No. 814,306. PATENTED MAR. 6, 1906.

A. LEVEDAHL.

PNEUMATIC HAMMER.

APPLICATION FILED AUG. 27, 1904.

3 SHEETS—SHEET 1.

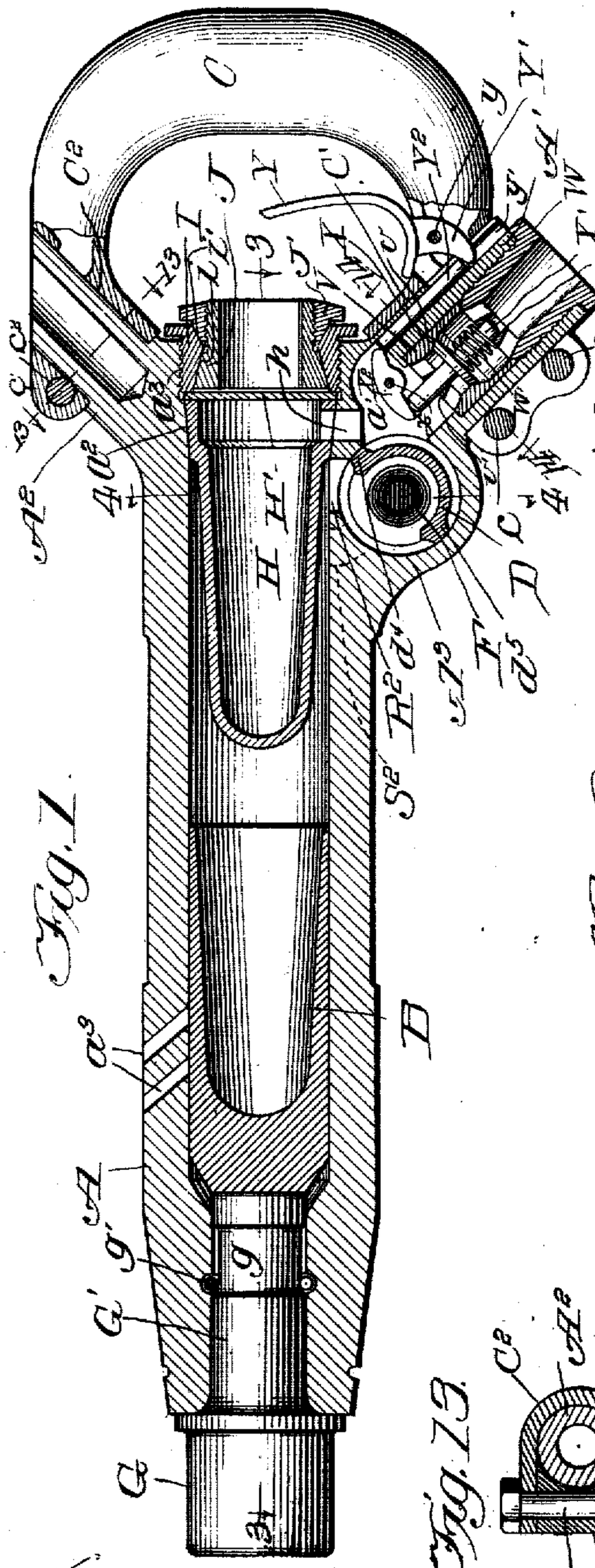

Fig. 1.

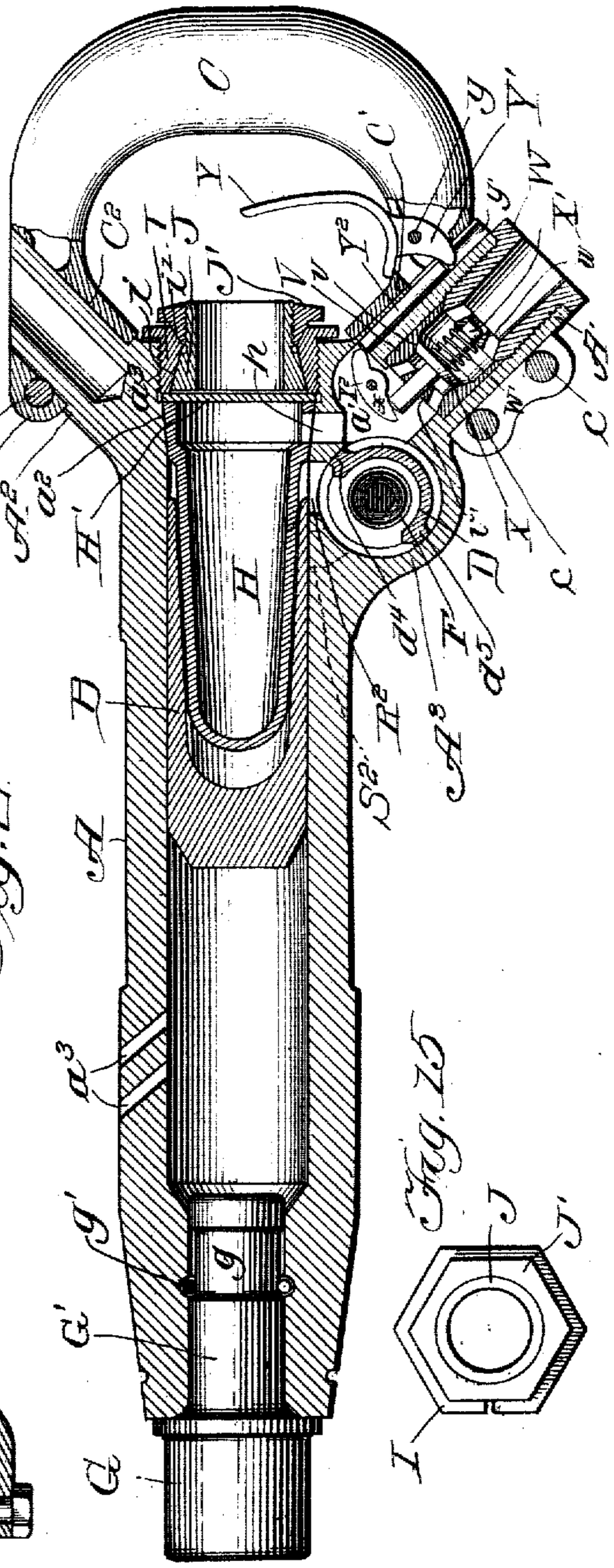

Fig. 2.

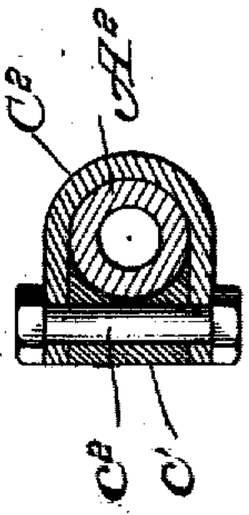

Fig. 13.

Fig. 15.

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3 SHEETS—SHEET 2.

Fig. 6.

