(No Model.) 4 Sheets—Sheet 1.

L. W. BATES.

METHOD OF AND APPARATUS FOR FIRING PNEUMATIC ORDNANCE.

No. 605,841. Patented June 21, 1898.

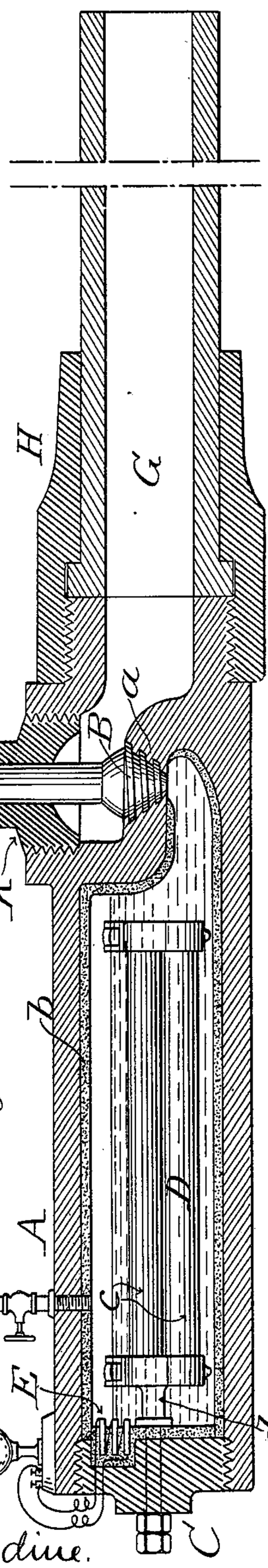

Fig. 1.

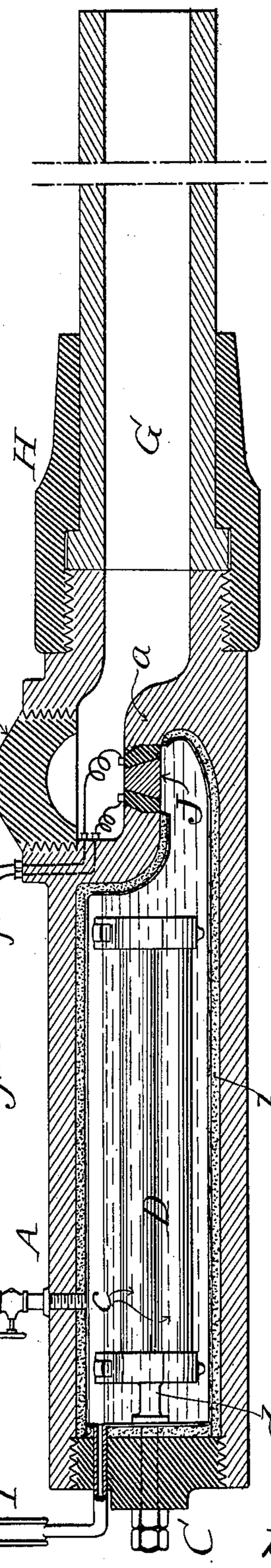

Fig. 2.

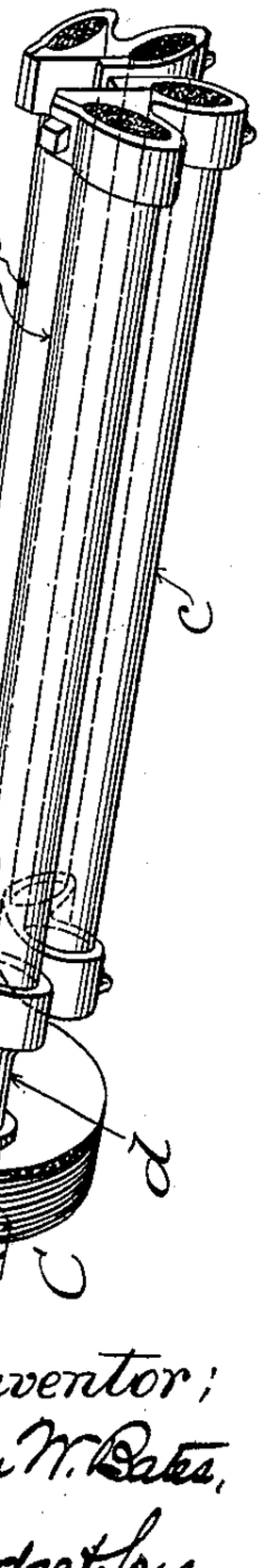

Fig. 3.

Attest
C. C. Burdine.
J. M. Pond

Inventor;
Linden W. Bates,
by Dodger Sons
Atty's.

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No. 605,841. Patented June 21, 1898.

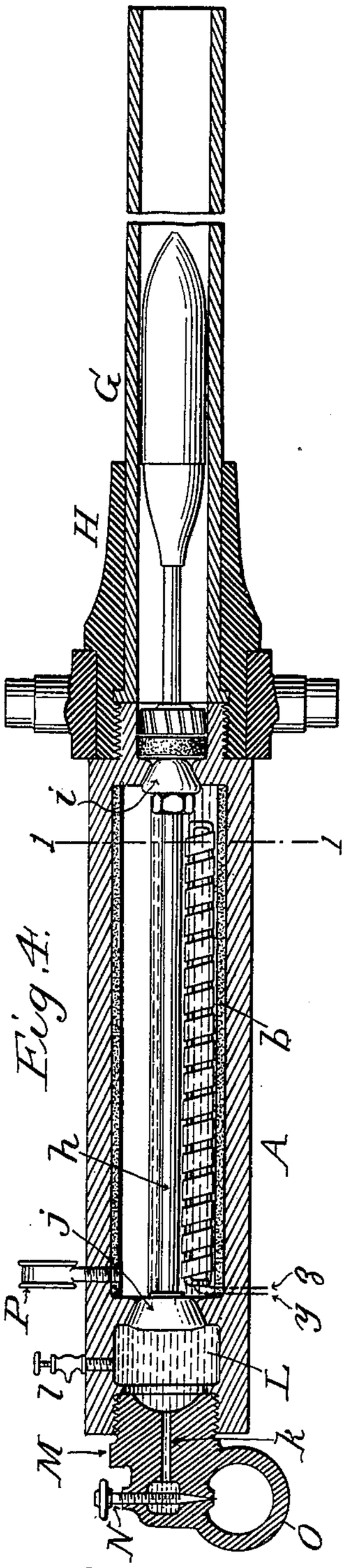

Fig. 4.

