To all whom it may concern:

Be it known that I, HAWLEY PETTIBONE, a citizen of the United States, residing at Bridgeport, in the county of Fairfield and State of Connecticut, have invented certain new and useful improvements in Apparatus for Manufacturing Gas; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to apparatus for manufacturing water-gas; and one object is to provide for producing an increased yield or volume of water-gas from a given quantity of fuel and to utilize all the producer-gas given off from the generator by burning it in superheaters and then superheating both air and steam by passage through such superheaters on their way to the generator.

Another object is to provide an improved construction and arrangement of the generator and connected superheaters and certain pipe and valve connection by means of which the body of the fuel may be blasted with hot air passed both upward and downward through it and by which superheated steam may be passed both upward and downward through the body of incandescent fuel and the gases passed off both at top and bottom of the body of fuel at alternate periods.

It is well known that it is advantageous to heat up the body of fuel in a water-gas generator by admitting the air-blast alternately at opposite ends or at the top and bottom thereof and also to decompose steam by passing it alternately in opposite directions up and down through the body of fuel. By means of my apparatus this can be done, and, moreover, both the air and steam supplied to the generator are superheated by passage through separate superheaters, which are separately connected with both the top and bottom of the generator. My particular object is to increase the yield of the water-gas by utilizing all the heat resulting from the combustion of the producer-gas and the sensible heat of the water-gas for superheating both air and steam which are supplied to the generator and for generating steam.

I will now describe the construction and arrangement of my improved apparatus by reference to the accompanying drawing, which represents a vertical longitudinal section of the apparatus with certain parts in elevation.

The generator A and the superheaters E and F are constructed of fire-brick and enclosed in tight iron jackets in the usual manner. The generator is provided with a fuel-opening a at the top and with the clean-out openings a' a'' at or near the bottom in the usual manner, and such openings are provided with doors a, a', and a''. The grate b is preferably constructed of fire-brick arches in a well-known manner and separates the fuel-chamber from the usual ash-pit B. The generator is provided at the top with a gas-outlet C and at the bottom or ash-pit chamber with a gas-outlet D. An air and steam superheater E connects with the upper gas-outlet C, and a separate air and steam superheater F connects with the lower gas-outlet D. The superheaters E and F may be constructed in separate shells and each rest on its own foundation, if desired; but they are preferably built in one structure, one above the other, with a thick horizontal partition g between them, as shown in the drawing.

The superheaters may be filled with the usual fire-brick checker-work constructed in a well-known manner; but I preferably construct them with numerous vertical fire-clay partitions forming numerous vertical connected flues, as shown. The superheater E is constructed with the fire-clay partitions f, forming the vertical flues e and having, alternately at top and bottom, the connecting-passages e'. The superheater F is constructed in a similar manner with vertical fire-clay partitions f', forming the vertical flues e' and having, alternately at top and bottom, the connecting-passages e''. At the bottoms of the superheaters and in the side walls are provided the clean-out openings h and h', having in practice tight-closing doors for removing the dust and ashes. A gas-outlet opening and pipe G connects the discharge side or end of superheater E with the valve-box e', and a separate gas-outlet and pipe H connect the superheater F with the valve-box h'. Both of the valve-boxes e' and h' connect with the gas-discharge pipe H, which con-
nects with the gas-chamber $m$ at the lower end of the steam-boiler $M$. The valve-box $h''$ is provided with the usual annular seat and a ball or disk valve $K$, to which is connected a rod $k$, connecting at its upper end to the pivoted lever $L$. The valve-box $g''$ is provided with a similar seat and valve.

The valve-boxes $g''$ and $h''$ are surrounded by the water-tank $I$, through which water is circulated in practice in a well-known manner. The steam-boiler $M$ is of the well-known tubular kind and is provided with gas-chambers $m$ and $m'$ at the lower and upper end. A gas-take-off pipe $T$ connects the upper gas-chamber $m'$ with the stack or blow-off pipe $T'$, which is provided at the top with a hinged stopper $u$. A branch pipe $T''$ may connect pipe $T'$ with a valve-box and valve $U$ for controlling the flow of water-gas to a holder or place of immediate use. The pipe $T$ may dip down into a water-seal box $W$, from which a pipe may lead to a holder or scrubber in a well-known manner.

Air-blast is supplied to the generator and to the superheaters under pressure by means of the blower $O$. An air-blast pipe $N$ leads from the blower and connects with a vertical branch $N'$, from which short branch pipes $n$ and $n'$ connect, respectively, with the superheaters $E$ and $F$ near the connection of the upper and lower gas-outlet pipes $C$ and $D$, leading from the top and bottom of the generator. These branch pipes are provided with valves $o$ and $o'$. A second air-blast pipe $N''$ leads from pipe $N$ and is provided with short branches $n''$ and $n'''$, which connect with the gas-discharge sides or ends of the superheaters $E$ and $F$ and are provided with valves $o''$ and $o'''$. A steam-supply pipe $S$ leads from the top of the boiler and is provided with a branch pipe $s$, having valve $s'$, connecting with the superheater $E$ at its gas-discharge end; also, with a second branch pipe $s'$, having valve $s''$, which connects at the gas-discharge end of the superheater $F$.

