(No Model.) 2 Sheets—Sheet 1.

J. W. BOOKWALTER.

PROCESS OF CONVERTING CRUDE IRON INTO MALLEABLE IRON OR STEEL.

No. 411,418. Patented Sept. 24, 1889.

Fig. 2.

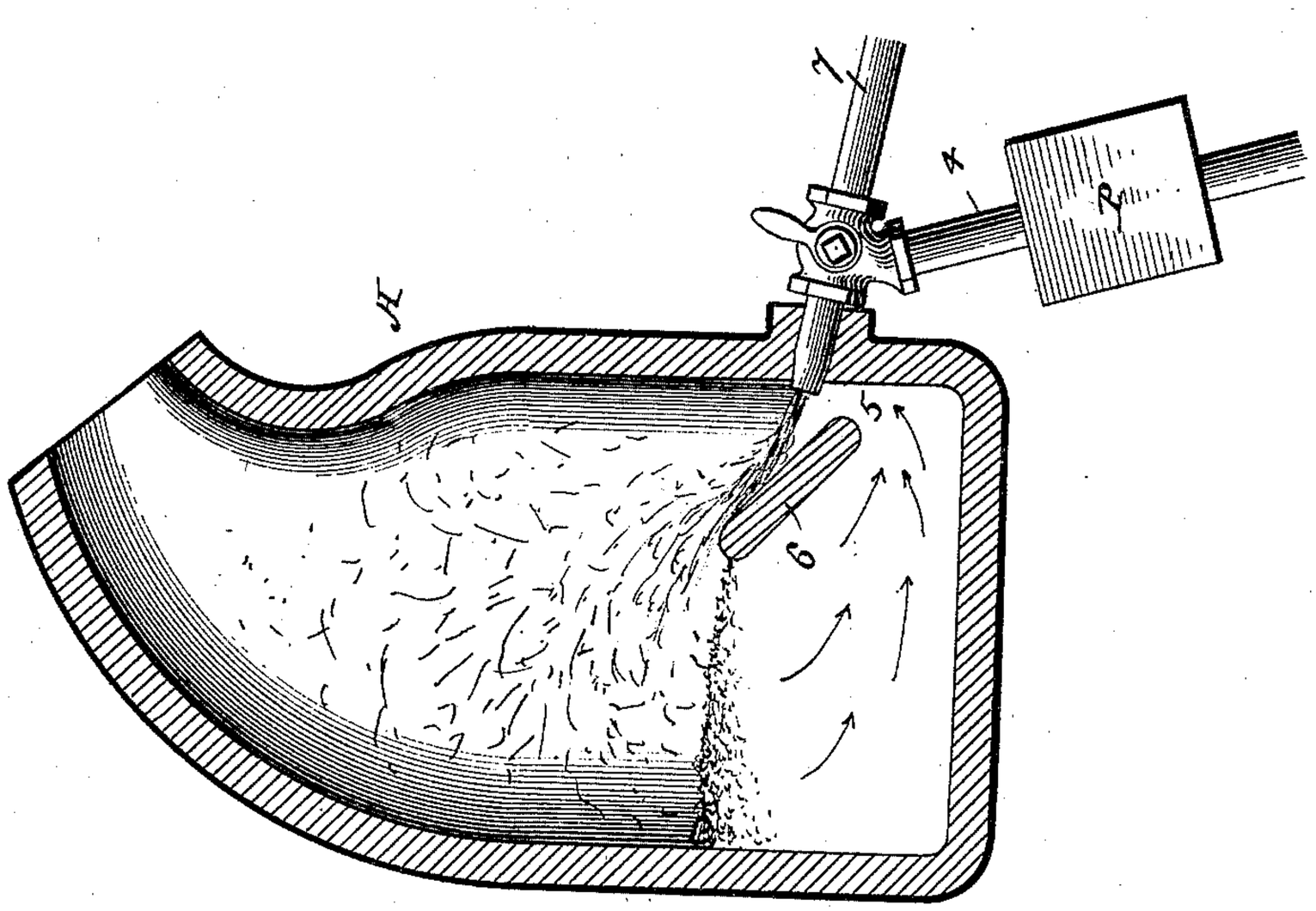
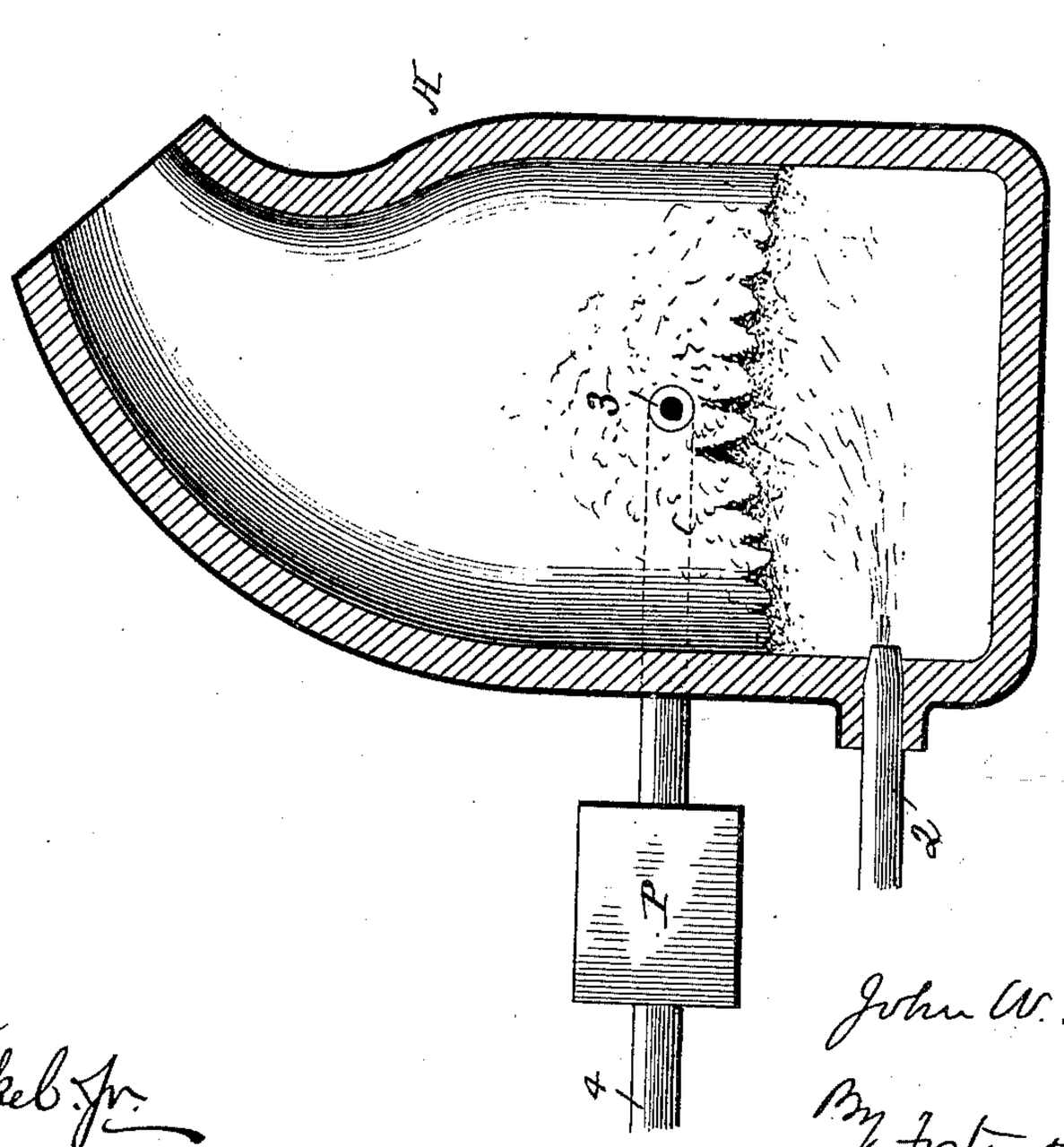


Fig. 1.