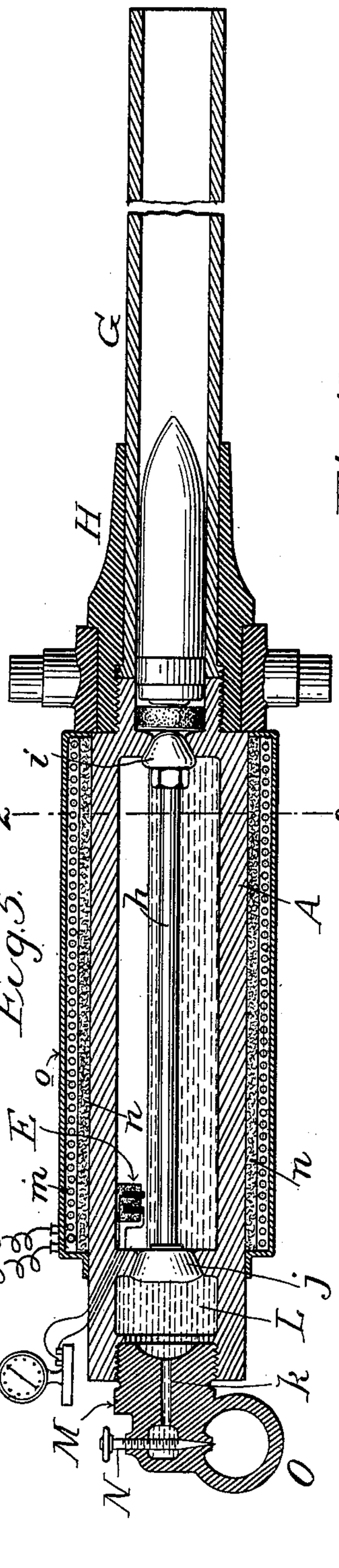

Fig. 5.

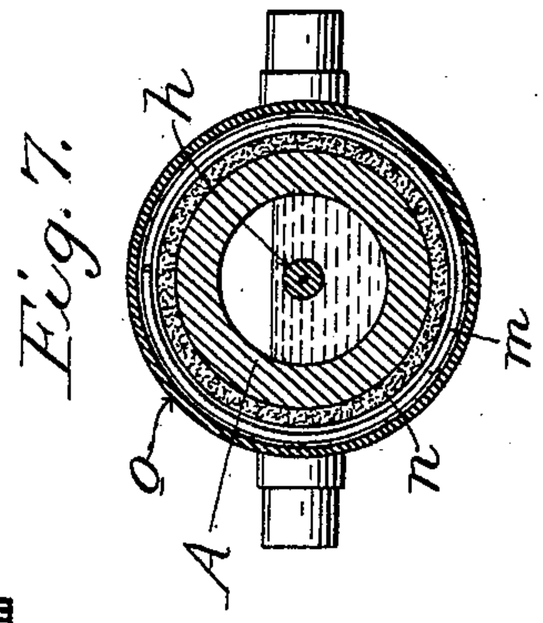

Fig. 7.

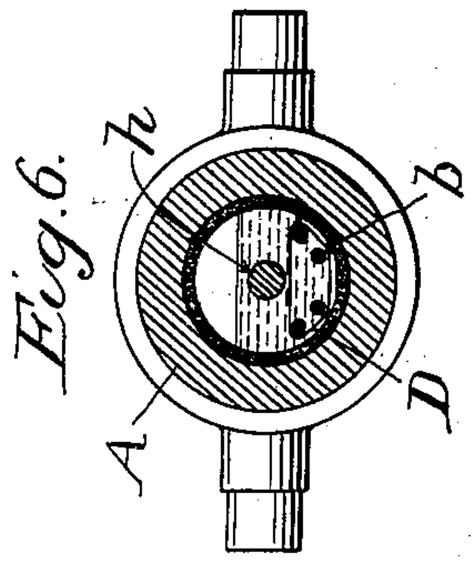

Fig. 6.

Attest:
C. C. Burdine
J. M. Paul.

Inventor:
Lindon W. Bates,
by Dodger Sons & Fitzg's

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L. W. BATES.

METHOD OF AND APPARATUS FOR FIRING PNEUMATIC ORDNANCE.