The operation is very simple and may be conducted as follows: The door $x$ of the fuel-opening $a$ being opened, fire is kindled on the grate and is allowed to burn by natural draft and fuel is gradually supplied until a suitable body of fuel is well ignited, when the door $x$ is closed. The stopper $u$ at the top of the blow-off pipe, the gas-outlet valve $K'$, and the air-inlet valve $o''$ are opened and air is forced by the blower $O$ through superheater $F$ into the bottom of the generator, causing active combustion of the fuel. The resulting producer-gas passes off through the upper outlet $C$ into superheater $E$, where it is burned by the blast of air admitted through the valve $o$. The resulting hot products are passed up and down through the flues $e$ and passages $e'$, thereby heating the brick partitions $f$, and finally escape through pipe $G$ (valve $K'$ being open) and pipe $H'$ into gas-chamber $m$ and pass thence up through the tubes of the boiler and out through the stack-pipe $T'$ to the open air. The body of fuel having been heated to incandescence and the superheater $E$ heated to the desired temperature, the air-inlet valves $o$ and $o''$, the valve $K'$, and stopper $u$ are closed and then the water-gas valve $U$ and the valve $K$ are opened, and steam is then admitted to the superheater $E$ by opening valve $i$ in branch pipe $s'$. In passing through the superheater the steam is heated to a high degree in contact with the fire-clay partitions $f$ and then passes into the top of the generator and down through the body of fuel, where it is decomposed. The resulting water-gas passes off through the lower outlet-pipe $D$, through the flues and passages of superheater $F$, and out through pipes $H$ and $H'$, and thence through the tubes of the boiler and off through the valve $U$ to a holder or other place of use. Decomposition of steam continues until the temperature of the fuel is reduced too low for effective action, when steam is shut off by closing valve $i$ and valve $U$ is closed. The stopper $u$ and the air-inlet valves $o'$ and $o''$ are then opened. Air is now heated by passage through the superheater $E$ and passes thence through passage $C$ into the top of the generator and down through the body of fuel, causing combustion thereof at a higher temperature, it going on to incandescence. The resulting producer-gas passes off through the lower outlet $D$ into superheater $F$, where it is burned by the blast of air admitted through the valve $o'$, and the resulting hot products heat the superheater $F$ and then pass off through pipes $H$ and $H'$, the steam-boiler, and out of the stack-pipe $T'$. The body of fuel in the generator having been heated to the proper state of incandescence, the air-blasts are shut off by closing valve $o'$ and $o''$ and the valve $K$ and stopper $u$ are closed. Valves $U$ and $K'$ are then opened, and steam is admitted to the superheater $F$ by opening valve $i'$ in pipe $s'$. Steam is highly superheated by passing through the superheater $F$ and passes thence through the passage $D$, and thence up through the body of fuel, where it is decomposed. The resulting water-gas passes off through the outlet $C$, and thence through the superheater $E$ and off through the pipes $G$ and $H'$ into the gas-chamber $m$, through the tubes of the boiler, and off through valve $U$ to the open air. The operations above described are repeated and fuel is supplied to the generator as required as long as it is desired to manufacture water-gas.

By passing the air-blast both up and down through the body of fuel at suitable intervals the fuel is more uniformly burned and heated to incandescence. By means of my apparatus constructed and arranged as shown both air and steam may be conveniently superheated and passed alternately up and down through the body of fuel. The producer-gas is also effectively used by being burned in the
superheaters, so that the heat resulting from this combustion may be best utilized for superheating steam and air.

Instead of using an air-blower for forcing blasts of air under pressure into the superheaters and thence into the generator an exhaustor may be connected with the gas-take-off pipe T or the stack-pipe T' and used for drawing off the waste products of combustion and also for drawing air into the superheaters through several valved inlet-openings in a well-known manner.

Having described my invention, what I claim, and desire to secure by Letters Patent, is:

1. The combination with a gas-generating furnace having gas-outlet pipes as C and D at top and bottom, of two superheaters, one of which connects with the top of the generator through pipe C and the other of which connects with the bottom of the superheater, as D, a valved gas-outlet pipe as G and a air and steam supply pipes connecting with the gas-discharge side or end of each superheater, substantially as described.

2. The combination with a gas-generating furnace having gas-outlet pipes as C and D at top and bottom, of a superheater connecting with the top of the generator through pipe C and having an air-inlet o adjacent to the gas-inlet, a second superheater connecting with the bottom of the generator through pipe D and having an air-inlet o' adjacent to the gas-inlet, a valved gas-outlet pipe and valved

3. The combination with a gas-generating furnace having gas-outlet pipes as C and D at top and bottom, of two superheaters, one of which connects with the top of the generator and the other of which connects with the bottom of the same, a tubular steam-boiler having a gas-receiving chamber, a valved gas-outlet pipe connecting each superheater with said chamber of the boiler, and valved air and steam supply pipes connecting with the gas-discharge side or end of each of said superheaters, substantially as described.

4. The combination with a gas-generating furnace having a gas-outlet pipe C at the top and a gas-outlet pipe D at the bottom, of a superheater, as E, connecting by said pipe C with the top of the generator, and having at its discharge side or end a valved gas-outlet pipe G, a valved air-supply pipe n' and a valved steam-supply s, a second superheater, as F, connecting by said pipe D with the base of the generator and having at its discharge side or end a valved gas-outlet pipe H, and the valved air and steam supply pipes n'' and s', substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

HAWLEY PETTIBONE.

Witnesses:

P. T. STAPLES,

PERCY G. OVERTON.