Plate I.

IMPROVEMENT IN CONVERTING CRUDE IRON IN MALLEABLE IRON AND STEEL

INVENTOR: HENRY BESSEMER. PATENTED JUL 25 1871

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Fig. 1.

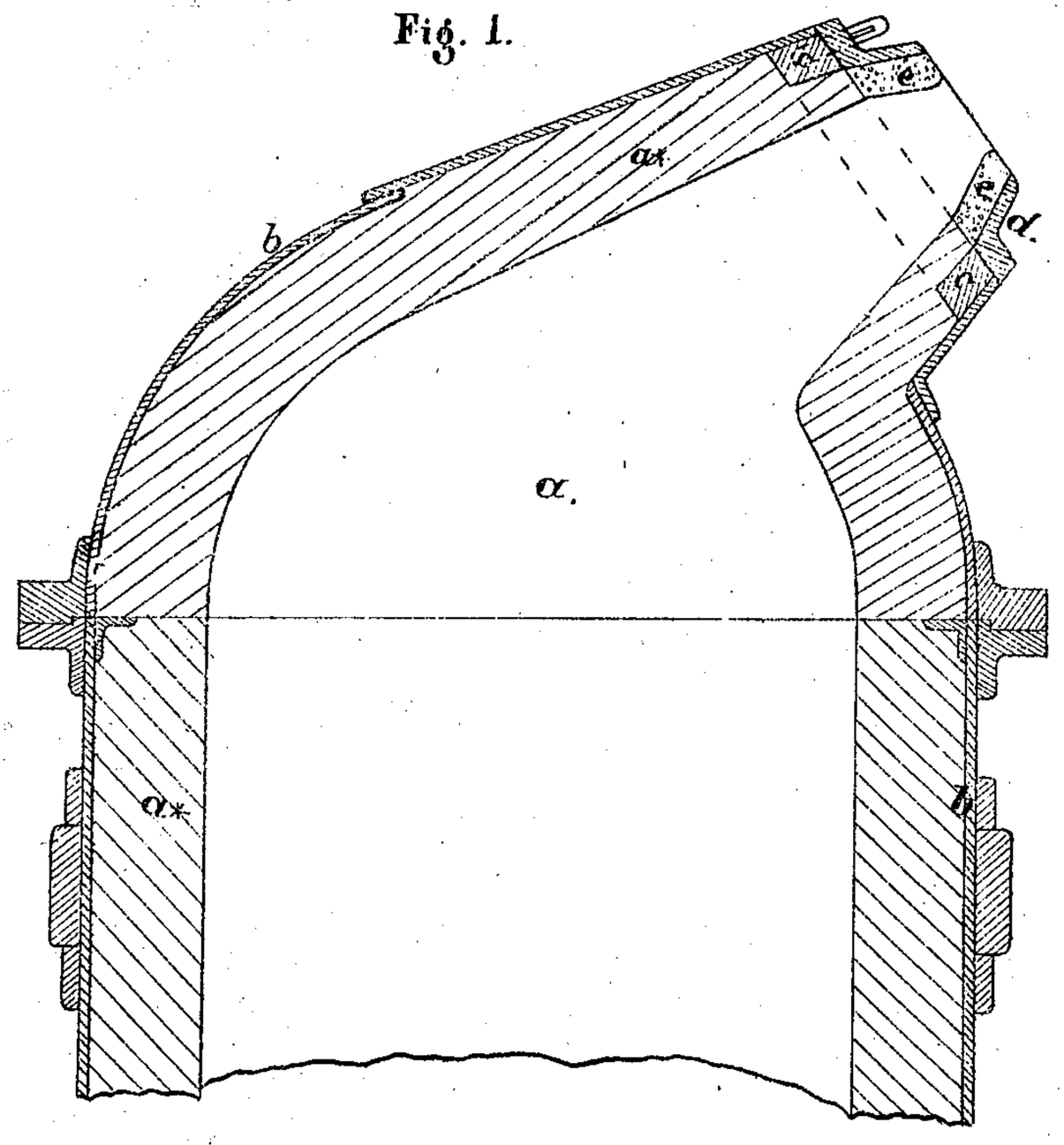

Fig. 2.

