C. K. LASSITER & F. E. BOCORSELSKI.

HYDROPNEUMATIC DRILL.

APPLICATION FILED JAN. 4, 1912.

1,046,311.

Patented Dec. 3, 1912.

10 SHEETS—SHEET 1.

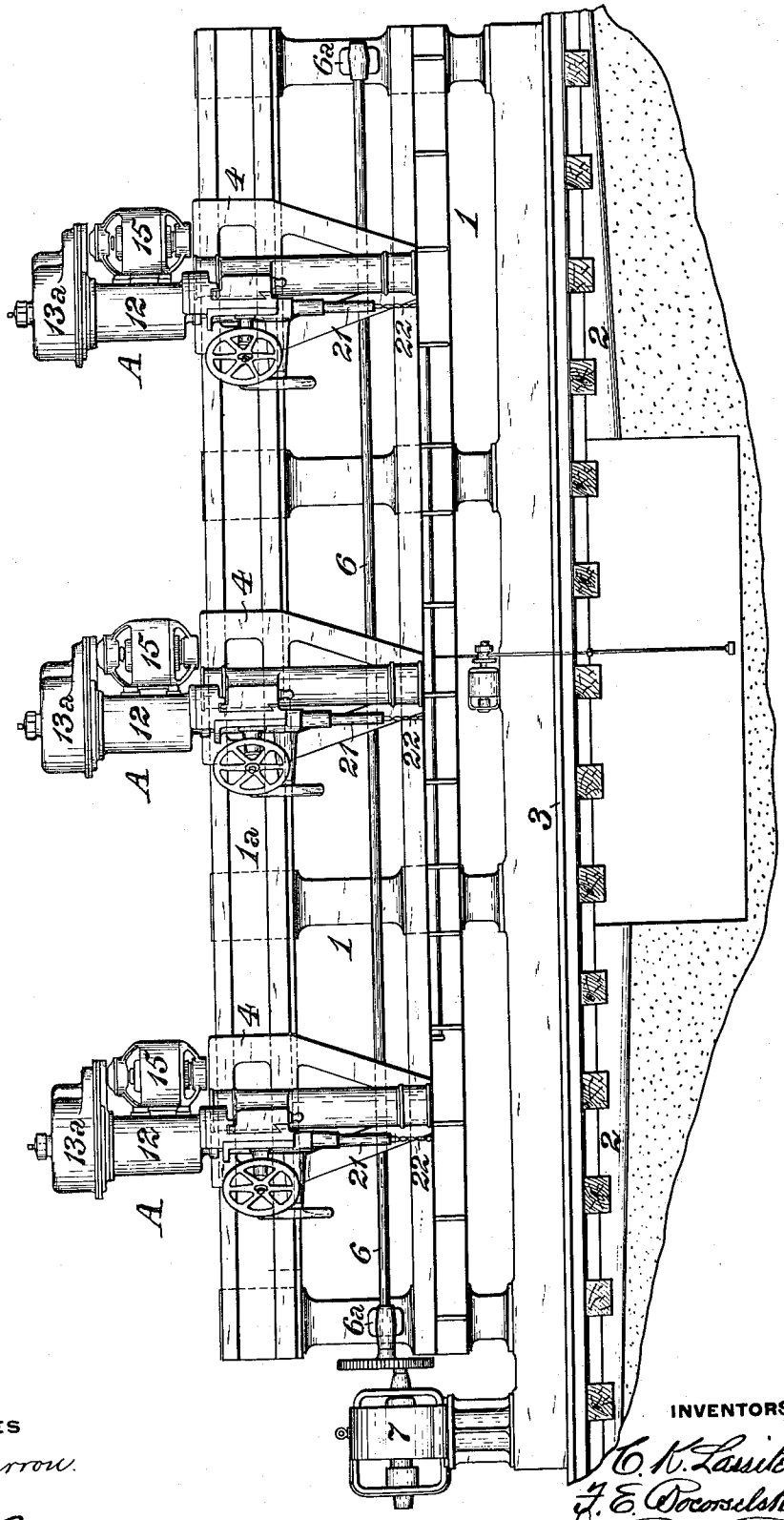


FIG. 1.

WITNESSES

James C. Herron.

S. R. Bell.

INVENTORS

C. K. Lassiter.

F. E. Bocorselski,

by J. Howden Dell.

Atty.

C. K. LASSITER & F. E. BOCORSELSKI.

HYDROPNEUMATIC DRILL.

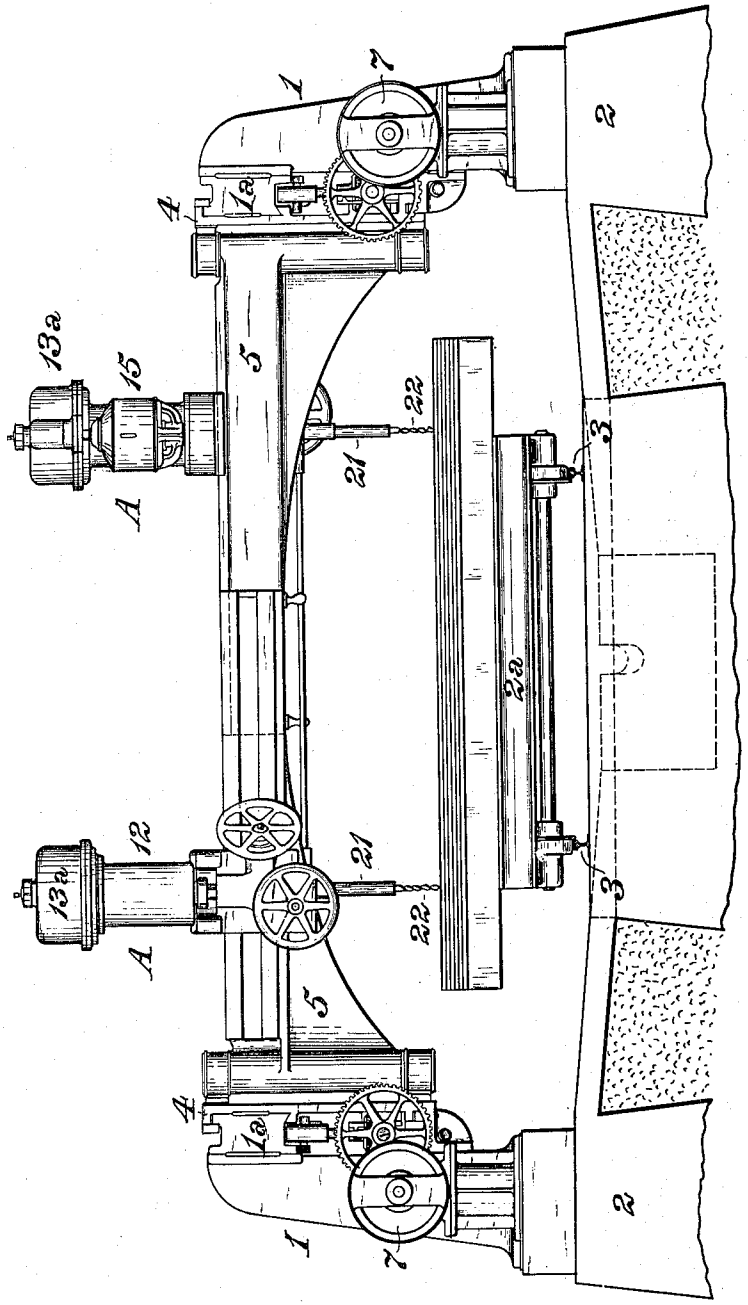
APPLICATION FILED JAN. 4, 1912.

1,046,311.

Patented Dec. 3, 1912.

10 SHEETS—SHEET 2.

FIG. 2.



WITNESSES

James C. Herron.

S. R. Bell.

INVENTORS

C. K. Lassiter

F. E. Bocorselski

by J. Worden Bell, atty.

C. K. LASSITER & F. E. BOCORSELSKI.

HYDROPNEUMATIC DRILL.