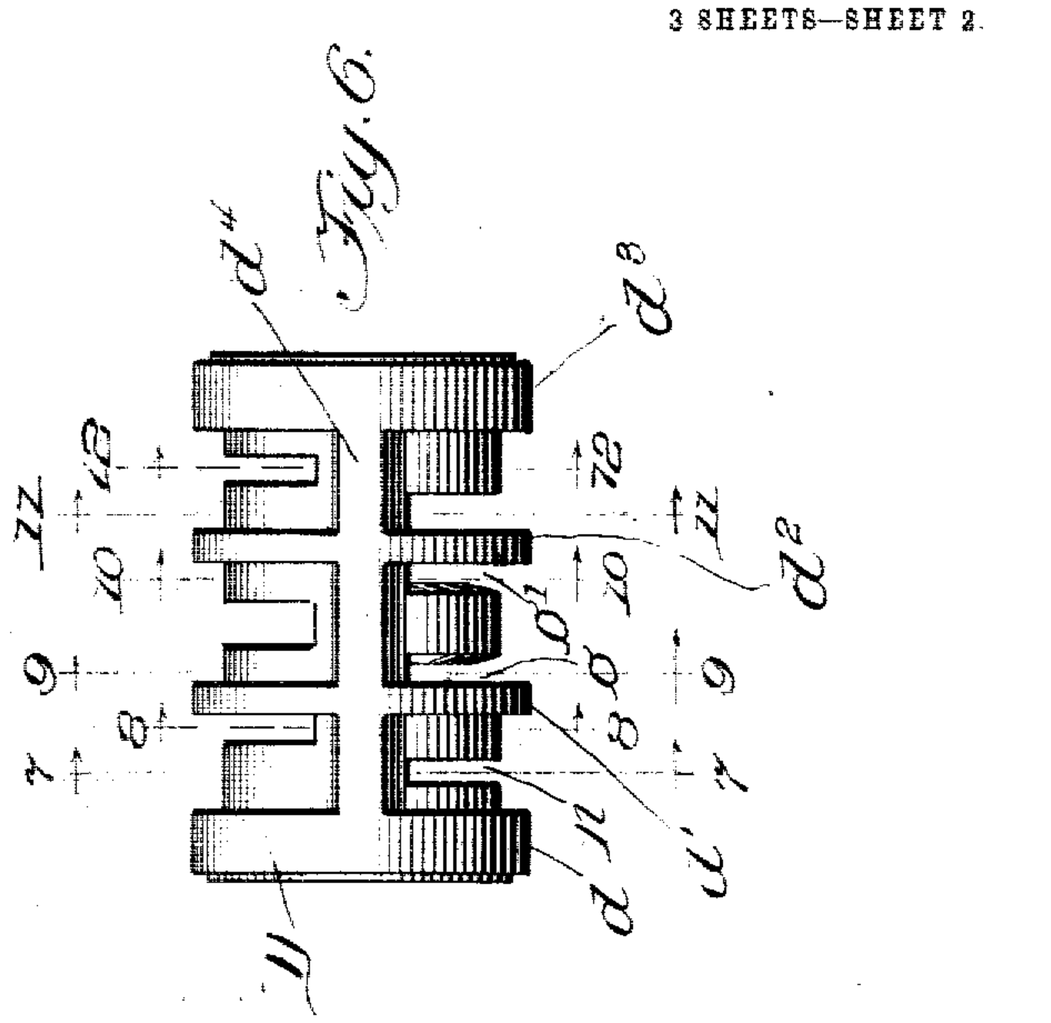


Fig. 1.

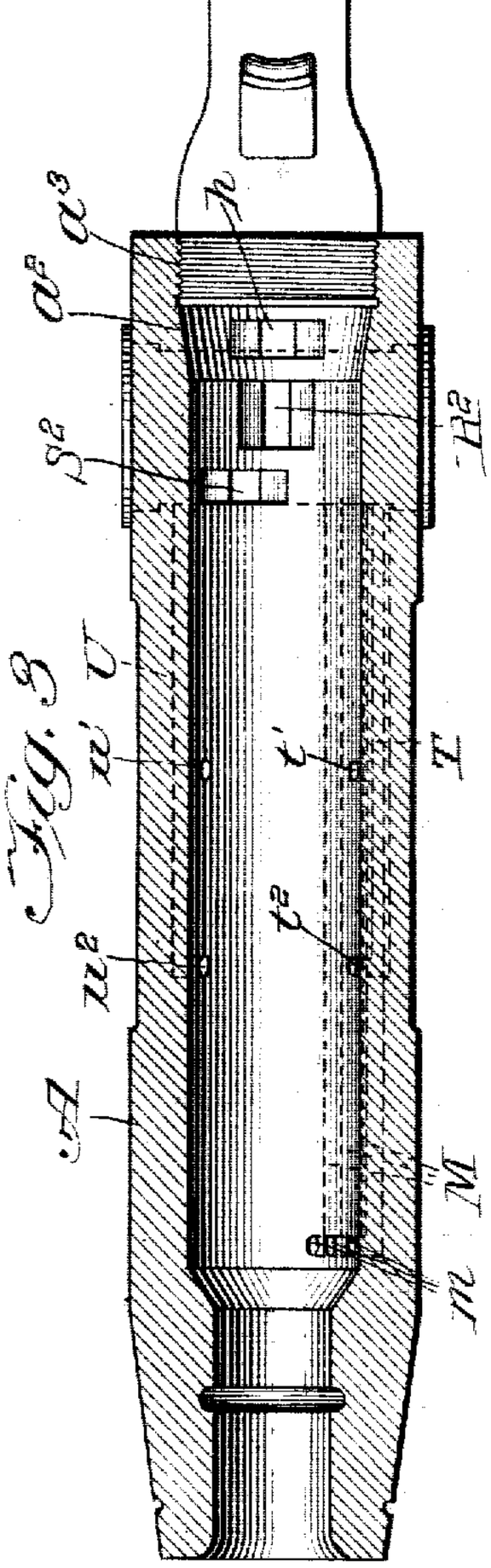
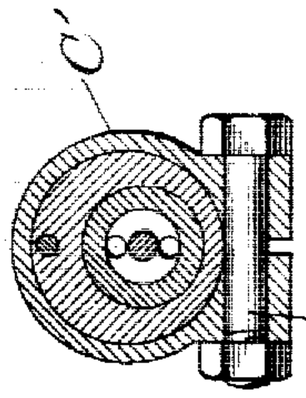


Fig. 4.