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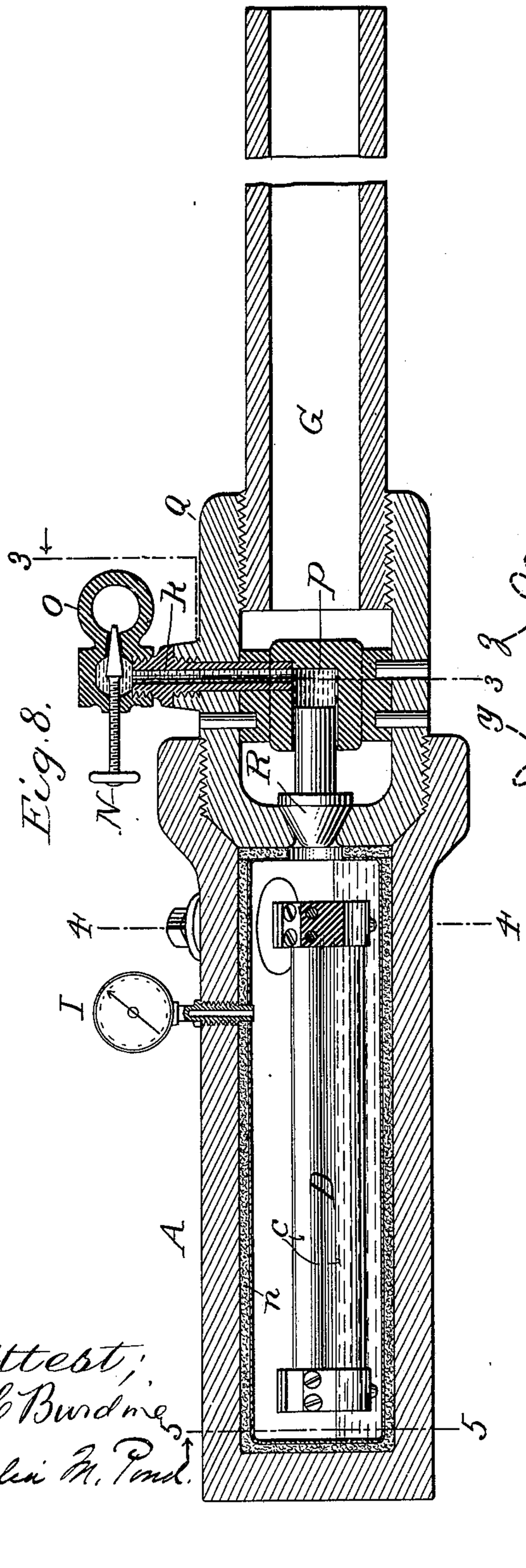

Fig. 8.

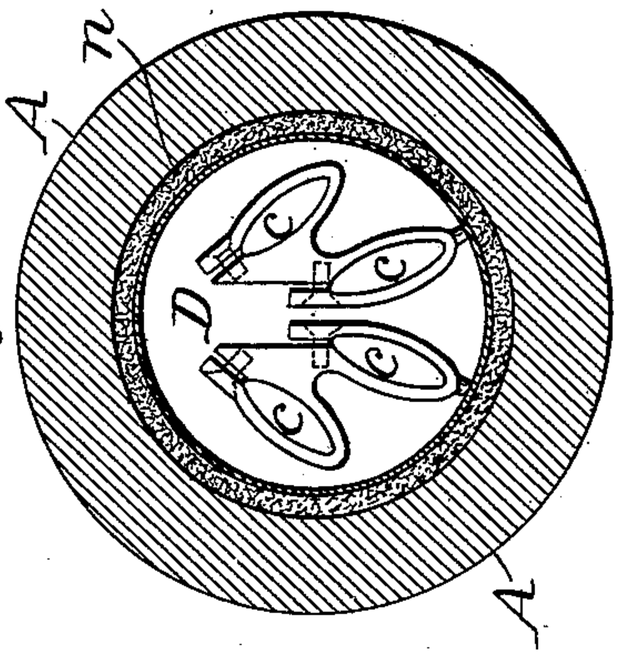

Fig. 11.

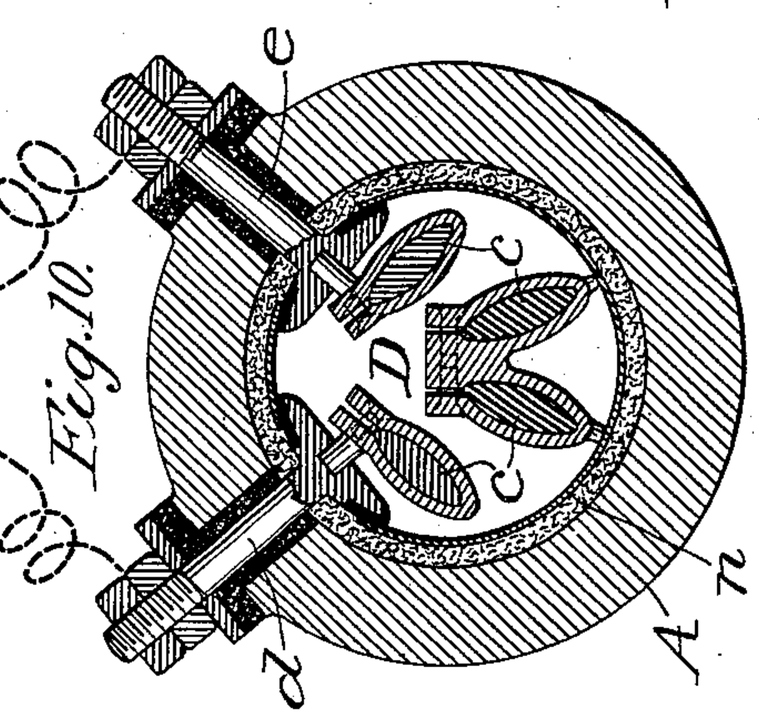

Fig. 10.