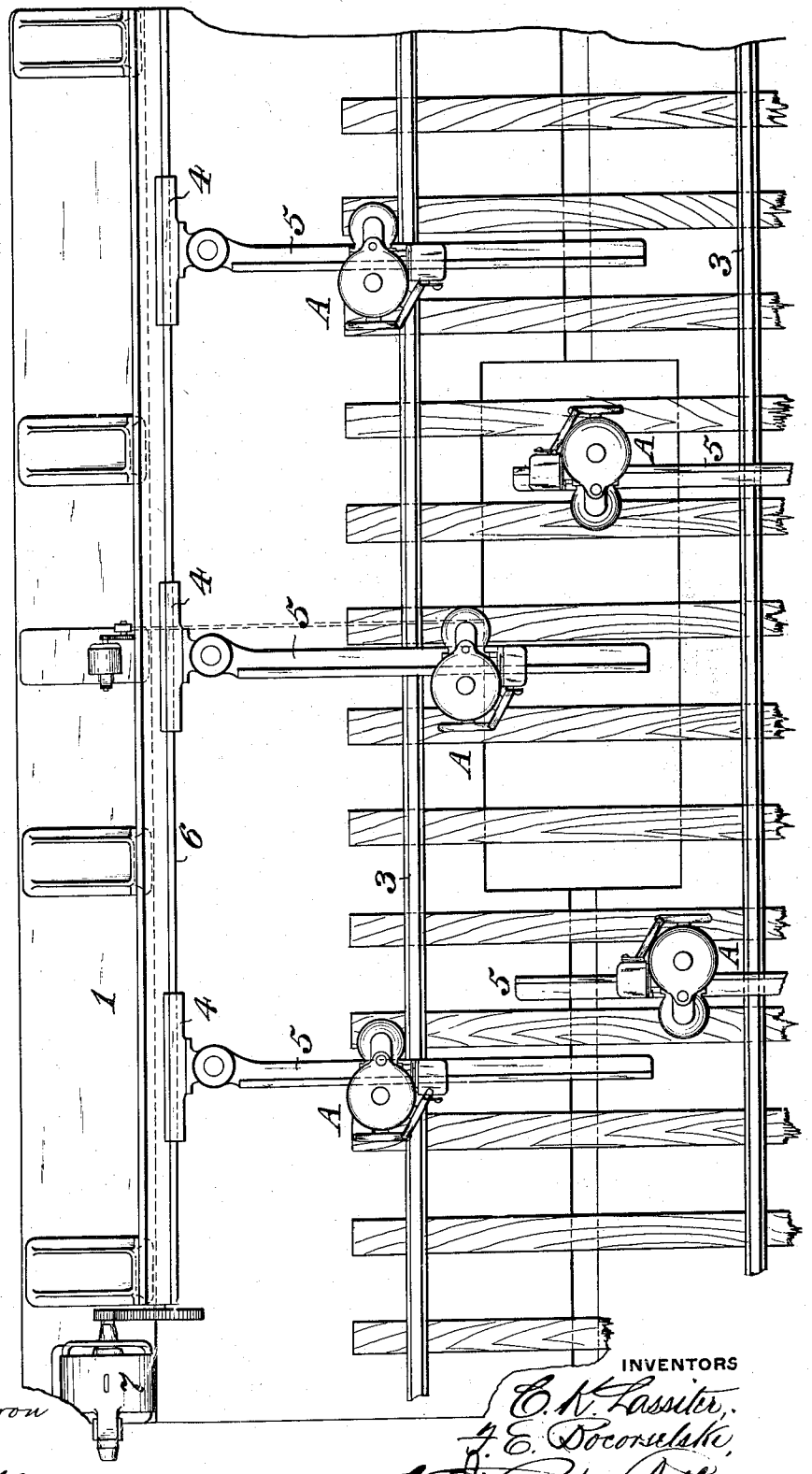
APPLICATION FILED JAN. 4, 1912.

1,046,311.

Patented Dec. 3, 1912.

10 SHEETS—SHEET 3.

FIG. 3.



WITNESSES

James C. Herron

S. R. Bell.

INVENTORS

C. K. Lassiter,

F. E. Bocorselski,

by Thurston Sell,

Atty.

C. K. LASSITER & F. E. BOCORSELSKI.

HYDROPNEUMATIC DRILL.

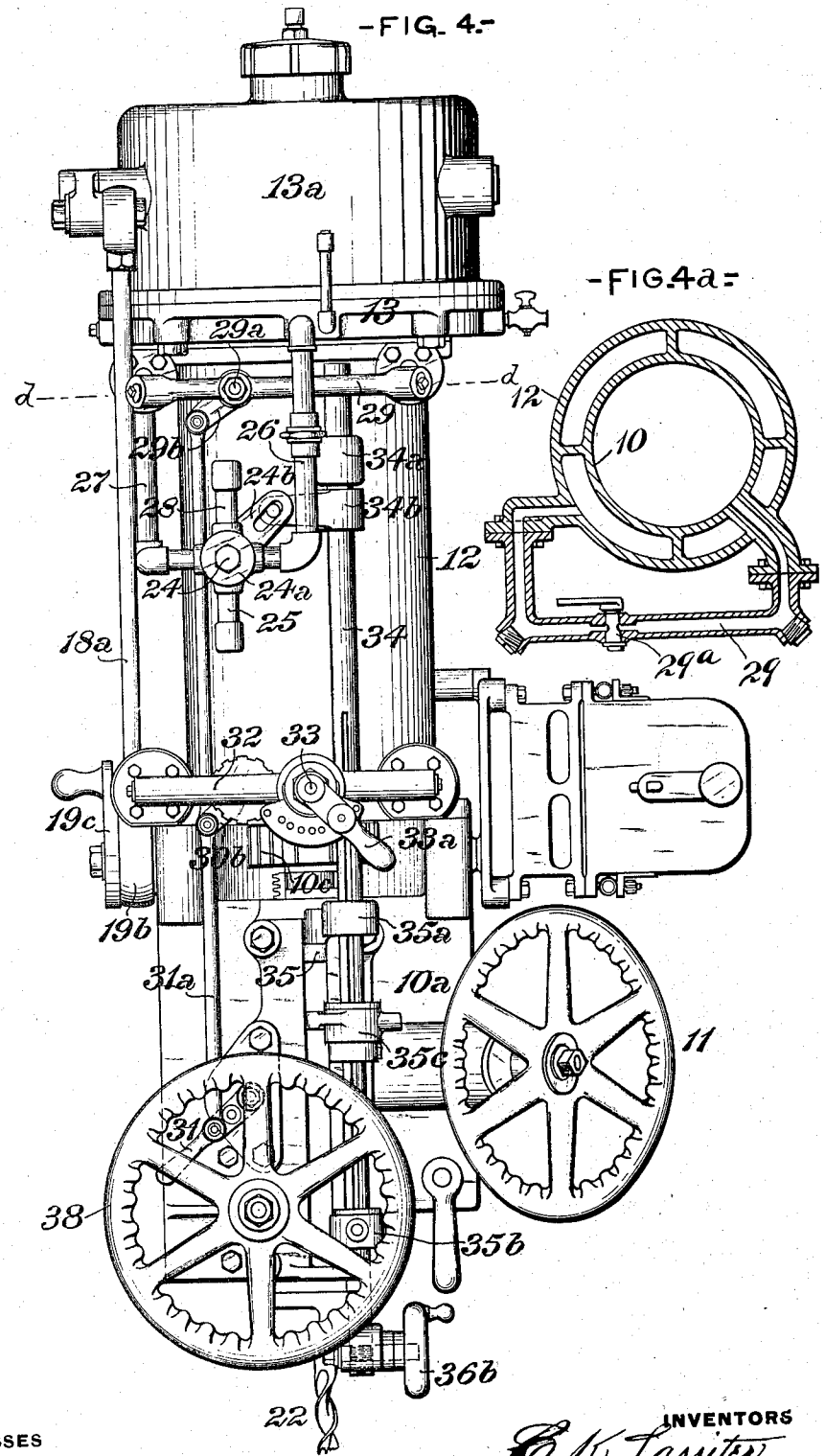
APPLICATION FILED JAN. 4, 1912.

1,046,311.

Patented Dec. 3, 1912.

10 SHEETS—SHEET 4.

-FIG. 4.-



-FIG. 4a-

WITNESSES

James C. Herron

S. R. Bell.

INVENTORS

C. K. Lassiter.

F. E. Bocorselski.

by J. V. Worden Sons. atty.

C. K. LASSITER & F. E. BOCORSELSKI.

HYDROPNEUMATIC DRILL.