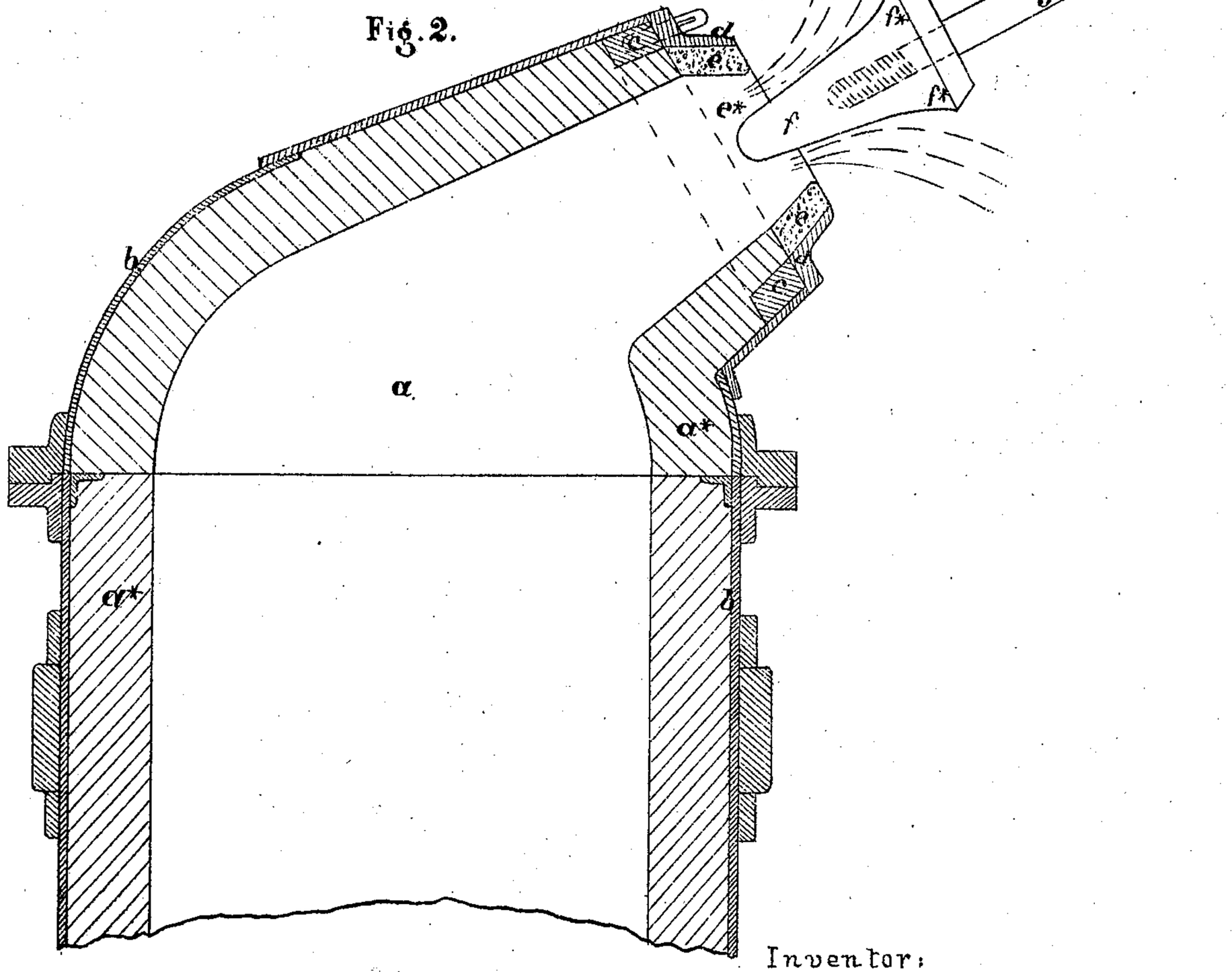

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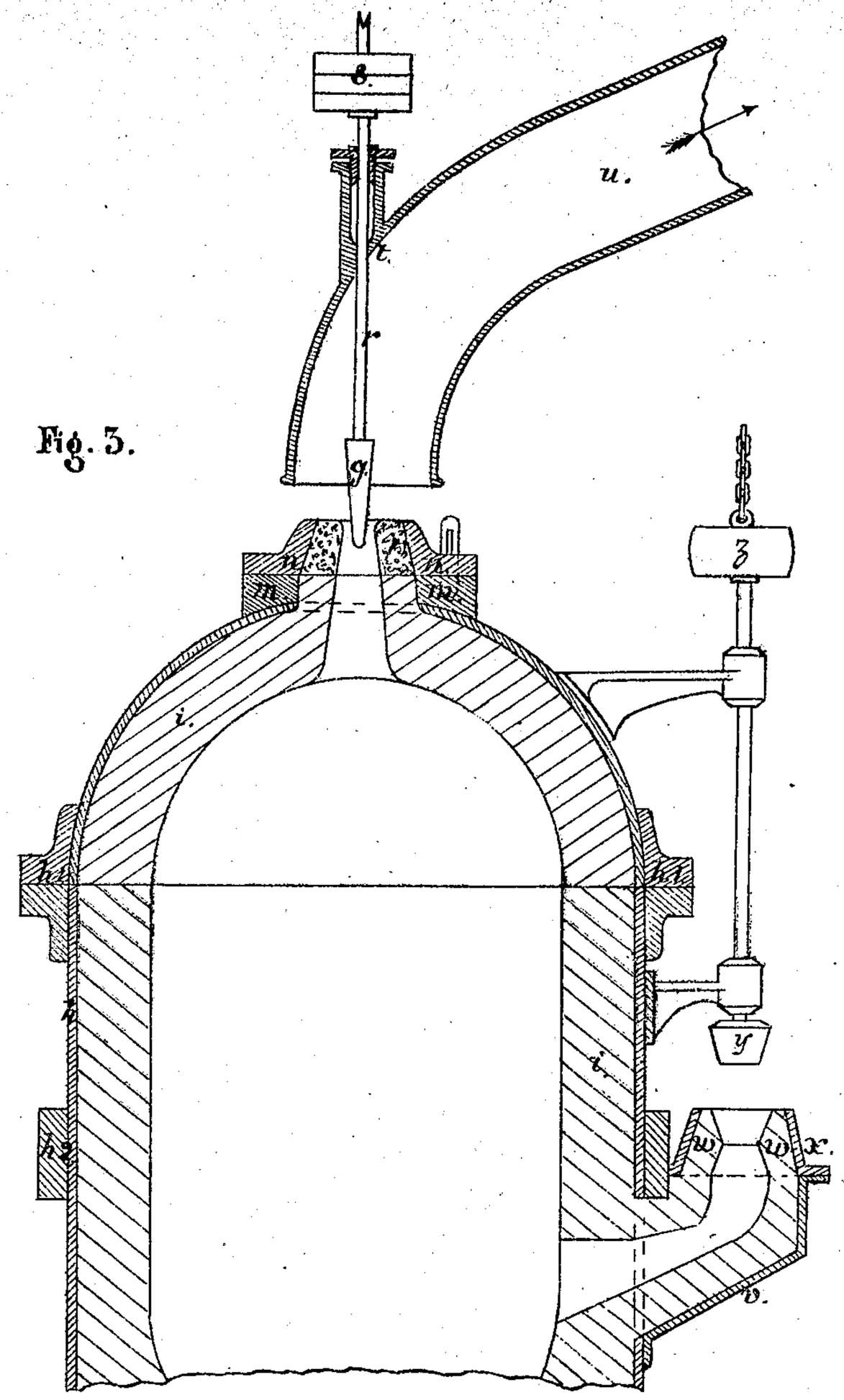
Plate II.

Fig. 3.



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UNITED STATES PATENT OFFICE.

HENRY BESSEMER, OF LONDON, ENGLAND.

IMPROVEMENT IN BESSEMER CONVERTERS FOR CONVERTING CRUDE IRON INTO STEEL, &c.

Specification forming part of Letters Patent No. 117,248, 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 conversion of fluid crude iron and molten pig or other carburets of iron into fluid homogeneous malleable iron and steel, whether such pig or other crude iron is used alone or is mixed with a portion of malleable or more or less decarburized iron in a solid or fluid state; 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 decarburation or partial decarburation of molten crude iron, or remelted pig or other carburet of iron may be effected by passing atmospheric air upward through the fluid metal in suitable vessels in the manner now generally known as the Bessemer process.

