Plate I.

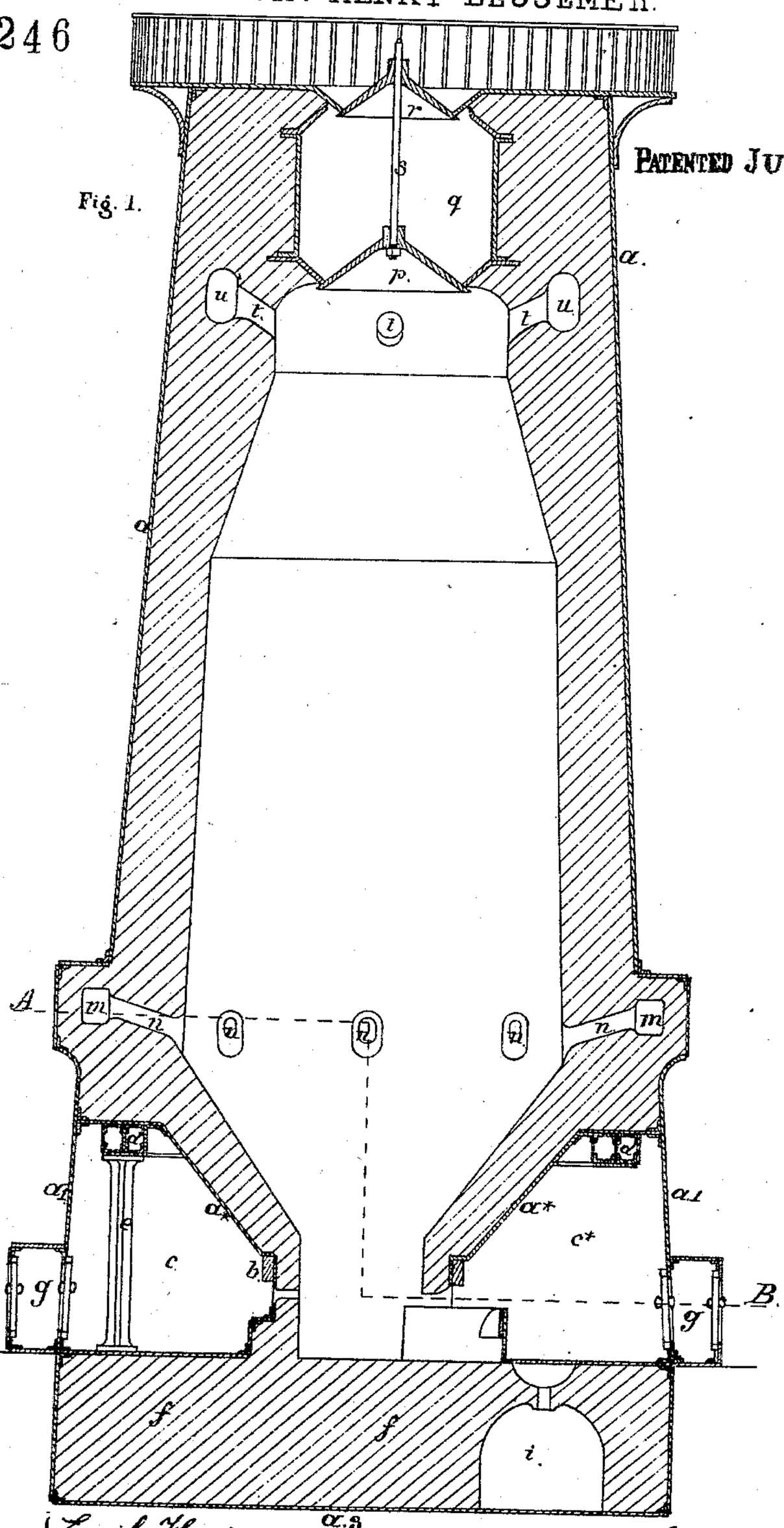
# IMPROVEMENTS IN WORKING BLAST-FURNACES.

INVENTOR: HENRY BESSEMER.

117246

PATENTED JUL 25 1871

Fig. 1.