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(No Model.)

J. W. BOOKWALTER. 2 Sheets—Sheet 2.

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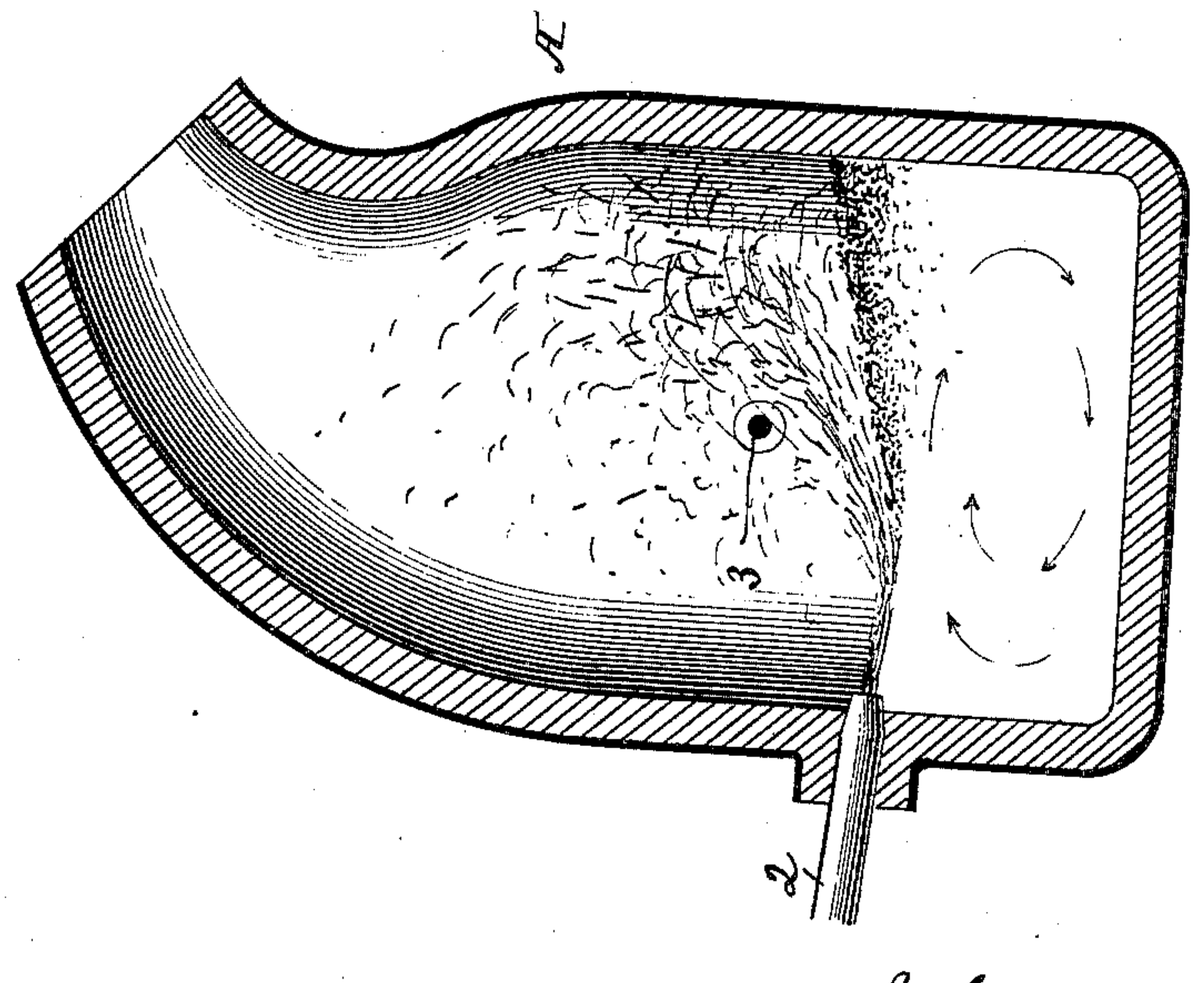
Fig. 3.



