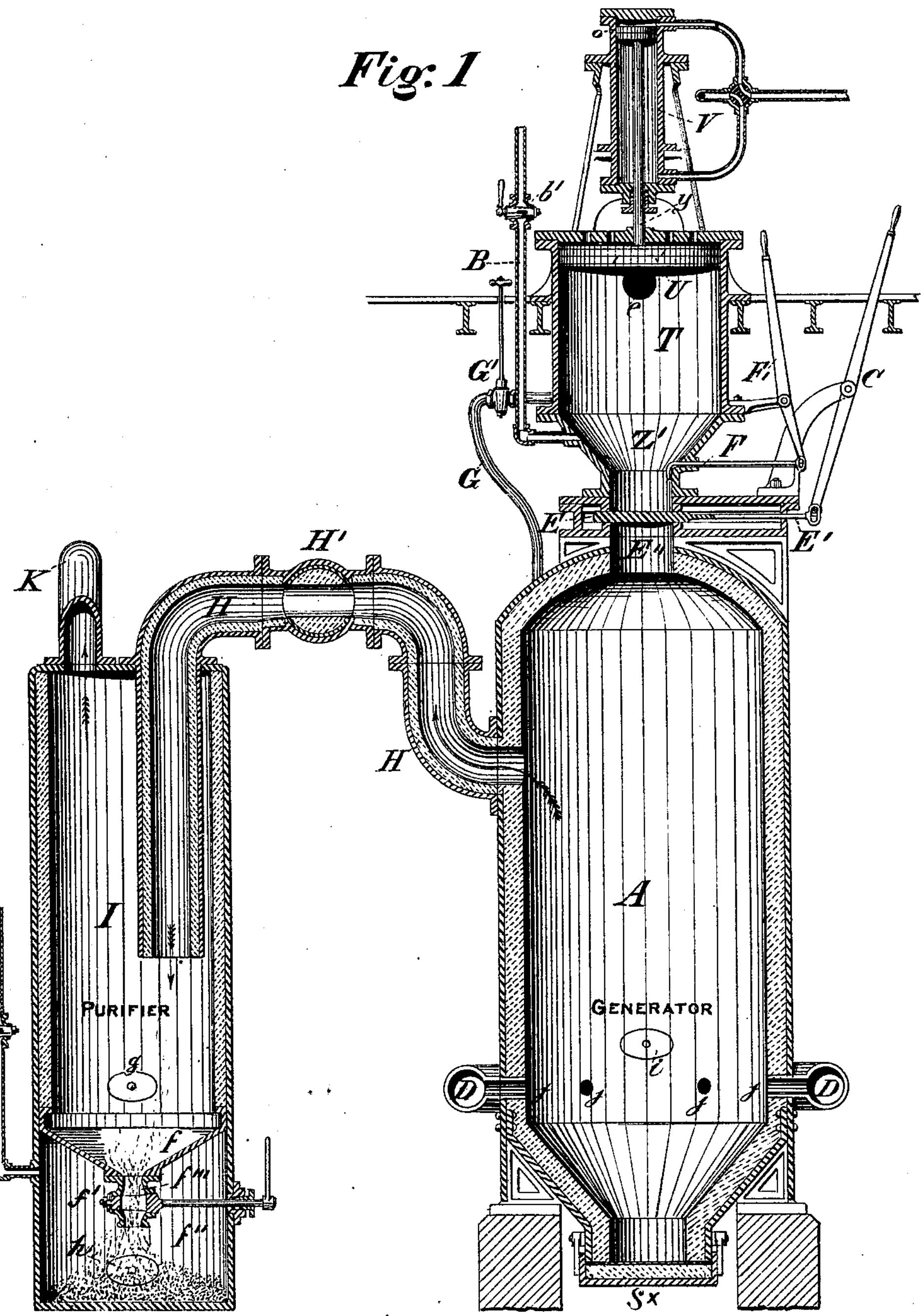
M. J. HAMILTON.

Manufacture of Steel.

No. 195,891. Patented Oct. 9, 1877.



