(No Model.)

# J. F. BENNETT.

## APPARATUS FOR COMPRESSING LIQUID STEEL.

No. 282,041. Patented July 31, 1883.

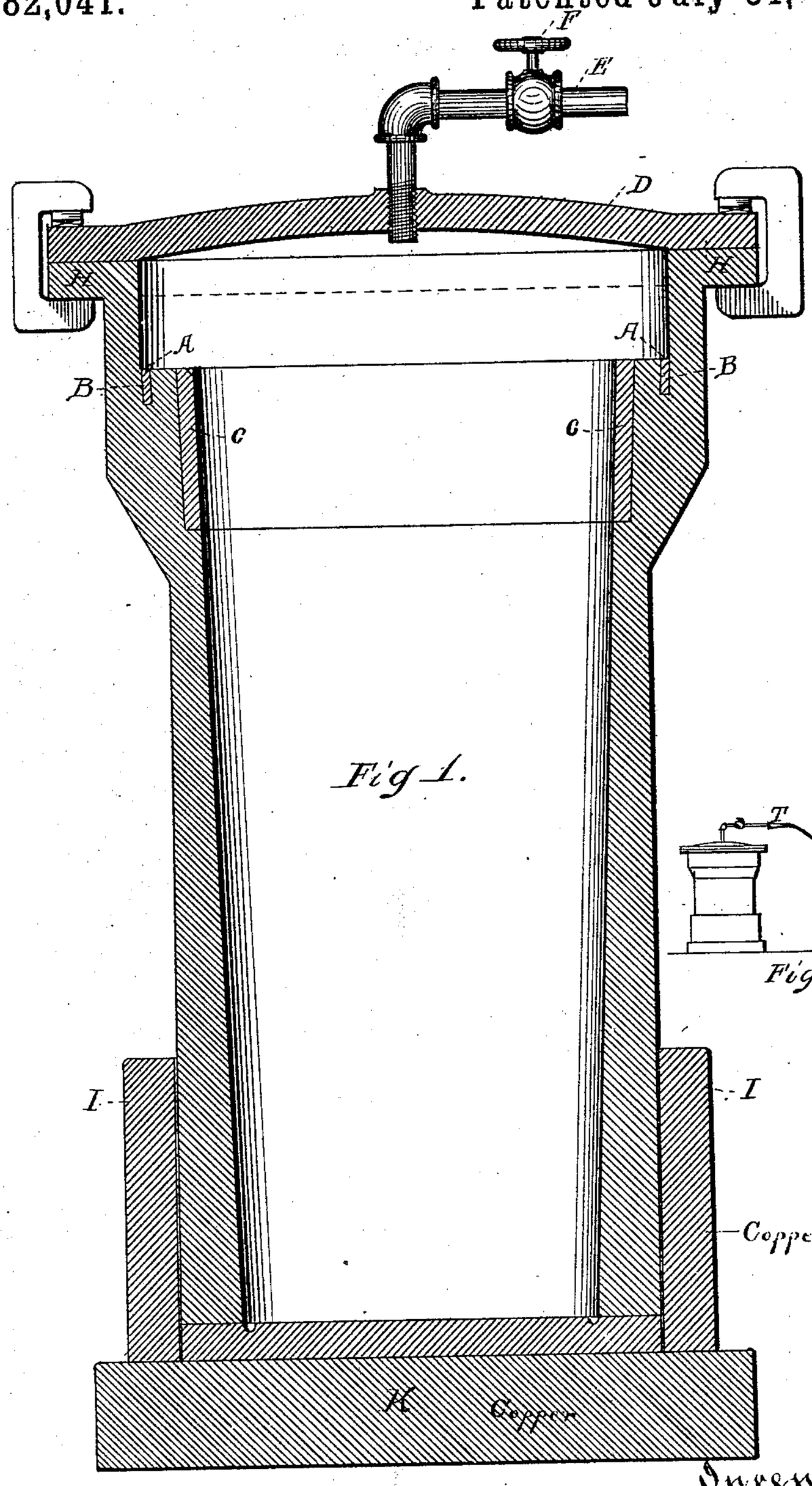


Fig 1.

