Plate A.

IMPROVEMENT IN FUSING MALLEABLE IRON AND STEEL

INVENTOR: HENRY BESSEMER

117250

PATENTED JUL 25 1871

Fig. 1.

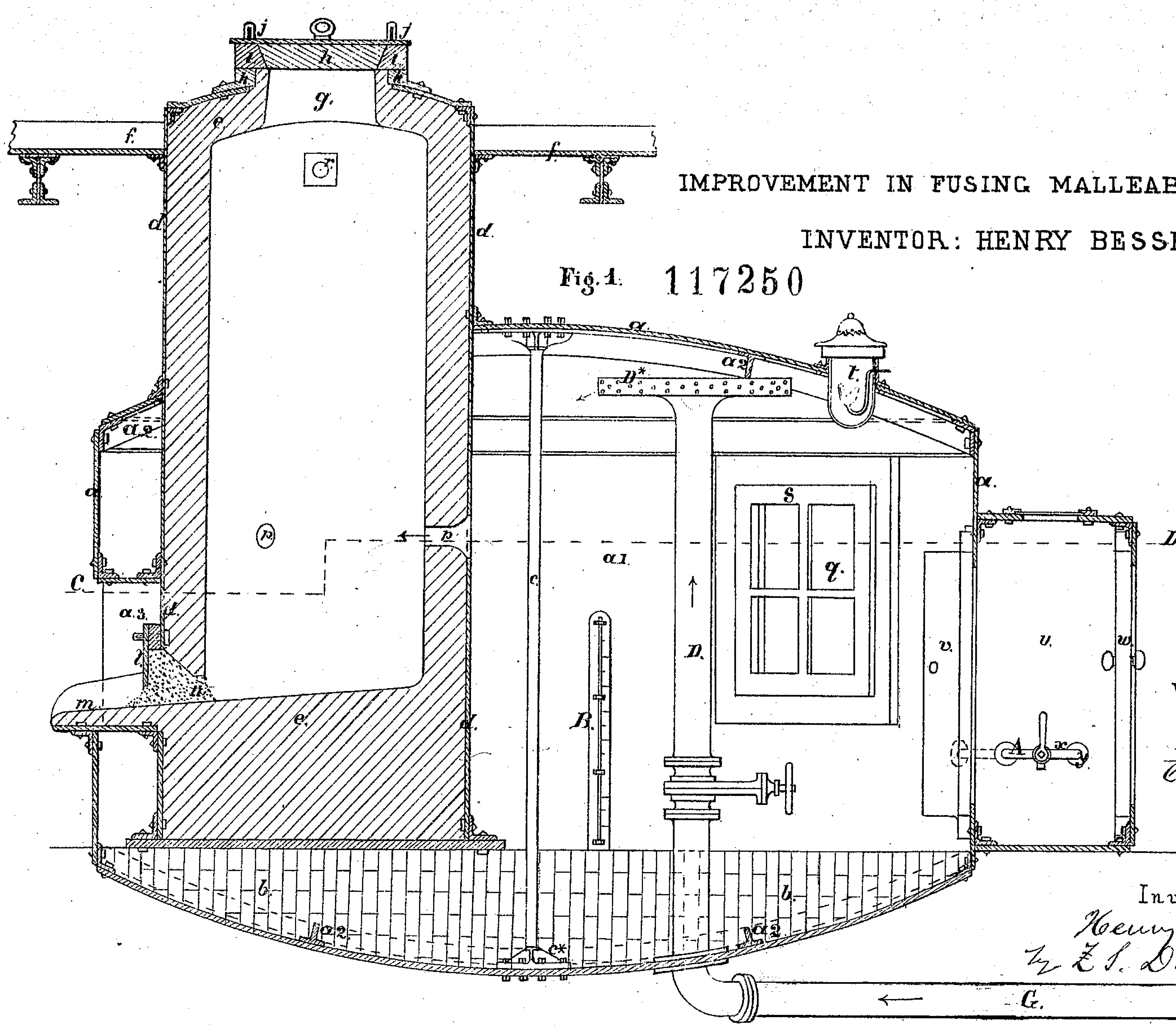
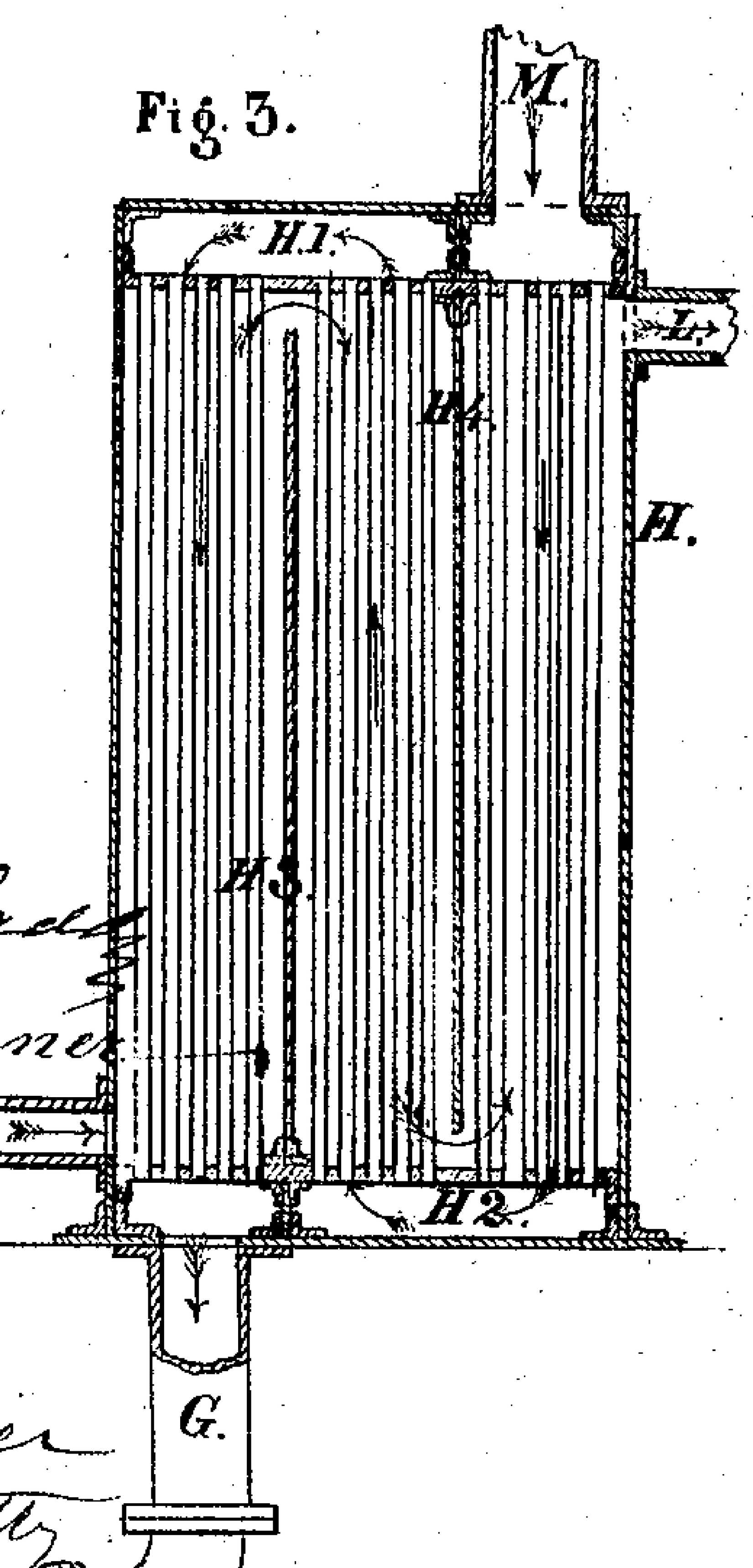


