(No Model.)

5 Sheets—Sheet 1.

J. L. STEWART.

APPARATUS FOR MANUFACTURING GAS.

No. 333,693. Patented Jan. 5, 1886.

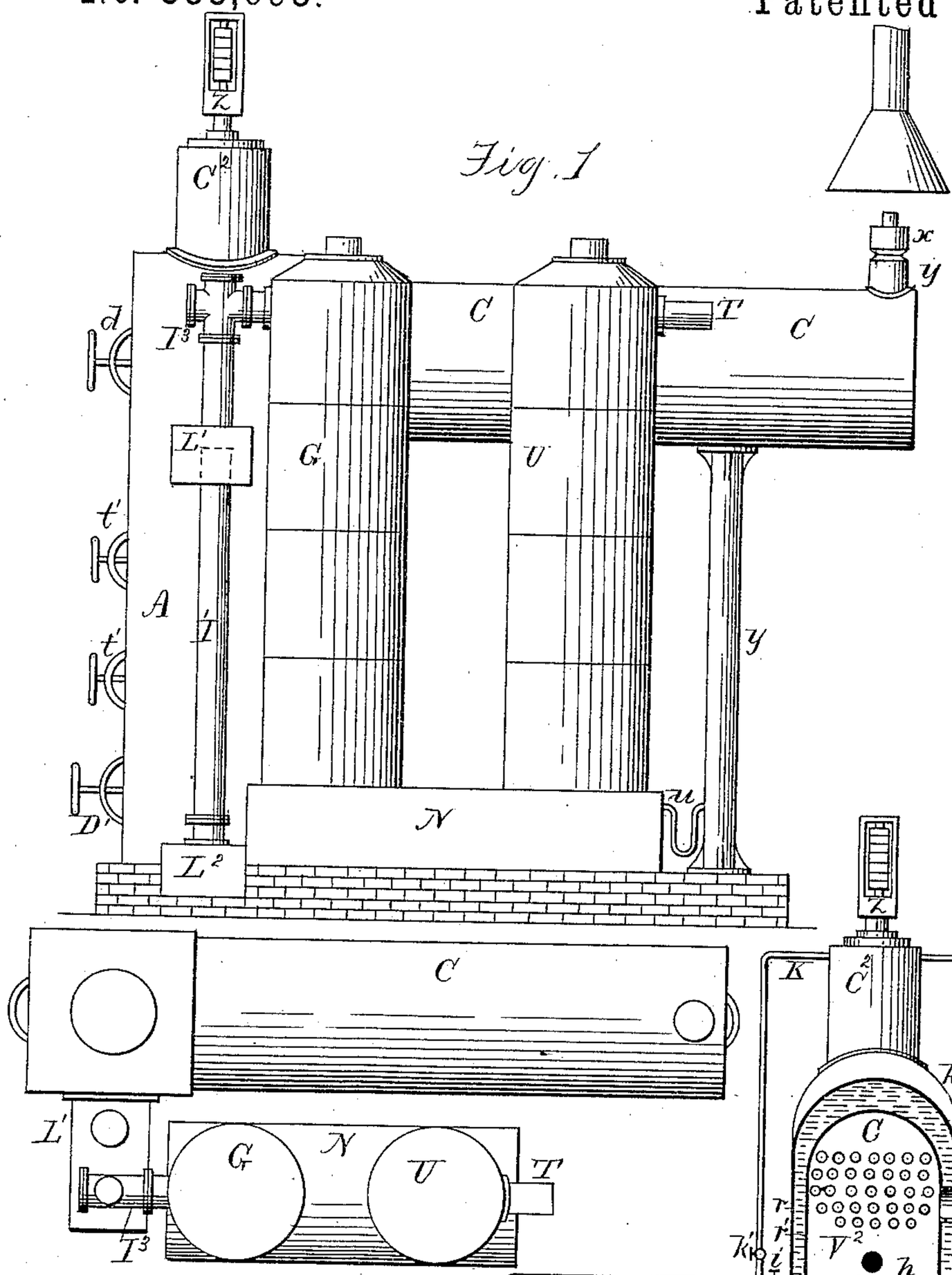


Fig. 1

Fig. 2

Fig. 3

Witnesses
H. C. Lewis of
C. A. Dubree

Inventor
John L. Stewart.

(No Model.)

5 Sheets—Sheet 2.

J. L. STEWART.

APPARATUS FOR MANUFACTURING GAS.

No. 333,693. Patented Jan. 5, 1886.