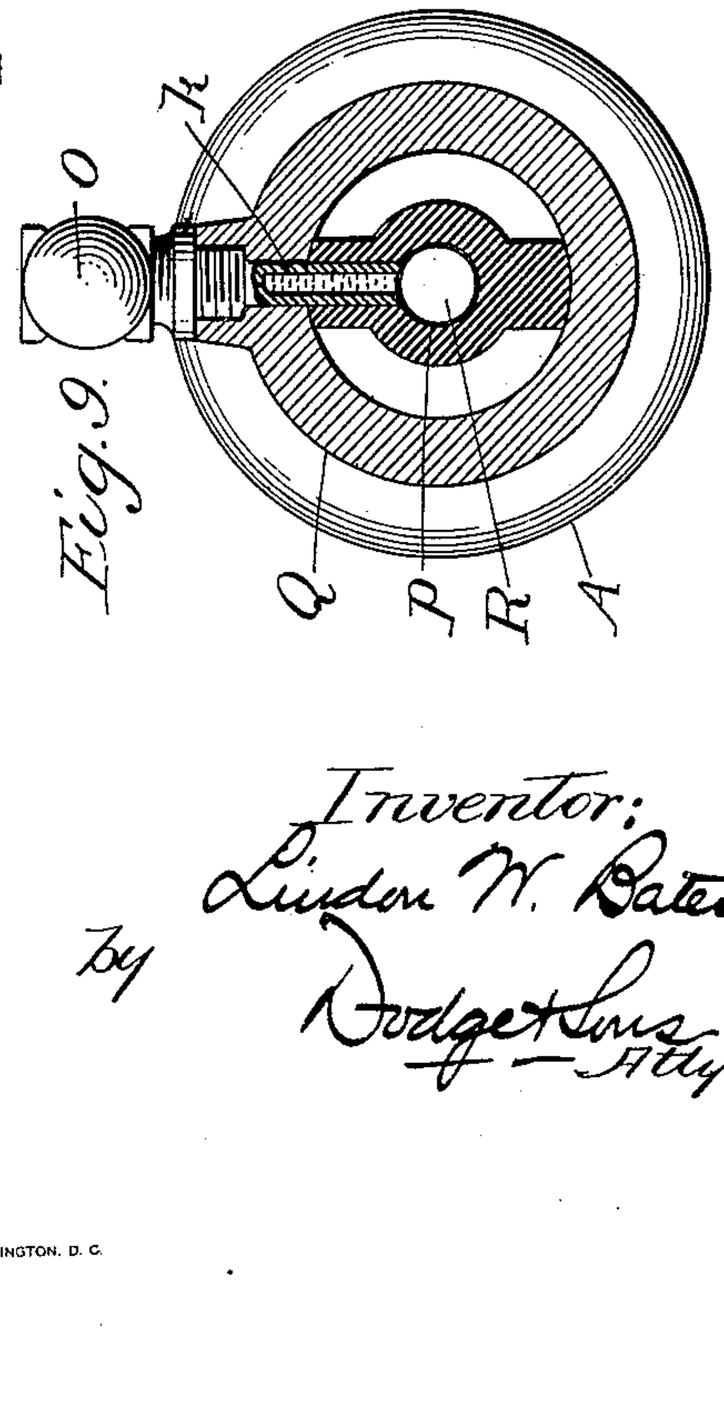

Fig. 9.

Attest;
C. C. Burdine
Julia M. Pond.

Inventor:
Linden W. Bates,
by Dodger & Sons
Attys.

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METHOD OF AND APPARATUS FOR FIRING PNEUMATIC ORDNANCE.

No. 605,841. Patented June 21, 1898.

Fig. 12.

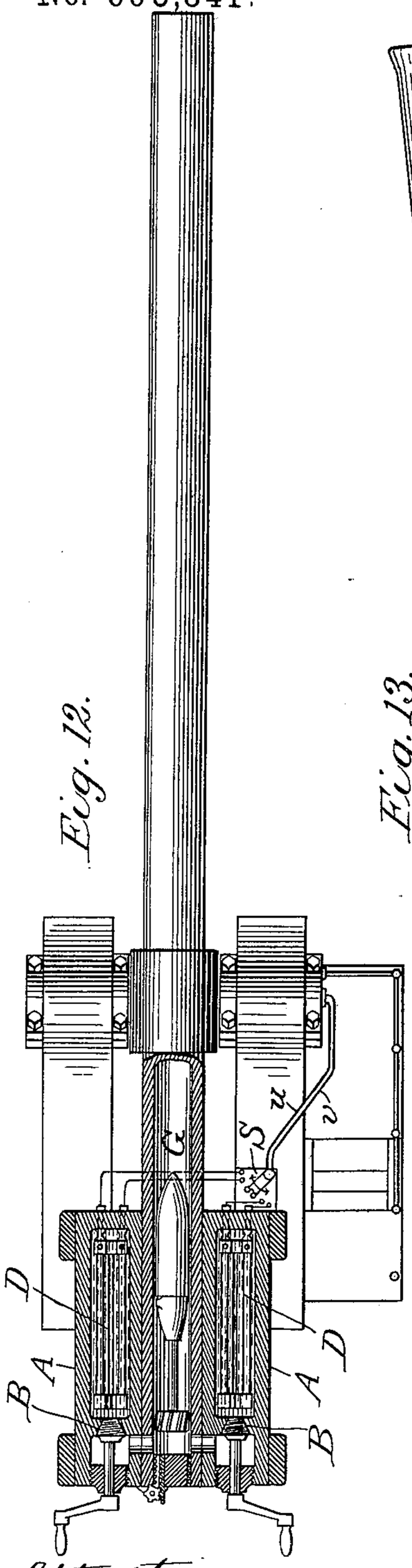
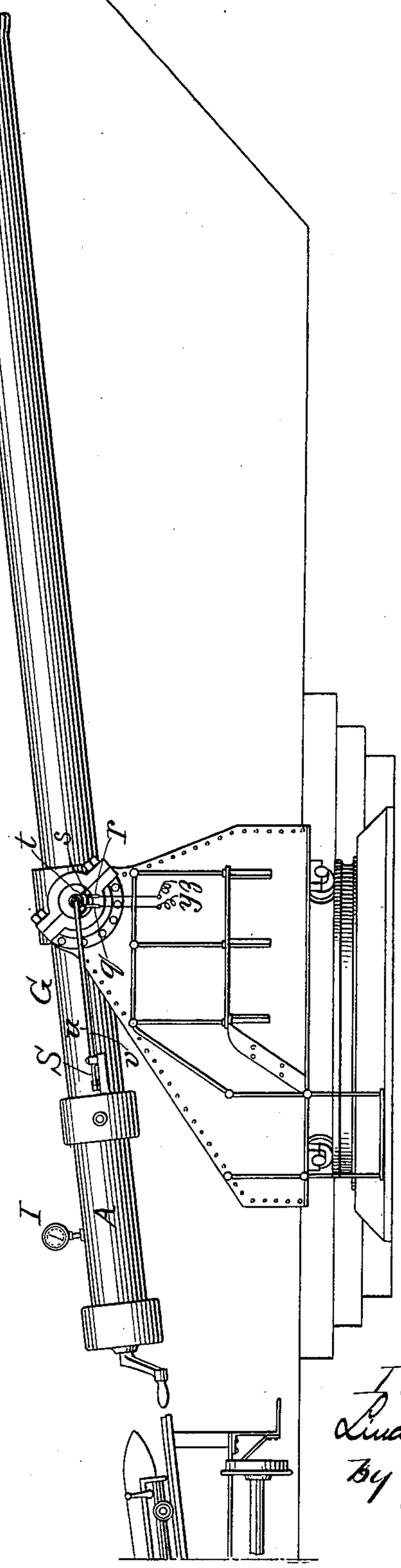