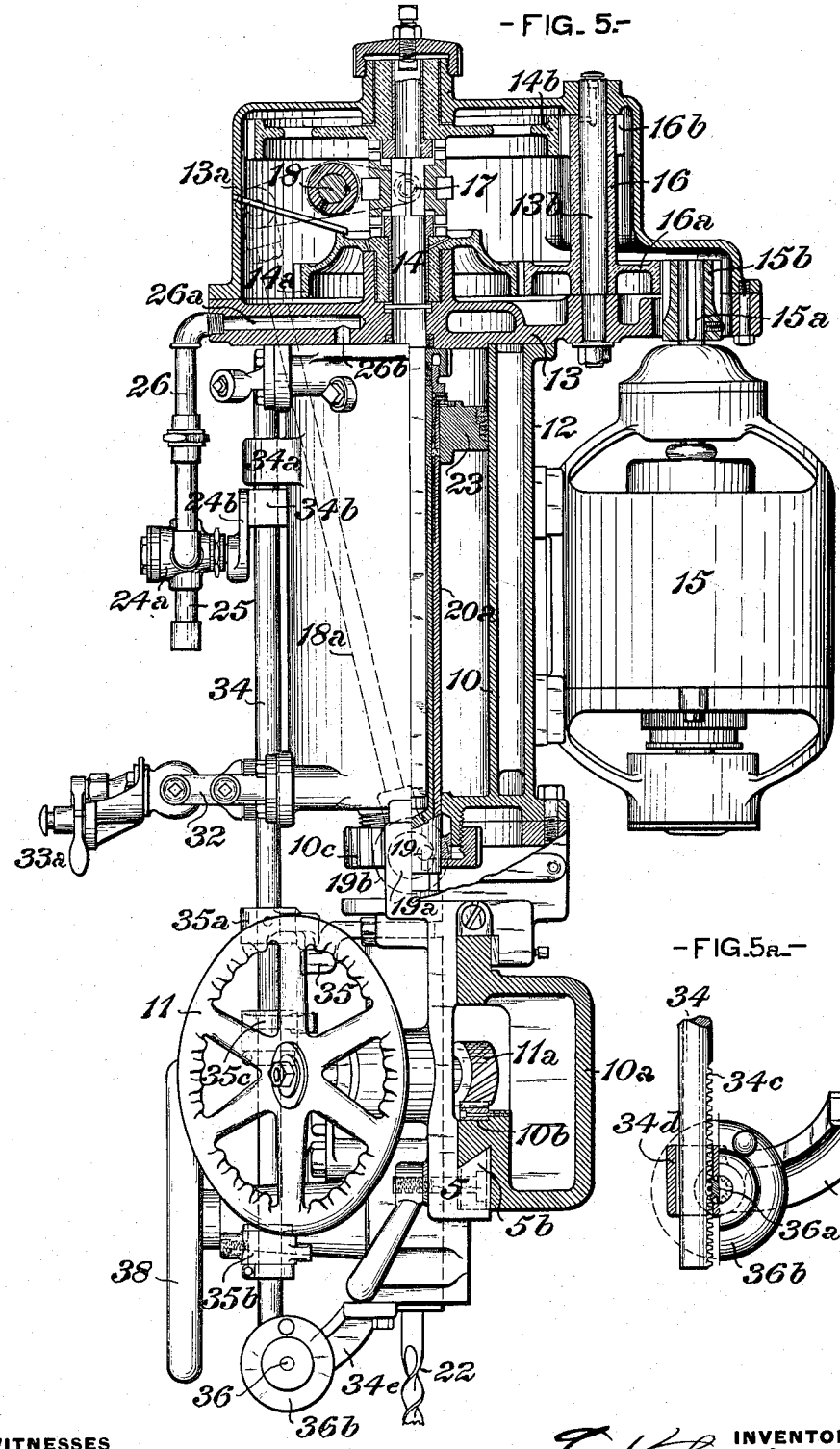
APPLICATION FILED JAN. 4, 1912.

1,046,311.

Patented Dec. 3, 1912.

10 SHEETS—SHEET 5.

-FIG. 5.-



-FIG.5a.-

WITNESSES

James C. Herron

S. R. Bell.

INVENTORS

C. K. Lassiter.

F. E. Bocorselska,

by Lemuel Wooden Bell, atty.

C. K. LASSITER & F. E. BOCORSELSKI.

HYDROPNEUMATIC DRILL.

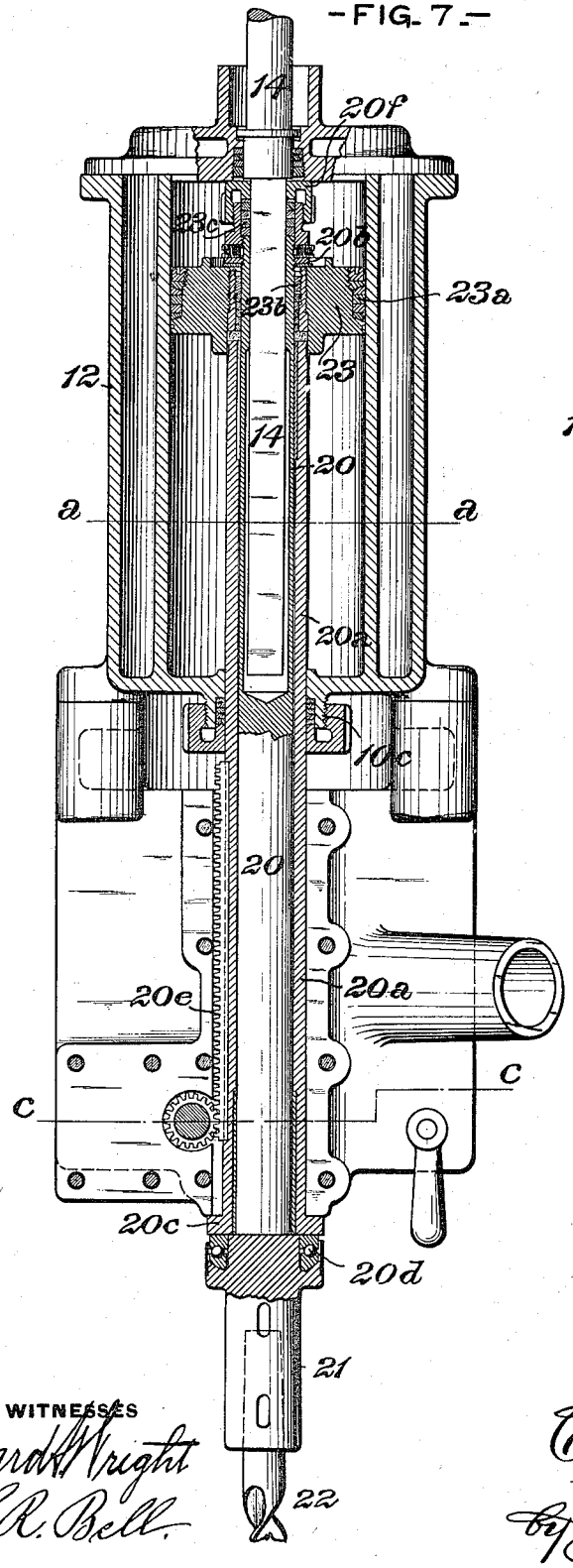
APPLICATION FILED JAN. 4, 1912.

1,046,311.

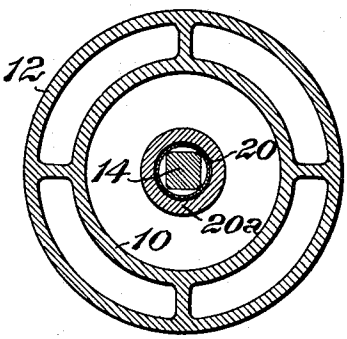
Patented Dec. 3, 1912.