Witnesses:

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Fig: 2

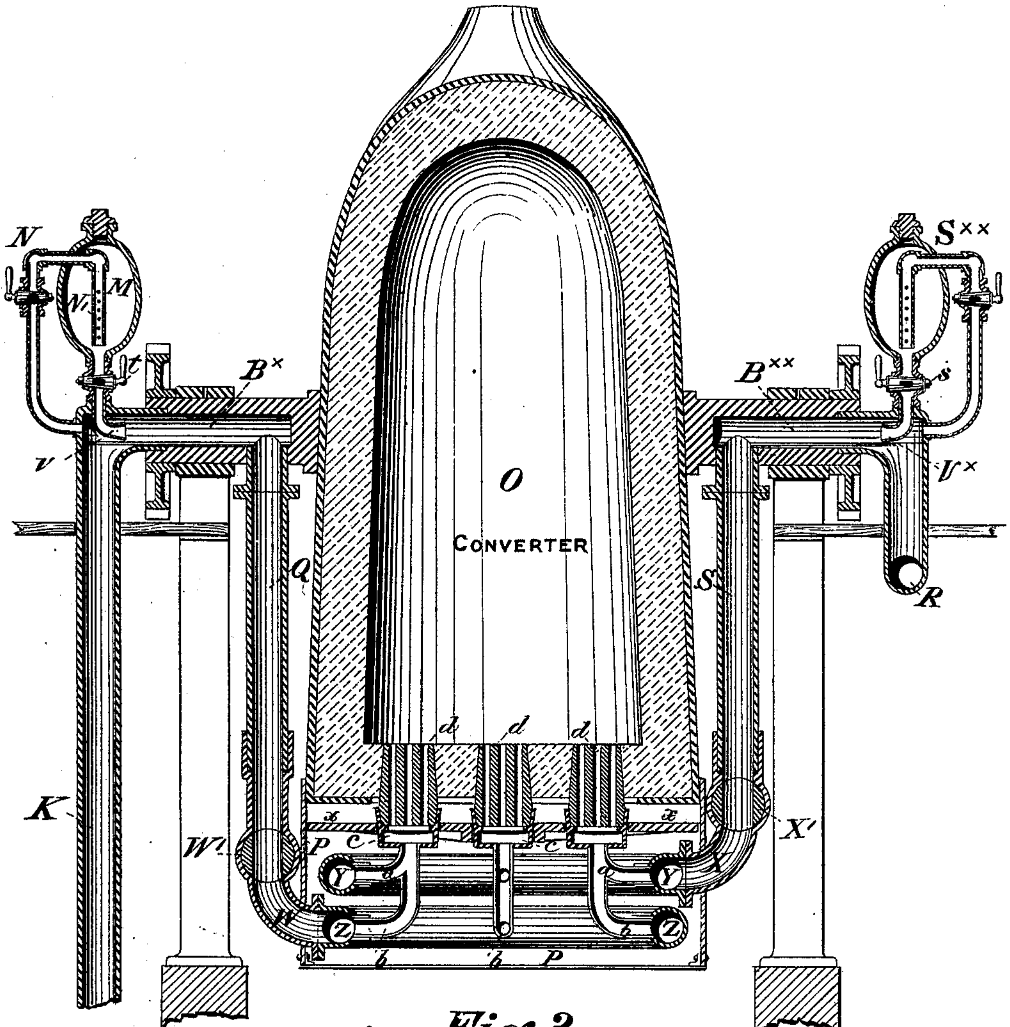
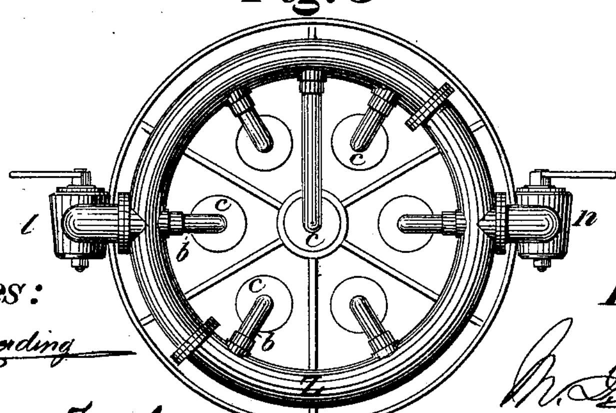


Fig: 3



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3 Sheets—Sheet 3.