Fig. 13.



Attest
C. C. Burdine
J. M. Pond

Inventor:
Linden W. Bates,
By Dodger Sons,
Atty's.

UNITED STATES PATENT OFFICE.

LINDON W. BATES, OF CHICAGO, ILLINOIS.

METHOD OF AND APPARATUS FOR FIRING PNEUMATIC ORDNANCE.

SPECIFICATION forming part of Letters Patent No. 605,841, dated June 21, 1898.

Application filed June 25, 1896. Renewed November 18, 1897. Serial No. 659,016. (No model.)

To all whom it may concern:

Be it known that I, LINDON W. BATES, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Methods of and Apparatus for Propulsion of Projectiles, of which the following is a specification.

My invention pertains to the propulsion of projectiles, and more particularly to the method of and apparatus for generating or developing the pressure requisite to such propulsion.

Stated generally the invention consists in confining a body or volume of water or other suitable agent within a chamber of the gun, subjecting said agent to heat and to the pressure consequent upon its expansion, thereby converting it into high-pressure steam or into a high-tension vapor or gas, and finally, when the proper pressure is attained, permitting said vapor or gas to act upon the projectile.

The means for carrying out the invention are susceptible of considerable variation as to details; but in order that the gun may be provided with the necessary pressure-generating apparatus and yet be readily portable and manageable it is essential that it be a part of the gun or its "mount" or contained within the gun or the mount. The present case is designed to cover the plan broadly and generically, leaving to other cases the special details and features or plans of application not herein particularly set forth. Thus I have represented in the accompanying drawings the pressure-generating chamber as constituting a permanent or continuing part of the gun, and have embodied in application, Serial No. 597,599, of June 30, 1896, a cartridge or charge containing the pressure-generator, and in application, Serial No. 597,600, of June 30, 1896, a gun having said apparatus in its mount, and shall therefore not claim specifically those constructions herein.

Referring now to the drawings, Figure 1 is a longitudinal sectional view of a gun provided with a pressure-generator in accordance with my invention, and showing a mechanical valve between the pressure-generator and the projectile-chamber; Fig. 2, a similar view, but with a fusible plug sealing the pressure-chamber; Fig. 3, a perspective view of the heater of Figs. 1 and 2 removed from the pressure-chamber; Fig. 4, a longitudinal sectional view of a gun provided with an electric heater in the pressure-chamber constructed to heat by resistance and provided with a differential valve mechanism; Fig. 5, a similar view of a gun provided with an induction heating apparatus designed to utilize Foucault or eddy currents; Figs. 6 and 7, transverse sections on the lines 1 1 and 2 2 of Figs. 4 and 5, respectively; Fig. 8, a sectional view of a gun embodying the same general principles of construction, but showing a modified sealing-valve; Figs. 9, 10, and 11, transverse sections on the lines 3 3, 4 4, and 5 5 of Fig. 8; Fig. 12, a top plan view, partly in section, of a gun provided with a plurality of heaters adapted to be used successively or jointly; Fig. 13, a side elevation of the same.

The present invention is designed to effect the propulsion of projectiles of all classes, solid and explosive, armor-piercing, dynamite, or others, though primarily intended for use with dynamite charges and others requiring cushioning of the charge to prevent premature explosion by reason of concussion.

Prior to my invention various plans have been proposed and tested for throwing both solid projectiles and dynamite shells, the latter class involving generally the use of air under high compression or the explosion of a gas or gases in a chamber, between which and the projectile-chamber was contained a body of confined air, serving as a cushion to relieve the projectile and its contained charge from the effects of concussion. My plan contemplates the generation of fluid-pressure or the formation of a high-tension gas or vapor in a space immediately in rear of the projectile and communicating with the projectile-chamber. The gas so produced is in itself so highly elastic and so controlled in its introduction into the projectile-chamber that concussion is reduced to a minimum and the projectile is started easily and gradually, but is speedily brought to a velocity far higher than has heretofore been practicable with projectiles containing dynamite or other highly-explosive compounds.

To enable me to generate the necessary high-tension vapor within the limited space available and within a reasonably short space of time, I employ electric heating devices of suitable design and construction contained within or surrounding the pressure-chamber and under the control of the gunner. The particular form or construction of the heater, the principle involved in its action, the form of the chamber, the mode of sealing the same, the manner of and means for controlling communication between the pressure-chamber and the projectile-chamber are all susceptible of considerable variation, as will be hereinafter pointed out.