10 SHEETS—SHEET 6.

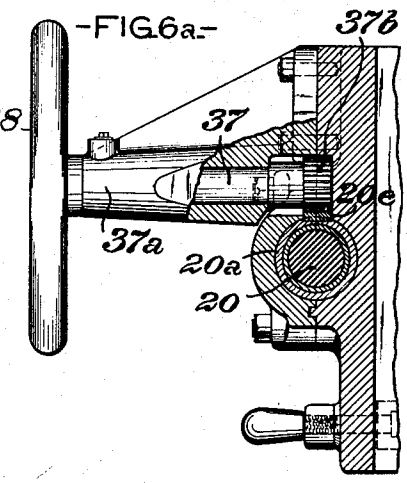
-FIG. 7.-



-FIG. 6.-



-FIG. 6a.-



WITNESSES

Edward H. Wright

S. R. Bell.

INVENTORS

C. K. Lassiter.

F. E. Bocorselski.

by Howson & Sell. atty.

C. K. LASSITER & F. E. BOCORSELSKI.

HYDROPNEUMATIC DRILL.

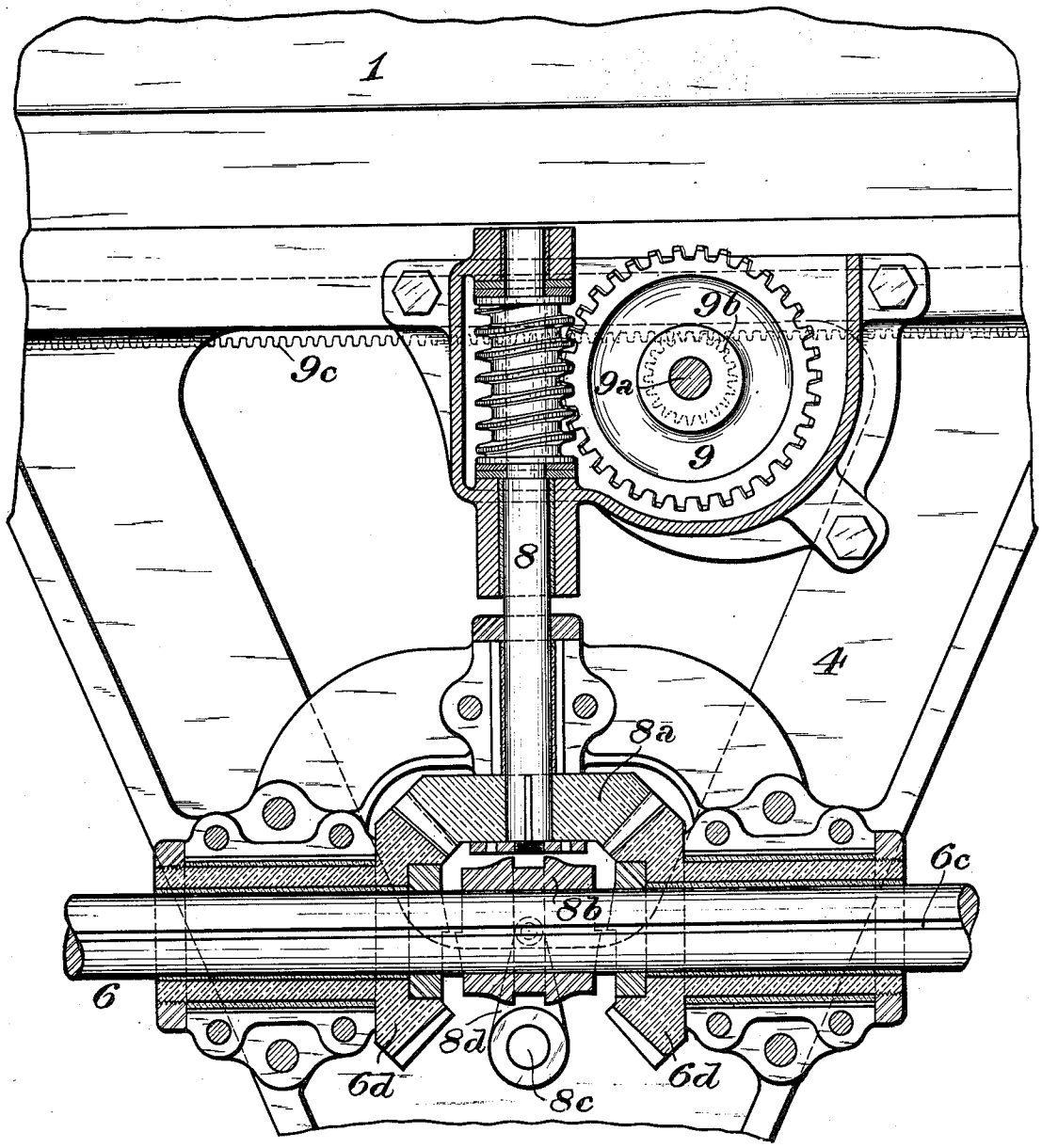
APPLICATION FILED JAN. 4, 1912.

1,046,311.

Patented Dec. 3, 1912.

10 SHEETS—SHEET 7.

-FIG. 8-



WITNESSES

James C. Herron.

S. R. Bell.

INVENTORS

C. K. Lassiter

F. E. Bocorselski,

by Marsden Bell atty.

C. K. LASSITER & F. E. BOCORSELSKI.

HYDROPNEUMATIC DRILL.

APPLICATION FILED JAN. 4, 1912.

1,046,311.

Patented Dec. 3, 1912.

10 SHEETS—SHEET 8.

FIG. 9.

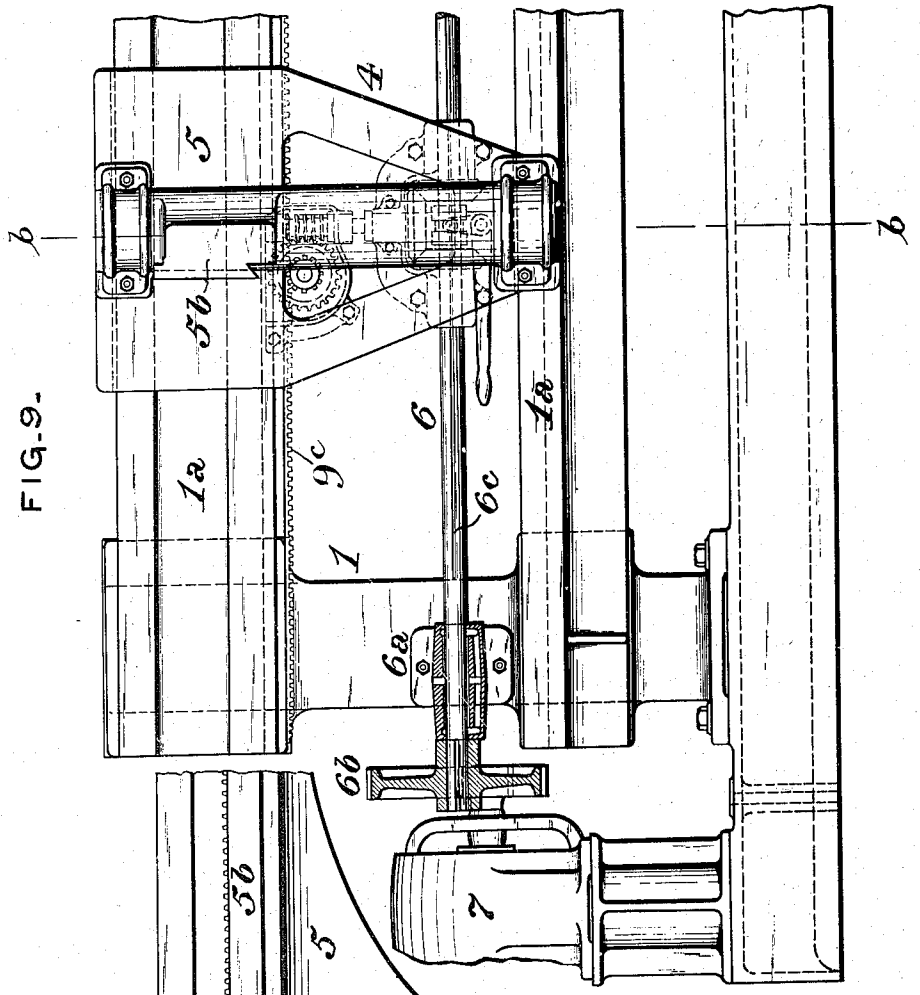


FIG. 10.

WITNESSES

James b. Herron

S. R. Bell.

INVENTORS

C. K. Lassiter,

F. E. Bocorselska,

By J. Andrew Bell. Atty.