Fig. 3.



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AM. PHOTO-LITHOGRAPHIC CO. N.Y. (OSBORNE'S PROCESS.)

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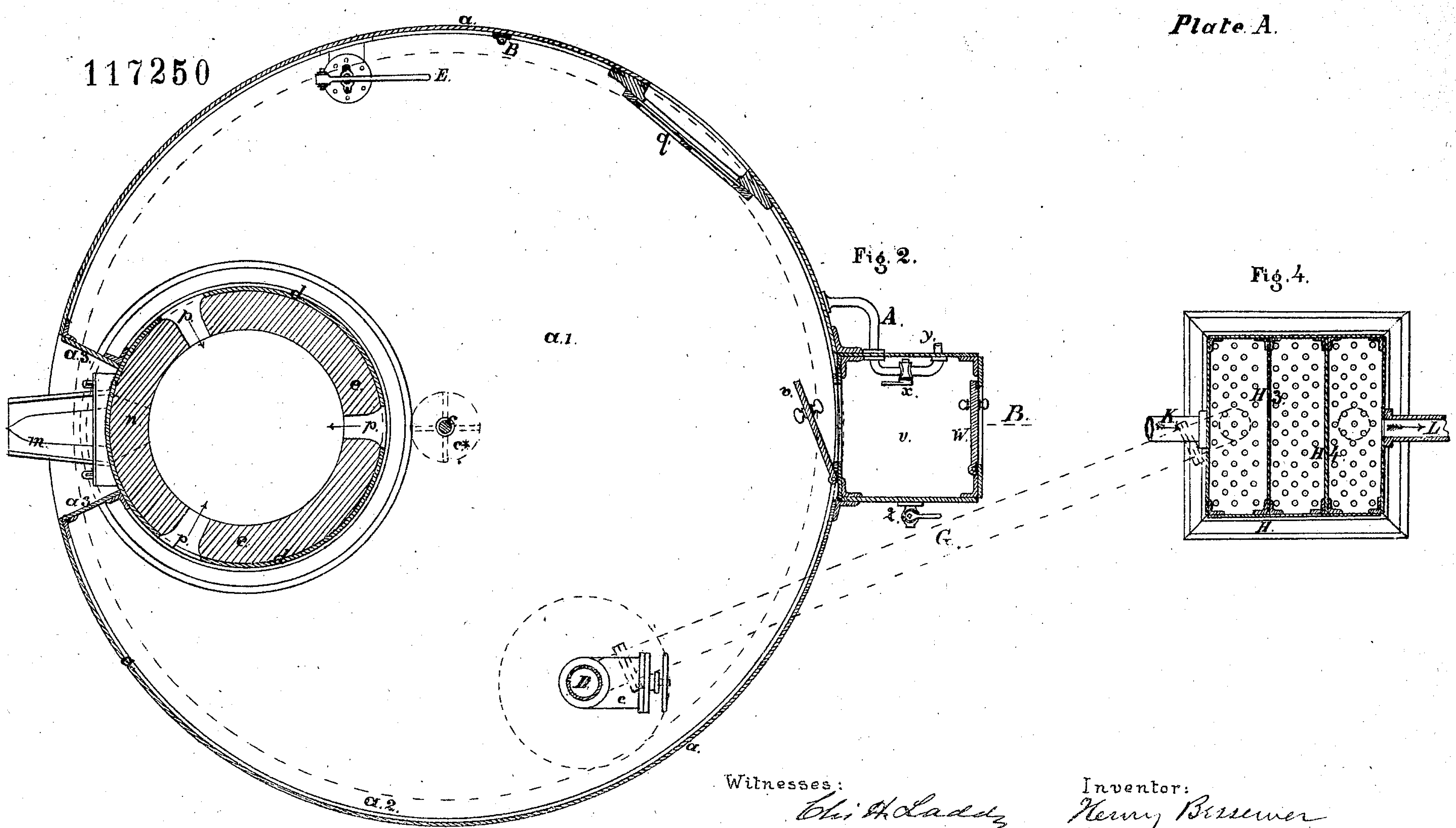

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Plate B.

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Fig. 1.