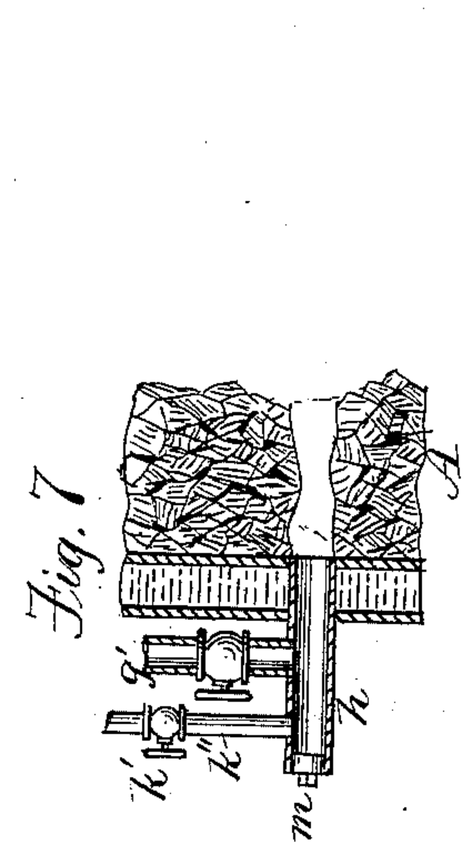


Fig. 7

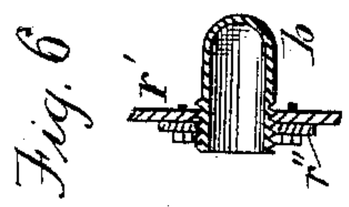


Fig. 6

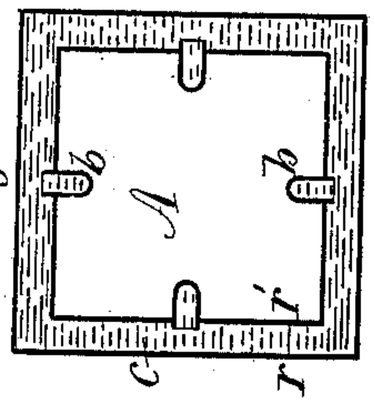


Fig. 5

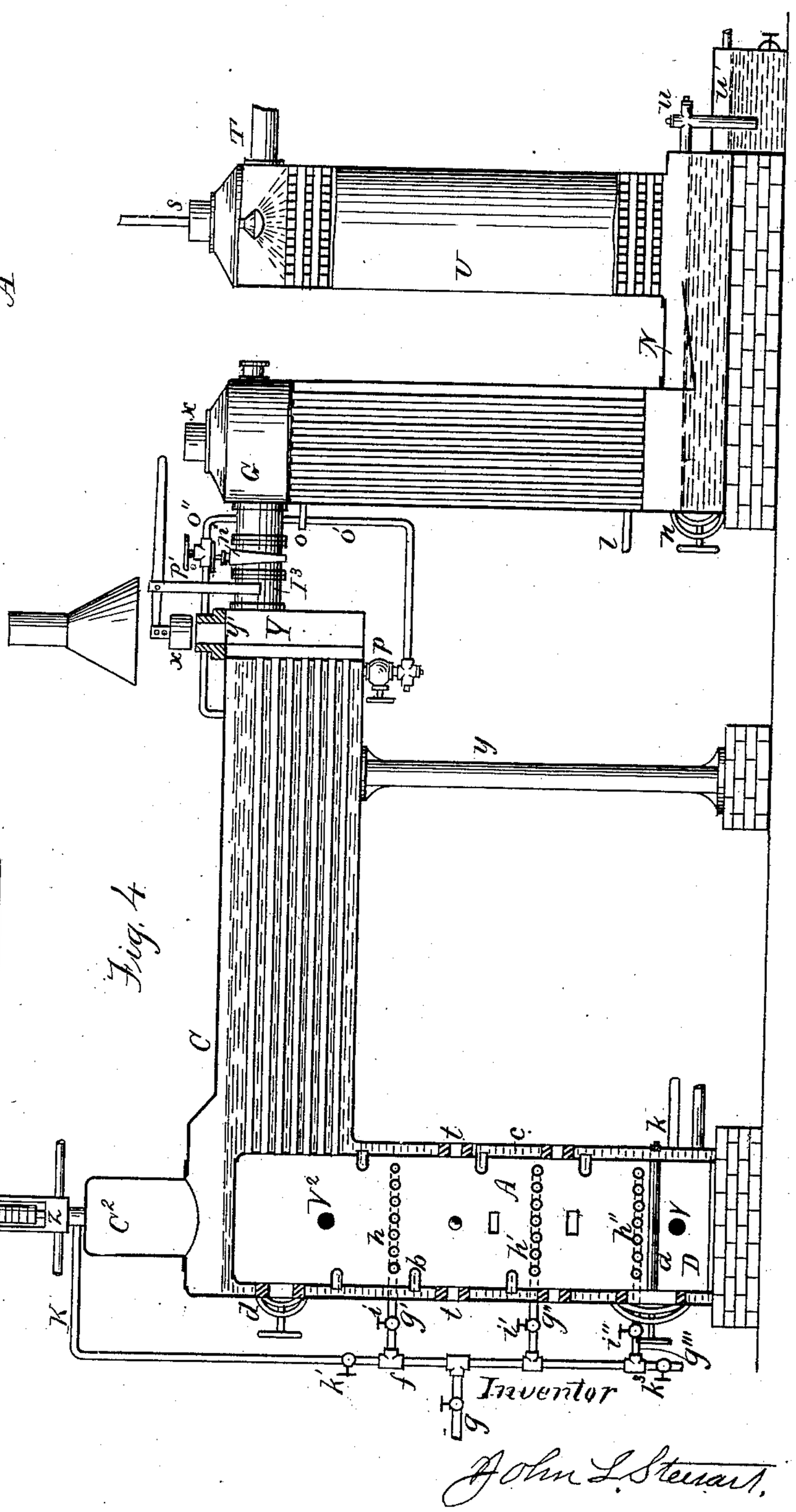


Fig. 4

Witnesses