C. K. LASSITER & F. E. BOCORSELSKI.

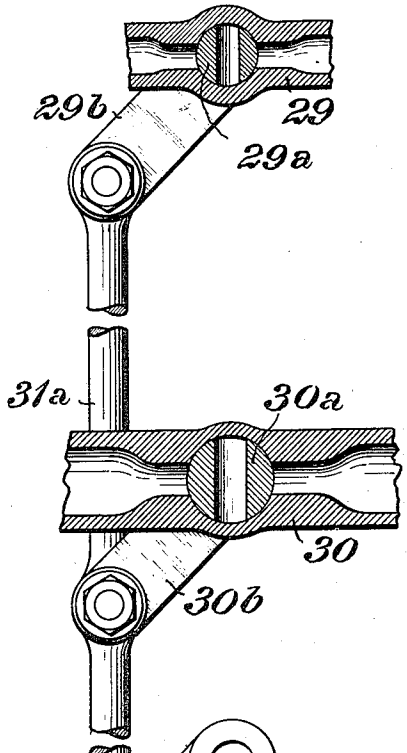
HYDROPNEUMATIC DRILL.

APPLICATION FILED JAN. 4, 1912.

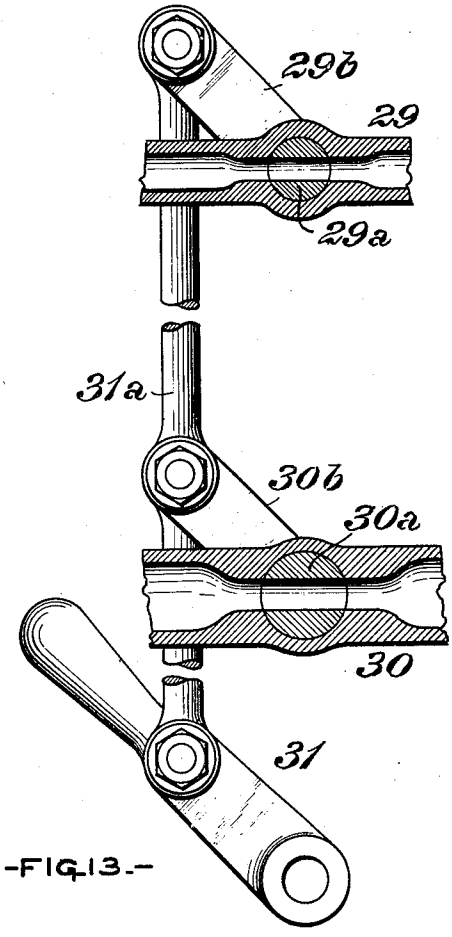
1,046,311.

Patented Dec. 3, 1912.

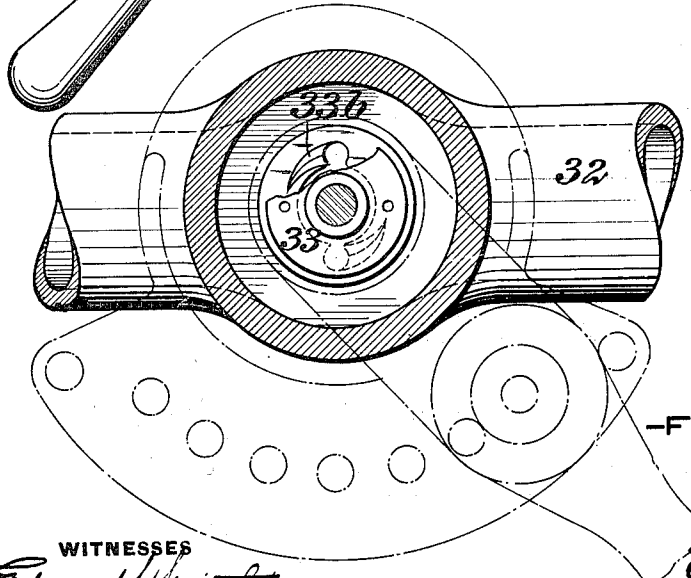
10 SHEETS—SHEET 9.



-FIG.12.-



-FIG.13.-



-FIG.11.-

WITNESSES

Edward L. Wright

S. R. Bell.

INVENTORS.

C. K. Lassiter

F. E. Bocorselski

by J. Harrison Bell. atty.

C. K. LASSITER & F. E. BOCORSELSKI.

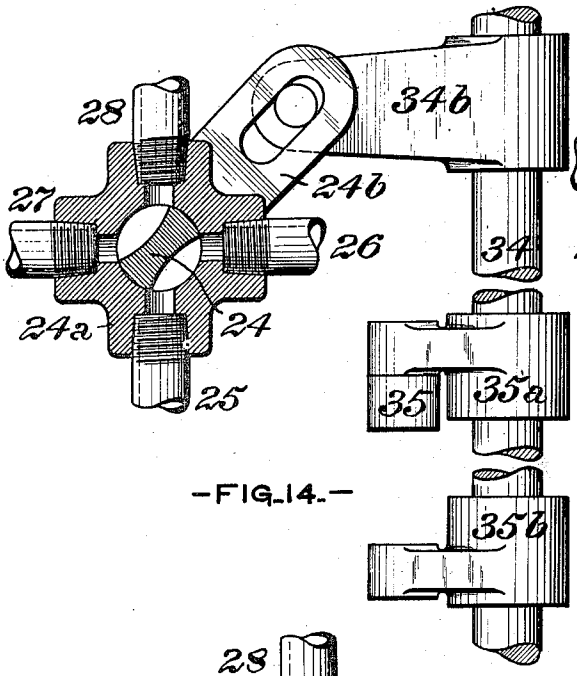
HYDROPNEUMATIC DRILL.

APPLICATION FILED JAN. 4, 1912.

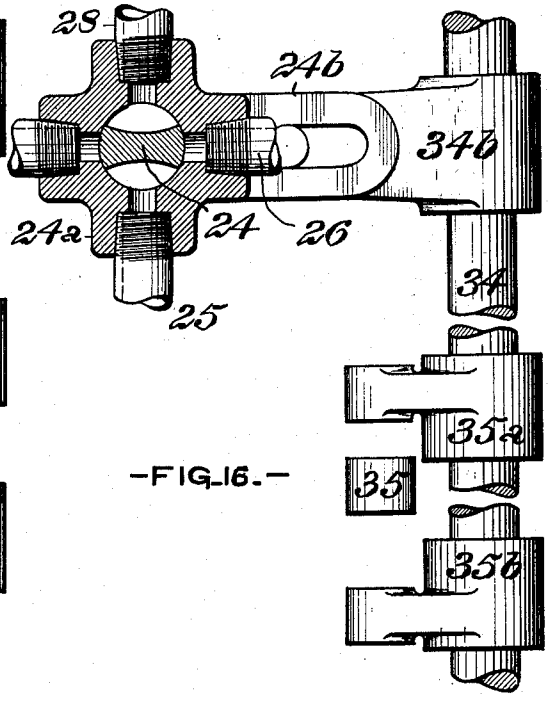
1,046,311.

Patented Dec. 3, 1912.

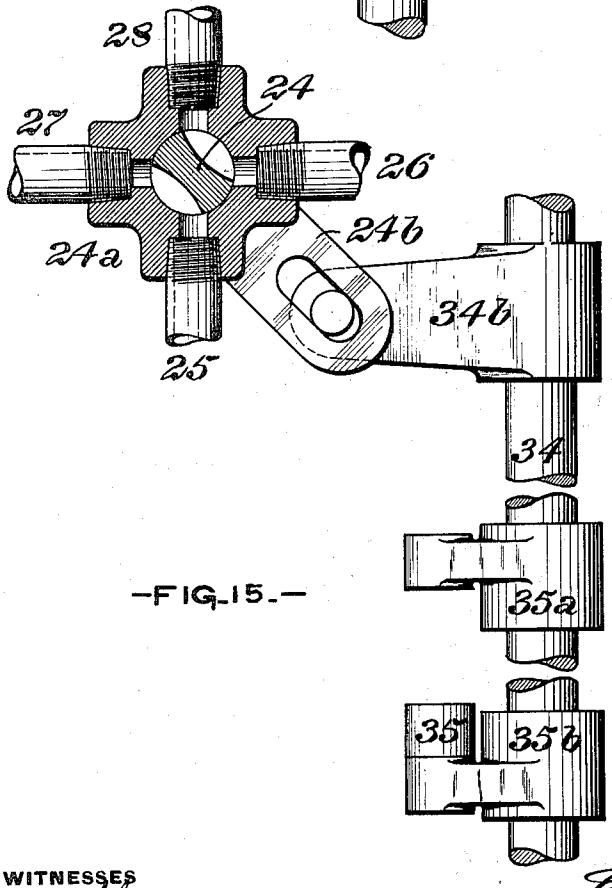
10 SHEETS—SHEET 10.