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Fig: 4

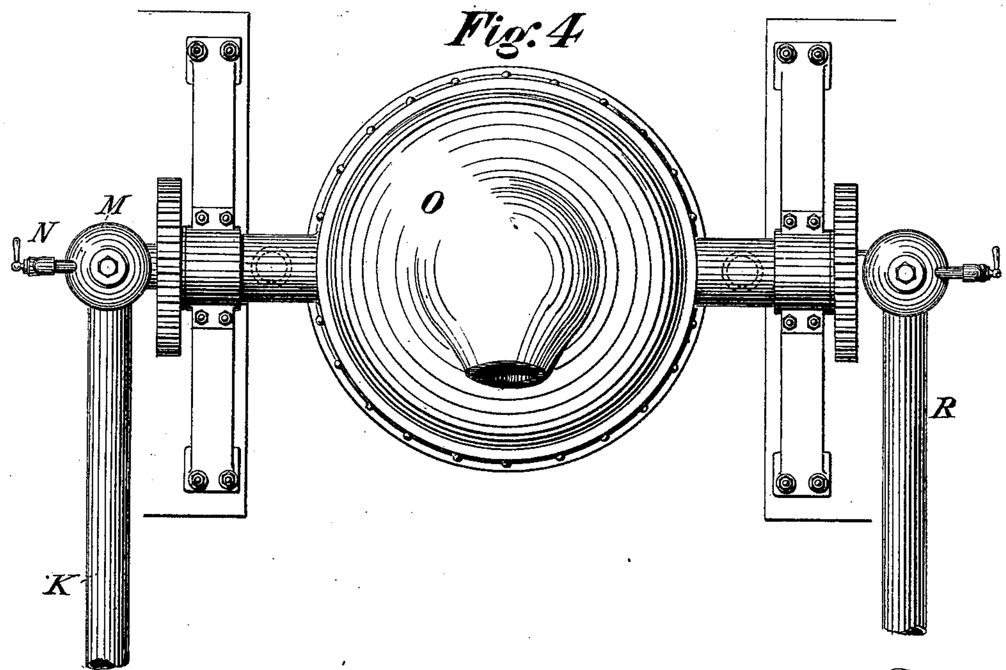
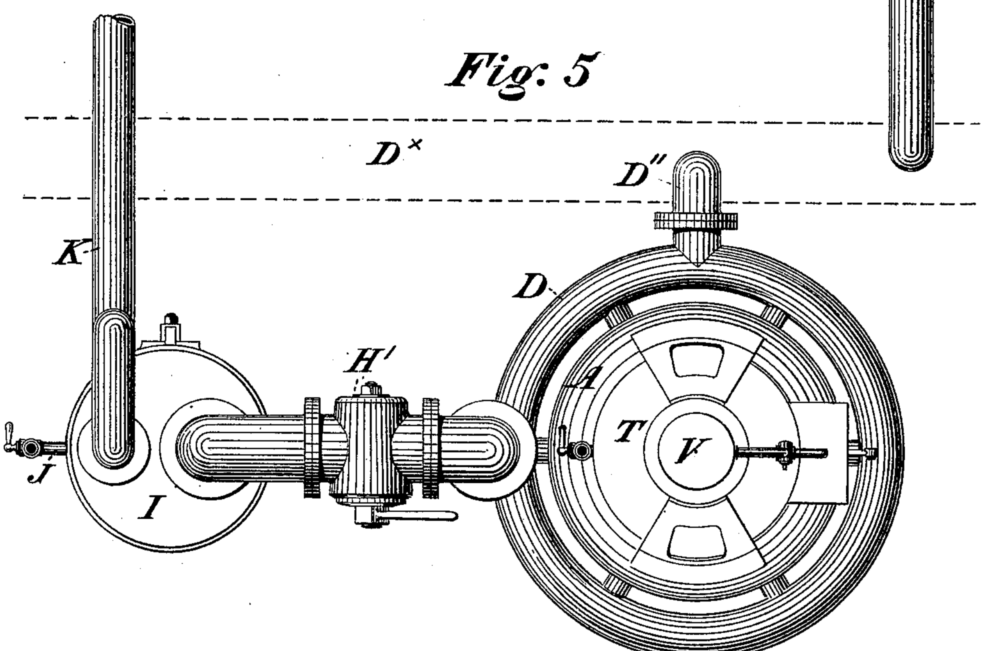


Fig: 5



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UNITED STATES PATENT OFFICE.

MARK JOHN HAMILTON, OF ST. LOUIS, MISSOURI.

IMPROVEMENT IN THE MANUFACTURE OF STEEL.

Specification forming part of Letters Patent No. **195,891**, dated October 9, 1877; application filed November 10, 1876.