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UNITED STATES PATENT OFFICE.

JOHN WESLEY BOOKWALTER, OF SPRINGFIELD, OHIO, ASSIGNOR TO THE BOOKWALTER STEEL AND IRON COMPANY, OF JERSEY CITY, NEW JERSEY.

PROCESS OF CONVERTING CRUDE IRON INTO MALLEABLE IRON OR STEEL.

SPECIFICATION forming part of Letters Patent No. 411,418, dated September 24, 1889.

Application filed November 6, 1888. Serial No. 290,121. (No model.)

To all whom it may concern:

Be it known that I, JOHN WESLEY BOOKWALTER, a citizen of the United States, residing at Springfield, Clark county, State of Ohio, have invented a new and useful Improvement in the Process of Converting Crude Iron into Malleable Iron or Steel, of which the following is a full, clear, and exact specification.

In all the rapid modes of converting crude iron into malleable iron or steel wherein there is a large quantity of air forced into or upon the metal in a short space of time, there is a tendency of the oxygen to unite with the iron, even though there be present at the same time a full proportion of carbon and silicon or other combustible elements held by the crude iron. This tendency of the oxygen to unite with the iron simultaneously with that of the other combustible elements held by the crude iron is greatly increased where the jets or blasts of air are applied to the metal at or near the surface, as under these conditions, having a less resisting-power to the force of the air-blast than where the latter is applied in the bulk or body of the metal, the metal more easily yields to the pulverizing or atomizing effect of the blast, and therefore a more intimate admixture of air, and consequently oxygen, with the metal and its contained combustible elements is brought about, and as a consequence a tendency to a more rapid and intense combustion and heat. During all the processes of conversion, as the action of conversion proceeds successively, portions of the silicon and carbon and other combustible elements are continuously burned out or consumed by oxygen of the atmosphere; and as the oxygen of the atmosphere is contained in the same proportion throughout all the periods of the conversion the carbon and silicon and other combustible elements are therefore relatively to the quantity of oxygen admitted in a given time less and less in quantity as the act of conversion approaches the period of completion. It follows, therefore, as the proportion of oxygen becomes relatively greater this tendency to unite with the iron also becomes greater as the quantity of other combustible elements—such as carbon and silicon—becomes less. Therefore a theoretically-perfect mode of conversion would imply that the quantity of oxygen admitted should vary in the ratio of the quantity of the combustible elements contained in the iron at different stages of the process of conversion, and should therefore be less toward the close of the converting period, when these combustible elements have been somewhat eliminated, than at the beginning, when they were held by the iron in their full proportion.

My invention consists in regulating the quantity of oxygen to suit the varying decrease in quantity of carbon and silicon and other combustible elements held by the crude iron during the different stages of conversion, thus avoiding the difficulties above enumerated.