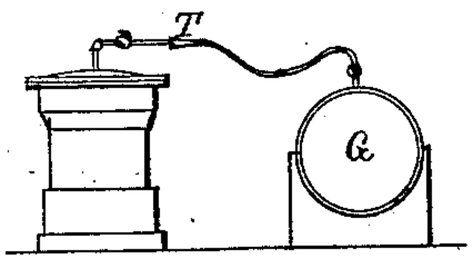


Fig 2.

Witnesses.
H. E. Harrison.
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# UNITED STATES PATENT OFFICE.

JOHN F. BENNETT, OF PITTSBURG, PENNSYLVANIA.

## APPARATUS FOR COMPRESSING LIQUID STEEL.

SPECIFICATION forming part of Letters Patent No. 282,041, dated July 31, 1883.

Application filed January 27, 1883. (No model.)

*To all whom it may concern:*

Be it known that I, JOHN FRANCIS BENNETT, a citizen of the United States, residing at Pittsburg, in the county of Allegheny and State of Pennsylvania, have discovered certain new and useful Improvements in Apparatus for Compressing Liquid Steel while Becoming Solid; and I do hereby declare that the following is a full, clear, and exact description of the invention, which will enable others skilled in the art to which it appertains to make and use the same, reference being had to drawings accompanying and forming part of this specification, in which like letters indicate like parts.

Figure 1 is a vertical section of an ingot-mold. Fig. 2 is a side elvation of air-reservoir and mold.

A is gutter or channel in wall of mold, near the top. B is lead or other easily-fusible metal in gutter. C is inner casing of fire-brick in wall of mold. D is cover or cap for mold. E is pipe connecting mold with air-reservoir. F is stop-cock in pipe. G is compressed-air reservoir. H is flange of mold. I is copper casing round lower part of mold. K is copper block or plate beneath mold.

Heretofore when liquid steel in molds has been compressed by the application of steam applied to its surface at the top of the mold the steam has penetrated between the inner wall of the mold and the outer wall of the cooling ingot. In practice the result has been to prevent (to a considerable extent) holes being formed in the interior of the ingot; but this advantage has been more than counterbalanced by a greater evil—namely, the formation of holes in the wall of the ingot to as great or a greater extent and volume.

In the ordinary Bessemer-steel ingots, not compressed by steam or air, the holes in the interior of the ingot usually amount to about ten per cent. of the whole volume of the steel, and are filled with non-oxiding gases—carbonic oxide, nitrogen, and hydrogen chiefly—which holes close and weld when rolled or hammered, excepting a few near the wall, which have been formed by the contraction of the cooling steel drawing in atmospheric air through the wall. These latter are usually, and ought always to be, cut out by what is technically called "hot chipping," inasmuch as the walls of such holes, having become oxidized by the air, never can be welded perfectly, but being thin strata of oxide of iron are flaws in the steel totally without tensile strength. By compressing with steam, as at present practiced, the wall of the ingot is completely honey-combed with holes from a quarter of an inch to one and a half inch deep, averaging about one inch deep, and together equal to about one-tenth of the volume of the whole ingot. These holes can be closed but never welded. When the ingot is rolled they become thin strata of oxide of iron, of depth from the surface in proportion to their depth when holes. For example, an ingot of eighteen inches square—three hundred and twenty-four square inches area—if rolled into a bar of five square inches area, would have the depth from the surface of a one-inch hole in the ingot reduced to a flaw filled with a stratum of oxide of iron of depth of about one-twentieth part of an inch in the bar. These cracks on the surface of rolled steel may not be very injurious in material for rough coarse purposes—such as rails; but for structural purposes they would be very objectionable, and for fine purposes utterly inadmissible, however good (by further improvements in the art of steel-making) the quantity of Bessemer or "open-hearth" steel may become. My improvement obviates this difficulty, and in addition admits of the application of a greater pressure than has hitherto been obtained when compressing steel by means of steam, air, or other gases.