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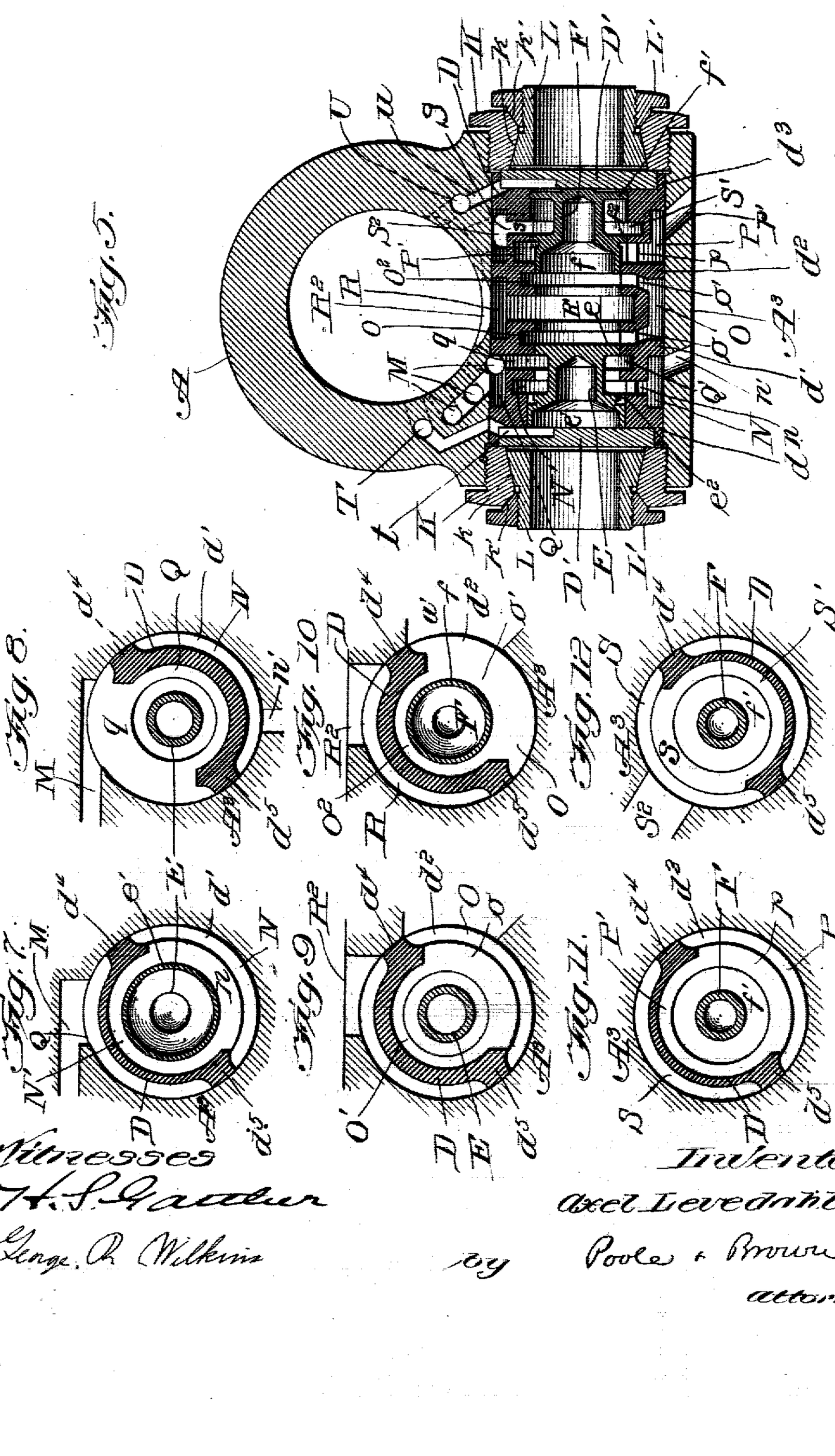
3 SHEETS—SHEET 3.



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UNITED STATES PATENT OFFICE.

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PNEUMATIC HAMMER.

No. 814,306. Specification of Letters Patent. Patented March 6, 1906.

Application filed August 27, 1904. Serial No. 222,455.

To all whom it may concern:

Be it known that I, AXEL LEVEDAHL, a citizen of the United States, residing at Aurora, in the county of Kane and State of Illinois, have invented certain new and useful Improvements in Pneumatic Hammers; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

This invention relates to a pneumatic tool in the nature of a portable pneumatic hammer or device of that kind embracing a barrel or cylinder, a piston or plunger adapted to slide endwise therein, and a controlling-valve through which air or other fluid under pressure is admitted to and permitted to escape from opposite ends of the cylinder to give reciprocatory movement to the plunger in the barrel.

The tool illustrated in the accompanying drawings is designed for use as a riveting-hammer; but the same features of construction illustrated in said drawings and herein claimed may be employed in a tool used for other purposes, as for chipping and the like.

The invention consists in the matters hereinafter described, and pointed out in the appended claims.

As shown in the drawings, Figure 1 is a view in central longitudinal section of a tool embodying my invention taken through the central axes of the barrel and throttle-valve and transversely through the controlling-valve. Fig. 2 is a like section showing a changed position of the parts. Fig. 3 is a view in central longitudinal section of the barrel of the tool with the handle attached thereto, but with parts therein removed, taken on the line 3 3 of Fig. 1. Fig. 4 is a view in cross-section of the barrel and controlling-valve, taken through the central axis of the valve-casing and showing the valve-pistons in elevation, said section being taken upon the line 4 4 of Fig. 1. Fig. 5 is a section like Fig. 4, showing a changed position of the valve-pistons and the latter in section. Fig. 6 is a view in side elevation of the valve-bushing. Figs. 7, 8, 9, 10, 11, and 12 are cross-sectional views of the valve-bushing and valve-pistons with the surrounding parts of the valve-casing, taken on the lines 7 7, 8 8, 9 9, 10 10, 11 11, and 12 12 of Fig. 6. Fig. 13 is a detail section taken on line 13 13 of Fig. 1. Fig. 14 is a detail section taken on line 14 14 of Fig. 1. Fig. 15 is a detail face view of the split thimble and clamping-sleeve and nut shown in Figs. 1 and 2.

In the preferred form of tool illustrated in the accompanying drawings, A indicates the working cylinder or barrel of the tool, B the sliding piston or plunger therein, and C a handle which is attached to the inner end or base of the barrel.

D indicates the bushing of the controlling-valve which is located within a cylindric recess or bore formed in a valve-casing A^3, which is located near the inner end or base of the barrel and cast integral therewith. The said controlling-valve is arranged with its central axis at right angles to the central axis of the tool and perpendicular to the plane of the handle C. The interior of the bushing D constitutes a valve-chamber in which is located two valve-pistons E and F which are adapted to slide endwise in the bushing and which form in connection with ports and recesses in said bushing the controlling-valve.

G is a riveting-tool of common type which is provided with a shank G′, that passes through and is guided in a guide-passage at the outer end of the barrel and the inner end of which projects into the barrel in position for contact therewith of the plunger B. The said shank G′ of the tool G is reduced in diameter between its ends to form a wide and shallow annular groove *g*, which receives a split ring *g′*, adapted to embrace the said reduced part of the shank and to fit in a groove G′, formed in the inner surface of the guide-passage of the barrel. The ring *g′* holds the tool from disengagement from the barrel, while permitting necessary endwise reciprocatory movement thereof.

The plunger B is exteriorly smooth or cylindric and is provided in its rear end with a recess or cavity extending nearly to the forward end of the plunger and which is preferably made of tapered form. The rear end of the barrel A is closed by means of an end wall shaped to form an air-displacing projection H, which projects into the barrel and conforms nearly to the shape of the cavity in the rear end of the plunger, so that it will practically fill said cavity in the plunger when the

latter is at the inward limit of its stroke, and thereby afford a minimum clearance space or area in the inner end of the barrel.