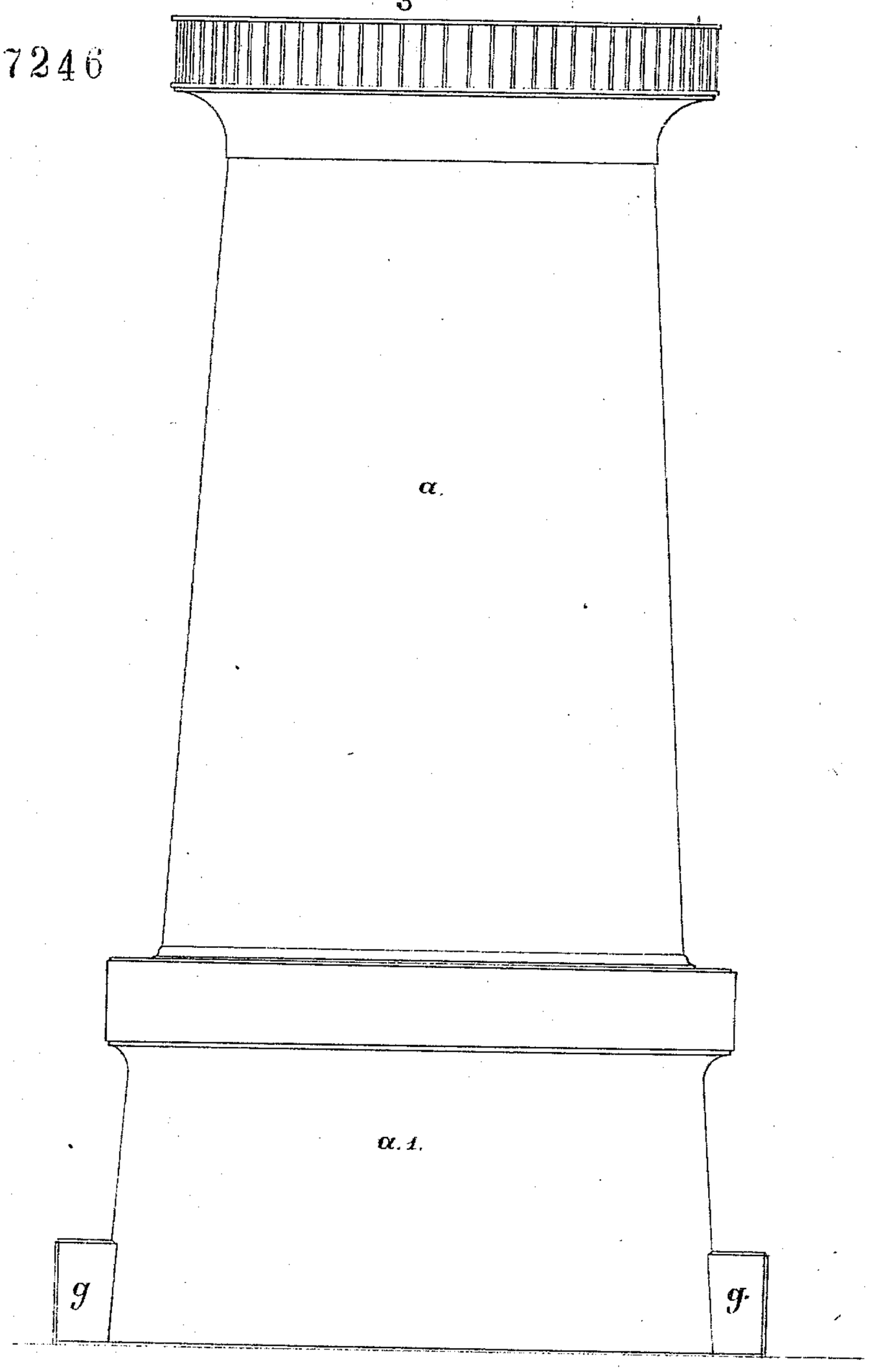

Witnesses { Emil Heusner
Chas. H. Laddey

Inventor: Henry Bessemer
per E. S. Burke Jr. Atty

H. BESSEMER. Plate II.

Fig. 2.






Witnesses:
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Plate III.

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Fig. 4.