Referring to drawings, I make an ingot-mold of any desirable dimensions, Fig. 1, with its wall at lower part thicker than at top, and with its inner area at bottom smaller than at top, with intent that the liquid steel shall set more quickly at the bottom than at the top, and also readily drop out of the mold by inverting it. At the top of the mold is flange H, to which is attached cap D, which has pipe E, with stop-cock F, leading to reservoir of compressed air G. I make the area at the top of the mold greater than that of its main body. At a short distance from the top is a gutter, A, of about two inches deep and half an inch wide, in which I place metallic lead B, or other easily-fusible metal. The inner wall of gutter is about one and a half inch in thickness, level with the top of which, and descending downward, is a recess in the wall, of six or more

inches deep, of about one inch in thickness, filled with fire-brick C, or other refractory non-heat-conducting material.

The apparatus being thus arranged the operation is as follows: I pour liquid steel in at the top of the mold and fill it to about three inches above the gutter, (in a mold of about five feet long and twenty-four inches square,) attach the lid and admit compressed air from the reservoir until the steel has set, when I shut off the air by the stop-cock, lift and reverse the mold, and the ingot drops out.

My object in making the lower part of the mold thicker than the upper is that the liquid steel may crystallize and become solid more quickly in the lower part than in the upper, and then contracting may draw upon the steel yet liquid in the more lately poured upper part with its thinner and less heat-absorbing wall, and to attain this more effectually I recommend that the iron plate on which the mold stands shall have under it a thick plate or block of copper or other rapidly heat-conducting substance, and that the lower part of the mold (for about one-fourth of the whole height) shall be incased in a thick copper covering, preferably cast around it.

My object in making the upper part of the mold thinner is that it may absorb less heat from the liquid steel, and thus keep the steel in that part liquid for a longer period of time, taking care, however, that it shall be thick enough not to melt, and strong enough to withstand the pressure of the compressed air.

My object in making a gutter filled with lead is that the lead, becoming liquid, will form a lute which will prevent the compressed air from passing between the steel and the wall of the mold.

My object in preferring compressed air to steam is that it can be compressed to any desirable degree without danger, even up to one hundred or two hundred atmospheres, or fifteen hundred to three thousand pounds on the square inch, (or up to the strength of the mold to resist rupture,) which would be practically impossible with steam. By compressed air I mean atmospheric air, or any other gases that are not explosive.

My object in incasing the inner sides of the wall of the upper part of the mold with fire-brick or other non-heat-conducting material is that the steel may continue longer liquid there, and so be the better capable of being compressed toward and into the spaces that would become holes or "toad's eyes" in the contracting of the steel after it has crystallized, but yet in a pasty condition, (during the act of crystallization it expands,) and, becoming colder, by a law of nature must contract. I do not limit the inner incasing-wall of fire-brick to extend only to about six inches below the gutter. It may be found beneficial to extend it half-way down the mold.

In practice it can be determined how high above the gutter the liquid steel may be most beneficially filled. The point is that there shall be a little depth of steel on the top of the inner wall of the gutter when the compression is completed; also, I recommend that, in order to carry out this invention to the fullest effect, the mold should be of the greatest area and of the shortest length compatible with other requirements of the art.

I claim—

1. An ingot-mold for liquid steel, with gutter around its inner wall, near the top, which gutter is filled with lead or other easily-fusible metal, substantially as set forth.

2. An ingot-mold for liquid steel, with gutter around its inner wall, near the top, which gutter is filled with lead or other easily-fusible metal, in combination, and connected with a reservoir of compressed air or other non-explosive gases, substantially as set forth.

JOHN FRANCIS BENNETT.

Witnesses:
J. J. McCORMICK,
M. J. McDONALD.

Correction in Letters Patent No. 282,041.

It is hereby certified that in Letters Patent No. 282,041, granted July 31, 1883, upon the application of John F. Bennett, of Pittsburg, Pennsylvania, for an improvement in "Apparatus for Compressing Liquid Steel," an error appears requiring correction, as follows: in line 79, page 1, of the printed specification, the word "quantity" should read *quality;* and that the patent should be read with this correction therein to make it conform to the record of the case in the Patent Office.

Signed, countersigned, and sealed this 23d day of October, A. D. 1883.

[SEAL.]

M. L. JOSLYN,
*Acting Secretary of the Interior.*

Countersigned:

E. M. MARBLE,
*Commissioner of Patents.*