-piece or plug adapted to close said opening, combined with a movable breech-piece abutment pivotally mounted and adapted to be turned on its pivot to and from its operative position, and a cross-head or holder secured to the container and arranged to support the said abutment against pressure from within the container, said cross-head having an opening of sufficient size to permit the passage of the breech-piece, as set forth.

9. In an apparatus for compressing and forming metal articles, a container having a supply opening, a discharge-opening or outlet, and a liquid-inlet, combined with a movable supply-opening plug or closing-piece, a movable drawing-die, one of the two last-mentioned parts being adapted to be moved by the liquid-pressure, and connections between said parts whereby the movement of one is imparted to the other.

10. In an apparatus for compressing and forming metal articles, the combination of a container, having a liquid-inlet, a supply-opening at one end, and a discharge-opening at the other end; a drawing-die at the discharge-opening; a plug at the supply-opening; a holder or support for said plug, the said die, plug and holder having a limited movement endwise of the die; and connections between the said plug-holder and the die, whereby liquid-pressure in the container exerted on the plug is caused to make the plug-support rigid and to tighten the joint between the die and the container.

11. In an apparatus for compressing and forming metal articles, a container having a liquid-inlet and a discharge-opening formed as a drawing-die, combined with a loose mandrel of smaller cross-sectional area than the die and adapted to carry the article to be formed and to be forced through the die by liquid-pressure within the container.

12. In an apparatus for compressing and forming metal articles, the combination of a container having a liquid-inlet and a discharge-opening formed as a drawing-die, a loose mandrel movable through said die and carrying the article to be formed, and a stop arranged to arrest the mandrel at the end of the drawing operation and thereby permit the disengagement of the formed or drawn article from the mandrel by the liquid-pressure.

13. In an apparatus for compressing and forming metal articles, the combination of a container having a liquid-inlet and a discharge-opening formed as a drawing-die, a loose mandrel movable through said die and carrying the article to be formed and provided with an extension projecting forward beyond the forming-portion of the mandrel, and a stop arranged to arrest said extension at the end of the drawing operation, whereby the liquid-pressure in the container is caused to force the formed article from the forming part of the mandrel onto said extension.

14. In an apparatus for compressing and forming metal articles, the combination of a container having a liquid-inlet and a discharge-opening formed as a drawing-die, a guide affixed to the container outside of the die, the interior of said guide constituting a continuation of the interior of the container, a loose mandrel movable through said die and carrying the article to be formed, a stop arranged to arrest the mandrel at the end of the drawing operation, and a piston or follower adapted to be moved by the liquid-press-

ure behind the blank, said follower passing through the die and into the guide after the arrest of the mandrel and forcing the formed article before it.

15. In an apparatus for compressing and forming metal articles, a container having an outlet formed as a drawing-die and two liquid-inlets, whereby a liquid under a relatively low pressure may be first introduced and then a liquid under a higher pressure, said container being unobstructed from the liquid-inlets to the die.

16. In an apparatus for compressing and forming metal articles, a container having an outlet formed as a drawing-die, and a liquid-inlet, combined with supporting stands or brackets having angular recesses or seats for the container, and holding-down blocks having corresponding angular recesses or seats and adjustably secured to the brackets, said brackets and blocks being adapted to hold different containers.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 8th day of September, A. D. 1893.

JAMES ROBERTSON.

Witnesses:

ARTHUR CHARLES HALL,

JOHN THOMAS.