Referring now to the drawings which represent a few of the many types in which the invention may be embodied and considering, first, Fig. 1, A indicates a strong walled chamber of steel or other suitable metal or alloy, provided at its forward end with a diaphragm or partition *a*, through which is formed an opening or passage-way which is closed by a valve B, preferably of the form shown in said figure and hereinafter more fully described. The rear end of the chamber A is closed by a screw-plug C or other suitable closure, and is advisably provided with a lining *b* of asbestos or other non-conducting material in order to retain the heat and prevent, so far as possible, conduction and radiation.

Within the chamber A is an electric heater D (better shown in Fig. 3) and consisting of a series of carbon-rods *c*, so connected at their ends as that the current entering by a supporting rod or stem *d* shall pass through the rods *c* in series or succession and return or pass out through a second stem *e*, said stems passing through and being electrically insulated from the plug or closure C. Any equivalent form of heater capable of affording a proper resistance to suitable electric current may obviously be substituted for that shown. Practical tests have demonstrated the high efficiency of the particular type of heater here illustrated. The chamber A will be charged with water or other suitable agent and to any desired extent, it being advisable, however, to leave a portion of the chamber unoccupied, as indicated in Figs. 1 and 2 and in other figures hereinafter referred to.

For the purpose of indicating to the gunner or officer in charge the temperature and pressure developed within the chamber A, I propose in some cases to place within the chamber A or to extend into the same a thermo-electric pile E and to include in the circuit thereof a galvanometer F or other instrument, which by its reading shall indicate the temperature or the pressure within the chamber A, the deflection of the needle or indicator being of course proportionate to the current developed and this in turn being dependent upon the temperature within the chamber, which latter must always bear a definite relation to the pressure therein.

G indicates a barrel or tube designed to receive and to guide the projectile, which, as above indicated, may be of any desired form. The barrel or tube G may be rifled or smooth, according to the nature of the projectile to be used. Under the construction shown in Fig. 1 the projectile may be inserted at the muzzle of the barrel and pushed back to a point near the diaphragm *a*, or the barrel G and chamber A may be uncoupled by unscrewing a connecting-sleeve H, in which latter event the thread connecting the sleeve and chamber A should be an interrupted or mutilated thread. Any common construction may be adopted to permit the introduction of the projectile at the rear of the barrel G, the invention being wholly independent of this feature.

As before indicated, it is desirable, at least when firing explosive charges, to introduce the gas or vapor into the projectile-chamber somewhat gradually at first, and this result is admirably attained through the employment of a valve of the particular construction illustrated in Fig. 1. As there seen, this consists of a conical or tapering valve-plug provided with a screw-thread on its circumference adapted to mesh with a like thread in the opening or passage through the diaphragm *a*. The stem of the valve B is provided with a handle by which it may be turned to unscrew the plug from the opening, and it will be seen that but a short turn will be necessary, since owing to the conical or tapering form of the plug it will be speedily caused to unlock and permitted to move in the direction of its axis out of the opening in the diaphragm *a* under the great pressure of the chamber A.

The operation of the device will then be as follows, assuming that the chamber A is supplied with a proper quantity of water or other suitable agent: Current from any suitable generator or source of supply will be delivered to the heater D through the stem *d*, the current returning by the stem *e* and being of proper voltage and of a sufficient number of amperes to effect an intense heating of the rods *c*. The great heat thus developed will first convert the water into steam, and this in turn, by reason of the high temperature and the great pressure due to the continued heating of the water and the steam within the confined space, will in short time pass into a high-tension gas or vapor. In this way an enormous pressure is developed, the degree of which is indicated by the reading of the galvanometer. A pyrometer may be substituted for the thermopile and galvanometer or used in addition thereto, the one to serve as a check upon the other.

In Fig. 2 I have represented, essentially, the same construction, except that a pressure-gage I is substituted for the galvanometer F and the thermopile E and that a fusible plug or seal J is substituted for the valve B. Under this construction the heat and pressure

will be developed as before, and when the gage I indicates the attainment of the predetermined pressure a current will be passed through the fusible plug J by means of conducting-wires *f g*, led into the gun in any convenient way. The effect of this current will be to fuse the plug J, thereby permitting the escape of the gas or vapor from chamber A into the barrel or tube G behind the projectile contained therein. As the fusion takes place somewhat gradually it follows that the gas or vapor will enter the barrel G gradually and without undue shock to the projectile. Under both these constructions a screw plug or cap K will be provided opposite the opening or passage through the diaphragm *a* to afford convenient access to said opening.

It is of course understood that the various wires or conductors are duly insulated to prevent short-circuiting of the current.

In Fig. 4 I have represented a somewhat different form of heater and a different sealing device, the heater comprising a metallic tape or ribbon wound spirally upon a non-conducting frame or support and connected with wires *y z*, as before. The sealing device comprises a rod or stem *h*, carrying at its forward end a conical valve-plug *i* and at its rear end a similar valve-plug *j*, of larger diameter or area than the plug *i*. The relative areas may vary according to the requirements of individual cases; but under all circumstances the plug *j* should present a larger surface to the gas or vapor of chamber A than does the plug *i* in order that the excess of pressure thereon may be utilized in retracting valve *i* when the plug *j* is permitted to move.

In rear of chamber A there is formed a smaller chamber L, closed at the rear end by a screw-plug or other closure M. The plug or closure M is provided with a vent *k*, controlled by a needle-valve N or equivalent sealing device capable of sealing the vent against high pressure and of opening the same gradually and to a limited extent, if so desired. The chamber L is designed to be charged with water or other liquid, which will extend into the vent-passage and completely exclude air from the chamber and the space communicating therewith. This confined body of liquid is designed to preclude the backward movement of the valve or head *j* so long as the vent-passage *k* remains sealed; but in order that this may result with certainty it is of course essential that no air-pocket be allowed to form within the chamber L or the space communicating therewith. To this end a vent-cock *l* may be placed in communication with the highest point of chamber L, so that in filling the same the water or other liquid may be permitted to pass out through said vent and to carry with it any air entering the chamber, which would of course pass to the highest point therein. To prevent the water or other liquid from causing annoyance or inconvenience to those about the gun, a chamber O may be arranged to receive the liquid escaping through the vent-passage *k*, as indicated in Figs. 4 and 5.