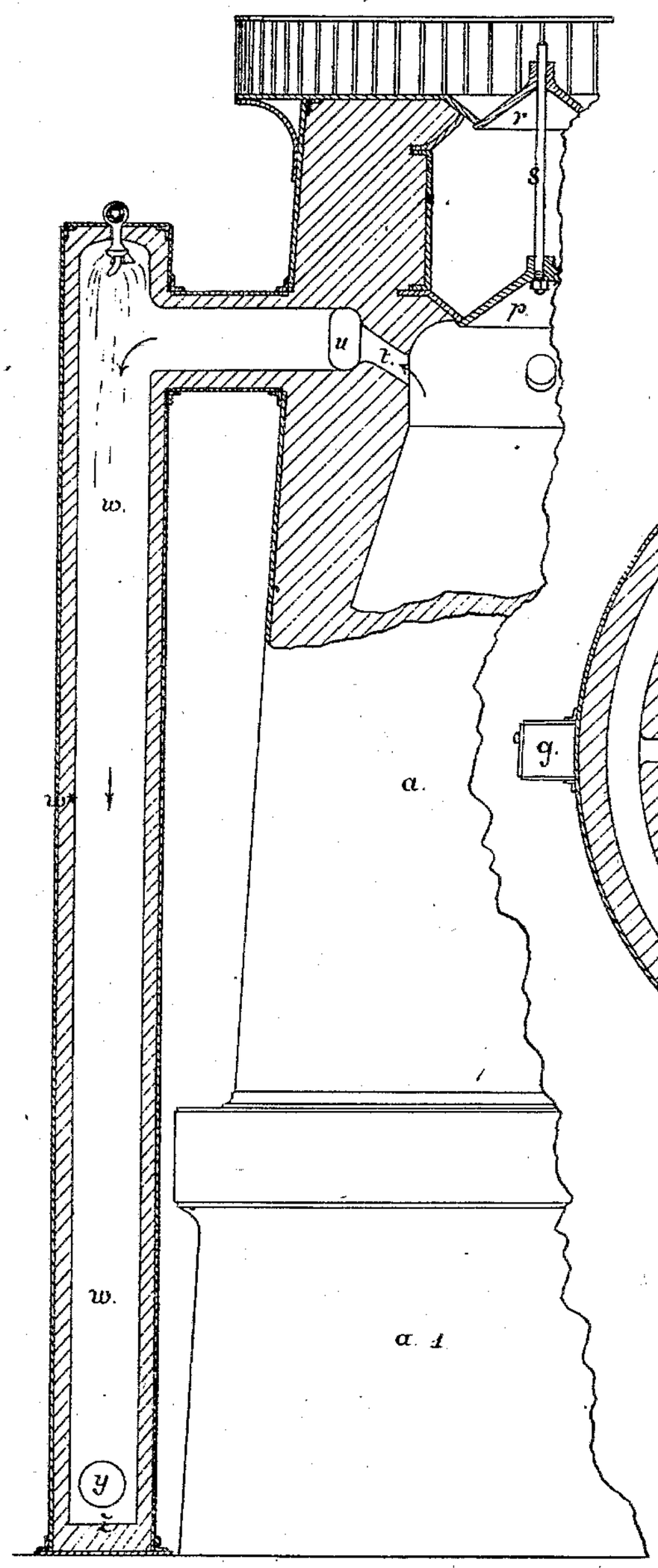