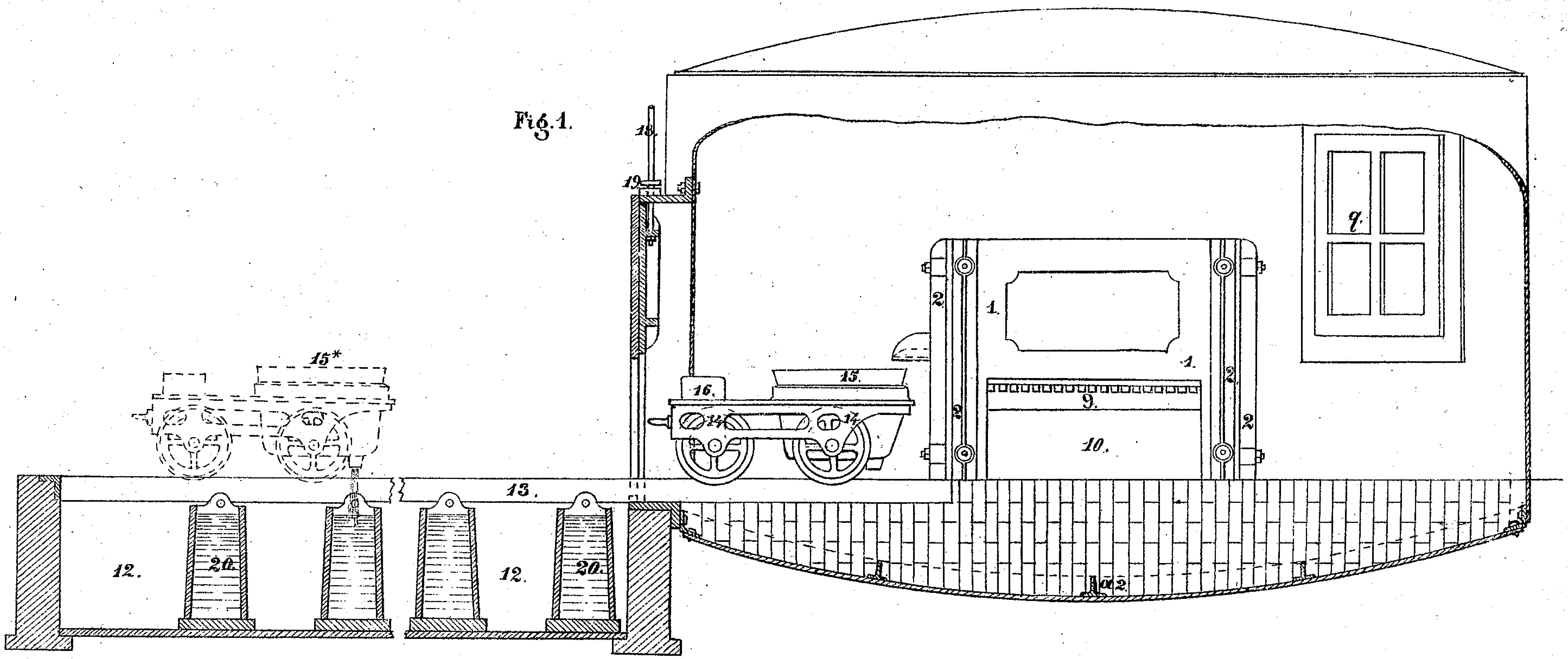

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Fig. 2.

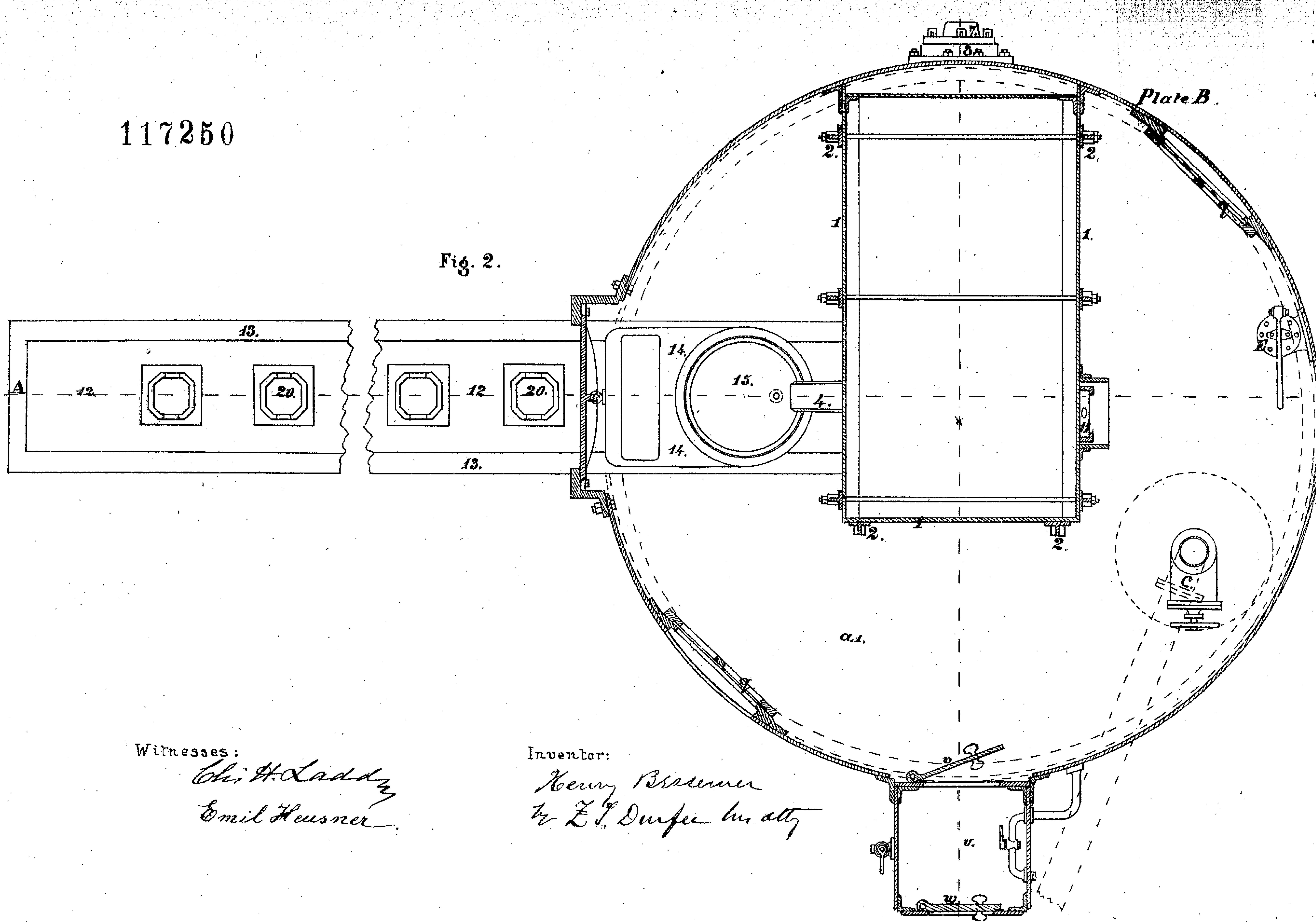

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Plate B.

Fig. 3.