To all whom it may concern:

Be it known that I, MARK JOHN HAMILTON, of St. Louis, in the State of Missouri, have invented a new and useful Process of Manufacturing Steel, and apparatus connected therewith, of which I hereby declare the following to be a full, clear, and precise description, which will enable others skilled in the art to which my invention appertains to comprehend my process and construct an apparatus necessary to put the same in effect, reference being had to the accompanying drawings, forming part of this specification, of which—

Figure 1 is a central sectional and detailed elevation of the generator and attachments, and of the purifier; Fig. 2, a similar view of the converter and attachments; Fig. 3, a bottom plan from beneath of the converter, the bottom of the lowermost inclosing casing being removed; Fig. 4, a top plan of the converter and attachments; and Fig. 5, a similar view of the generator and purifier.

Similar letters of reference indicate corresponding parts wherever used.

For the better comprehension of my invention I will first proceed to describe the difficulties which now exist in the manufacture of Bessemer and other steel from certain kinds of ore, and will explain at some length the processes now in vogue, setting forth their disadvantages.

The pig metal used in the manufacture of Bessemer steel is smelted from the purer and richer ores, and must contain a considerable amount of carbon, and also some silicon, so as to cause combustion in the molten mass when atmospheric air is blown through it, and generate the intense heat required to keep decarburized metal in the liquid state. It must also be almost entirely free from phosphorus and sulphur, as they cannot be eliminated by the present process on account of the impossibility of using fluxes. The lower grades of pig-iron are, therefore, excluded from the manufacture of Bessemer steel, and the limits within which it can be made consequently narrow.

It is also evident that Bessemer steel cannot be made in those sections of the country which yield only ores containing large percentages of phosphorus or sulphur, no matter how rich they may be in metallic iron. It therefore becomes of the greatest importance to invent a process and apparatus by which these ores and the lower grades of pig-iron can be brought within the limits of steel-manufacture.

The object of my invention is to cheapen the production and extend the field of steel-manufacture by utilizing low grades of pig metal and such rich ores as are now excluded on account of the presence in them of phosphorus or sulphur.

In the ordinary process, pig metal must be again melted in a cupola, and in the molten state charged into the converter, which has been brought into a nearly-horizontal position. Atmospheric air must then be blown through the tuyeres at a high pressure, and the converter brought to a vertical position. The blast is kept up until the carbon, silicon, &c., are removed, or very nearly so, by oxidation, when the converter is again brought to the horizontal position, and the spiegeleisen, in a determined proportion and in the molten state, poured into it. In a few moments the carbon of the spiegeleisen is disseminated throughout the mass, the iron converted into steel, and finally cast into ingots.

The present construction of the converters makes it impossible to employ fluxes, either in the powdered or gaseous form, and hence no impurities can be removed except such as can be oxidized out, and therefore the present impossibility of removing the phosphorus and sulphur, and the great waste caused by the formation of silicate with the impurities.

My present invention is designed to obviate such difficulties and defects.

The following is a description of the mechanical construction of my apparatus:

Referring to Fig. 1 of the drawing, A is the generator or vessel in which the fuel is placed and the carbonic-oxide gas generated. D is a circular pipe surrounding the generator at its base, and connected with the blast-engine through the pipe D″, Fig. 5. *j j* are tuyeres connecting the circular pipe D with the interior of the generator. *i* is a man-hole. H is pipe leading from the generator A to the purifier I, having in it a cock, H′. E is a gas-tight valve-box, in which a slide-valve, E′, moves, cutting off and opening communication between the generator A and the charging-cylinder T, located above it. This valve is moved by the hand-lever C or other device.

F is a poker to loosen the fuel in case it should jam in the cone Z′. It also is controlled by a hand-lever, F′, or other device, and moves through a gas-tight stuffing-box. The pipe G, provided with the cock G′, communicates with the interior of the generator A, and with that of the charging-cylinder, allowing the gases to flow freely between them when the cock G′ is opened. A pipe, B, provided with the cock *b*′, leads from the cone Z′ to the open air.

The piston U moves gas-tight in the charging-cylinder T when below the line of the lower edge of the charging hole or aperture *e*. It is connected, by the piston-rod *y*, with the piston *o*, which latter moves in a hydraulic cylinder, V, of ordinary construction.