The chamber A will be provided with a pressure-gage P to indicate the pressure developed within said chamber in order that the gunner may know when it has attained a sufficient degree to carry the projectile the intended distance. When this point is reached and the gun is properly aimed, the valve N is opened, at first somewhat gradually and then fully, thus permitting the liquid to escape from chamber L and allowing the valve or head *j* to recede under the pressure of the gas or vapor within the chamber A, the valve or head *j* carrying with it the stem *h* and sealing-valve *i*, owing to the greater area of, and consequently greater aggregate pressure upon, the head *j* as compared with that upon the valve-plug *i*.

The gradual venting of the chamber L involves, of course, a gradual opening of the valve *i* and a consequently easy and progressive application of the pressure to the projectile in the barrel or tube G, which is of advantage not only with projectiles containing high explosives, but also with solid shot and armor-piercing projectiles.

The term "gradual" is here used to distinguish between the concussion or sudden and instantaneous impact incident to the explosion of a powder charge and that action produced by the opening of a valve or port first partially and then more fully. While the total period elapsing between the initial and the final or complete opening of the valve is extremely short and scarcely measurable, there is nevertheless a marked difference in the effect or result of the two modes of action, the one resulting almost inevitably in the detonation of the explosive charge of the projectile and the other avoiding such detonation.

In practice it will be found expedient to grind the valves or plugs *i* and *j* to their seats, and the rod *h* should have a ratio of expansion such as will maintain the seating of the valve *i* notwithstanding any elongation of the chamber A that may result from the high temperature produced therein.

Fig. 5 shows a construction essentially the same as that of Fig. 4, except that instead of making the electric heater D to heat by resistance and placing it within the chamber A it is made to surround or encircle said chamber and to heat by induction or through the generation of eddy or Foucault currents in the metal constituting the walls of said chamber A. Under this construction alternating currents will be employed and the eddy currents will be set up in the walls of the chamber A, which should be of magnetic metal, and will constitute the core of the coil or helix *m* encircling said chamber. The coil *m* will of course be insulated and a layer *n* of asbestos or other suitable pyro-insulation will advisably be

placed between the helix and the outer wall of chamber A to prevent the heat from passing off and being dissipated in the air or destroying the insulation of the coil. A jacket *o*, of metal or other suitable material, will advisably be placed outside the coil or helix to protect the same against injury. Under this construction the chamber A may be provided with a thermopile and galvanometer, with a pressure-gage, or with a pyrometer, which latter is indicated in Fig. 5. Since the pressure will be directly proportionate to the temperature and the relation of the two may be accurately determined either by calculation or by tests, it will be seen that the readings of the pyrometer will serve as a safe and accurate indication of the pressure existing within the chamber A.

It is to be understood that these several modes of indicating the pressure within the chamber A are regarded as equivalents in the broad sense and may be adopted interchangeably in connection with the system here set forth.

Figs. 6 and 7 represent sections taken on the lines 1 1 and 2 2 of Figs. 4 and 5, respectively, and showing the sectional form and location of the heaters of said figures.

Fig. 8 represents a gun provided with the same type of heater shown in Figs. 1, 2, and 3, for which, however, that represented in Fig. 4 or that in Fig. 5 may be substituted. The distinctive feature of this embodiment of the invention is the sealing-valve controlling communication between the pressure-chamber A and the projectile chamber or tube G. In this figure, as in the preceding, the chamber A constitutes a rearward extension of the gun and is shown as screw-threaded and screwed tightly upon a valve-chamber section Q, into the forward end of which is screwed or otherwise secured the rear end of the barrel or projectile-tube G. The chamber A is here represented as lined with suitable non-conducting material *n*, which may in turn be lined with some stiffer material to maintain it in position. At the forward end of the chamber A is a passage or opening communicating with the interior of the valve-chamber Q and normally sealed by a conical valve R, the cylindrical stem of which enters a liquid-chamber *p*, provided with a vent passage or outlet *k*, controlled by a needle-valve N or equivalent device, as in Figs. 4 and 5. The liquid-chamber *p* and the vent-opening *k* are to be filled with water or other liquid, as before, and the release of the valve R will be effected in the same manner as under the previously-described construction—that is to say, by backing the needle-valve N at such rate as may be found necessary or expedient. When the liquid is thus allowed to escape from the chamber *p*, the valve R will recede and the gas or vapor will pass from chamber A into section or chamber Q, around the liquid-chamber *p*, and into the barrel or projectile-tube G, the chamber *p* being of the form in cross-section indicated in Fig. 9, and thus leaving adequate space for the passage of the liquid on either side. A pressure-gage I or other suitable indicating device will be applied to chamber A to indicate the pressure therein.

Figs. 10 and 11 indicate, respectively, the electrical connections at the forward end of the heater and the metallic connections at the rear end thereof, by which the current is caused to pass successively through the bars or rods *c* of the heater D.

Figs. 12 and 13 illustrate the application of the same principle and method of propulsion to a gun provided with two or more pressure-generating chambers. The gun here represented is of breech-loading construction, the breech mechanism being substantially that of the guns now in use in the United States Navy, though obviously any other suitable breech mechanism may be employed. A A indicate the two pressure-generating chambers, each containing an electrical heater D of any suitable construction, and sealed by a valve B of the same character as that shown in Fig. 1, for which may be substituted, however, any other closure or sealing device hereinbefore referred to.