In the preferred form of construction illustrated in the accompanying drawings the bore of the barrel A extends through the rear end of the barrel and the air-displacing projection H has the form of a hollow body or shell, the open bore of which is inserted and secured within the end of the bore of the barrel, so as to close the latter and form the inner or rear end wall thereof. The hollow interior of the shell H thus constructed is utilized to form an air-chamber, the rear wall of which is formed by a disk or plate H′, which makes a tight joint with and closes the open end of said shell H. Said disk H′ is inserted and secured in the end of the bore of the barrel in contact with the rear margin of the shell H. The air-chamber so formed by the shell H, and disk H′ is in communication with the air-supply passage by which air is supplied to the valve-chamber of the controlling-valve and contains a reserve quantity of air under pressure designed to compensate for any momentary deficiency in the air-supply through the feed pipe or bore.

As a means for connecting the handle C with the inner end or base of the barrel A, said barrel is shown as provided with two outwardly and rearwardly extending integral arms A′ A^2, arranged obliquely with respect to the central axis of the barrel and which are engaged with obliquely-arranged sockets C′ C^2 on the ends of the said handle. Said arms are preferably made exteriorly cylindric. The socket C′ is split and its parts are clamped together and around the arm A′ by means of clamp-bolts *c c*, as seen in Fig. 14. The socket C^2 is formed in part by the metal of the handle itself and in part by a separate removable section (shown as having the form of a block *c*′) made concave on its inner face and inserted between parallel lateral extensions of the socket and held in place therein by means of a bolt c^2, inserted through the block and the parallel lateral extension of the socket. The socket C^2 is so made with a separable part in order to enable the oblique arms A′ A^2 to be inserted in the oblique sockets. When assembling the parts, the block *c*′ is removed, when both sockets may be engaged with the arms, and the said block is then inserted and clamped in place by the bolt c^2, which also acts to tighten the socket C^2 around said arm A^2. Said arm A′ is made tubular and constitutes the air inlet or supply passage of the tool, being adapted at its outer end for connection with a hose or air-supply pipe. Said arm A′, moreover, contains parts constituting a throttle-valve, as will be hereinafter described. The inner end of the bore of the said projection A′ communicates with a recess or chamber *a*′, which is located in the wall of the barrel adjacent to the valve-casing A^2 and which forms part of the air-supply passage and is in open communication with the central part of the controlling-valve chamber. Said recess or chamber *a*′ is connected with the air-chamber formed by the hollow projection or wheel H within the base of the barrel by a passage *h*, extending through the bore portion of said shell and the adjacent part of the wall of the barrel.

Now referring to the means by which the said shell H and the disk H′ are secured within the inner end of the barrel A, these parts are made as follows: The bore of the barrel A, as hereinbefore stated, is extended through the inner or rear end of the said barrel, and the latter is provided near said inner end of the barrel with a conical bearing-surface a^2, Fig. 3, which is tapered outwardly from the cylindric bore of the barrel and also between the said tapered surface a^2 and the inner end of the barrel with internal screw-threads a^3. The inner end of the shell H is enlarged and made conical on its outer surface to fit the bearing-surface a^2. The disk H′, hereinbefore referred to, which closes the inner end of the shell H, is flat and circular and fits within the end of the barrel, with its margin in contact with the inner end or base of the said shell H. I is a screw-threaded thimble which is inserted in the end of the barrel and has external screw-threads engaging the screw-threads a^3, said thimble being adapted to bear at its inner edge against the plate H′, so as to clamp said plate firmly against the inner margin of the hollow plug H and to also clamp or force the conical surface of the plug into close contact with the conical seat a^2. Said thimble I, Fig. 15, is split or severed at one point to make it expansible and is provided with oppositely-inclined interior conical surfaces *i i*′. Within the said thimble I and projecting from the outer end thereof is a tube or sleeve J, having at its inner end an exterior conical surface adapted to fit the interior conical surface *i* of the thimble I. The outer end of said sleeve J is made cylindric and screw-threaded and is surrounded by a ring or nut J′, having at its inner end a conical exterior surface to fit the conical surface *i*′ of the thimble I. Said nut also has at its outer end a flat-sided flange by which it may be turned. When the thimble I is screwed into the inner end of the barrel and brought into bearing against the edge of the plate H′, the nut J′ may then be tightened on the sleeve J, so as to draw the conical surfaces of the said sleeve and nut into the conical bearing-surfaces *i i*′ of said sleeve, thereby expanding the thimble within the barrel and rigidly clamping or holding said sleeve in place. Possibility of the loosening of these parts through the jarring of the tool due to the action of the reciprocating plunger is by the use of the clamping device described entirely avoided.

Now referring to the features of construction in the controlling-valve illustrated in the accompanying drawings, the bushing D of said valve is generally of cylindric form and is contained within a cylindric bore or passage extending through the valve-casing A^3 transversely of the barrel adjacent to the tubular arm A', which constitutes the air-supply passage of the tool. The interior of the said tubular bushing D constitutes the valve-chamber, which is closed at its ends by means of end plates or disks D' D', that are somewhat larger in diameter than the adjacent ends of the valve-chamber and are fitted at their margins in rabbets or annular recesses formed in the bushing around the ends of said valve-chamber. The bushing is held in place in the said bore or passage of the barrel by means of two thimbles K K, which enter the opposite ends of the said bore or passage and have screw-threaded engagement therewith. The inner edges of the said thimbles are adapted to bear against the marginal parts of the cap-plates D' D', so as to press the same firmly against the ends of the bushing and at the same time to hold the bushing from endwise movement. Said thimbles K K are transversely split or severed to make them expansible, as in the thimble I, hereinbefore described, and are provided with oppositely-inclined conical bearing-surfaces *k k'*. Within said thimbles are located sleeves L L, having inner conical ports adapted to engage the inner conical bearing-surfaces *k* of the thimbles and screw-threaded at their outer ends to receive annular collars or nuts L', which are provided with conical ports adapted to engage inner conical bearing-surfaces *k' k'* of said thimbles K. Said conical sleeves L and collars L' provide means for expanding the thimbles K K into binding contact with the surrounding wall of the transverse bore or passage of the barrel. The said bushing D is provided at its ends with outwardly-extending annular parts or flanges *d d'* and between its ends with like annular ribs or flanges d^2 d^3, which ribs or flanges have the same external diameter as the interior of the bore or passage of the valve-casing and fit closely therein when the bushing is in place in said bore. The said bushing is also provided at opposite sides thereof with longitudinal ribs d^4 d^5, Figs. 1 and 6, which extend between the ribs *d d'* d^2 d^3 and form therewith in the outer surface of the bushing six approximately semicircular depressions or recesses, which when the bushing is in place within the transverse bore of the valve-casing constitute, with the surrounding parts of the said casing, admission and exhaust chambers adapted to communicate with ports and passages formed in the casting which constitutes the barrel and valve-casing. The air-admission passage *a'*, formed in the base part of the barrel at the inner end of the air-supply passage, as hereinbefore described, opens into the central part of the said transverse bore or chamber of the valve-casing, and said barrel is provided with an inlet and exhaust port R^2, which opens through the wall or barrel at the inner end thereof and communicates also with the central part of said transverse bore. An exhaust-port S^2 extends from the inner face of the barrel near its rear end into one end of the said bore of the valve-casing, and exhaust and admission passages M M M extend longitudinally through the wall of the barrel and are connected with the outer end of the same by ports *m m m*, Fig. 3, said passages M M M being connected with the interior of said bore near the end of the same opposite that at which the exhaust-port S^2 is located. As clearly seen in Figs. 1 and 2, the bushing D is placed in said transverse bore in such manner that one of the external longitudinal flanges d^4 on the bushing comes in contact with the inner surface of the bore between the opening *a'* and the exhaust-port R^2, while the longitudinal rib d^5 at the opposite side of the bushing comes in contact with the diametrically opposite surface of said bore. The circumferential and longitudinal ribs or flanges on the bushing D form at the external side of the bushing or that adjacent to the air-supply passage between the said bushing and the wall of the valve-casing three spaces or chambers, as follows: between the ribs *d d'* an exhaust-chamber N, between the ribs *d' d^2* a supply-chamber O, and between the ribs d^2 and d^3 an exhaust-chamber P. Likewise at the inner side of the bushing, or that adjacent to the bore of the barrel, the space between the ribs *d* and *d'* constitutes a supply and exhaust chamber Q, the space between the ribs *d'* and d^2 constitutes an admission-chamber R, while the space between the ribs d^2 and d^3 constitutes an exhaust-chamber S. The exhaust-chambers N and P adjacent to the end of the bushing at the outer side thereof communicate with the outer air by means of exhaust-ports *n'* and *p'*, formed in the wall of the valve-casing. The admission and exhaust chamber Q, formed at the inner side of the bushing at one end thereof, communicates with the longitudinal exhaust and admission passages M M M, leading to the outer end of the barrel A. The intermediate chamber R at the inner side of the bushing is in communication with the admission-port R', leading to the interior of the inner end of the said barrel and communicates with a central passage R' in the bushing, which, in effect, divides the valve-chamber therein into two separate chambers or valve-seats, each of which contains one of the valve-pistons E and F. The exhaust-chamber S communicates with the interior of the barrel by the exhaust-port S^2. The said bushing D is provided between the external ribs thereon with transversely-ar-