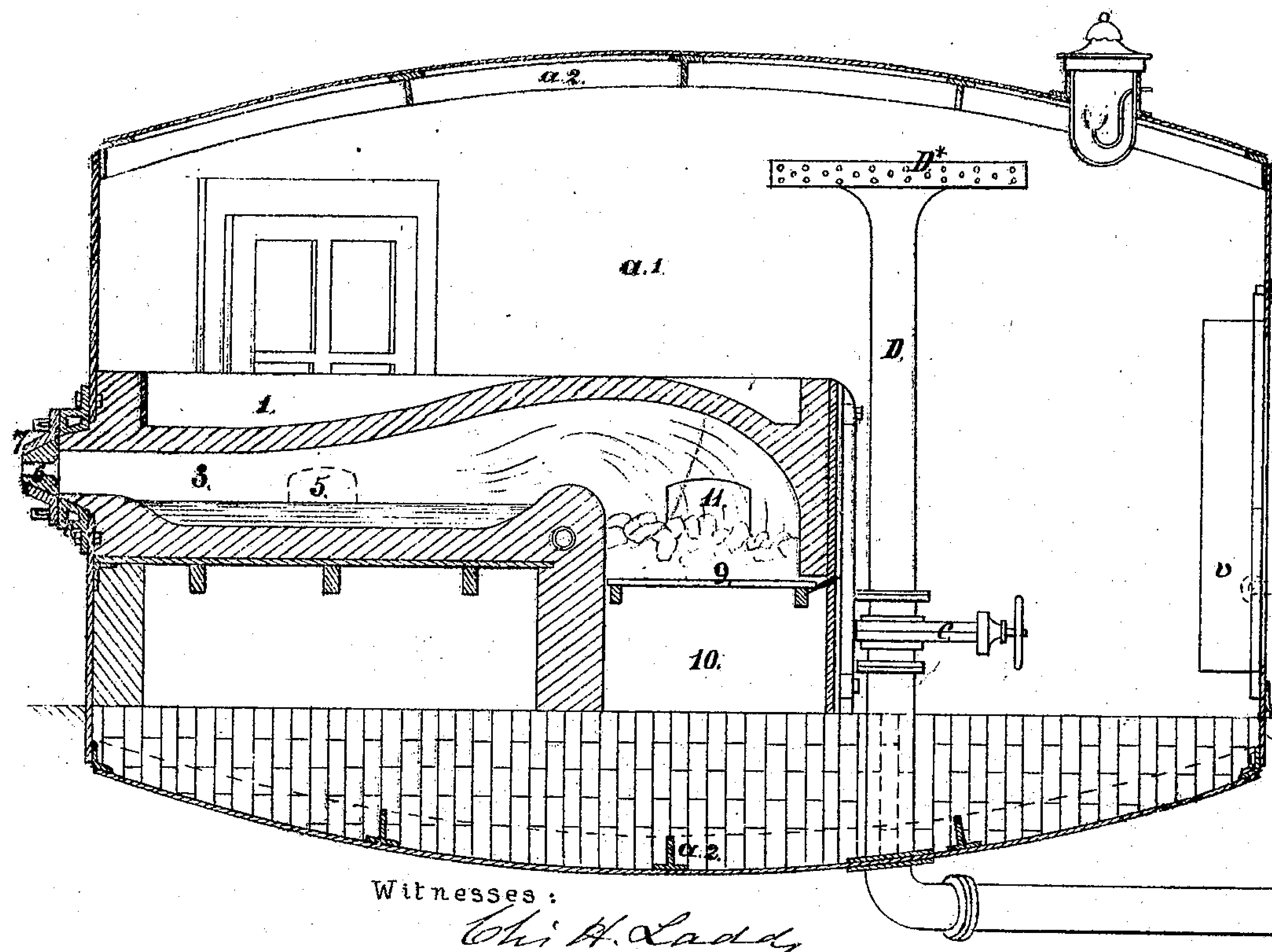


Fig. 4.