In those methods of conversion wherein the air-blast is applied at or near the surface, in order to insure the proper atomic disturbance of the metal and the proper motions in the mass of metal to secure the speedy and requisite return of all the metal to the point where the air-blast acts upon the metal, it is necessary that the aeriform substance be constantly admitted in sufficient volume or weight that its mechanical action upon the metal will induce these proper actions and currents. Therefore, in order to preserve the proper volume and quantity of aeriform substance for the mechanical effects referred to, the quantity of oxygen contained in this aeriform substance, admitted in substantially uniform volume, must be diminished or increased as the necessities of the conversion may require. Having this end in view, I resort to several different modes of varying the quantity of oxygen. First, either a non-oxygenated aeriform substance is admitted into the ordinary atmospheric blast, containing the usual quantity of oxygen, in such quantities as to dilute the aeriform volume without increasing the volume, and therefore reduce the quantity of oxygen relative to the quantity and weight of said aeriform substance; or, second, I pass into a body of non-oxygenated aeriform substance a varying quantity of oxygen, to give the relative proportions of oxygen that may

be required at the different stages of conversion without increasing the volume of the blast. A non-oxygenated aeriform substance is produced for this purpose by passing ordinary atmospheric air through a bed of ignited charcoal, in order to burn out the oxygen, or by passing it through any substance that has an affinity for oxygen, for the purpose of removing the same. This is done wholly or to a degree that will retain the proper amount of oxygen for the purpose heretofore referred to.

By the methods I have suggested the removal of the carbon and silicon can be almost entirely effected without the risk of having a material portion of the iron united with the oxygen also during the process of conversion.

The presence of oxide of iron in the completed product is most detrimental, as it is, perhaps, of all the impurities generated in the process of conversion, that which most affects the quality of the iron produced. I therefore specially aim by my invention to avoid the formation of this injurious impurity, and at the same time maintain the heat, and therefore the fluidity of the metal, by admitting heated air from some other source than the blast and passing it over the surface.

Different apparatus may be employed in carrying out my invention, according to the particular process of conversion in connection with which it may be used, and for purposes of illustration I have shown some forms of apparatus in the accompanying drawings, in which—

Figure 1 is a sectional view illustrating the character of apparatus employed for carrying out my invention in connection with the ordinary Bessemer process. Fig. 2 is a sectional elevation illustrating the form of apparatus employed in carrying out my improved process in connection with the process set forth in my application for Letters Patent, Serial No. 288,486. Fig. 3 is a sectional elevation of an apparatus which may be employed in connection with a process of a somewhat different character.

The converters A may be of any suitable form, and may be fixed or tilting.

In Fig. 1 the Bessemer converter A is provided with the usual tuyere 2, through which a blast of air is introduced directly into the body of the metal and passes through the same, while a hollow trunnion 3 communicates with a pipe 4 for supplying a blast or current of heated non-oxidizing air—such, for instance, as is secured by passing a current of air through burning carbon in a furnace P. The blast may be introduced first through the tuyere 2 to convert the metal and then through the trunnion 3 to maintain the temperature, or through both simultaneously, the proportion through the trunnion being gradually increased, while that through the tuyere is gradually diminished; or the blast may be otherwise regulated as above described, so that the oxidizing element is gradually reduced while the heat and fluidity of the bath are maintained.

In Figs. 2 and 3 the converter is shown as provided with tuyeres arranged to propel a blast in such manner as to act violently upon only a limited portion of the metal at any one time; and to avoid too minute pulverizing or atomizing of the molten metal and the resulting excessively rapid combustion and high temperature (which are brought about by the large amount of air moving at a high velocity having its whole force limited in its effect upon the relatively small amount of metal) it becomes desirable in some manner to regulate the proper amount of metal upon which the air-blasts impinge in a given time, so that while bringing about the necessary conversion the mechanical effect of the air upon the metal will not be such as to cause a too minute subdivision or atomizing of the metal with the attendant bad results referred to.

The securing of the desirable amount of metal to be acted upon by the air-blast to accomplish this purpose could be somewhat effected by causing the air to penetrate at some distance below the surface of the metal in the bath a short distance into the body thereof, as before described, and thus attain the proper atomic action both for purifying and conversion purposes without carrying the combustion to such a rapid point as to bring about the evil effects referred to. This penetration of the air below the metal to secure this object is, however, attended with a very material difficulty from the fact that the air-blast cannot be regulated with sufficient precision to prevent it from passing too extensively into the body of the metal, and therefore causing local vortices, which will return the scoria with the metal to be acted upon by the air-blast and cause a violent agitation in the body of the metal and at the surface, which would prevent the scoria and other impurities from accumulating thereon in a permanent state of separation from the metal.