ranged slots or openings forming valve-ports and within the interior or valve-chamber thereof with annular grooves or recesses, forming admission and exhaust passages, as follows: At the outer side of the bushing between the ribs d d' is a port n, which opens from the chamber N into an interior annular recess N'. Between the ribs d' and d^2 and opening from the chamber O are two ports o o', which open into annular interior recesses O' O², located at opposite sides of the central passage R'. Between the ribs d^2 and d^3 is a port p, which opens from the chamber P into an interior annular recess P'. At the inner side of the said bushing D between the ribs d and d' is a port q, which opens from the chamber Q into an annular recess Q'. Between the annular ribs d' and d^2 is located the central space or passage R', which extends into the bushing between the inner ends of the piston-valves E and F. Between the ribs d^2 and d^3 is formed a port s, which opens from the chamber S into an interior annular recess S'.

The valve-piston E has an intermediate reduced part or neck and at its inner end a cylindric flange e, which fits or slides in a valve-seat formed in the valve-chamber adjacent to the central recess R' and in which is formed the annular recess O', over or past which the flange e moves in the shifting of the valve-piston. Said valve-piston E is provided at its outer end with an enlarged cylindric part e', which fits and slides in a cylindric seat formed in the outer end of the valve-chamber exterior to the groove M'. On said piston E, between the enlarged parts e and e', is a circular flange e^2, which fits the inner surface of the bushing between the grooves N' and O'. When said valve-piston E is at the inner limit of its movement, as seen in Fig. 4, the flange e is interposed between the central recess R' and the groove O', and said groove O' is then cut off from the central admission-space R', but is in communication with the recess Q' and the inlet and exhaust passages M M M, while the flange e^2 on said valve-piston is at this time between the grooves N' and O' and cuts off communication between the exhaust-chamber Q and the said passages M M M. When the valve-piston E is at the outward limit of its movement, as shown in Fig. 5, the flange e stands between the grooves O' and Q', thereby cutting off connection between the recess Q' and the admission-recess O' and leaving open communication between the groove O' and the central admission-recess R', while the flange e^2 stands outside of the exhaust-recess N' and establishes free communication between the said recess N' and the passages M M M through the chamber Q and recess Q'.

The valve-piston F has a reduced intermediate part or neck and is provided at its inner end with an enlarged cylindric part f, which fits and slides in a seat formed in the valve-chamber at either side of the annular recess O². At its outer end said piston F is provided with a flange f', which fits and slides in a cylindric seat formed in the adjacent outer end of the valve-chamber outside of the annular recess S'. Said valve-piston F is also provided with an intermediate annular flange f^2, adapted to fit the valve-chamber between the annular recesses P' and S'. When the said piston F is at the inward limit of its movement, as seen in Fig. 4, the enlarged inner part f thereof covers the groove O² and cuts off communication between the same and the central recess R', while the intermediate flange f^2 is at some distance from the annular rib on the wall of the valve-chamber between the recesses P' and S², and thereby leaves free communication between the said recesses and establishes connection between the exhaust-port S² and exhaust-chamber P. When the said valve-piston F is at the outward limit of its movement, as seen in Fig. 5, its inner end stands outside of the recess O², and thereby leaves the same in free communication with the central admission-passage R', while the intermediate flange f^2 meets the wall of the valve-chamber between the grooves P' and S', and thereby cuts off communication between the exhaust-chamber P and exhaust-port S² and chamber S.

The space at the end of the valve-chamber between the valve-piston E and the adjacent outer end of the chamber is connected by means of a port or passage t, formed by the plate D', the end of the bushing, and the adjacent wall of the barrel, with a longitudinal passage T in the wall of the barrel, which opens thereinto through ports t' t^2, located between the ends of said barrel. The space at the opposite end of the said valve-chamber between the outer end of the piston F and the adjacent end of the chamber is connected by a port u, formed in the plate D', the end portion of the bushing and adjacent part of the barrel with a longitudinal passage U in said barrel, which opens into said barrel through ports u' u^2, located at the same distances from the inner end of the barrel as the ports t' t^2. Said ports t' t^2 and u' u^2 are so arranged in the barrel that when the plunger B is at the outward limit of its movement the ports t' and u' will be uncovered and in communication with the interior of the barrel at its inner end, and when said plunger is at the inward limit of its movement the ports t^2 u^2 will be uncovered and in communication with the interior of the barrel at its outer end. The barrel is also provided with two exhaust-ports a^3 a^3, located at such distance from the outer end of the barrel that they will be closed when the plunger is at the outer limit of its movement, but will be open when the piston is at the inner limit of its movement.