In order that the gun may be properly elevated or depressed by rocking or tipping upon its trunnions, as usual, and without interfering with the electrical connections, the feeder-wires *y z* are carried to spring-fingers *q* and *r*, arranged to bear upon insulated contact-plates *s* and *t* on a trunnion of the gun, whence conducting-wires *u* and *v* pass to a switch S, which can be set to connect the feeder-wires with either of the heaters D at will. In this way the heaters D may be used alternately or successively, if there be more than two, or they may be used jointly by making the proper connections from the switch S.

As shown in Fig. 12, each chamber A communicates directly with the rear end of the projectile chamber or barrel G of the gun, and consequently when one of the valves B is open the gas or vapor will pass into the barrel directly in rear of the projectile.

In the foregoing description I have spoken of a liquid or other agent as being contained within the chamber A and subjected to the action of an electric heater D, and in practice I contemplate ordinarily using water as such agent, believing that when all conditions are taken into consideration it will be found the most satisfactory. I desire, however, to have it perfectly understood that my invention comprehends the use not only of water, but also of other liquids, volatile or otherwise, and also such solids or semisolids as are capable of being converted into a gas or vapor when subjected to high heat in a confined space. Many of the hydrocarbons are suitable for such use either by themselves or with water or other agent, and many sub-

stances of a solid or semisolid nature are also capable of use in the manner set forth. So, too, gases, either in the gaseous state or compressed to a state of liquefaction may be employed. In other words, my invention comprehends, broadly, the production or generation of steam or vapor under high pressure or a high-tension gas or vapor by confining suitable agents within a strong chamber of restricted area or capacity and subjecting the same to intense heat generated within said chamber.

I desire also to have it understood that it is not essential for all uses or applications of the invention that a high-tension gas or vapor be produced, though the greatest efficiency will be attained when this is done. When using water, the temperature and pressure may be carried only to a point sufficient to produce steam under high pressure, or, in other words, the heat may be kept below the critical temperature of steam, which is 1,590° Fahrenheit. The pressure obtainable below the critical temperature of steam is sufficient for the propulsion of dynamite projectiles and the like to distances greater than are reached by the means at present in use for that purpose; but where greater range is to be attained, and particularly where it is desired to throw armor-piercing projectiles, it will be found advisable to carry the temperature beyond the critical point.

I am well aware that it has been proposed to propel projectiles by steam of high pressure and that experiments to that end have been made with a greater or less measure of success. I am not aware, however, that any one has hitherto proposed to generate and control a high-pressure gas or vapor within a gun in such a manner and by such means as herein set forth. I therefore mean to claim these ideas broadly and without restriction to the special mechanism illustrated or described. In other words,

Having thus described my invention, what I claim is—

1. The art of propelling projectiles, which consists in confining a body of water or other suitable agent in a strong chamber constituting a portion of the gun; subjecting the same to the heating effect of an electric current until it is converted into gas or vapor; and lastly, permitting the gas or vapor to enter the projectile tube or barrel and to act upon a projectile therein.

2. The art of propelling missiles and projectiles, which consists in confining a suitable agent in a strong chamber or receptacle of limited capacity; subjecting the same to high heat generated in said containing-receptacle; maintaining the heat until by reason thereof and of the vaporization of the agent a pressure is developed which converts the agent into a high-tension gas or vapor; and finally, permitting the gas or vapor to enter the projectile tube or barrel and to act upon the projectile therein.

3. A gun, having a strong pressure-generating chamber within it, to contain suitable agent, and capable of being placed in or out of communication with the projectile tube or barrel at will; and an electric heater applied to said generating-chamber, and adapted to heat the contents thereof and thereby to generate pressure within said chamber.

4. In a gun, the combination of a barrel or projectile-tube; a pressure-chamber; a sealing device interposed between the barrel and the pressure-chamber; and an electric heater adapted to produce a high temperature within the pressure-chamber.

5. In combination with the barrel or projectile-tube of a gun, a pressure-generating chamber directly attached thereto and forming a permanent part of the gun; a passage-way or opening connecting the chamber with the projectile-chamber or barrel; a seal applied to said opening; means for opening said seal from outside the gun; and an electric heater applied to the generating-chamber and serving to heat the contents thereof.

6. In combination with the barrel or projectile-chamber of a gun; a pressure-generating chamber directly attached thereto; an electric heater applied to said chamber and serving to heat its contents; a pressure-indicating device serving to show the pressure existing within the chamber; and a sealing device serving to close and open communication between the generating-chamber and the barrel or projectile-chamber.

7. In combination with the barrel of a gun; a pressure-generating chamber; a wall or diaphragm separating the barrel and said chamber; a liquid-chamber in rear of the fluid-pressure chamber; a diaphragm separating the two chambers; a differential valve mechanism sealing the openings in the two diaphragms; and a valve controlling escape of liquid from the liquid-chamber; whereby the differential valve is controlled, substantially as set forth.

8. In combination with pressure-chamber A, liquid-chamber L; and barrel or tube G; differential valve *h*, *i*, *j*, controlling communication between the pressure-chamber and the barrel; and vent-valve N, controlling escape of liquid from chamber L, all substantially as described and shown.

9. In combination with the barrel of a gun, a plurality of pressure-chambers permanently connected with and forming part of the gun, each provided with an electric heater within the gun, and with a sealing device controlling communication with the barrel.

10. In combination with the barrel of a gun mounted upon trunnions; a pressure-generating chamber connected therewith; an electric heater applied to said chamber; electric supply-wires passing from the trunnion of the

gun to the heater; and contact-plates located at the trunnion and permitting rise and fall of the barrel without disturbing the electrical connections.

11. In a gun, the combination of a barrel or projectile-tube; a pressure-generating chamber constituting a permanent and integral part of the gun; a wall or partition separating said chamber from the projectile-tube; and a sealing device serving to close and open a passage through said partition, substantially as and for the purpose set forth.

In witness whereof I hereunto set my hand in the presence of two witnesses.

LINDON W. BATES.

Witnesses:

HORACE A. DODGE,

C. C. BURDINE.