To insure that the air-blast may receive that proper quantity of metal which will bring about that degree of rapidity in the conversion thereof that will avoid the excessive heat with its evil consequences referred to, and that will retain the good advantages also referred to, and in order that this proper quantity of metal may be continuously brought to the air-blast and prevent the air-blast from penetrating into the bulk or body of the metal in the bath, I insert a partition or diaphragm 6, as shown in Fig. 2, inclined or in such other position as to separate the main body of the metal from the metal to be immediately acted upon by the air-blast from the nozzle 2. By proportioning properly the aperture 5 at the bottom, which governs the flow of metal into the space formed between the diaphragm and the side of the converter, any desired quantity of metal can be brought into contact with the air, so that it will act

upon it with the requisite degree of rapidity and violence to procure the good results referred to. The action of the air upon the metal inclosed within this space between the diaphragm and side of the converter will force the metal continuously out of this space onto the body of the metal contained in the converter and on the other side of the diaphragm, which will again return with proper rapidity and frequency to the space to be acted upon again by the air-blast. While thus penetrating into and intimately mixing with the small body of metal separated from the main body of the metal with sufficient violence to effect the results desired, the air-blasts are effectually prevented from penetrating into the main body of the metal by the diaphragm, which acts as a barrier between the small portions of the metal contained on the one side of the diaphragm and the large portion of the metal contained in the bath on the other side. In either case the tuyere 2 communicates with two pipes 4 7 and is provided with a valve 8, so that a converting blast can be directed from the pipe 7 to the tuyere, or a non-converting blast from the pipe 4; or the blast may be caused to consist of the two gases in different proportions, according to the adjustment of the valve, the converting-gas being gradually reduced. In this construction the action of the non-converting gas after the converter-gas has been cut off will be to violently agitate the small portions of the metal, separate or wash out the impurities, and maintain the circulation, as before described, until all of the scoria and impurities, are practically washed or worked out of the body of the metal; and the desired heat and fluidity of the metal may be preserved by heating the non-converting gas.

In the construction illustrated in Fig. 3 the tuyere 2, through which the non-converting gas is introduced, is arranged to cause the blast to come into contact directly with a small area only of the surface of the metal, thereby imparting a violent atomic action upon small portions of the metal at one time, while imparting a gyratory motion to the body of the metal, every portion of which is thereby brought repeatedly to the location acted directly upon by the blast. The converting gas or agent is introduced through the hollow trunnion 3 and occupies a position above the surface of the metal, so as to readily act upon that portion which is washed clean by the action of the blast, as well as envelop and seize upon the particles into which the metal is divided by the action of the blast. In this case, also, the proportions of the converting and non-converting agents are varied during the progress of conversion, as before described.

It will be evident that the converting and non-converting aeriform agents may be introduced through the same tuyere or through different tuyeres or openings of a series, and that the same constitute practically a single blast varying in character as the process of conversion progresses.

I do not limit myself to the use of the apparatus specified, as the same may be varied in carrying out my invention in connection with different processes of conversion.

I claim—

1. In the process of converting crude iron, maintaining the molten metal under the action of a blast containing an oxidizing agent, and reducing the proportion of oxidizing agent during the process of conversion while maintaining substantially the volume of the blast, substantially as set forth.

2. The improvement in converting crude iron, consisting in subjecting the molten metal to the action of a blast both of oxidizing and non-oxidizing gas, and in reducing the volume of oxidizing-gas as the process proceeds without materially reducing the volume of the blast, substantially as set forth.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

JOHN WESLEY BOOKWALTER.

Witnesses:

EDITH J. GRISWOLD,

JOHN REVELL.