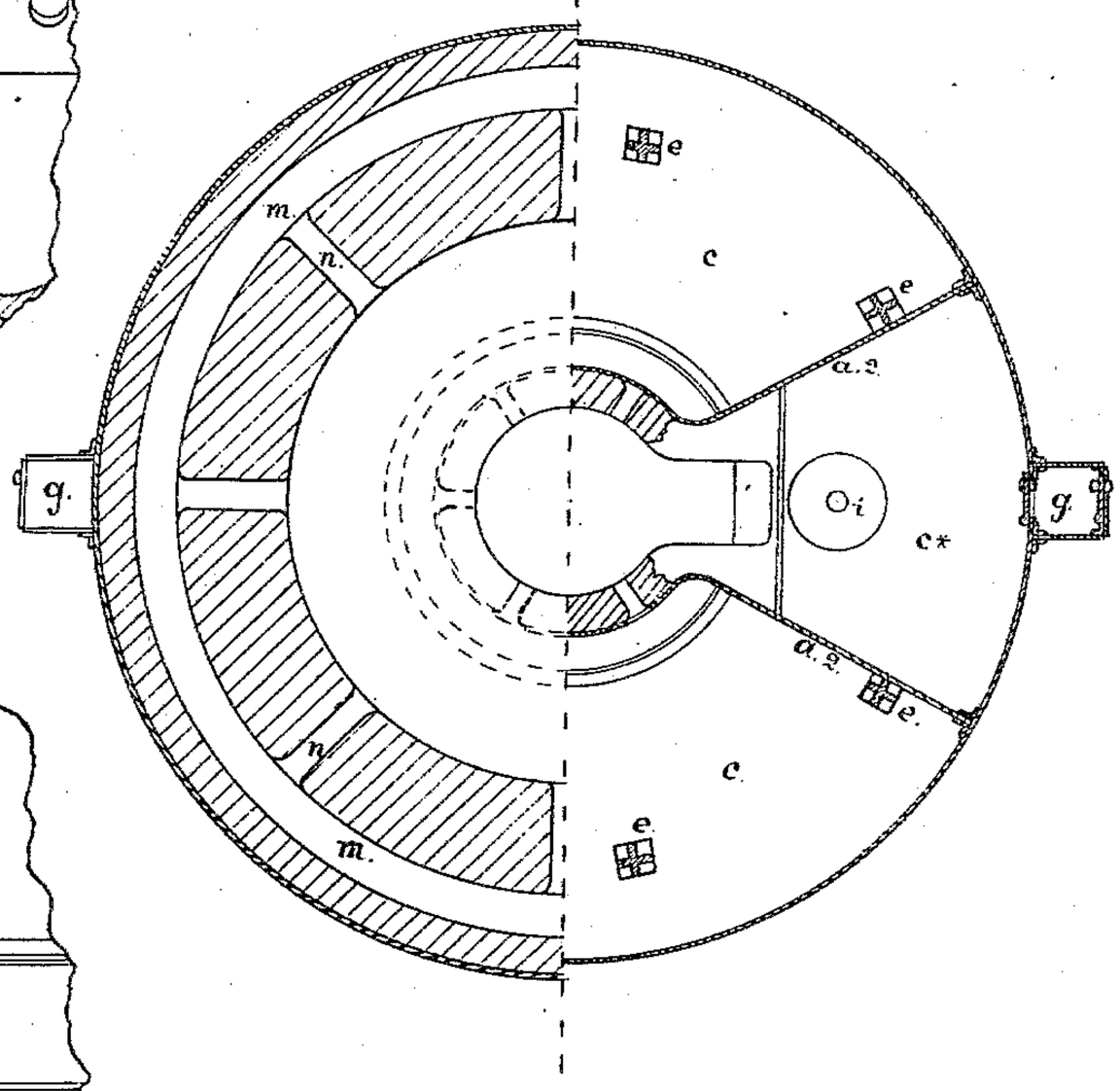