—FIG. 14.—



—FIG. 16.—



—FIG. 15.—

WITNESSES

Edward A. Wright

S. R. Bell.

INVENTORS

C. K. Lassiter

F. E. Bocorselski

by Howson & Sell atty

UNITED STATES PATENT OFFICE.

COLUMBUS K. LASSITER AND FRANK E. BOCORSELSKI, OF RICHMOND, VIRGINIA.

HYDROPNEUMATIC DRILL.

1,046,311. Specification of Letters Patent. Patented Dec. 3, 1912.

Application filed January 4, 1912. Serial No. 669,441.

To all whom it may concern:

Be it known that we, COLUMBUS K. LASSITER and FRANK E. BOCORSELSKI, citizens of the United States, and both residents of Richmond, in the county of Henrico and State of Virginia, have invented a certain new and useful Improvement in Hydropneumatic Drills, of which improvement the following is a specification.

Our invention relates to machines for drilling metal or other material, of the general class or type in which the feed of the drill to the work is effected by the direct application of the pressure of an elastic fluid to a piston to which the tool is connected, and the retraction or opposite movement of the drill by the indirect application of said pressure to the piston through the intermediation of an inelastic fluid, said direct and indirect applications being controlled, as to period and degree, by suitable valve mechanism.

The object of our invention is to provide a drilling machine of the above recited type, in which increased rapidity, safety, and effectiveness of operation shall be attained by improved means for mounting and adjusting the drilling mechanism, and effecting and regulating the application of fluid pressure in feeding the drill to, and retracting it from, the work; said feeding and retracting means being controllable either automatically or manually, accordingly as may, in either case, be rendered more desirable by or under the conditions of operation.

The improvement claimed is hereinafter fully set forth.

In the accompanying drawings: Figure 1 is a view, in elevation, of one side of a multiple hydro-pneumatic drill, embodying our invention; Fig. 2, an end view of the same; Fig. 3, a half plan or top view; Fig. 4, a view, in elevation and on an enlarged scale, of one of the fluid pressure feed mechanisms; Fig. 5, a view, partly in elevation and partly in vertical central section, of the same, taken at right angles to Fig. 4; Fig. 4ª, a horizontal section through the feed cylinder, liquid chamber, and by pass pipe, on the line *d d* of Fig. 4; Fig. 5ª, a view, in elevation, and on a further enlarged scale, of the lower portion of the trip shaft and its supporting bracket; Fig. 6, a horizontal section through the feed cylinder and oil chamber, on the line *a a* of Fig. 7; Fig. 6ª, a horizontal section on the line *c c* of Fig. 7; Fig. 7, a longitudinal central section through the feed cylinder, the liquid chamber, and the piston and its accessories; Fig. 8, a vertical central section through one of the gearing mechanisms for effecting the longitudinal traverse of the drilling mechanisms; Fig. 9, a side view, in elevation, of a portion of one of the longitudinal guides for the heads which carry the radial supporting arms of the drilling mechanisms, and an end view of a head and arm mounted therein; Fig. 10, a vertical transverse section through the guides and head and a partial section through the arm, on the line *b b* of Fig. 9; Fig. 11, a transverse section through the casing of the feed supply valve; Fig. 12, a similar section through the by pass valves provided for permitting the free passage of fluid when manually operating the feed of the drill, said valves being shown in the closed positions occupied in fluid pressure feed; Fig. 13, a similar section, showing the valves in the open positions occupied when feeding the drill manually; Fig. 14, a similar section through the four way valve which controls the direction of the application of fluid pressure to the feed piston, the valve being shown in the position occupied when the drill is being fed to the work by fluid pressure; Fig. 15, a similar section showing the valve in the position occupied when the drill is being retracted from the work by fluid pressure; and, Fig. 16, a similar view showing the valve in the position occupied when the feed piston is held stationary by equilibrium of pressure on its opposite sides.

Our invention is herein exemplified in a multiple metal drilling machine, comprising a plurality of hydro-pneumatic feed drilling mechanisms, each of which, as an entirety, is adapted to be longitudinally, transversely, and radially adjusted, relatively to a supporting frame and to the "work" or material to be operated on by the drills. In the instance illustrated, two substantial longitudinally extending supporting frames, 1, 1, are fixed upon a suitable foundation, 2, on opposite sides of an intermediate space through which the metal plates or other material to be operated on are traversed, so as to be subjected to the action of drilling mechanisms supported on the frames, 1, 1.

In order to facilitate the movement of the material to and from the drilling mechanisms, track rails, 3, extend centrally through the space between the frames, and for any desired distance beyond the ends thereof, the rails receiving and supporting a truck or movable bed, 2^a, which may be of any suitable and preferred construction, and by which the material to be operated on is transported to and from positions for such operation, and supported while being subjected thereto.

Heads, 4, are fitted to traverse longitudinally on guides, 1^a, formed on or fixed to the supporting frames, 1, 1, said heads being alternated in position on the opposite frames, so as to occupy different transverse planes on the respective frames. A radial arm, 5, is journaled vertically at one end on each of the heads, 4, being, for this purpose, provided with upper and lower trunnions, 5^a, which are mounted in suitable bearings, 4^a, on the head, 4. A drill mechanism, hereinafter described, is mounted on each of the radial arms, 5, and is fitted to traverse longitudinally on a guide, 5^b, formed on one side of the arm, so as to be located thereon at any desired distance from the head.

The longitudinal movement of the heads on the supporting frames, 1, 1, is effected by mechanism of substantially the following construction: A longitudinally extending shaft, 6, is journaled in bearings, 6^a, on each supporting frame, 1, said shaft carrying on one end a gear, 6^b, meshing with a pinion on the shaft of a motor, 7, and having a longitudinal spline or keyway, 6^c, which extends throughout its length up to short distances from its bearings. Vertical shafts, 8, journaled in the heads, 4, carry, on their lower ends, bevel gears, 8^a, each of which meshes with two corresponding gears, 6^d, fitted freely on the adjacent shaft, 6. A clutch, 8^b, having an internal key or feather which engages the spline of the shaft, 6, and end projections adapted to engage corresponding projections on the bevel gears, 6^d, is fitted on the shaft, 6, between said gears, and is movable into engagement with one or the other gear, as desired, by a shaft, 8^c, having an arm, 8^d, the outer end of which engages a circumferential groove on the clutch. By engaging the clutch with one or the other of the bevel gears, 6^d, said gear will be caused to rotate with the shaft, 6, and to rotate the bevel gear, 8^a, and shaft, 8, the rotation of said shaft being in one direction or the opposite, accordingly as one or the other of the gears, 6^d, is engaged by the clutch. The shaft, 8, carries, adjacent to its upper end, a worm, 8^e, which meshes with a worm wheel, 9, fixed on a horizontal shaft, 9^a, journaled in the head, 4, said shaft carrying a pinion, 9^b, which meshes with a longitudinal rack, 9^c, on the adjacent supporting frame, 1. It will be seen that by the engagement of the pinion and rack, the head will be moved longitudinally on the frame, the direction of its movement being dependent upon that of the rotation of the vertical shaft, 8.

The drilling mechanisms proper, indicated, as entireties, on the drawings by the reference symbol A, are all of similar construction, and the description of one of them, which will now be given, will therefore be applicable to all.