H. E. Garrard
C. Dietrich

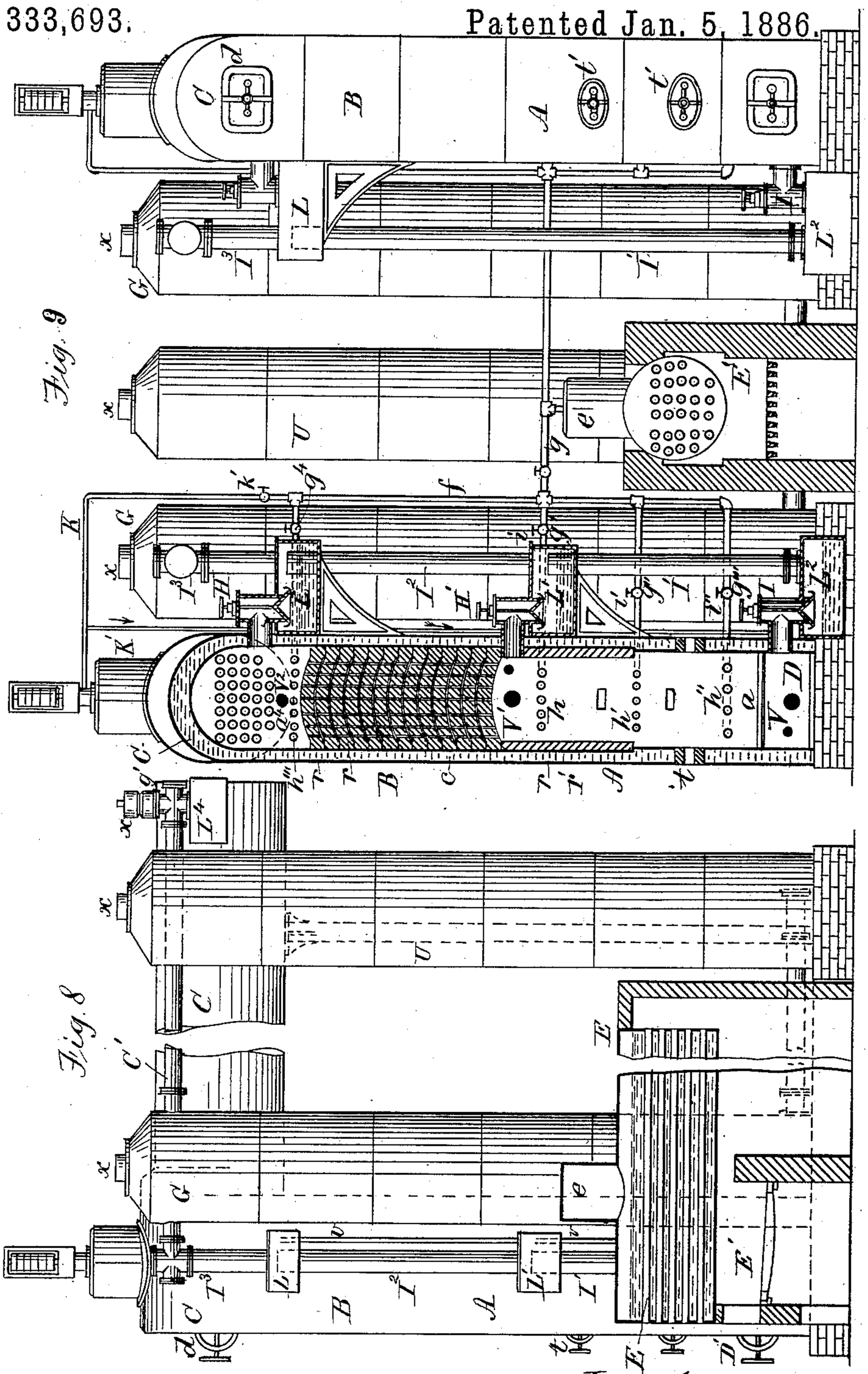
Inventor
John L. Stewart.

(No Model.) 5 Sheets—Sheet 3.

J. L. STEWART.

APPARATUS FOR MANUFACTURING GAS.

No. 333,693. Patented Jan. 5, 1886.