The operation of the valve described is as follows: Air under pressure is admitted from

the throttle-valve through the passage *a'* to the central admission-chamber O at the outer side of the valve-bushing. As shown in Figs. 1 and 4, the plunger is at the outward limit of its movement and ready to start inward, the valve-pistons E and F having at this time just been thrown inwardly by live air from the inner end of the barrel passing through the passages T and U and ports *t* and *u* to the outer ends of the valve-chambers, it being manifest that as soon as the ports *t' u'* have been uncovered by the inner end of the plunger in its outward movement live air in the inner end of the barrel will pass through the passages T U to the said outer ends of the valve-chamber. The said valve-pistons E and F being in their inward positions or adjacent to each other and the plunger being ready to start in its return or inward movement, air passes from the chamber O through the port *o* to the annular recess O', and thence to the recess Q' and chamber Q and through the passages M M M to the outer end of the barrel, in which it acts to force the plungers inwardly. In the backward movement of the piston exhaust-air passes through the port s^2 to the chamber S and through the port *s* and recess S' to the recess P' and then outwardly through the chamber P and exhaust-port *p* to the outer air. The exhaust-port S^2 being located at some distance from the inner end of the barrel, as soon as the plunger passes said port S^2 in its inward movement the air is compressed in the inner end of the barrel and the compressed air passes through the port R^2 to the chamber R and central recess R' and acts on the adjacent or inner ends of the two valve-pistons E and F to throw the same outward. In the outward movement of the valve-pistons air from the ends of the valve-chamber will exhaust through the passages T and U and ports *t' u'*, which latter ports, as well as the exhaust-ports a^3 a^3 in the barrel, will be uncovered by the plunger as it moves inwardly, with the result that the ports t^2 t^3 will be brought into communication with the ports a^3 a^3 and through the same with the outer air. When the plunger has reached the inward limit of its movement, the parts will be in the position shown in Figs. 2 and 5, with the valve-pistons at the outward limits of their strokes, and air for driving the plunger outwardly will then enter from the chamber O through the ports *o o'* and recesses O' O^2 to the central passage R', and thence through the chamber R to the admission-port R^2. At this time entrance of live air to the outer end of the barrel will be prevented by the flange *e*, which will be interposed between the recess O' and the recess Q', while the exhaust from the said outer end of the barrel will pass from the passages M M M through the port *q*, the recess Q', the recess N', the port *n*, and chamber N to the exhaust-port *n'*.

By arranging the valve-pistons as described, so that each piston controls a separate inlet-port admitting air to the inner end of the cylinder, a large air-supply is afforded to drive the plunger outward in its working stroke; while each valve-piston has a relatively short stroke and correspondingly quick action in opening the inlet-port.

Now referring to the throttle-valve hereinbefore referred to, the same, as herein illustrated, embraces features of construction, as follows: The bore or passage formed in the oblique arm A' of the barrel is shaped to form a seat for a valve-bushing V, provided with an interior outwardly-facing conical valve-seat *v*. Said bushing is held in its seat within the arm A' by means of a thimble W, having screw-threaded engagement with the interior of the arm A' and shaped to bear at its inner end against the outer end of said bushing V, which latter has a conical or tapered interior bearing-surface engaging a tapered external surface on the inner end of said thimble. Within the bushing V is located a valve-disk X, adapted for contact with the outwardly-facing valve-seat *v*. Said valve-disk is mounted on a valve-stem X', which extends inwardly and outwardly from the disk. Said stem slides at its inner end in a guide-ring *v'*, which is supported centrally at the inner end of the bushing V. The outer end of said stem slides in a guide-ring *w*, which is supported centrally at the inner end of the thimble W. A coiled spring W' is interposed between the guide-ring *w* and the outer face of the said valve-disk and tends to hold the said valve-disk against its seat. For operating the said throttle-valve an actuating-lever Y is pivoted to the end of the handle C, adjacent to the arm A', by means of a pivot-pin *y*, which passes through a flattened arm Y' on said actuating-lever. Said arm Y' passes through a slot formed in the base of the handle and opening into a guide-passage *y'*, which is formed in the arm A', parallel with the central axis of the throttle-valve. Said guide-passage contains an endwise-moving rod or plunger Y^2. The inner end of said plunger acts on a rocking lever X^2, which is pivotally supported by a transverse pivot *x* and is engaged at its outer end by said plunger Y^2 and at its inner end bears against the inner end of the valve-stem X'.

The spring W' holds the valve-disk V' against its seat, and the valve is opened by pressure of the hand on the actuating-lever Y, by which the same is thrown outwardly and the plunger Y^2 moved inwardly, so as to actuate the lever X^2, and thereby throw outwardly the valve-stem and carry the disk away from the valve-seat.

As hereinbefore described, an air-chamber is formed by the hollow interior of the plug H, which is in communication with the air-supply passage through the passage *h* at a point

inside the throttle-valve. The air contained in said air-chamber being under a compression equal to that of the maximum pressure supplied through the hose or supply-pipe, a reserved supply of air under pressure is provided by which an ample supply of air is afforded to provide for the rapid admission which will arise from the use of two valve-pistons having short strokes and consequent quick action. In other words, the air-chamber gives an additional supply of air called for by quick admission without using a large hose.

An important feature of the invention lies in the construction of the plungers, whereby the same is made of large diameter and light in weight and has a high velocity with a short stroke.

The tool described possesses in its entirety the features of a large diameter of barrel and quick admission of air for driving the plunger forward by reason of having the two admission-controlling valve-pistons, which are light and have correspondingly-quick movement, with the result that each stroke given by the plunger will be as hard as that which would be given by a plunger with a longer stroke, while at the same time the plunger will move with great rapidity and give frequent strokes, thus making the tool as a whole more effective in action.

I claim as my invention—

1. The combination with a barrel, of a plunger therein, an air-supply pipe, a throttle-valve, and a controlling-valve acting to control the supply of air to both ends of the barrel, said barrel being provided with an air-chamber in communication by a branch passage with the air-supply passage between the throttle-valve and the controlling-valve, said air-chamber being adapted to contain a reserve quantity of air under pressure in volume sufficient to compensate for any momentary deficiency in the air-supply.

2. The combination with a barrel, of a plunger therein, and a controlling-valve, said plunger having a cavity or recess in its inner end and the barrel having at its inner end an air-displacing projection, said projection being hollow and forming an air-chamber which is in communication with the air-supply passage outside of the controlling-valve and is adapted to contain a reserve supply of air under pressure sufficient in quantity to compensate for momentary deficiency in the air-supply.

3. The combination with a barrel, of a plunger therein, provided with a recess or cavity in its inner end, a controlling-valve, the barrel being provided at its inner end with an inwardly-projecting shell which closes said inner end of the barrel and forms an air-displacing projection, said shell also constituting part of an air-chamber which is in communication with the air-supply passage outside of the controlling-valve and is adapted to contain a reserve quantity of air under pressure sufficient in volume to compensate for momentary deficiency in the air-supply from the air-supply passage.

4. The combination with a barrel, of a plunger therein provided with a recess or cavity at its inner end, and a controlling-valve, said barrel being provided at its inner end with an inwardly-projecting shell, the base of which is located and secured within the inner end of the barrel, a disk or plate closing the inner end of said shell and means for securing said shell and said disk or plate in place within the barrel, said shell and disk forming an air-chamber which is in communication with the air-supply passage outside of the controlling-valve and which is adapted to contain a reserve quantity of air under pressure designed to compensate for any momentary deficiency in the supply of air to the controlling-valve.