I is a vessel or purifier, into which the pipe H leads, so placed that particles of fuel too large to float in the gaseous atmosphere in I (whereof hereinafter) will be dropped on the hollow inverted cone *f*, which forms its bottom, and pass into the lower chamber or cinder trap *f*″ through the short pipe *f*‴, which contains the cock *f*′. This cock is always open, except when it is necessary to remove the cinders from the cinder-trap *f*″, in which case it is closed. J is a pipe communicating from the cinder-trap with the open air, and provided with a cock, J′, which is always open when cock *f*′ is closed. *g* and *h* are man-holes, the former for the purpose of repairs and the latter for the removal of the cinders from the cinder-trap.

The pipe K forms a communication between the purifier and the converter O through the medium of the pipe Q, the circular pipe Z, the branch pipes *b b b b*, and the tuyeres *d d*.

The lower end of the pipe Q is connected, by the elbow W, with the pipe Z, and has in it a cock, W′.

The converter O, of the shape represented in the drawing, is journaled upon hollow trunnions B× B××, from one of which, B×, leads the pipe Q, which communicates with the pipe Z, and from the other, B××, the pipe S, communicating with the pipe Y, which is fed with an air-blast from the pipe R itself, leading direct from the main blast-pipe D× from the engine, as shown in Fig. 5.

The pipes K and R communicate direct with the trunnions.

The lower end of the pipe S is provided with a cock, X′, and connected by an elbow, X, with the pipe Y.

The pipes *a a*, &c., connect the upper pipe Y, and the pipes *b b b*, &c., connect the lower pipe Z, with the chambers *c c*, &c. These chambers communicate with the interior of the converter through the holes *d d*, &c., in the tuyeres, which are fixed gas-tight in the sockets above the chambers *c c c*, &c. They are firmly fixed in the upper plate *x* of the cylindrical chamber P, which incloses the pipes Y and Z and branch pipes leading to the tuyeres *d d*. This cylindrical chamber is connected by any convenient means to the converter. The space between the plate *x* and the bottom of the converter is filled with moistened fire-clay or other suitable material.

The bottom is movable, and connected with the sides by bolts and keys or other devices.

M is the carbon-receiver—an air-tight vessel of any form, provided that its lower end tapers toward a point and ends in a pipe, in which a cock, *t*, is placed. The lower part of this pipe is curved after entering the pipe K, and ends in a conical nozzle, *v*. N is a pipe, one end of which opens into the pipe K, and the other in an agitator or perforated nozzle, N′, in the carbon-receiver M.

The object of the perforated nozzle is to keep the powdered carbon in a state of agitation, and insure a constant and steady flow into the pipe K and through the trunnion B×, and thence through the tuyeres *d d*, when the cock *t* is opened. On the other side of the converter is a flux-receiver similar in every respect to the carbon-receiver described, and for a similar object. Without these nozzles the carbon or flux would pack, and not blow out steadily.

Such being the mechanical construction of my apparatus, the following is the mode of operating its various parts.

The generator is charged with any common fuel, as follows: The piston U, Fig. 1, is lifted a little above the aperture *e* in the charging-cylinder T by the movement of the piston *o* in the hydraulic cylinder V, the valve E′ being closed. The charging-cylinder T is then filled with fuel to within a few inches of the lower edge of the aperture *e*, and the piston U lowered upon it, so as to cut off all communication between the lower part of the cylinder T and the aperture *e*. The cock *b*′ is now closed and G′ opened, allowing any gas in the generator to flow into that portion of the charging-cylinder which is below the piston U, thus equalizing the pressure above and below the valve E′, which is then drawn back by the lever C or other device, and the fuel allowed to fall into the generator A. The cock G is then closed, and the piston forced down to the junction of the cylinder with Z′, and the valve E′ pushed forward, thereby intercepting communication between A and T. The cock *b*′ is now opened, and the gas in Z′ between the piston U and the valve E′ permitted to escape into the air. The piston U is now raised above the upper edge of the aperture *e*, and the process of charging repeated.

If the fuel jams in Z′, it can be loosened by the poker F operated by the lever F′.

When it becomes necessary to clean out the generator the cock H′ is closed, and the gas allowed to escape through *b*′ or *e* by opening the cock G′ when the piston U is at its highest position. The movable bottom S× is then detached, permitting thorough cleaning.

When necessary to remove the cinders from the cinder-trap *f″*, or lower part of the purifier I, the cock *f′* must be closed and the cock J′ opened. As soon as the pressure of the gas in the cinder-trap is equal to that of the atmosphere the man-hole *h* is opened and the cinders removed. The man-hole *h* and the cock J′ are then closed, as before, and the cock *f′* opened, so that the cinders may again fall into the cinder-trap.