It has, however, been found that certain of the purer qualities of Swedish pig-iron made with charcoal, and also some of the less gray and the white hematite pig-irons of this country do not produce sufficient heat in the converting-vessel under ordinary circumstances to allow all the steel made therefrom to retain complete fluidity until it is poured into molds, and hence sometimes it happens that large "skulls" or shells of solidified steel are left in the casting-ladle. This evil is increased when malleable scrap-iron or steel in a solid state is added to the charge of metal in the converter. Now, one of the chief objects sought to be obtained by my present invention is to raise the temperature of that metal during the process of conversion so high that no skull or solidified metal shall be left in the casting-ladle when employing carburets of iron not rich in graphitic or other carbon, and thus enable the manufacturer to use many qualities of iron that do not produce a maximum of heat under the ordinary converting process, and also enable him to put into the converting-vessel a portion of steel-scrap or scrap-iron, or other kinds of decarburized or malleable iron in a solid state, and which, by means of the extremely high temperature imparted to the metal, become fused and form part of the charge of molten malleable iron or steel obtained. For this purpose I make the converting-vessel of great strength, securely riveting and calking all the laps and joints, so as to render it air-tight as near as may be. I, by preference, form the mouth of the vessel circular instead of oval, and of a smaller size than usual, lining the mouth with a single ring of well-burned fire-clay or composition of clay and plumbago, and I form the metal part of the mouth of the converter with a movable dovetailed flanged ring, so that the fire-clay mouth of the vessel may be readily taken out and renewed by unbolting or uncottering the iron ring which retains it in place. And in order that this mode of constructing the mouth of the converting-vessel may be fully understood, I have represented the same in vertical section at Fig. 1 in the drawing hereunto annexed, where—

a represents the upper part of a Bessemer converting-vessel; *a**, the lining or ganister; and *b*, the strong riveted iron shell or vessel on the inside of which the iron hoop *c* is riveted. *d* is a flanged iron ring, beveled on the inside, and secured by screwed studs or cotter-bolts to the hoop *c*. A molded ring, *e*, of fire-brick or other suitable refractory material, forms the escape-opening or mouth of the vessel. It is retained in place by means of the flanged ring *d*, and when it is worn out or damaged the ring *e* may be renewed by unfastening the ring *d*, a mixture of fire-clay and ganister being first smeared over those parts of the ring *e* which come in contact with the lining *a** and with the beveled interior of the ring *d* for the purpose of making the joints air-tight. The aperture in the movable mouth of the vessel thus formed may, in some cases, be made small enough to retain the gaseous products resulting from the combustion of the carbon or other matter contained in the pig-iron under a pressure much above that of the surrounding atmosphere, so that the combustion going on in the converting-vessel may be under high pressure, as described in reference to melting furnaces 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 mode of forming this contraction of this mouth of the vessel for the purpose of retaining the gaseous products under considerable pressure therein is shown in vertical section in Fig. 1, and is so much reduced in area as to cause the flame and gaseous

products evolved during the process to be pent up until a considerable amount of pressure is produced, in order that the gaseous products resulting from the combustion of carbon and other matters in or among the fluid metal may be prevented from expanding freely, and by reason of the combustion so taking place, under a pressure much greater than that of the external atmosphere, a more intense heat will be produced and imparted to the metal. The amount of pressure thus obtained should vary with the heat-producing properties of the carburet of iron operated upon and the quantity of scrap or other infused metal forming part of the charge, so that no precise rule can be laid down as to the pressure to be employed; but as a guide to the workman I desire to state that, for the conversion of the purer kinds of Swedish charcoal pig-iron, and for mottled or white hematite pig-iron mixed with gray, a back pressure in the vessel from eight to fifteen pounds on the square inch will give good results, and in but few cases will a pressure of twenty pounds per square inch be necessary, while a pressure as low as three or four pounds will be but of little practical advantage, and below two pounds per square inch I lay no claim to as a useful effect. It will be understood that the pressure of the blast of air forced into the converting-vessel must be increased in proportion to the back pressure caused by the penning up of the gases within the vessel. I would also remark that the mode of obtaining the required back pressure by simply diminishing the outlet does not offer all the desired facility of regulating the pressure from time to time during the process, while, at the same time, the accumulation of slags in the aperture may, in some cases, reduce the area of outlet so much as to retard the inflow of air through the tuyeres. For these several reasons the opening in the mouth of the converting-vessel may be made much too large if left open to retain the gaseous matters in the converter at the high pressure desired, such larger-sized mouth being provided with a conical stopper inserted in the opening, and so arranged as to be advanced or further withdrawn by being itself movable or by the motion of the vessel on its axis, the vessel being made to advance toward or recede from a fixed conical stopper. I, however, prefer to use a non-movable conical stopper attached to the end of an iron rod, as shown in Fig. 2, which represents the upper part of a Bessemer converting-vessel, with a contracted mouth-piece similar (but larger in diameter) to that represented in Fig. 1, the several parts of which are indicated by the same letters of reference. The conical piece of fire-brick *f* is circular in form, and spreads outward in a curved line at *f** for the purpose of deflecting the flame and preventing its too powerful action on the iron rod *g* which supports the cone *f*. The rod *g* protrudes through the back wall of the converting-house, or may be supported on a bracket or piece of iron framing, in connection with the standards which support the vessel, and by means of a screw or lever the cone *f* may be made to advance further into or recede from the mouth of the vessel, thus increasing or diminishing the area of the annular opening at *e**, and thus regulate the pressure of the confined gases in the vessel. In some cases it may be found desirable to render the stopper *f* self-acting by applying a spring or weighted lever to press it forward against the pressure of the escaping gases, so that either by reason of its enlargement by the accretion of slags on its surface, or by being partially burned away, it will occupy such a position in the mouth of the vessel throughout the process as will give a sufficiently-equal amount of back pressure, and prevent that pressure from exceeding what is necessary by any partial clogging up of the escape-opening; or, in lieu of employing a conical stopper, a flat or other shaped surface may be employed, the object in either case being to enlarge or contract the opening for the escape of flame, as found desirable at different stages of the process; the pressure of the confined gaseous products being indicated by a mercurial column, so arranged that the mercury is prevented from coming in contact with the heated products of combustion by means of a current of air, as described in my English patent bearing date May 10, 1869, and numbered 1,431. This gauge will allow the workman to employ, from time to time, such an amount of internal pressure in the vessed as the known qualities of the material he employs may render necessary.