Witnesses
H. E. Garrett
C. Ontree

Inventor
John L. Stewart.

(No Model.) 5 Sheets—Sheet 4.

J. L. STEWART.

APPARATUS FOR MANUFACTURING GAS.

No. 333,693. Patented Jan. 5, 1886.

Fig. 11

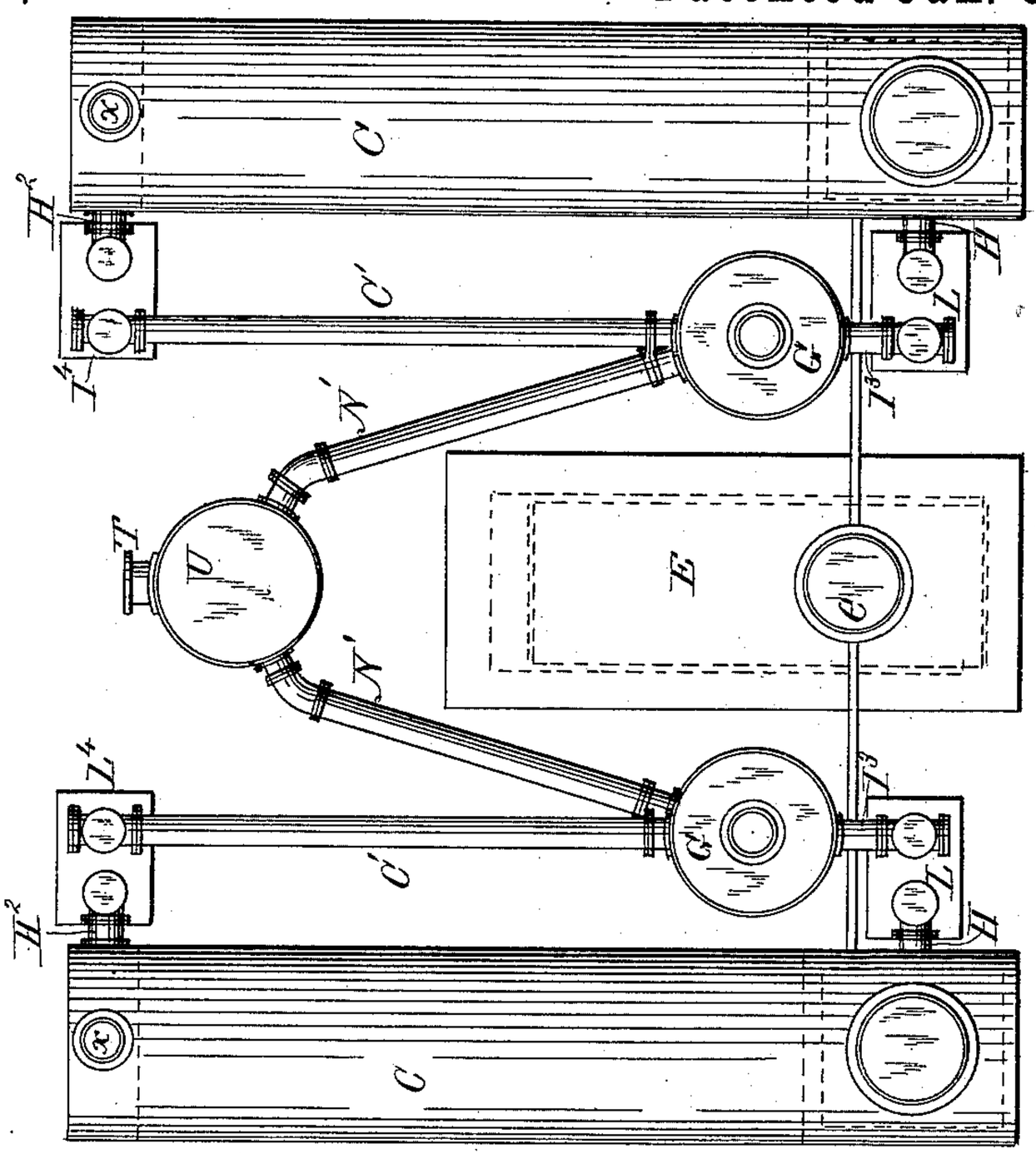
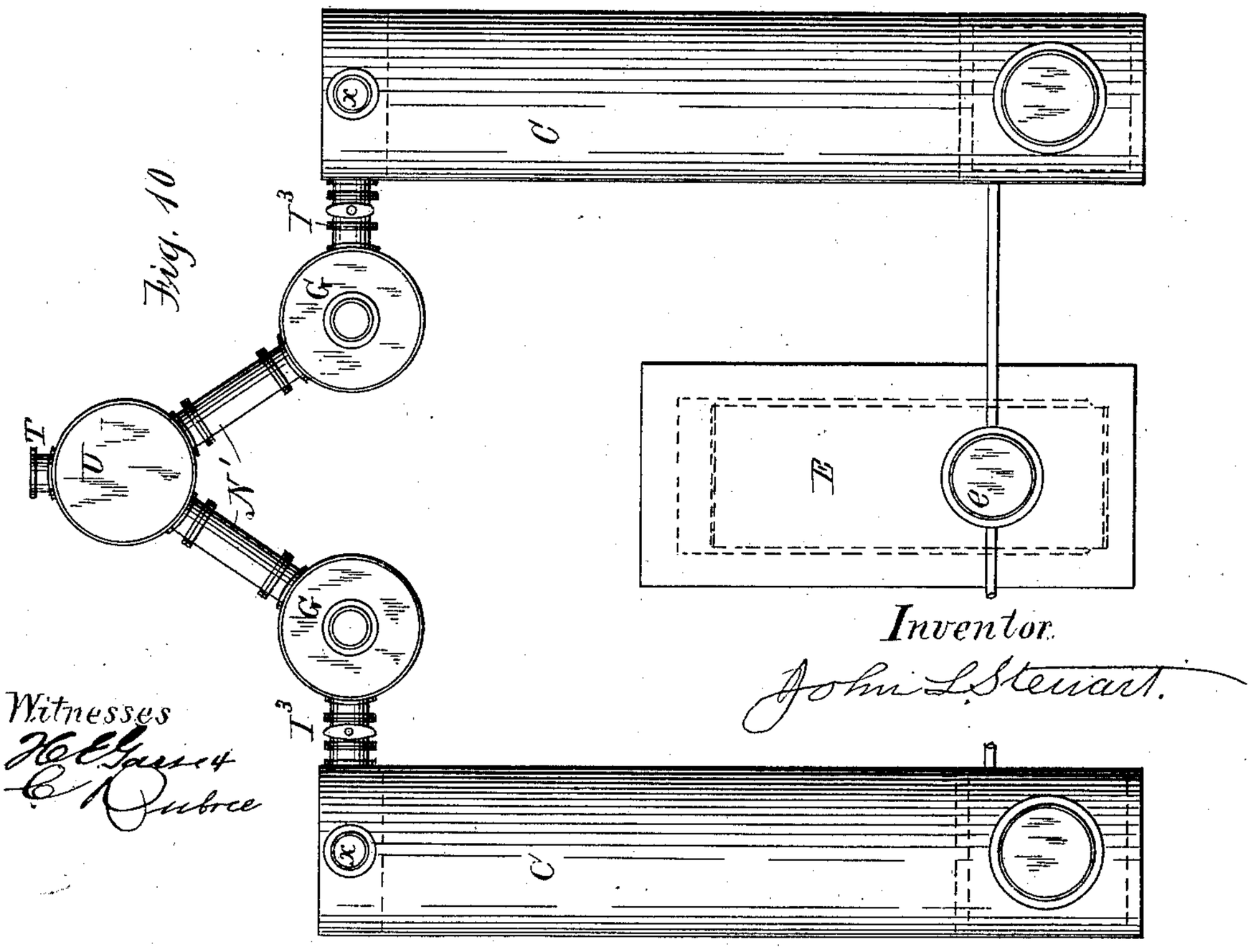