A vertical feed cylinder, 10, has secured upon its lower end a saddle block, 10^a, through which it is supported on the guide, 5^b, of the adjacent radial arm, 5, with the capacity of longitudinal movement and adjustment thereon which is manually effected by means of a hand wheel 11, fixed on one end of a horizontal shaft journaled in the arm, 5, and carrying, on its opposite end, a spiral gear, 11^a, meshing with a corresponding rack, 10^b, on the block, 10^a. The feed cylinder, 10, is surrounded by a liquid chamber, 12, which, as well as the feed cylinder, is closed at bottom by a head cast integral with the chamber and the cylinder, and said chamber and cylinder are closed at top by a removable head, 13. The chamber, 12, is provided for the reception of a suitable inelastic fluid, which is preferably oil. A driving shaft, 14, passes centrally through the feed cylinder and its heads, and is journaled in bearings in the heads and in a gear case, 13^a, secured to the upper head, 13. A motor, 15, which is bolted to the wall of the liquid chamber, 12, carries on the upper end of its shaft, 15^a, a pinion, 15^b, which meshes with a high speed gear, 16^a, on a tubular countershaft, 16, which is fitted to rotate on a vertical rod, 13^b, fixed in the head, 13, and gear case, 13^a, and carries, on its upper end, a low speed pinion, 16^b. The high speed gear, 16^a, meshes with a gear, 14^a, which is fitted to rotate freely on the driving shaft, 14, and the low speed pinion, 16^b, meshes with a gear, 14^b, also fitted to rotate freely on the driving shaft. A clutch, 17, having end projections adapted to engage corresponding projections on the adjoining ends of the gears, 14^a and 14^b, is moved into engagement with either of said gears, as desired, by one of the arms of a double armed rock shaft, 18, journaled in the gear case, 13^a, the other arm of which rock shaft is coupled, by a link, 18^a, to the strap, 19^b, of an eccentric, 19^a, fixed on an operating shaft, 19, journaled near the bottom of the feed cylinder, 10, and carrying an arm, 19^c, by which said shaft may be rocked in its bearings, to correspondingly rock the shaft, 18, and engage the clutch with the gear, 14^a, or the gear, 14^b, accordingly as a high or a low speed of rotation of the driving shaft, 14, is desired.

The portion of the driving shaft, 14,

which extends below the upper head, 13, of the feed cylinder, 10, and liquid chamber, 12, is squared, or made of substantially quadrangular transverse section, and is fitted in a corresponding bore at, and extending downwardly from, the upper end of a tubular spindle, 20, which is surrounded by a quill or sleeve, 20^a, extending downwardly through a stuffing box, 10^c, in the lower head of the feed cylinder and liquid chamber. The tubular spindle, 20, extends below the lower end of the quill, 20^a, and has fixed to its own lower end, a drill stock or socket, 21, in which the drill, 22, is secured in the ordinary manner. A feed piston, 23, is fixed upon the quill, 20^a, adjacent to its upper end, said piston abutting, on its upper side, against a collar, 20^b, secured on the tubular spindle, 20, and a collar, 20^c, on the lower end of the quill, 20^a, abuts against the drill socket, 21, which, as before stated, is secured to the tubular spindle. Ball bearings, 20^d, on which the spindle rotates, are interposed between the collar, 20^c, and the drill socket. It will be seen that under the above construction, upon the application of fluid pressure to the upper side of the piston, 23, the tubular spindle and connected drill socket and drill will be fed downwardly to the work, by the bearing of the collar, 20^c, on the drill socket, such longitudinal movement being effected without interference with the rotation of the tubular spindle and drill. As the upper collar, 20^b, is maintained in contact with the piston during the downward traverse of the tubular spindle and drill, said members will be raised by the piston, through its bearing on said collar, when fluid under pressure is admitted to the feed cylinder on the lower side of the piston.

The piston, 23, is fitted with suitable packing rings, 23^a, on its periphery, and packing rings, 23^b, are interposed between the quill, 20^a, and tubular spindle, 20, within the piston, for the purpose of preventing leakage of fluid between the spindle and quill, while permitting free rotation of the former within the latter. Packing gaskets, 23^c, are also fitted around the squared portion of the driving shaft, 14, at the upper end of the tubular spindle, 20, and are held in a stuffing box, 20^e, formed on the top of the collar, 20^b, by a packing nut, 20^f.

The longitudinal traverses of the feed piston and the connected drill socket and drill, whereby the drill is fed to and retracted from the work, respectively, are effected by the application of fluid under pressure, (which is ordinarily compressed air) to one or the other side of the piston, 23, the preferred construction of means provided therefor being the following: A four way control valve, 24, is fitted to work in a casing, 24^a, to which are connected a supply pipe, 25, leading from a reservoir, compressor, or other source of fluid pressure supply; a pipe, 26, leading to a passage, 26^a, in the upper head, 13, of the feed cylinder, 10, from which a port, 26^b, leads into said cylinder; a pipe, 27, leading to a by-pass pipe, 29, which is controlled by a by-pass valve, 29^a, and communicates, at its opposite ends, with the upper ends of the feed cylinder, 10, and of the liquid chamber, 12, respectively, and a fluid pressure exhaust pipe, 28. The lower ends of the feed cylinder and liquid chamber are connected by a by-pass pipe, 30, controlled by a by-pass valve 30^a. The by-pass valves 29^a and 30^a, are provided for the purpose of permitting the air and oil or other liquid to pass freely in either direction when operating the feed manually, and are closed when the feed is being effected by fluid pressure. To this end, the valves are provided with arms 29^b and 30^b, respectively, which are coupled one to the other and to a hand lever, 31, by a rod or link 31^a. The lower ends of the feed cylinder and liquid chamber are also connected by a communication pipe, 32, controlled by a regulating valve, 33, which is operated by a handle, 33^a, and works over a flat seat having ports, 33^b, which are of gradually increasing transverse area from one end to the other, so as to enable the adjustment of the rate of flow of liquid to be varied by slight increase or decrease as required.

The fluid pressure feed of the drill to the work is automatically cut off at any desired and determined point, and the feed piston and connected drill returned to position for commencing another drilling operation, by a vertical trip shaft, 34, which is fitted to traverse longitudinally in an upper bearing, 34^a, on the liquid chamber, and a lower bearing, 34^d, on a bracket, 34^e, bolted to the saddle block. The trip shaft, 34, carries an arm, 34^b, which is coupled to a longitudinally slotted arm, 24^b, on the control valve, 24, and upper and lower trip dogs, 35^a and 35^b, between which a tappet, 35, is secured on the quill, 20^a, in position to engage the upper or the lower trip dog, respectively, at the corresponding terminal of the normal stroke of the piston. By such engagement, the trip shaft, through its connection with the control valve, 24^a, opens communication through said valve between the fluid pressure supply reservoir and the feed cylinder, above the piston, and opens communication between the liquid chamber and the exhaust, as indicated in Fig. 14, when the tappet, 35, strikes the upper trip dog, 35^a, at the upper limit of the piston, thereby admitting fluid pressure to effect the downward or feeding stroke of the piston. During the downward stroke of the piston, the liquid which is below it in the feed cylinder, passes therefrom, through the communication pipe, 32, to the liquid chamber, the flow of liquid through

said pipe being graduated, in accordance with the rate or speed of feed desired, by manual adjustment of the regulating valve, 33. The control valve remains in this feeding position until the piston reaches the normal lower limit of its stroke, when, by the contact of the tappet, 35, with the lower trip dog, 35^b, the trip shaft is depressed and moves the control valve into the position shown in Fig. 15, in which communication is opened between the feed cylinder, above the piston, with the exhaust, and between the fluid pressure supply reservoir, and the liquid chamber. The pressure in said reservoir, then acting on the liquid in the chamber, forces liquid therefrom, through the communication pipe, 32, into the feed cylinder, below the piston, and effects the upward or retracting stroke of the piston.

The trip dog, 35^b, is adjustable in position longitudinally on the quill, and may also be swung thereon, out of the way of the tappet, 35, so as to allow the piston and its connected members to be manually raised or lowered when desired, and an intermediate adjustable trip dog, 35^c, is also fitted on the quill, to enable the stroke of the piston to be automatically limited, as may, from time to time, become desirable for certain classes of work. To enable the trip rod, 34, to be longitudinally adjusted in its bearings, a rack, 34^a, is formed upon it, at and adjacent to its lower end, said rack being engaged by a pinion, 36^a, on a shaft, 36, journaled in the bracket, 34^e, which carries the lower bearing, 34^d, of the trip shaft, and provided with a hand wheel, 36^b.