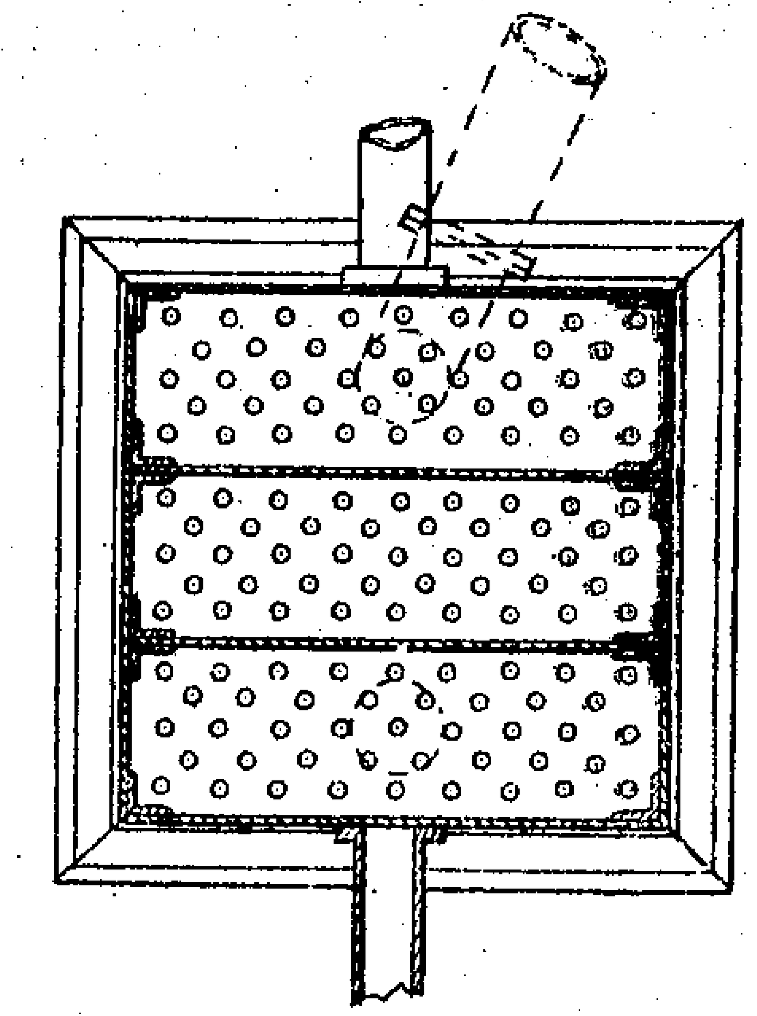
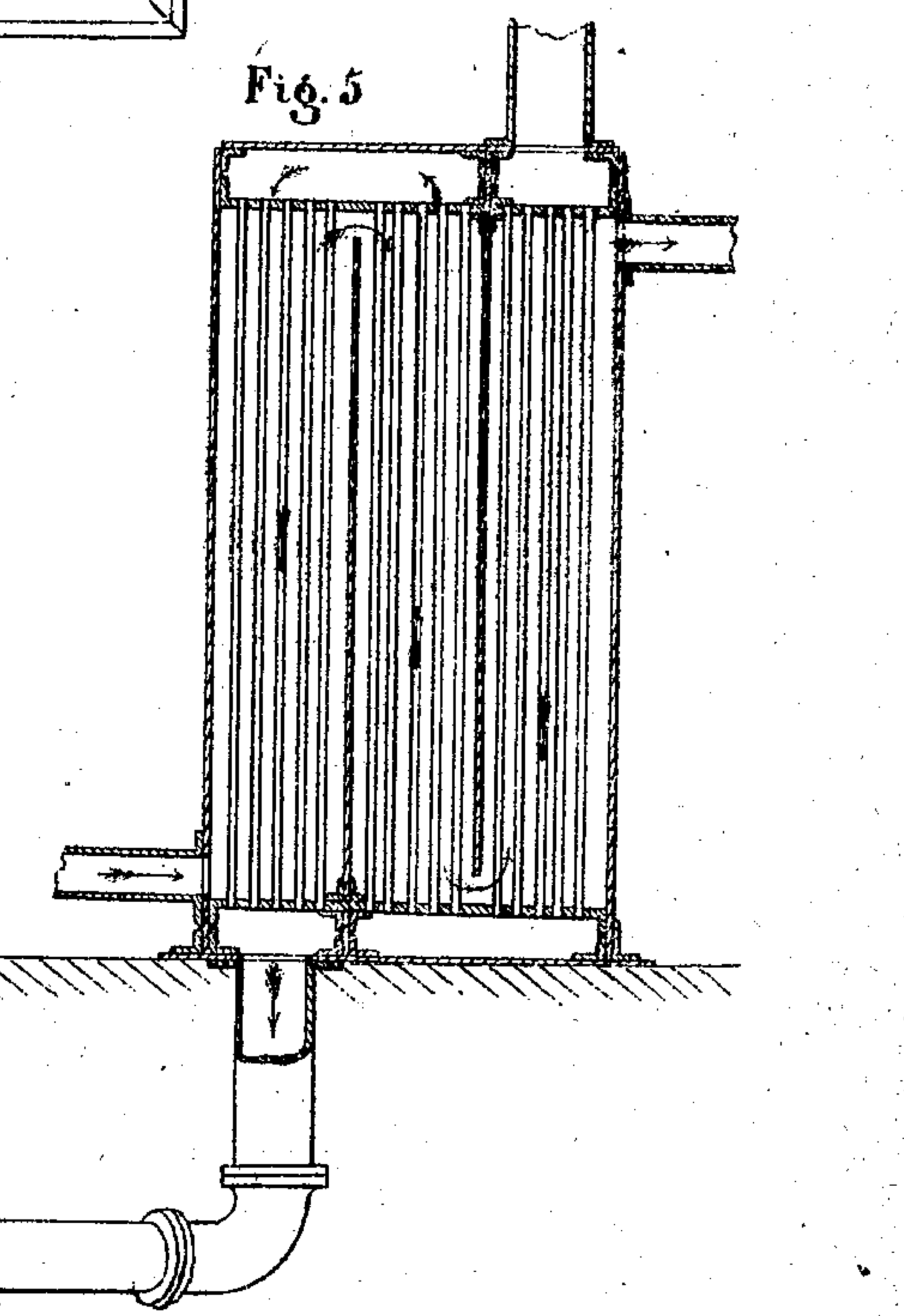


Fig. 5



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UNITED STATES PATENT OFFICE.

HENRY BESSEMER, OF LONDON, ENGLAND.

IMPROVEMENT IN THE CONSTRUCTION AND OPERATION OF METALLURGICAL FURNACES.

Specification forming part of Letters Patent No. 117,250, dated July 25, 1871.

To all whom it may concern:

Be it known that I, HENRY BESSEMER, of Queen Street Place, Cannon street, in the city of London, England, a subject of the Queen of Great Britain, have invented or discovered new and useful improvements in the construction and mode of working furnaces and apparatus employed in fusing malleable or wrought-iron and steel, and pig or other carburets of iron, and obtaining cast-steel or homogeneous malleable iron therefrom; and I, the said HENRY BESSEMER, do hereby declare that the nature of the said invention, and in what manner the same is to be performed, are particularly described and ascertained in and by the following statement thereof—that is to say:

This invention consists, first, in fusing malleable or wrought-iron and steel, and also pig or other carburets of iron, in furnaces where the gaseous products of combustion within the said furnaces are retained under a pressure much greater than that of the external atmosphere, but which gaseous products are not in excess, but somewhat less than the pressure of the atmosphere which immediately surrounds the exterior of the furnace or some parts thereof, the difference being only such as will cause a powerful draught or current of air to pass through the fuel in such furnaces. For this purpose I employ both the cupola and the reverberatory form of furnaces, constructed in the usual manner except in so far as they require to be modified to suit the conditions under which they are employed in carrying out my invention. These furnaces are erected in the interior of a strong close iron room or chamber, the iron casing extending beneath the floor of the room having all its joints rendered sound and tight. These furnaces are provided with an outlet for the escape of the gaseous products of combustion exterior to the close chamber, the outlet being so small as to prevent the free escape of the gaseous products of combustion and retain the same within the furnace until the pressure is much in excess of the external atmosphere, in a similar manner to that fully set forth in the specification of a patent granted to me in England, and bearing date the 10th day of November, 1868, and numbered 3,419. The air to support combustion in these high-pressure furnaces is forced by a powerful blast-engine into the close chamber in which the furnaces are erected. I prefer to introduce it through numerous small openings in a diffused state. The tapping-holes or other discharge-openings of these furnaces may be made to open externally to the close chamber, and in some cases the feeding-doors may also be made to open outwardly or be accessible from the outside of the close chamber, or the tapping or discharge-openings may open direct into the chamber, and in cupola-furnaces the upper part may in some cases pass through the roof or crown of the close chamber and be fed from an elevated feeding-stage exterior to it, the mouth of the furnace being closed by a strong, well-fitting door or cover to prevent the escape of gases. In constructing these iron rooms or chambers I give the necessary strength and stiffness to them by means of suitable angle-flanges, ribs, or girders, to which the plating of the shell is riveted, and I provide a double iron door with well-fitted metallic faces or joints, or with joints covered with vulcanized rubber or other suitable material, the inner door opening into the chamber and the outer one opening into the external atmosphere, a space being inclosed between the doors, forming a sort of small ante-chamber, into which the workmen enter, and, having shut themselves in, they admit air under pressure from the chamber or blast-pipe until the pressure of the atmosphere in the small ante-chamber is equal to the pressure in the large one, when the inner door may be readily opened without stopping the blast. In coming out the workman, after closing the inner door, opens a stop-cock, by which the compressed air in the small ante-chamber escapes into the external atmosphere until the pressures are equalized, when the outer door will readily open. I prefer that the cock or valve thus used by the workmen should be made so small that the change of pressure may take place slowly and regularly, and thus not subject the men to violent changes in the pressure of the air surrounding them. The air by compression with the blast-engine is increased in temperature, and, if a pressure of two or three atmospheres is used, the temperature of the air would be too great for the men to endure. I therefore, in all cases, prefer to cool the air before it enters into the iron room or chamber; for this purpose the air is forced through numerous small tubes immersed in a tank of cold water, or having a shower of cold water falling upon them. I prefer to compress the air by the blast-engine to a greater extent than is required for the furnace, in which case the air, after being cooled, may be allowed to expand again to some extent on entering the iron room, such expansion further reducing the temperature, even, if desired, below that of the external atmosphere. When the metal is to be tapped from the furnace in the interior of the chamber I provide a door through which a ladle, suspended from or mounted on a crane, may enter for the purpose of receiving the metal and conveying it away to be cast in molds. Or I provide a door opening down to the floor-level, and I employ a truck on which a casting-ladle is mounted; this truck runs on rails through the door last named, and receives the metal in the ladle carried by it. Outside the chamber I make a sunk trench between the rails on which the truck moves. This sunk trench forms a casting-pit. The molds into which the fluid metal is to be run are placed in a line in this casting-pit, and as the truck is moved over each one in succession it may be filled with fluid metal from the ladle by employing the valve arrangement generally employed in casting Bessemer steel. The same arrangement for moving the ladle may be used for casting when tapping the furnace from the exterior of the chamber; or the ladle may be carried on a crane-arm and the molds be placed in a semicircle, as in the Bessemer process of casting steel ingots. The door by which the casting-ladle is taken into the chamber I prefer to slide against faced surfaces on the inside of the chamber. The rails may also be employed to convey fuel or metal to the interior of the chamber when these materials are not supplied to the furnace from doors formed in it opening externally. I fit a large safety-valve to the chamber, by means of which the pressure of the air therein may be limited to the amount desired. It may be constructed with a handle, so as to allow the workmen to let down the pressure to that of the external atmosphere, if desired. I prefer to make this a double valve, almost in equilibrium. A sluice in the blast-pipe accessible to the workmen inside the chamber will allow them to regulate the admission of blast, or shut it off when desired. I also place a mercurial glass gauge inside the chamber to indicate at all times the internal pressure of the air; and in the sides or on the top of the chamber I make one or more openings for the admission of daylight through stout plate glass. The iron frame of the window I face truly, allowing the glass to bear on the several compartments into which the frame is divided, and into which it is fitted air-tight; or I otherwise frame a number of smaller pieces together. These windows may be made the means, also, of admitting gas or other artificial light, or in lieu thereof lamps similar to those used in railway carriages may be employed, or oil or other lamps or candles may be employed in the interior of the chamber.