Fig. 10



Witnesses
H. C. Gaines
C. Dubois

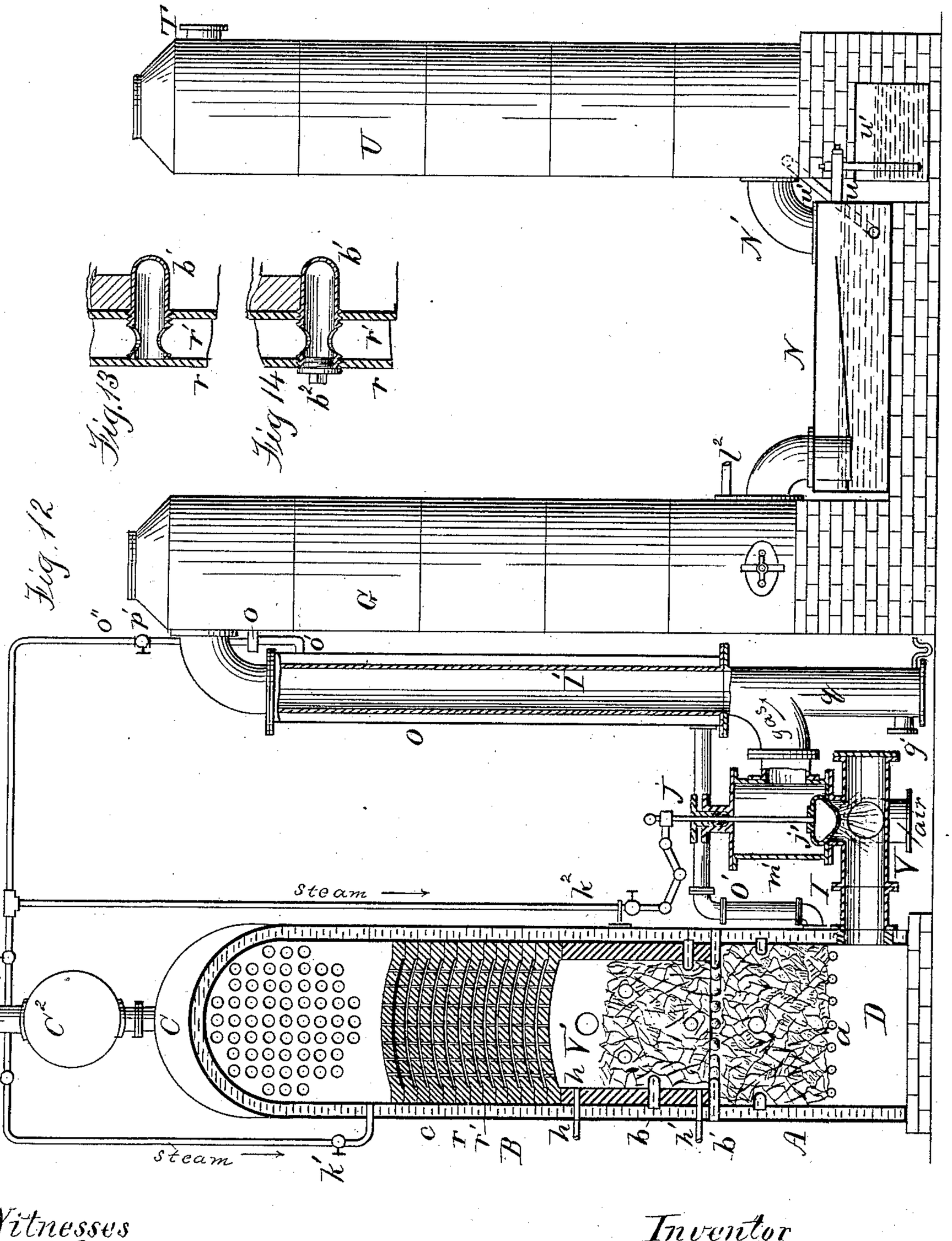
Inventor.
John L. Stewart.

(No Model.) 5 Sheets—Sheet 5.

J. L. STEWART.

APPARATUS FOR MANUFACTURING GAS.

No. 333,693. Patented Jan. 5, 1886.



Witnesses
H. E. Garrard
C. Dutrow

Inventor
John L. Stewart.

UNITED STATES PATENT OFFICE.

JOHN L. STEWART, OF PHILADELPHIA, PENNSYLVANIA.

APPARATUS FOR MANUFACTURING GAS.

SPECIFICATION forming part of Letters Patent No. 333,693, dated January 5, 1886.

Application filed June 25, 1885. Serial No. 169,732. (No model.)

To all whom it may concern:

Be it known that I, JOHN L. STEWART, a citizen of the United States, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in Apparatus for Manufacturing Gas, of which the following is a specification, reference being had therein to the accompanying drawings.

This invention relates to apparatus for manufacturing heating and illuminating gas in an economical manner; and the apparatus embraces a number of improvements in construction, whereby it is adapted for a variety of operations, and for producing gas by a number of modified processes, so that it may be operated in the most economical and successful manner to produce the desired quality of gas, according to circumstances.

The particular improvements in the apparatus constituting my invention herein will be defined in the claims.

The process and method of operating described in this application are made the subject of a separate application bearing Serial No. 168,822, and filed June 15, 1885.

The accompanying drawings represent my improved apparatus.

Figure 1 represents a side elevation of one of the forms of apparatus. Fig. 2 represents a vertical transverse section of the generator and oil still or vaporizer. Fig. 3 represents a plan view of the apparatus. Fig. 4 represents a vertical longitudinal section of the apparatus with a modified arrangement of parts. Fig. 5 is a horizontal section of the water-jacket generator. Figs. 6 and 7 are sectional detail views of parts of the apparatus. Fig. 8 represents a side elevation of the apparatus, of modified construction, partly in section. Fig. 9 represents a double set of apparatus, partly in front elevation and partly in vertical transverse section. Fig. 10 represents a plan view of a double set of the apparatus shown in Fig. 4. Fig. 11 represents a plan view of the double set shown in Fig. 9. Fig. 12 represents the apparatus partly in vertical section and partly in elevation, and showing some peculiar features of construction. Figs. 13 and 14 are sectional detail views, on an enlarged scale, of the tubular projections for supporting the fuel or the fire-brick lining of the furnace.

The process will be fully set forth in the description of the operation of the apparatus.