Fig. 3




Witnesses :

Emil Heusner
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117,246

# UNITED STATES PATENT OFFICE.

HENRY BESSEMER, OF LONDON, ENGLAND.

## IMPROVEMENT IN CONSTRUCTION AND MODES OF WORKING BLAST-FURNACES.

Specification forming part of Letters Patent No. 117,246, 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, a subject of the Queen of Great Britain, have invented or discovered new and useful Improvements in the construction and mode of working blast-furnaces employed for smelting the ores of iron, and in the mode of employing and utilizing the gaseous products of such furnaces, and also in the construction and mode of working blast-engines employed to force air into blast and other furnaces; and I, the said HENRY BESSEMER, do hereby declare the nature of the said invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement thereof—that is to say:

The outer shell or case of the furnace, which, for the purposes of my invention, I make of very strong plate-iron or steel, and which extends from below the bottom of the hearth up to the crown or top of the furnace, there uniting with the metal ring which forms the mouth of the furnace, and thus incasing the whole of the fire-brick or stone-work which constitutes the furnace, suitable openings being left in the shell for the purpose hereinafter referred to, I prefer to make the shell in separate rings or sections united by stout flanges, by means of which the several portions are firmly united, the whole being, as far as needful, strengthened by hoops, angle-ribs, or T-irons securely riveted to the plating, the general structure being further supported on cast-iron or riveted plate-iron columns surrounding the lower part, all the joints of the shell being well caulked and capable of resisting an internal pressure of twenty or more pounds per square inch on the whole internal surface of the furnace. Into this furnace I force air by a suitable blast-engine through several tuyeres or openings used in lieu of tuyeres, employing, by preference, a pressure varying from ten to twenty pounds per square inch; and I retain in such furnaces the gaseous products of combustion at a pressure, preferably, of about three or four pounds on every square inch less than the pressure of the blast in each case, thus obtaining an available pressure of three or four pounds per square inch to cause the blast to force its way through the charge of materials. The blast-furnace so arranged I call by way of distinction a high-pressure blast-furnace. The method in which I prefer to confine the gases in the furnace until sufficient pressure is attained is hereinafter described. In consequence of the pressure thus employed the temperature of the gaseous products of combustion will be greatly increased, and I am thereby enabled to dispense with the whole of stoves, pipes, and furnaces generally employed for heating the blast, although the high-pressure blast-furnace may, if desired, be worked with hot instead of cold blast. In some cases it may be found desirable to lower the temperature of the gaseous products of combustion after they have left the blast-furnace. To some extent this may be done by causing the hot gaseous products to envelop or come in contact with the pipes which convey the blast to the furnace, and thus a certain amount of heat may be readily transmitted to the air circulating through them. The arrangements for feeding in the fuel, ore, and fluxes at the top of the furnaces must be such as to effect this object without allowing much of the gases to escape if the cup and cone arrangement be employed, or if a piston be used in lieu thereof to close the furnace. I, in either case, continue the sides of the cup vertically upward, forming thereby a strong plate-iron cylinder having a cover into which another cone or piston is fitted, thus making the cylinder a close chamber. A feeding-floor or stage may be made at a level with the upper cone or piston-valve. When feeding the furnace I lower the upper valve and put the requisite charges of ore and fuel into the cylinder and then close the upper valve, after which I open the lower one and allow the material to fall into the furnace, thus loosing a cylinder-full of the compressed gases at every such discharge of fuel into the furnace. The joints of the cone or piston-valve or other joints may be prevented from leaking gases outwardly by the employment of air or steam of greater pressure introduced between the joints or valve-fittings, and the metal-work constituting all such valves, cones, or valve-seats may be kept from injury by heat by coring or otherwise forming therein passages for the circulation of water. Such parts may also be made to receive less heat by conduction by using thin fire-tiles or other slow conducting materials between the flanges, which unite them to other parts, which are unavoidably made very hot. My invention also consists in economizing fuel in