I have not herein particularly described the general details of the several kinds of furnaces that may be employed; nor the kinds of fuel or mixture of fuel used therein; nor the very many varieties of iron known in commerce and included under the general heads recited in the title of my said invention; but I desire it to be understood that any of the forms or modifications of furnaces shown and described in the patent granted to me in England on the 10th day of November, 1868, and numbered 3,419, may be employed, with such alterations as the use of such furnaces in a close chamber may render necessary or desirable. So, also, the several modifications of reverberatory and other furnaces set forth in a specification bearing even date herewith (for improvements in the manufacture of malleable iron and steel, and in furnaces and apparatus employed in their fusion and treatment) may be used, all such furnaces being so modified as to render them suitable for use in the close room or chamber, and which alterations consist chiefly in dispensing with the strong external shell of the furnace and the closely-fitting fire-doors used in my former invention. And in order that this mode of constructing furnaces and apparatus employed for the fusion of malleable iron and steel may be readily understood, I have shown the same as applied to cupola-furnaces on Sheet A of the annexed drawing, where Figure 1 is a vertical section on the line A B of Fig. 2, and Fig. 2 a horizontal section on the line C D of Fig. 1; Fig. 3, a vertical section of the air-cooling apparatus, and Fig. 4 a horizontal section of the same. The same letters are used in all the figures and indicate the same parts where repeated. *a* is the outer shell of the close chamber a^1. The shell is composed of well-riveted iron or steel plates, strengthened by T-angle ribs a^2 extending across its upper and lower sides, which are curved in order better to resist the internal pressure, and are also further secured by a central tension-rod, *c*, having large flanged ends c^*, which are firmly bolted both to the top and bottom of the chamber. The lower curved part of the chamber is filled in with brickwork *b*, forming a flat floor to the interior. Near to one side of the chamber a cupola-furnace is erected, having an iron shell, *d*, lined with fire-brick *e*. This cupola passes through the top of the chamber a^1. Around the upper part of the cupola is formed a feeding-stage, the floor of which is, in part, shown at *f*. The materials to be fused and the fuel employed for that purpose are put into the cupola at the opening *g*. In most cases it will be found convenient to charge on at one time all the fuel and the metal forming one charge, and then to close the feeding-hole by a fire-tile, *h*, which is fitted into a frame, *i*, through which the cottered studs *j* pass. These studs are screwed to the flanged ring of iron *k* riveted to the dome or upper part of the cupola, the metal surfaces coming in contact being first smeared with a luting of clay or lime to render the joint air-tight. Or, in lieu of this mode of closing the mouth of the cupola, it may be effected by a compound screw apparatus, such as is shown and described as applied to a cupola-furnace in a patent granted to me in England and bearing date the 10th day of November, 1868, and numbered 3,419. The lower part of the interior of the cupola-furnace slopes down to the tapping-hole *n* and spout *m*, which projects through one side of the close chamber a^1, the outer shell of which at this point is curved inward at an angle, as shown at a^3, thus affording ready access to the tapping-hole and the larger opening usually provided for cleaning out the furnace, which is secured by the iron plate *l*. At *p* are openings leading from the interior of the chamber a^1 into the cupola-furnace, serving as tuyeres, and admitting as much air, under pressure, as can pass through the flue therein contained. The rate of combustion and the pressure of the heated gaseous products are regulated by the size of the opening *r*, which is formed in a well-burned lump of fire-clay and securely held in place. The area of this opening may be about one square inch for every square foot area of the hearth or bottom of the cupola, but they will depend somewhat on the pressure of air in the chamber a^1. The workman can watch the operations going on in the interior of the furnace through the openings *p*, and can keep them clear of slag from time to time. Light is admitted by day through the stout plate-glass windows *q*. The glass is firmly embedded in a strong iron frame, *s*, and at night by means of the gas-lamp *t*, which is fitted air-tight through the top of the chamber a^1, and is supplied with air from the external atmosphere. Means of ingress and egress are provided for the workmen at *u*, which is a close-riveted iron box or ante-chamber having two well-fitted doors, *v* and *w*, the door-frames against which they close being covered with vulcanized rubber, and thus forming large valves through which a man may readily pass. The door *v* being in the position shown, the workman, by further opening it, may step from the chamber a^1 into the box *u*, and, after closing the door *v*, will open the small two-way cock *x*, by which means the compressed air in the box *u* will escape at *y* into the external atmosphere. So soon as the pressure is thus equalized he will open the door *w* and step out, leaving this door open. On his desire again to enter the chamber a^1 he will step again into the box *u*, unless the door *w* should have been closed, in which case a small amount of leakage of air through the door *v* will prevent his opening it. He must, therefore, allow the air to escape therefrom by opening the cock *z*. He will thus be enabled to enter the box *u*. He will then close the door *w* after him and open the cock *x*, so as to admit air to the pipe A from the chamber a^1. As soon as the pressures thus become equalized he can readily open the door *v* and pass into the chamber a^1. The pressure of the air in the chamber a^1 will be indicated by a mercurial gauge, B, the cistern of mercury being open to the chamber a^1 and the upper end of the glass tube communicating with the external atmosphere. The rate of admission of the air to the chamber a^1 and its consequent pressure may be regulated or shut off by means of the valve C, the discharge-pipe D of which rises nearly to the top of the chamber, and is provided with a large hollow disk, D*, perforated with numerous small holes around its edge for the purpose of diffusing the blast and preventing the inconvenience of a powerful jet at a particular spot. Should the workman desire at any time to discharge the air from the chamber a^1, he can do so by raising the handle E, which will raise a valve in the valve-box F, allowing the compressed air to escape into the external atmosphere. A safety-valve (not shown) should also be placed on the chamber a^1, or on the blast-pipe G, to prevent the pressure of air in the chamber from at any time exceeding the pressure desired, and which may, by preference, range from fifteen to thirty pounds pressure on the square inch, although this may be exceeded; a pressure as low as six to seven pounds per square inch will assist the fusion of the metal, but does not give satisfactory results, and a pressure not exceeding three pounds per square inch is of little or no practical utility. When working under a pressure of from twenty to thirty pounds per square inch or upward in the chamber a^1, the high temperature produced by the compression of the atmosphere renders it unbearable to the workmen employed, unless some mode is adopted to lessen the temperature of air supplied to the chamber. For this purpose I employ the cooling apparatus shown in section at Figs. 3 and 4, and which consists of a square vertical box or chamber H, having a separate compartment, H^1, at top, and another compartment, H^2, at bottom. The central space between these compartments is divided by the partitions H^3 and H^4, through which numerous small brass pipes pass vertically upward from the compartment H^2 into the compartment H^1. The whole of the brass tubes have open ends, and are riveted or calked air-tight into the upper and lower tube-plates J J. Cold water from an elevated reservoir enters the apparatus by the pipe K, and passes upward between the brass pipes and over the top of the partition H^3. It then descends in the center space between the partitions H^3 and H^4, passing under the latter, and again ascends and passes off by the pipe L, following the route indicated by arrows, and coming in contact throughout its course with the interior of the brass pipes before named. The air under pressure from the blast-engine enters the cooling apparatus by the pipe M and passes downward through the numerous small brass pipes into the lower compartment H^2, from which it ascends through the brass pipes which occupy the space between the partitions H^3 and H^4, and enters the upper compartment H^1, from which it descends again through small brass pipes and passes into the pipe G, by which it is conveyed into the chamber a^1, having parted with much of its heat to the current of water traversing the exterior of the series of brass pipes in an opposite direction to that in which the air is moving. By partially closing the valve *c* in the chamber a^1, the pressure of air will be increased, (provided that sufficient force is employed to compress the blast;) the air will consequently be raised in temperature, but as a large portion of the heat so rendered sensible will be carried off by the water, the air, after passing the valve *c*, will expand on entering the chamber a^1 and become sufficiently cool for the workmen employed therein. A pressure of about forty pounds per square inch in the cooling apparatus, expanding to about thirty pounds pressure in the chamber a^1, will render the air cool and agreeable. And in order that the mode of arranging reverberatory melting-furnaces (working under pressure in a close chamber) and the cooling apparatus connected therewith may be fully understood, I have shown how the same may be arranged and worked on Sheet B of the drawing hereunto annexed, where Fig. 1 is a vertical longitudinal section on the line A B of Fig. 2; Fig. 2 is a horizontal section through the close chamber, showing the furnace, casting-pit, and molds in plan; Fig. 3 is a vertical section of the furnace and chamber on the line C D of Fig. 2; and Figs. 4 and 5 are cross and horizontal sections of the air-cooling apparatus before described. All letters of reference on this sheet of drawing indicate parts constructed and arranged in the same manner and for the same purposes as those hereinbefore described in reference to the apparatus on Sheet A, and the parts peculiar to the present arrangement of reverberatory furnace and casting apparatus being indicated by numbers only. Thus it will be understood that the chamber a^1 with its strengthening-ribs a^2, window q, valves C and F, inlet-pipe D, and perferforted disk D*, and the entire arrangement of ingress and egress-doors v and w, and box u, and the entire details and arrangement of cooling-pipes and apparatus, as shown at Figs. 4 and 5 on Sheet A, are also the same in construction, and are used for the same purposes with the reverberatory furnace and casting apparatus herein lastly shown and described.