When crude molten iron or remelted pig or refined iron is decarburized or partially decarburized, or converted into refined iron or into malleable iron or steel, by the action of nitrate of soda or potash, or by other oxidizing salts, as set forth in a patent granted to me in England, and bearing date the 21st day of March, 1868, and numbered 965, or when such decarburation or conversion is effected by any other modes or processes in which the decomposition of nitrate of soda or potash or other oxygen-yielding salts, alone or mixed with metallic oxides, takes place in, among, or below the fluid metal in a converting-vessel or chamber, a large amount of heat is absorbed and rendered latent, thus tending to solidify the metal and rendering it unfit for forming into ingots or castings without being remelted.

Now, the object of this part of my said invention is to raise the temperature of metal (while so treated or converted) to such a degree as to allow it to be cast into ingots or other cast articles or masses prior to its solidification. For this purpose I construct the vessels in which the process is to be carried on of great strength, preferring to use stout iron or steel plates, well riveted and calked, and, if needful, further strengthened by stout hoops. I make the mouth of the vessel very small, preferring, for that purpose, to employ a well-burned fire-brick ring, into which a long taper cone of the same material is placed. The cone is fastened to a long rod working in suitable guides, so as to keep it central with the mouth of the vessel. The space between the exterior of this cone and the interior of the fire-clay ring determines the area of outlet for the gaseous products given off during