5. The combination with a barrel, of a plunger therein provided with a recess or cavity in its inner end, a shell which closes the inner end of the bore of the barrel and fits at its base in the bore of the same, and means for securing the said shell in the barrel comprising a split thimble having screw-threaded engagement with the bore of the barrel, a sleeve having an exterior conical surface engaging an interior conical surface on the thimble, and a nut having screw-threaded engagement with the sleeve and provided with a conical surface engaging an interior conical surface on the said thimble.

6. The combination with a barrel, of a plunger therein provided with a recess or cavity in its inner end, a shell which closes the said inner end of the barrel and projects into said cavity when the plunger is at the inward limit of its movement, the base of said shell being located and secured within the bore of the barrel, a disk or plate located within the bore of the barrel in contact with said inner end of said shell and means for clamping said shell and said disk in place within the barrel, embracing a split thimble having screw-threaded engagement with the barrel and provided with an interior conical surface, a sleeve having a conical surface at its inner end, and a nut engaging the outer end of the sleeve.

7. The combination with a barrel, of a plunger therein provided with a recess or cavity in its inner end, said barrel having a bore which extends through the inner end of the barrel and has a tapered annular surface, a shell which closes the inner end of the barrel and is adapted to project into said cavity when the plunger is at the inward limit of its movement, said shell being provided at its base with a conical surface adapted to engage the conical surface in the bore, a disk inserted in the end of the barrel in contact with the inner margin of said shell, a split thimble hav-

ing screw-threaded engagement with the inner end of the barrel and bearing on said plate, a sleeve having a conical surface engaging the conical surface of the thimble, and a nut having screw-threaded engagement with said sleeve.

8. The combination with a barrel, of a plunger therein provided with a recess or cavity in its inner end, a hollow shell which closes the inner end of the barrel and is adapted to form an air-displacing projection, said shell being provided at its base with an inwardly-tapered conical surface adapted to engage a corresponding conical surface in the bore of the barrel, and a disk inserted in the end of the barel in contact with the inner margin of said shell and forming with the shell an air-chamber, said air-chamber being connected with the air-supply passage of the tool by means of a port extending through the base portion of said shell and through the adjacent part of the wall of the barrel.

9. The combination with a barrel, of a plunger therein provided with a recess or cavity in its inner end, a shell for closing the inner end of the barrel and which is adapted to project into the barrel to form an air-displacing projection, said shell being provided at its base with an inwardly-tapered conical surface adapted to engage a corresponding conical surface in the bore of the barrel, a disk inserted in the bore of the barrel in contact with the inner margin of said hollow shell and a thimble having screw-threaded engagement with the inner end of the barrel and bearing on said plate, said barrel being provided with a controlling-valve chamber, a controlling-valve therein, and an air-supply passage communicating with said controlling-valve chamber, the base of said shell and the adjacent part of the barrel being provided with an air-port which communicates with said air-supply passage.

10. The combination with a barrel, and a plunger therein provided with a recess or cavity in its inner end, said barrel having at its inner end an air-displacing projection adapted to project into said cavity in the plunger when the latter is at the inward limit of its stroke, and a controlling-valve comprising a valve-chamber provided with an air-supply passage, and with two admission-ports communicating with the inner end of the barrel, and two valve-pistons in said valve-chamber, both of which control the admission of air to the inner end of the barrel through said admission-ports.

11. The combination with a barrel and a plunger therein, of a controlling-valve comprising a valve-chamber, two endwise-sliding valve-pistons located in said valve-chamber, and means for giving endwise movement to said valve-pistons, comprising passages connected with the ends of said valve-chamber and opening into the interior of the barrel by ports which are uncovered when the plunger is at the outward limit of its movement, an exhaust-passage for the inner end of the barrel which opens into the barrel through a port located in position to be covered by the piston before the same reaches the inward limit of its stroke, and an admission-port opening into the inner end of the barrel, and connected with the valve-chamber between the inner ends of the said pistons.

12. The combination with a barrel and a plunger therein, of a controlling-valve comprising a valve-chamber provided with an air-supply passage, and with admission and exhaust ports, including two admission-ports which are connected with the barrel by an admission-passage which opens into the inner end of the barrel, and an exhaust-port for the inner end of the barrel which communicates with the barrel by a passage opening into the barrel through a port located at a greater distance from the inner end of the barrel than the admission-passage, two endwise-sliding valve-pistons the inner ends of which control the said two admission-ports and are subject to pressure of compressed air within the barrel in the back stroke of the plunger, and means for connecting the outer ends of said valve-chamber exterior to the said valve-piston alternately with said air-supply passage and with the outer air.

13. The combination with a barrel and a plunger therein, of a controlling-valve comprising a valve-chamber with an air-supply passage, and with admission and exhaust ports connected with the inner and outer ends of the barrel, the exhaust-port for the inner end of the barrel being located at a greater distance from the inner end of the barrel than the admission-port at such inner end of the barrel, two endwise-sliding valve-pistons located in said valve-chamber, the inner ends of said pistons being subject to pressure of air in the inner end of the barrel, and means for alternately connecting the outer ends of said valve-chamber with the air-supply passage and with the outer air comprising a passage leading from each end of said valve-chamber and opening into the barrel through two ports, one of which is uncovered by the piston in the outward limit of its movement and the other uncovered by the piston when at the inward limit of its movement, and ports leading through the wall of the barrel to the outer air which are uncovered by the piston when at the inward limit of its movement.

14. The combination with a barrel, and a plunger therein, of a controlling-valve comprising a valve-chamber provided with a central air-admission passage communicating with an admission-port which opens into the inner end of the barrel, with two ports located

at opposite sides of said air-admission passage and connected with an air-supply passage, with an exhaust-port communicating with the inner end of the barrel, and with an admission and exhaust port communicating with the outer end of the barrel, and two endwise-sliding piston-valves in said chamber, the inner or adjacent ends of which control the passage of air from said air-supply passage through said admission-ports to the admission-port leading to the inner end of the barrel, one of which controls the passage of air through the exhaust-passage leading from the inner end of the barrel and the other of which controls the passage of air from said air-supply passage to the outer end of the barrel and also controls the exhaust from the outer end of the barrel.

15. The combination with a barrel and a plunger therein, of a controlling-valve comprising a valve-chamber provided with a central admission-passage communicating with the inner end of the barrel, with two annular admission-recesses located at either side of the said central admission-passage, and communicating with an air-supply passage, said valve-chamber also having between one of said annular admission-recesses and one end of the valve-chamber two annular exhaust-recesses, one of which communicates with the inner end of the barrel by an exhaust-port, and the other of which communicates with the outer air and two endwise-sliding valve-pistons in said chamber the inner ends of which control the passage of air from the said air-supply passage to said central admission-passage, one of said valve-pistons having a flange by which communication between said exhaust-recesses for the inner end of the barrel is alternately opened and closed.