blast-furnaces by preventing so large an escape of carbonic-oxide gas at the upper part of the furnace as usually takes place. The bulk of the air entering the furnace should, on meeting the incandescent fuel, be at once converted into carbonic-acid gas mixed with nitrogen in passing upward among the fuel. This carbonic-acid gas is converted, for the most part, into carbonic-oxide gas, and in this state is in part utilized in the reduction of the ore; but a very large quantity escapes from the furnace still in the condition of carbonic oxide, thus robbing the furnace of a large amount of expensive fuel. To avoid this loss I do not allow all the carbonic-acid gas formed to pass up the furnace, but draw off a portion of it at a low level in the furnace, allowing the remainder only to pass up the furnace to become converted into carbonic oxide to reduce the ore. When working in this way with a high-pressure blast-furnace, I make openings in the outer wall of the furnace leading into an annular flue or other flues. The opening from the furnace into the flue, by means of which a portion of the escape from the furnace takes place, should be of considerable size, so that there may be a comparatively gentle current out of the furnace. The escape from the flue may be by an aperture so contracted as to allow only a portion of the gases of the furnace to pass off through this flue. I make the openings at such a height as I find best adapted to let out the first products of combustion in the form of carbonic-acid gas. Now, if we suppose a furnace working so that no carbonic-acid gas escaped from the mouth of it, the whole having been converted into carbonic oxide, it will be understood that in such a case all the carbonic-acid gas that may be let out at the lower part of the furnace will prevent the destruction of as much fuel as would have been absorbed by its conversion into carbonic oxide on its passage up through the mass of fuel. By thus letting out a portion of the gas below, that portion traversing the fuel in the upper part of the furnace will have a much larger surface of carbon to act upon in proportion to its volume than it would have if the whole of the gases had been passed upward, while the high temperature consequent on the pressure of the gases should not only facilitate the rapid conversion of the reduced quantity of carbonic acid into carbonic oxide, but should also effect a rapid deoxidation of the porous oxides of iron so subjected to heat and pressure. The tap-hole and tymp may be inclosed in an air-tight chamber into which air under pressure is admitted in such quantities as to render the pressure of the air in the chamber so nearly in equilibrium with the gases in the furnace as to prevent any violent outflow of gases at the tymp, although the running of the cinder may be allowed to go continuously. When the workmen require to clear a passage for the cinder, or approach the tap-hole for other purposes, the pressure in the chamber may be so far increased for the time as to cause the air from the chamber to enter the furnace and thus entirely prevent the escape of any flame or gases by this opening. Small chambers may in some cases be made to inclose each tuyere, or the whole of the lower part of the furnace may be inclosed in one large chamber, into which the blast may be forced, and from which simple openings, much larger than ordinary tuyeres, may enter the furnace, and the tuyeres and pipes be thus dispensed with. The openings used in lieu of tuyeres will be thus always accessible to the workmen, who may pass in and out of the chamber through closely-fitting doors. The chamber or chambers may be lighted, and the air may be cooled before entering them, in the manner described in a specification bearing even date herewith for 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 numbered, in England, 1,432. The cinder flowing from the furnace may descend through an opening in the floor of the chamber into a wagon inclosed in another small chamber below the first-named one. A small quantity of air may be allowed to escape from the slag-chamber, and thus a current of air will flow through the hole with the slag and prevent it from heating the upper chamber. In some cases it may be found desirable to place the tuyeres, or the openings used in lieu thereof, at a higher level than usual, and in that case allow the carbonic-acid gas to escape at suitable openings below the level of the tuyeres, such as at the tymp, which may form one outlet, a similar one being formed at the opposite side; and although I have described simple openings for the escape of gas and for inlet of blast, such openings may in some cases extend so far round the lower part of the furnace as to form more or less completely annular passages communicating with the interior of the furnace all round. My improvements also consist in a mode of preventing the decarburation of the metal by the blast after fusion, and facilitating its further carburation after leaving the blast-furnace. For this purpose I lessen the capacity of the hearth and form a much smaller passage than is now used to conduct the metal to the tap-hole, using in lieu thereof a small inclined channel or pipe, through which both the metal and slag may flow from the furnace continuously and as quickly as they come down, some portion of the flame or heated products of combustion escaping down the passage through which the metal flows. I collect or receive the metal in a heated vessel more or less completely filled with incandescent coke for the purpose of keeping it fluid and further carburizing it, in the manner described in a specification, in England, bearing even date herewith, for improvements in the treatment of crude or pig-iron and other carburets of iron and in the apparatus employed for such purposes, and numbered 1,434. The gaseous products of combustion may be conveyed from the top of the furnace down to the land-level by a large vertical pipe, on the top of which a close cistern is fitted, the lower side of the cistern being perforated with small holes, through which a shower of water, in a finely-divided state, is caused to

flow by a pump attached to the blast-engine, whereby the quantity of water injected may be regulated. By this means the highly-heated gases may be cooled down and mixed with steam arising from the evaporation of the injected shower of water.

For the purpose of forcing the blast into high-pressure furnaces when used for smelting iron ores, as in the invention herein described, and also when employed for forcing blast under pressure into furnaces employed in fusing malleable or wrought-iron and steel and other carburets of iron, I employ the gaseous products of such high-pressure furnaces when cooled down with water or otherwise, for giving motion to a hot-air-blast engine, in which the said gaseous products (in combination with the steam produced in the cooling process) are made to act in a direct-acting blast apparatus. I prefer to arrange the air-cylinder and the gas-cylinder in a line with one piston-rod connected to both pistons. I prefer to use either piston-valves or double-beat equilibrium-valves both for the air and gas-cylinders, each of which I line with a plain shell of hard metal, so made and fitted in between the covers as to readily be removed and exchanged for a similar one when too much worn for use. The air so forced is conveyed into a receiver having two diaphragms dividing it into three compartments which communicate with each other by small openings and thus tend much to equalize the blast. A fly-wheel and crank are employed to regulate the motion of the engine, and one or more valves are employed to regulate the pressure of the gases and prevent the pressure from exceeding the proper limit. It will thus be seen that the high-pressure furnace, to whatever purpose it is applied, may be supplied with blast at the pressure desired without employing boiler-power and fuel for that purpose, the high-pressure furnace itself furnishing all the power necessary for this purpose without burning the gas in other furnaces to obtain power through the agency of steam. The escaping carbonic-acid gas from the lower part of the furnace may be conducted also to the blast-engine, or it may be used to work the winding-engine, or the heat thus escaping may be employed to burn the lime or roast or dry the ore or fuel employed.