the time that the decomposition of the nitrate or other oxygen-yielding materials is going on. A weight or spring-lever, acting on the rod to which the fire-clay cone is attached, may be made to regulate the amount of pressure required to lift the cone and permit the escape of the gaseous matters. Any other suitable valve may be employed, or a more restricted outlet may be used, the object in either case being to prevent the free escape of the gaseous matters resulting from the combustion of the carbon contained in the crude iron, and to retain such gaseous products in the converting-chamber or vessel under a pressure of several atmospheres, if needful, and thus cause the heat developed by the combustion of the carbon contained in the crude iron to become highly concentrated, and the metal thereby raised in temperature. An artificial atmosphere of air or steam, under great pressure, may be employed, if desired, at the commencement of the process, and the valve or restricted outlet may be inclosed within a tube or shaft, whereby the gaseous matters may be conveyed away. The opening by which the metal is admitted must also be securely closed to prevent any escape of the gases from the vessel. The manner in which this part of my said invention is carried into practical operation is represented on the drawing hereunto annexed, where Fig. 3 represents a vertical section of the upper portion of a converting-vessel or chamber in which molten pig or other carburet of iron is to be treated either by the injection of the fluid nitrate into the molten metal, as described in a patent granted to me in England on the 21st day of March, 1868, for improvements in the manufacture of refined iron and of malleable iron and steel, and numbered 965, or in which vessel the nitrates or other oxygen-yielding salts or substances are so brought in contact with the hot metal as to be decomposed thereby. The outer shell *h* of the vessel or chamber is made of thick plates of iron or steel, securely riveted and calked at all joints, and capable of withstanding safely a pressure of from five to ten or more atmospheres. For the convenience of lining the vessel the upper part may be removed by unbolting the stout flanges h^1. One or more hoops, h^2, are riveted to the exterior of the vessel to strengthen it. A lining of fire-brick, ganister, or other refractory material, *i*, is used to defend the outer shell from the high temperature generated within, and, previous to its use for conversion, I prefer to make a fire in the interior, so as to highly heat the lining and lessen its power of absorbing heat from the metal. On the upper part of the dome an iron ring, *m*, is riveted, to which a flanged ring, *n*, is fitted. The inside of this ring is conical, and is made to embrace the conical fire-clay ring *p*, through which the gaseous matters evolved during the process are allowed to escape. A cone of fire-clay or iron, *g*, is attached to the guide-rod *r* for the purpose of closing or diminishing the area of the outlet-opening in the fire-clay ring *p*. On the upper end of the rod *r* are placed weights *s*, to regulate the pressure. The rod *r* is guided vertically upward and downward by passing through the tubular guides and stuffing-box formed at *t t* on the curved exit-passage *u*, which leads to a chimney and conveys away the gaseous products escaping from the converting-chamber. On one side of the vessel or chamber is a projection, *v*, on the upper part of which a ring of fire-brick, *w*, is retained in place by a conical flanged iron ring, *x*. The opening in the ring *w* serves for the admission of the molten metal to the vessel, after which the cone *y*, smeared with fire-clay, is lowered down into the opening of the molded fire-brick *w*, and, by means of the weight *z*, is retained in place and prevents the escape of gaseous matters during the converting process. The cone *y* and its rod and weight *z* are suspended by a chain in the position shown during the period of running in the metal. When the metal so run in comes in contact with the nitrates or other oxygen-yielding materials large volumes of gaseous matters are evolved, as is well known and understood, which, instead of escaping freely from the vessel, as heretofore practiced, will rapidly accumulate in the vessel until the pressure within it is sufficient to raise the cone *g* and escape by the small annular opening thus made, the pressure being regulated by the weight *s;* and hence the combustion of the carbon contained in the molten iron, by reason of its union with oxygen derived from the decomposition of the nitrates or other oxygen-yielding materials, will be effected under considerable pressure. The gaseous products, instead of expanding freely, as under the ordinary conditions of combustion, will be in a highly-condensed state, by which means their temperature will be considerably raised, and additional heat so generated will be imparted to the metal and retain its fluidity.

Having thus described my invention and the manner in which it may be carried into practical operation, I desire it to be understood that I lay no claim under these, in part, recited Letters Patent to the conversion of pig or other carburets of iron into malleable iron or steel by the passage of air through the molten metal, nor by means of the action of nitrates or other oxygen-yielding substances thereon, so long as the gaseous products evolved in either of these processes are allowed to escape freely from the vessels or chambers in which such converting processes are carried on; but

What I do claim is—

1. The constructing the Bessemer converting-vessel in such manner that the metal contained therein may have its temperature increased by being exposed to a considerable back pressure of gas during the converting process.

2. The conversion of molten pig or other carburet of iron into malleable iron or steel by passing atmospheric air through the fluid metal contained in vessels in which the gaseous products of combustion are retained above the surface of the metal at a considerable pressure in excess of the pressure of the external atmosphere.

3. The employment of movable rings or mouthpieces in vessels employed to convert molten pig

or other carburet of iron into malleable iron or steel by the passing of atmospheric air through the molten metal.

4. Regulating the pressure of the gaseous products of combustion within the Bessemer converting-vessel, in the manner herein described.

5. The treatment of, or conversion into malleable iron or steel of molten pig or other carburet of iron by means of nitrate of soda or nitrate of potash, or by other oxygen-yielding salts or substances, when such treatment or conversion is carried on in vessels or chambers in which the gaseous products resulting from such treatment or conversion are retained under considerable pressure, as and for the purposes herein described.

6. The apparatus and methods herein described for effecting and regulating the pressure of the gaseous products within the vessels or chambers in which molten pig or other carburets of iron are treated, and converted into malleable iron or steel by the action of nitrate of soda, or nitrate of potash, or other oxygen-yielding salts or substances.

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