16. The combination with a barrel and a plunger therein, of a controlling-valve comprising a valve-chamber provided with a central admission-passage communicating with the inner end of the barrel, with two annular recesses located at opposite sides of said admission-passage and communicating with an air-supply passage, with an annular recess communicating with the inner end of the barrel by an exhaust-port located at a distance from the inner end wall of the same and with an annular recess communicating by an admission and exhaust port with the outer end of the barrel and with an annular recess communicating with the outer air, and two endwise-sliding piston-valves, the adjacent parts of which control the passage of air from said air-supply passage to said central admission-passage, one of which controls the exhaust-passage leading from the inner end of the barrel, and the other of which controls the passage of air from said air-supply passage to the outer end of the barrel and also controls the exhaust from the outer end of the barrel, and means for connecting the outer ends of said valve-chamber alternately with the air-supply passage and with the outer air.

17. The combination with a barrel and a plunger therein, of a controlling-valve comprising a valve-chamber provided with a central admission-passage communicating with the inner end of the barrel, with two annular recesses located at opposite sides of said admission-passage, and communicating with an air-supply passage, with an annular recess communicating by an exhaust-port with the inner end of the barrel, and with an annular admission and exhaust passage communicating with the outer end of the barrel and two endwise-sliding piston-valves the inner or adjacent parts of which control the passage of air from the air-supply passage to said admission-ports leading to the inner end of the barrel, one of which controls the exhaust-passage leading from the inner end of the barrel, and the other of which controls the passage of air from said air-supply passage to the outer end of the barrel and also controls the exhaust from the outer end of the barrel.

18. The combination with a barrel and a plunger therein, of a controlling-valve comprising a valve-chamber provided with a central admission-passage communicating with the inner end of the barrel, with two annular recesses located at opposite sides of said admission-passage and communicating with an air-supply passage; said valve-chamber also having between one of said annular recesses and the end of the barrel two annular exhaust-recesses, one of which communicates by an exhaust-port with the inner end of the barrel and the other with the outer air, said valve-chamber also having between the other of said air-admission recesses and the opposite end of the barrel an annular admission and exhaust recess communicating by a passage with the outer end of the barrel, and an adjacent annular exhaust-recess communicating with the outer air, and two valve-pistons in said chamber, the inner ends of which control the passage of air from said air-supply passage to said admission-ports leading to the inner end of the barrel, one of said valve-pistons having a flange by which communication between said exhaust-recesses for the inner end of the barrel are alternately brought into and cut off from communication with each other, and the other one of said pistons having an annular flange adapted to open and close communication between said admission and exhaust recess for the outer end of the barrel and the said exhaust-recess adjacent thereto.

19. The combination with a barrel and a plunger therein, of a controlling-valve comprising a valve-chamber provided with a central admission-passage communicating with the inner end of the barrel, with two annular admission-recesses located at opposite sides of said admission-passage and commu-

nicating with an air-supply passage, said valve-chamber also having an annular exhaust-recess communicating by an exhaust-port with the inner end of the barrel and adjacent thereto an exhaust-recess connected with the outer air, an annular admission and exhaust recess communicating with the outer end of the barrel, and an annular exhaust-recess adjacent to said admission and exhaust recess communicating with the outer air, and two valve-pistons in said chamber, the inner ends of which control the passage of air from said air-supply passage to the central admission-passage leading to the inner end of the barrel, and the outer ends of which are adapted to slide in cylindric seats in the outer ends of the valve-chamber, one of said valve-pistons being provided with an annular flange which controls the exhaust-passages communicating with the inner end of the barrel, and the other of said valve-pistons being provided with a flange controlling the admission of air from the said supply-passage to the outer end of the barrel, and means for bringing the outer ends of the valve-chamber exterior to the outer ends of the valve-pistons alternately in communication with said air-supply passage and with the outer air, said exhaust-port at the inner end of the barrel being located at a greater distance from the inner end of the barrel than the admission-port.

20. The combination with a barrel and a plunger therein, of a valve-casing on the barrel provided with a cylindric bore and a valve-bushing located in said chamber and provided with an interior valve-chamber, said valve-bushing having on its outer surface circumferential and longitudinal ribs forming with the wall of the valve-casing a plurality of exterior spaces or chambers communicating with the inner and outer ends of the barrel, with an air-supply passage and with the outer air, said bushing being also provided with a plurality of admission and exhaust ports communicating with said exterior chambers.

21. The combination with a barrel and a plunger therein, of a valve-casing on the barrel provided with a cylindric bore and a valve-bushing located in said chamber and provided with an interior valve-chamber, said valve-bushing having on its outer surface circumferential and longitudinal ribs forming with the wall of the valve-casing a plurality of exterior spaces or chambers communicating with the air-supply passage, with the interior of the barrel, and with the outer air, said bushing being also provided with a plurality of admission and exhaust ports communicating with said exterior chambers, and with interior annular grooves or recesses communicating with said admission and exhaust ports.

22. The combination with a barrel and a plunger therein, of a valve-casing attached to said barrel, a valve-bushing located within said casing, said valve-bushing being provided with a valve-chamber and on its outer face with circumferential and longitudinal ribs forming with the surrounding wall of the valve-casing, a plurality of exterior chambers, including a central chamber which is in communication with the inner end of the barrel by an admission-port, a central chamber which is in communication with the air-supply passage, two external chambers one communicating with the inner end of the barrel by an exhaust-passage, and the other with the outer end of the barrel by an exhaust and admission passage and with two chambers which communicate with the outer air through exhaust-ports in the valve-casing, said bushing also having a central admission-passage, two annular admission-grooves located at either side of said central admission-passage, two annular exhaust-recesses located adjacent to each other for the exhaust from the inner end of the barrel, an annular admission and exhaust recess for the outer end of the barrel and an annular exhaust-recess adjacent thereto for the outer end of the barrel, and two valve-pistons in said valve-chamber, the inner ends of which are adapted to control the passage of air from said annular admission-passages to the central admission-passage and which are provided with annular flanges controlling the exhaust from the inner end of the barrel, and the admission and exhaust from the outer end of the barrel.

23. The combination with a barrel, of a plunger therein, a valve-casing attached to the barrel and provided with a cylindric bore, a valve-bushing located in said casing, cap-plates closing the ends of said valve-bushing, the said valve-casing being provided at its opposite ends with screw-threaded thimbles inserted in the open ends thereof and bearing against the said cap-plates, and means for holding each of said thimbles from turning in the end of the casing, including a sleeve having a conical inner end engaging a conical inner surface on the said thimbles, and a nut having screw-threaded engagement with the outer end of said sleeve and having a conical inner end adapted to engage a conical inner surface on the said thimble, said thimble being split to permit expansion of the same.

24. The combination with a barrel, and a plunger therein, said barrel being provided at its base or inner end with two divergent integral arms each extending outward from the barrel at an angle to the central axis thereof, and a handle having at its ends divergent tubular sockets in line with and adapted to receive said divergent arms.

25. The combination with a barrel, and a plunger therein, said barrel being provided at its base or inner end with two integral

arms each extending at an angle to the central axis of the barrel, and a handle having at its ends sockets adapted for detachable engagement with said arms, one of said sockets having a detachably-secured separable section.

In testimony that I claim the foregoing as my invention I affix my signature, in presence of two witnesses, this 23d day of August, A. D. 1904.

AXEL LEVEDAHL.

Witnesses:
W. H. PENN,
CARRIE MUSCHLER.