It will be observed that I construct the valve E′ of the generator A as described, so that after the cock G′ has been closed and *b′* opened the pressure of gases in the generator holds the valve tightly up against its case, tightly closing up the generator, and preventing the retraction of the valve without considerable force, and also the escape of gases; but when the cock G′ is again opened the circulation of gases from the generator into the charging-cylinder establishes an equilibrium of pressure throughout the two, and permits the easy retraction of the valve E′. After the charging operations in the generator are completed the man-holes *g* and *h* in the purifier, Fig. 1, are closed and luted, the man-hole *i* in the generator and all the cocks leading to the open air are opened, the valve E is closed, and the fuel ignited through the man-hole *i*.

As soon as the fire has spread, this man-hole is closed, luted, and firmly fixed. A gentle blast is then put on, and the heat gradually increased until it becomes safe to use a full blast.

The converter O must be gradually heated before charging, whereof hereinafter.

All the cocks are then closed, except H′ and *f′*, until the gases in the generator attain the desired pressure.

The gases formed in the generator are nitrogen, carbonic oxide, and hydrocarbons, the last-named gases being distilled in the upper part of the generator.

The formation of the other gases may be described as follows: Air is composed of two gases—nitrogen and oxygen—the latter of which combines with carbon at a high temperature, setting the nitrogen free. It forms two combinations with carbon, viz., one equivalent of carbon to one of oxygen forming carbonic oxide, and one equivalent of carbon to two of oxygen forming carbonic acid.

These gases pass very readily from one to the other at a high temperature, according as oxygen or carbon is present in excess. Hence it is evident that at the point of the tuyeres in the generator, where the oxygen of the blast is in excess, carbonic acid must always be formed, and also that as this gas passes up through the incandescent fuel it will combine with an additional equivalent of carbon, and become carbonic oxide, in which form it will pass into the purifier and through the pipes, to the chambers *c c c* under the tuyeres in the converter, where it again meets the oxygen of the blast through the air-pipes R S X *y a*, and, mingled with that blast, passes up into the converter. As soon as the mingled blast encounters the high temperature at the point of the tuyeres in the converter it is decomposed, the nitrogen being, as before, set free, and the oxygen combining with the carbon in the carbonic oxide, forming again carbonic acid, and generating intense heat.

When charging the converter the bottom is first covered with a thin layer of ignited fuel, and on this is placed the ore to be converted, broken into small pieces, and spread as evenly as possible over it. A very gentle air-blast is then put on through the blast-pipe R, so as to cause the fuel in the bottom to burn to flame. The cock W′ is then gradually opened, permitting streams of carbonated gases through the pipes *b b* to meet those of atmospheric air through the pipes *a a*, and commingle in the chambers *c c*, whence they pass up the tuyeres *d d* in a mixed condition, and, coming into contact with the flame of the ignited fuel in the bottom of the converter, ignite and turn to carbonic acid, generating an intense heat by the oxidation of carbonated gases sufficient to melt even malleable iron. By the heat thus generated the ore is fused. After fusion is completed the atmospheric air is cut off by closing the cock X′, and the flow of carbonated gases through the molten mass continued until the ore is reduced, the carbonic-acid gas formed escaping through the throat.

In order to facilitate this latter part of the operation, the cock *t* is opened, permitting the powdered carbon previously placed in the receiver to pass out through the nozzle, and, borne on by the current of the gases, to pass up with it into the molten mass and combine with the oxygen in it, and thereby assisting in the deoxidation of the ore.

The ore thus reduced may now be fluxed by such agents in the powdered or gaseous state as may be found most desirable.

The receiver S×× being used to contain the powdered flux which is carried through the tuyeres *d d d* by means of the air-blast, if the ore contains any very considerable percentage of foreign matters, such as silica, &c., it may be found economical to use the carbonated gases as the vehicle or means by which the flux is carried into the molten metal, using the carbon-receiver or its duplicate on the same side for the flux; but if the ore contains only a small percentage of foreign matters it can be fluxed from the flux-receiver proper, located as shown in the drawings, using air as the vehicle or means by which it is carried into the molten metal through the tuyeres *a a*. If air be used, when the quantity of impurities is large there is danger of waste by the formation of silicates, &c. On the other hand, if the gases are made the vehicle, when the quantity of impurities is small there will be a waste of fuel in generating the gases for that purpose. An analysis of the ore will determine which should be used. But it may happen, from one cause or another, that the temperature of the bath has been somewhat reduced below the intense heat required. In this case the air and gases must be used at the same time, in order to restore the lost heat, the air being the vehicle by which the flux is carried into the metal.