And in order that this mode of constructing and working blast-furnaces may be fully understood, the same is represented in vertical section at Fig. 1, and in elevation at Fig. 2. Fig. 3 is a cross-section taken at two different heights on the crooked line A B. Fig. 4 is a vertical section of the pipe for conveying the furnace-gases to the blast-engine.

The same letters are used in each figure to denote a repetition of that part.

*a* is the outer shell or case of the furnace, which incloses the whole of the masonry or brick-work. This case may be further strengthened by hoops or angle-flanges of iron or steel so as to render it capable of withstanding safely internal pressure from one or two atmospheres in excess of the external atmospheric pressure. The slope of the boshes is similarly incased in a cone of plate-metal, $a^*$, the base of the cone being further strengthened by the iron band *b*. The outer shell of the furnace slopes down to the ground level all round the furnace, as shown at $a^1$, and also beneath it, as shown at $a^3$. An annular space or chamber, *c*, is inclosed around the boshes, the partitions $a^2$ dividing this space into two chambers, *c* and $c^*$. A strong box-girder, *d*, with central web, extends entirely around the under side of the outer wall of the furnace, and at intervals rests on strong iron-webbed columns *e*, which occupy the chamber *c*, resting below on the bed or foundation of masonry *f*. Two small ante-chambers, *g* and *h*, are made with two doors, each for the purpose of affording entrance and exit for the workmen from and into the chambers *c* and $c^*$ at all times, when required. Notwithstanding, the air in these chambers is greatly in excess of the external atmospheric pressure, and which mode of gaining access to and egress from chamber is fully described in a patent in England bearing even date herewith and numbered 1,432, and consequently does not form part of the present invention. Below the level of the tymp I form an arched chamber, *i*, into which a truck or carriage can be moved on rails for the purpose of receiving the cinder flowing from the furnace, or the cast of metal may be run into a movable receptacle so placed. The chamber *i* is provided with a well-fitted sliding door, made as near as may be air-tight; a little leakage of air from the chamber *i* is preferable, as it will cause an outward flow of air from the chamber $c^*$ through the hole *j* and thus prevent the ascent of heated fumes from the chamber *i*. An annular flue, *m*, is formed around the furnace, into which several passages, *n*, lead from the furnace. At any part of the flue *m* a restricted outlet may be made of such a size as will allow the desired amount of carbonic-acid gas to escape, while the rest of the gas passes upward and is converted into carbonic oxide, and in that state deoxidizes the ore, but without taking up as much carbon as the whole of the gases would do if allowed to pass upward among the fuel. The area of the escape-openings *n* is each so greatly in excess of the area of the one restricted outlet as to cause a very slow and gentle current of gas to pass up them, and thus not tend to carry out any fuel by these passages. Man-holes for clearing out dust, if necessary, can be made in the flue *m*, and if found desirable that portion of the carbonic-acid gas allowed to escape by these passages from the furnace may be taken off at a much lower level than that shown in the drawing, the outlets *n* being in that case much nearer to the level of the layers and communicating with a passage or passages which pass out through the chamber *c*. At the top of the furnace I have shown a cup-valve, *p*, which forms the lower portion of the chamber *q*. The upper part of this chamber is fitted with a second cone, *r*, through the center of which the rod *s* of the cone *p* passes, the cone *r* having a jointed sling to support it and allow it to be balanced in the usual way and raised or lowered as required; the cone *p* having a separate arrangement of the same kind, so that each of the cones *p* and

*r* may be moved independently of each other, and so that the ore and fuel may be admitted to the chamber *q* by lowering the cone *r* while the cone *p* is closed. After the materials are thus admitted to the chamber *q* the workman will raise the cone *r* and lower the cone *p*, by which means the materials will fall into the furnace. The raising of the cone *p* and the lowering of the cone *r* will allow another charge to enter the chamber, and so on, a chamber full of gas being allowed to escape at each operation of filling.