The piston and its connected members are adapted to be manually raised and lowered when desired by a shaft, 37, journaled in a bearing, 37^a, secured to the saddle block, 10^a, and having fixed upon an operating hand wheel, 38, and a pinion, 37^b, which engages a rack, 20^e, fixed to the quill, 20^a. During the manual operation of the piston and connected members, free communication is established between the fluid pressure supply reservoir and the liquid chamber, both above and below the piston, by opening the valves of the by pass pipes, 29 and 30, as indicated in Fig. 13.

The means for the application of power to, and the regulation of the feed of, the drilling tools which are provided under our invention, enable substantial economy of operation and maintenance to be effected in a mechanism of large capacity and power. The graduated regulation of the flow of liquid effects a steady feed of the spindle and drill and the consequent elimination of backlash obviates all liability to breakage under operative conditions such as the burning of a tool, striking an extremely hard spot in the work, or when breaking through at the finish of the drilled hole. The maximum of safety is afforded, for the reason that whenever the cutting resistance becomes greater than the total fluid pressure acting on the piston, the spindle merely revolves without advancing and no damage can result.

We claim as our invention, and desire to secure by Letters Patent:—

1. In a hydro-pneumatic drill, the combination of a feed cylinder, a liquid chamber surrounding said cylinder, a piston fitting the feed cylinder, a metal cutting tool connected to said piston, pipes connecting the feed cylinder and the liquid chamber above and below the feed cylinder piston, and a valve controlling the admission and exhaust of fluid under pressure to and from one side of said piston and to and from the corresponding end of the liquid chamber.

2. In a hydro-pneumatic drill, the combination of a feed cylinder, a liquid chamber surrounding said cylinder, a piston fitting the feed cylinder, a metal cutting tool connected to said piston, pipes connecting the feed cylinder and the liquid chamber above and below the feed cylinder piston, manually operated valves controlling said pipes, and an independent valve controlling the admission and exhaust of fluid under pressure to and from one side of the piston and to and from the corresponding end of the liquid chamber.

3. In a hydro-pneumatic drill, the combination of a feed cylinder, a liquid chamber surrounding said cylinder, a piston fitting the feed cylinder, a metal cutting tool connected to said piston, pipes connecting the feed cylinder and the liquid chamber above and below the feed cylinder piston, manually operated valves controlling said pipes, a communication pipe connecting the feed cylinder and liquid chamber, a manually operated regulating valve controlling said communication pipe, and a valve controlling the admission and exhaust of fluid under pressure to and from one side of the piston and to and from the corresponding end of the liquid chamber.

4. In a hydro-pneumatic drill, the combination of a feed cylinder, a liquid chamber, a piston fitting the feed cylinder, a metal cutting tool connected to said piston, a valve controlling the admission and exhaust of fluid under pressure to and from one side of said piston and to and from the corresponding end of the liquid chamber, and means, wholly actuated by the movement of the piston, for moving said valve into position to reverse the direction of admission of fluid to the piston at predetermined points in both traverses thereof.

5. In a hydro-pneumatic drill, the combination of a feed cylinder, a liquid chamber, a piston fitting the feed cylinder, a metal cutting tool connected to said piston, a valve

controlling the admission and exhaust of fluid under pressure to and from one side of said piston and to and from the corresponding end of the liquid chamber, means for establishing equilibrium of pressures on opposite sides of said piston, and means for manually operating the piston and its connected members upon the establishment of such equilibrium.

6. In a hydro-pneumatic drill, the combination of a feed cylinder, a liquid chamber, a piston fitting the feed cylinder, a metal cutting tool connected to said piston, a valve controlling the admission and exhaust of fluid to and from one side of said piston and to and from the corresponding end of the liquid chamber, a communication pipe connecting the feed cylinder and liquid chamber, and a regulating valve fitted in said pipe and controlling ports which are of gradually increasing transverse area from one end to the other.

7. In a hydro-pneumatic drill, the combination of a feed cylinder, a liquid chamber surrounding said feed cylinder, a head closing one end of said feed cylinder and liquid chamber, a driving shaft passing through the head, a gear casing fixed to the head, gearing mounted in said casing and adapted to rotate the driving shaft, a longitudinally movable spindle engaging and rotated by the driving shaft, a metal cutting tool connected to said spindle, a sleeve surrounding said spindle and bearing at each of its ends thereon, a piston fitting the feed cylinder and fixed to said sleeve, and a valve controlling the admission and exhaust of fluid under pressure to and from one side of said piston and to and from the corresponding end of the liquid chamber.

8. In a hydro-pneumatic drill, the combination of a feed cylinder, a liquid chamber surrounding said feed cylinder, a motor supported on the liquid chamber, a piston fitting the feed cylinder, a metal cutting tool connected to said piston, means for imparting longitudinal traverse to the piston and cutting tool by the admission of fluid under pressure to the feed cylinder, and gearing for imparting rotation from the motor to the cutting tool.

9. In a hydro-pneumatic drill, the combination of a feed cylinder, a liquid chamber surrounding said feed cylinder, a head closing one end of said feed cylinder and feed chamber, a driving shaft passing through the head, a gear casing fixed to the head, gearing mounted in said casing and adapted to rotate the driving shaft, a motor supported on the liquid chamber and engaging said gearing, a longitudinally movable spindle rotated by the driving shaft, a metal cutting tool connected to said spindle, a piston fitting the feed cylinder and adapted to impart longitudinal movement to the spindle, and a valve controlling the admission and exhaust of fluid under pressure to and from one side of said piston and to and from the corresponding end of the liquid chamber.

10. In a hydro-pneumatic drill, the combination of a feed cylinder, a liquid chamber surrounding said cylinder, a piston fitting the feed cylinder, a metal cutting tool connected to said piston, a valve controlling the admission and exhaust of fluid under pressure to and from one side of said piston and to and from the corresponding end of the liquid chamber, a longitudinally movable trip shaft mounted on the liquid chamber and coupled to the controlling valve, trip dogs mounted on said trip shaft, and a tappet connected and moving with the piston and adapted to abut against the trip dogs at determined points in the traverse of the piston.

11. In a hydro-pneumatic drill, the combination of a feed cylinder, a liquid chamber surrounding said cylinder, a driving shaft fitted to rotate in line axially with the feed cylinder and liquid chamber, a spindle having a bore of angular cross section for a portion of its length engaging a portion of the driving shaft of corresponding section, a metal cutting tool connected to said spindle, a sleeve surrounding said spindle and abutting at its ends on collars or shoulders thereon, a piston fixed on said sleeve and fitting the feed cylinder, packing rings fitted in the face of said piston, packing rings interposed between the spindle and the sleeve, inside the piston, pipes connecting the feed cylinder and liquid chamber above and below the piston, and a valve controlling the admission and exhaust of fluid to and from one side of the piston and to and from the corresponding end of the liquid chamber.

12. In a hydro-pneumatic drill, the combination of an integral casting comprising an open topped feed cylinder, a surrounding open topped liquid chamber, and a head closing said cylinder and chamber at bottom, and a detachable head closing the tops of the cylinder and chamber, said top head being provided with a fluid pressure supply and exhaust port, and adapted to support a gear casing.

13. In a hydro-pneumatic drill, the combination of a feed cylinder, a liquid chamber surrounding said cylinder, a saddle block fixed to the bottoms of the cylinder and chamber, a piston fitting the feed cylinder, a metal cutting tool connected to said piston, means for imparting longitudinal traverse to the piston and cutting tool by the admission of fluid under pressure to the feed cylinder, a motor supported on the liquid chamber, gearing for imparting rotation from the motor to the cutting tool, a supporting arm on which the saddle block is fitted to traverse longitudinally, and means, mounted in the

saddle block, for moving said block and the members connected therewith on the supporting arm.

14. In a hydro-pneumatic machine-tool, the combination of a feed cylinder, a piston therein, a tool arranged to be actuated by said piston, a liquid chamber, a four-way valve connected to a source of fluid under pressure, a pipe leading from said valve into one end of the feed cylinder, an exhaust outlet from said valve, a pipe leading from said valve to one end of the liquid chamber, a connection from said last mentioned pipe into said cylinder, a by-pass valve in said connection, a pipe connecting the other ends of said cylinder and chamber, a by-pass valve in said last mentioned pipe, and means for manually raising and lowering said piston, available for use when said by-pass valves are open and said four-way valve is closed.

COLUMBUS K. LASSITER.
FRANK E. BOCORSELSKI.

Witnesses:
A. H. WARD,
E. W. FARLEY.