The mechanical arrangements are such as to meet any of those cases.

The ore being thus reduced and fluxed, the converter is turned on its side sufficiently to allow the cinder or slag to flow into a ladle or other vessel prepared for that purpose.

After the slag is removed the converter is brought again into the vertical position, and a stream of atmospheric air sent through the molten metal, (the full pressure of blast is put on just before the converter begins to move toward the vertical,) in order to remove any carbon that may have been in excess of that required for reduction or deoxidation, so that the proper quantity of carbonic oxide and carbon required to cause the desired degree of hardness may be accurately determined.

When thus purified the metal can be carburized to steel of any degree of hardness desired by cutting off the atmospheric air and sending through the molten metal a determined weight of powdered carbon from the refilled carbon-receiver in streams or jets of carbonated gases flowing for a definite time. When this last part of the operation is completed the converter is turned on its side, the cocks closed, and the steel poured into ladles, ready for casting into ingots or molds of any required shape.

When scrap-iron pig is to be changed into steel, it must be broken or cut into small pieces and spread in the converter, as in the case of the ore, on a layer of ignited fuel. In this case carbonated gases should be in excess in the fusing-flame, a part only of that gas being burned to carbonic acid, thereby avoiding the waste that would ensue from the oxidation of the metal if all the carbonic oxide were burned to carbonic acid. The removal of the impurities, if any, and the final carburization of the metal into steel, are accomplished by similar means to those employed in the case of metal made direct from the ore.

When the ore or metal contains phosphorus or sulphur, and it is considered desirable to use carbonic oxide as the vehicle by which the regular flux is carried through the molten mass, the agents—such as chlorine, chloride of sodium, &c.—used for the removal of the above impurities must be employed after the fluxing of the other impurities is complete, and should be carried through the molten metal by atmospheric air or carbonic-acid gas; but if the regular flux is carried into the metal by either atmospheric air or carbonic-acid gas, the agents used for the removal of the phosphorus or sulphur may be mixed with it, and all the impurities acted upon at the same time.

If gases are used as fluxes, instead of powder, for the removal of phosphorus or sulphur, they are put into a gas-receiver similar to the flux-receiver, and blown through the tuyeres, and thence through the molten mass, by a blast of atmospheric air or carbonic-acid gas.

If the steel is made by the ordinary process now in use, and it is only necessary to remove the phosphorus or sulphur, the generator and gas-pipes may be dispensed with, the air-pipes alone being necessary.

The cocks W′ and X′ are to be gradually, not suddenly, opened.

I do not claim, broadly, recarburizing the metal by blowing in powdered carbon through the tuyeres by aid of a motive blast, but by aid of a blast of carbonic-oxide gas, as set forth and claimed in clause 9.

The following are the claims which I make:

1. The combination of the generator A, the charging-cylinder T, the valve E′, and the equalizing-pipe G.

2. In combination with the charging-cylinder T and the generator A, the escape-pipe B and pipe G, for the purpose specified.

3. The combination, with the cylinder T, of the piston U and the hydraulic piston O, connected therewith by the piston-rod *y*, and inclosed in the cylinder V.

4. The perforated nozzle N′, in combination with the carbon-receiver M, to agitate the carbon contained in said receiver, so as to cause it to flow regularly from the same.

5. The combination of pipe K, pipe Z, branch pipes *b*, and chambers *c*, substantially as and for the purposes set forth.

6. The combination of pipe R, pipe Y, branch pipes *a*, and chambers *c*, substantially as and for the purposes set forth.

7. In combination with tuyeres *d*, the chambers *c*, whereby the commixture of atmospheric air and carbonic-oxide gas prior to their passage through the tuyeres into the converter is effected.

8. The process of reducing iron from its ores, which consists in forcing carbonic-oxide gas, with or without carbon, through a molten mass of the ore contained in a converter until the metal is reduced, and then injecting flux to separate it from the gangue, as described.

9. The process of carbonizing molten iron in the converter by jets of carbonic-oxide gas, with powdered carbon blown through the tuyeres into the converter.

In testimony whereof I have hereunto signed my name.

M. J. HAMILTON.

In the presence of—
J. BONSALL TAYLOR,
W. C. STRAWBRIDGE.