A convenient and simple form of apparatus is illustrated in Figs. 1, 2, 3, and 4, in which the fuel and generating chamber A is formed by two casings or jackets, *r r'*, of riveted plate-iron, placed one within the other, so as to form a water-space, *c*, between them. They are secured by stay-bolts, and are arched at the top to form the shell of the horizontal boiler C, which freely communicates with the water-space *c* of the jackets. The casings forming the walls of the furnace are made rectangular in cross-section, as shown in Fig. 5, and the horizontal tubular boiler C is joined onto them at the top, in a manner similar to that used in the construction of locomotive-boilers and fire-boxes. Water-tubes *a*, forming the grate-bars, connect opposite sides of inner jacket, *r'*, so that water may circulate through them, as described and claimed in a separate application. Ash-pit D has an opening for removal of ashes, &c., closed by a tight door, D', and has connecting with it air-blast pipe V, steam-pipe *k*, and gas-outlet pipe I, leading to hydraulic-seal box L^2. Pipe I and box L^2 are omitted from Fig. 4, but are shown in Figs. 1, 2, and 9. Stoke-holes *t* are formed at various points in the jacket-walls from near the base of the fuel-chamber to near its top, and are closed by plugs or caps *t'*. Short pieces of pipe or sockets *b*, closed at their projecting ends and open at their attached ends, are screwed into openings in the inner jacket and in the strengthening-plates *r''*, riveted to such jacket. (See Figs. 5 and 6.) They are placed at different heights in each of the side walls, and being hollow will be kept sufficiently cool and prevented from burning off by the circulation of water. Such tubular projections are made one or more inches long and project far enough into the furnace to support the fuel and prevent it from packing injuriously down upon the grate-bars, and they may be formed with flanges and secured by rivets to the inner jacket. These tubular projections also serve an important and useful purpose in assisting to fracture the coke, particularly when bituminous coal is used, as such fuel, by its weight, will settle in the cen-

tral portion of the furnace first, thus breaking away from the portions supported upon the short pipes. By a suitable arrangement of the number and length of the tubular projections the generator can be operated with a much deeper bituminous-coal fire than it otherwise could, as they will keep the fuel loose and prevent packing, so that the air and steam will pass through the same more freely. By means of bars inserted in the stoke-holes *t*, and operated to break up masses of fuel, and the projecting tubes *b*, the whole body of fuel is readily kept in condition for the free passage of air and steam or gas uniformly through its entire area, and improved results thereby secured. These stoke holes or openings *t*, arranged at different points in the circumference and height of the walls of the fuel-chamber are important features, especially where a fixing-chamber or steam-boiler is placed above the fuel-chamber, as with such construction clinkering-bars cannot be conveniently inserted at an opening in the top of the fuel-chamber for breaking up the caked fuel, and the openings must therefore be provided for the insertion of bars at various points in the circumference of the fuel-chamber from near the grate-bars to near the top of such chamber. A steam-dome, C^2, having a safety-valve, *z*, rises from the front end of the boiler, and from such dome steam-pipes K and K′ lead to the interior of the furnace. Pipe K connects by a branch, *k*, with the ash-pit, and pipe K′ communicates with the top of the fuel-chamber through the medium of gas take-off pipe H. The rear end of the boiler is supported on a column, *y*, and is provided with smoke-chamber Y, having a smoke-escape passage, *y′*, (see Fig. 4,) which may be tightly closed or opened by cap *x*. The generator is supplied with hydrocarbon-oil vapor, or hot oil by still or vaporizer E. Such still E is constructed like a tubular boiler, having a vapor-dome, *e*, and is set in furnace E′. Pipe *e′*, having a valve and connecting with the top of the dome, connects with pipe *g*, which connects with vertical pipe *f*, and from this pipe branch pipe *g′* leads to the top of the fuel and generating chamber A. Branch *g″* leads to the middle portion and branch *g‴* leads to the lower portion just above the grate. These oil-vapor pipes connect with the furnace, as shown in detail view, Fig. 7. Vapor-pipe *g′* connects with the short horizontal pipe *h*, which opens into the fuel-chamber, and has at its outer end a removable cap or plug, *m*, and a steam-pipe, *k″*, having a valve, *k′*, connects with pipe *h* just back of the vapor-pipe, whereby oil-vapor or hot oil may be blown into the generator by a small jet of steam. One or more vapor-pipes *h* connect with the generator at each level for better distributing the vapor in the fuel at the particular level where it is admitted Pipes *h* lead from vapor-pipe *g′*, pipes *h′* lead from pipe *g″*, and pipes *h″* lead from pipe *g‴* into the fuel-chamber. When the hydrocarbon vapor or steam is introduced into the fuel-chamber above the grate-bars and below the surface of the fuel, it is desirable before turning on the same to first run a stoking-bar through the pipes *h*, plugs *m* being removed for the purpose, and thus opening passage-ways in the fuel, in order that the vapors may be better distributed through the whole mass of fuel. Oil-still E is adapted to stand a high pressure, and vapor is accumulated in it under pressure, to be supplied in the desired quantity to the generator. It has an oil-outlet pipe, *e″*, provided with a valve extending through the dome down to near its bottom, and connecting externally with pipe *g*, leading to the generator. Heavy residual oil is forced and sprayed by vapor-pressure in the still into the generator when desired by partly closing the valve of pipe *e′* and opening the valve of pipe *e″*.