I will now proceed to describe those parts of the furnace and apparatus which differ from the arrangements shown on Sheet B, and which constitute the peculiarities of this modification of my invention. The furnace is of the reverberatory kind, incased with cast-iron plates 1 and binders 2, as usual in this class of furnace. The hearth 3 is nearly flat, sloping a little toward the tap-hole and spout 4. The piles or loose pieces of iron or steel to be fused may be introduced at a door, 5, at the side of the hearth nearly opposite to the tap-hole; or the metal may be supplied to such furnace by a suitable door formed at 6, where the escape-opening is now shown; or in lieu thereof two movable flue-tubes may be employed and be constructed in the manner represented on Sheet C of the drawing annexed to the specification of a patent granted to me in England, and bearing even date herewith, and numbered 1,431, so that the reverberatory furnace in the close chamber a^1 may be worked by simple chimney draught at the early stage of the fusing operations, the final heat or fusing point being obtained by the employment of high-pressure blast retained therein. I, however, desire it to be understood that I do not claim the use of a double movable flue-tube as forming part of the present invention, although it may be employed in connection therewith; when, however, the movable flue-tubes are not used I prefer to employ a fixed restricted outlet, as shown at 6, which represents a piece of burned fire-clay, of a conical form, fitted and luted into the flanged ring 7. At this end of the furnace a ring, 8, is formed, having a hollow channel, in which water circulates in order to keep the contiguous parts of the iron-work from becoming overheated. The hearth of the furnace narrows at 3*, and terminates in a circular opening of sufficient size to admit the introduction of a charge of water through it if desired by removing the flanged ring 7, which is held in place by cotter-bolts, as shown. The fire-bars are shown at 9, resting on bearers which cross the ash-pit 10, the ash-pit being open, as usual in such furnaces. Fuel is supplied to the fire-grate through the door 11 from the interior of the close chamber. It will nevertheless be obvious that, by placing the furnace sufficiently near to the side of the chamber, the fuel may be supplied through a sliding door from the exterior of the chamber; but I prefer to supply it from the interior, as described. On the outside of the chamber a^1 a long narrow pit, 12, is formed, having an angled curb, 13, forming a rail for the wheels of the ladle-carriage to move on; this carriage is fitted at one end with a casting ladle, 15, having a valve and handle (not shown) after the manner of the ordinary casting-ladles employed in casting Bessemer steel. A counter-weight, 16, rests on the opposite end of the carriage and prevents the weight of the metal in the ladle from tipping the carriage over. A door, 17, is fitted as a dovetailed slide moving vertically. A rod, 18, attached to the door, passes through a stuffing-box, 19, and is shown broken off; the upper end of this rod may be attached to a rack or screw for lifting the door, but I prefer to fasten to it a wire rope, which may pass over a pulley attached to the roof of the building, and have a balance-weight attached so that the sliding door 17 may be run up and down by hand. When the metal in the furnace is fused, the workman proceeds to clear the tap-hole and allow the metal to run by the spout A into the ladle; he will then push the carriage along the rails until the running-out hole 24 of the ladle is vertically over the first of a series of molds, 20, which he will fill and "stopper" in the usual way, proceeding to the next, and so on until all the metal is run from the ladle. The carriage and ladle are shown by dots at 15* in the position they occupy while the casting operation is going on, after which they may be rolled on a continuation of the rails, and the ladle be lifted by crane from the carriage and turned upside down so as to discharge the scoria if needful; or, if preferred, the ladle may be mounted on trunnions as usual on the casting-crane in general use for casting Bessemer steel, and be turned over and the slags discharged therefrom. The line of rails at the side of the casting-pit may also be employed to convey an empty truck, into which the molds and ingots may be lifted and taken away.

I desire it also to be understood that the different kinds or qualities of malleable or wrought-iron and steel, or other carburets of iron enumerated in the before-named patent of the 10th day of November, 1868, may be employed for the production of cast-steel or homogeneous malleable iron by means of my present invention, using for this purpose the fuel or mixtures of fuel set forth in either or both of the patents hereinbefore referred to.

I would further remark that in the production of malleable iron or steel by the use of high-pressure furnaces inclosed within a strong chamber, as herein described, I am enabled to attain so high a temperature as to fuse these refractory substances with great facility, and to give to the metal so melted such a degree of heat as to admit of its being transferred to several molds while still retaining its fluid state; but it will be understood that such furnaces are not applicable for the fusion of substances where the heat of an ordinary furnace is or has been found sufficient to produce fusion, because all such ordinary furnaces are worked with greater facility by the workman, are less costly to construct, consume less fuel, and also require much less engine power than the apparatus constituting my present invention. I therefore do not claim its use for simply heating iron bars or for melting pig-iron; the special use and value of my improved apparatus being the fusion of malleable iron, decarburized iron, or uncarburized or spongy iron or steel, or steely iron, such qualities or kinds of iron or steel, in the form of scrap or otherwise, being used alone or mixed with as much speigel-eisen or other carburet of iron as may be found desirable in the manufacture of malleable iron and steel by means of the said apparatus.

Having described my invention and the manner in which the same may be carried into practical operation, I desire it to be understood that I do not confine myself to the precise details herein given, provided that the general character of my invention be retained; but

What I do claim as my improvements in the construction and mode of working furnaces and apparatus employed in fusing malleable or wrought-iron and steel, and pig or other carburets of iron, and obtaining cast-steel or homogeneous malleable iron or steel therefrom, is—

1. The employment, for the fusion of scrap or other decarburized or uncarburized malleable iron or steel, of a cupola-furnace inclosed or partially inclosed in a chamber, into which the air for combustion is forced at a pressure much in excess of the external atmosphere.

2. The employment, for the fusion of scrap or other decarburized or uncarburized malleable iron or steel, of a reverberatory furnace inclosed in a chamber, into which the air for combustion is forced at a pressure much in excess of the external atmosphere.

3. The mode herein described of constructing and lighting the close iron chambers in which melting-furnaces for the melting of scrap or other decarburized or uncarburized malleable iron or steel are worked at high pressure.

4. The constructing-chambers, containing high-pressure furnaces, for the melting of scrap or other decarburized or uncarburized malleable iron or steel, with double inlet-doors, combined with inlet and outlet-pipes, as herein described.

5. The causing compressed air, in its passage into a chamber containing a high-pressure furnace for the melting of scrap or other decarburized or uncarburized malleable iron or steel, to pass through suitable cooling apparatus to prevent the said chamber becoming unduly hot.

6. The general arrangement and combination of parts constituting the melting and casting apparatus shown in Figs. 1, 2, and 3 on Sheet B of the annexed drawing.

HENRY BESSEMER.

Witnesses:

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Thos. Brown,

Both of No. 17 *Gracechurch street, London.*