I would observe that in all cases before the cone *p* is lowered an equilibrium of pressure must be effected between the chamber *q* and the inside of the furnace. For this purpose a valve, not shown in the drawing, is provided, by means of which the workman may admit the furnace gases or steam into the chamber *q* and thus equalize the pressure above and below the cone *p*; and so, also, before lowering the cone *r*, he will allow such steam or gases to escape by a valve into the external atmosphere, in that case equalizing the pressure above and below the cone *r*. It is desirable that the fitting-surfaces of these valves should be more perfect than usual, the metal parts being defended, if necessary, from the action of escaping gases by the passage of steam into the joint in a manner similar to that by which the leakage of flame and heated gases is prevented from escaping from the doors of high-pressure melting-furnaces, by the use of air under pressure, as fully described in a patent granted to me in England, and bearing date the 10th day of November, 1868, and numbered 3,419. The gases, after passing up through the materials in the furnace, find their escape by the openings *t*, and pass into an annular channel, *u*, and from thence into a large pipe, *w*, shown in vertical section at Fig. 4, where a portion of the side of the furnace is also shown to render the position of the pipe *w* and its connection with the channel *u* more clearly understood. The pipe *w* is lined with segmental fire-bricks *w**, in order to defend the outer iron shell from the effects of heat, and also to prevent loss of pressure in the gases and vapors by the radiation of heat therefrom. A force-pump, worked by the blast-engine, forces water to the top of the pipe *w* by a pipe which passes through top of the pipe *w* at *x*, having a rose-head, *v*, perforated in such a way as to cause water forced through it to fall in a shower down the pipe *w* for the purpose of lowering the temperature of the furnace-gases to a point suitable for the hot-air engine to be driven by them; and, although I prefer a direct-acting blast-engine, as before named, it will nevertheless be obvious that any efficient plan of blast-engine may be used, the ordinary steam-cylinder of which will be supplied with waste gases mixed with the steam generated by them from the falling shower of water, such cylinder being in all cases of sufficient diameter to compress the blast the desired extent; the volume of steam and gases always being in excess of the volume of air and water injected, by reason of the expansion of the air by the heat of the furnace and the formation of steam from the falling shower of water.

And although I have described the working of the blast-furnace under the pressure of confined gases, I desire it to be understood that certain parts of my said improvements are equally applicable to blast-furnaces working with open tops, and furnaces where the waste gases are collected for combustion in hot-air stoves or under boilers. These improvements consist in the mode, shown and described, of allowing an outflow of a portion of the carbonic-acid gas a short distance from the tuyeres, and also the continuous flow of metal and cinder from the furnace.

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

I claim as my improvements in the construction and mode of working blast-furnaces employed for smelting the ores of iron, and in the mode of employing and utilizing the gaseous products of such furnaces, and also in the construction and mode of working blast-engines employed to force air into blast and other furnaces—

1. The entirely enveloping the masonry or brick-work of a blast-furnace in a strong air-tight case or jacket, to admit of the gaseous products of combustion being retained under considerable pressure.

2. The inclosing the boshes of blast-furnaces, so as to have the tuyere-holes opening externally into a large chamber accessible to workmen and containing air under pressure.

3. The inclosing the tap-hole of blast-furnaces in a large chamber capable of containing air under pressure, so that the pressure of air therein may, when required, prevent escape of flame thereat.

4. The providing outlets from a blast-furnace near the tuyeres for the escape of a portion of the gases in the state of carbonic acid.

5. The so arranging and operating, when a carburizing-vessel is used, that the metal may run continuously from the blast-furnace into the carburizing-vessel.

6. The smelting ores of iron in blast-furnaces, in which the gaseous products of combustion are retained throughout the furnace under a pressure considerably exceeding that of the external atmosphere.

7. The combining an air-engine and air-pump with a high-pressure blast-furnace in such manner that the gases issuing from such furnace are caused to pass through and work such engine, and thereby actuate the pumps which supply the blast to the furnace.

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