In practice a vapor-escape pipe having a safety-valve is to be connected to the dome *e* or pipe *e′* and lead to a condenser, which is in communication with a receiving-tank, for the purpose of relieving the still of an excessive pressure of vapor, and at the same time condensing and saving any vapor that may escape, as shown, described, and claimed in a separate application.

The generator shown in Figs. 1, 2, and 3 has an outlet-gas pipe, H, at the top, connecting by a dip-pipe directly with hydraulic seal-box L, and the dip-pipe is provided with a cup and cone valve for closing its end in box L. Such generator also has a gas-outlet pipe, I, connecting the ash-pit with seal-box L^2, pipe I also having a cup and cone valve. Pipe I^3 connects box L with the upper part of the tubular water-heater G, and pipe I′ connects box L^2 with box L, opening above the water-line therein, as shown, so that gas may be conducted from either box to the heater by properly operating the valves in pipes H and I. The water-heater G, wash-box N, and scrubber U are of the kind shown in section in Fig. 4. The generator and boiler, in the apparatus shown in Fig. 4, are constructed and provided with connections mainly like those in Fig. 2; but in Fig. 4 the rear end of the boiler is connected by a gas-outlet pipe, I^3, directly with the top of the heater G, pipe I^3 being provided with a valve, *n′*. The ash-pit of the generator may also have a gas-outlet pipe, though none is shown. Heater G has a water-supply pipe, *l*, at its base, and outlet-pipes *o o′* leading from its top to the boiler C, and an air-vent pipe, *o″*, leading to the steam-space of the boiler. Valves *p* and *p′* are applied, respectively, to pipes *o′* and *o″*. The wash-box has a man-hole closed by a tight-fitting lid, *n*, and it has an overflow-pipe, *u*, connecting with trap *u′*. Gas-outlet pipe T leads from the top of the scrubber, and water-pipe S, with a rose-head, supplies water to the top of the scrubber. Fig. 10 illustrates in plan view a double set of the apparatus shown in Fig. 4, except that the two heaters G are connected by pipe N′ with a single scrubber, U. Oil-still E is placed between the gener-

ators for supplying both of them, or it may be located in any convenient safe place.

In the modified form of apparatus shown in Figs. 8, 9, and 11 a superheating or fixing chamber, B, filled with perforated brick arches, is built in the generator between the fuel and generating chamber A and boiler C. An additional gas-outlet pipe, H′, connects the top of the fuel-chamber with seal-box L′, and the additional pipe I^2 connects box L′ with box L, into which leads pipe H from the top of the generator above the superheater B, so that three gas-outlet pipes lead from the different portions of the generator, as shown. Steam-pipe K′ connects by branch pipes with three different portions of the furnace—viz, at the top of chamber B, above the brick-work; at the top of chamber A, above the fuel; and at the base of chamber A, below the fuel, or with the ash-pit. Steam-pipe K may also connect with vapor-pipe *f*, so that steam may be passed through any of the vapor-pipes into different portions of the furnace. Steam-pipe K′, or its branches, may connect directly with the gas-outlet pipes H, H′, and I, for conducting steam into the furnace. Overflow-pipes *v* connect the hydraulic seal-boxes, opening into such boxes slightly below the tops of the connecting gas-pipes I′ I^2. The rear end of the boiler C has a smoke-escape passage closed by cap *x*, and also connects by pipe H^2 with seal-box L^4, which is connected by pipe C′ with the top of heater G, as shown in Figs. 8 and 11, so that products of combustion, after passing through the boiler, may be passed down through the tubular heater and escape by a pipe (not shown) leading from the base thereof. Pipe N′ connects the base of heater G with the base of the scrubber U. (See Figs. 8 and 11.) The heaters and scrubbers may have outlet-passages at the top closed by tight-fitting caps *x*. An additional vapor-pipe, g^4, extends from pipe *f* to inlet-pipes *h‴*, above chamber B. The hydrocarbon vapor or oil may be blown in above the superheater, and at other parts of the generator, by a jet or jets of water-gas under pressure, instead of steam, mentioned with reference to pipe *k″*, Fig. 7. The pipe for water-gas should be connected to steam-pipe *k″*, or directly to pipe *h*. The air-blast pipes V connect below the grate V′ at the top of the fuel-chamber and V^2 at the top of superheating-chamber B, whereby gaseous products resulting from combustion of the fuel may be burned both below and above the chamber B. By arranging the boiler horizontally and placing an opening and tight-fitting door in the wall opposite the ends of the tubes such tubes may be readily cleaned. Fuel is charged into the furnace through the opening closed by door *d*.

The apparatus shown in Fig. 12 is provided with superheating or fixing chamber B, and the fuel-chamber is provided at a suitable distance above the grate with a circle of tubular projections, *b′*, secured in the metal casings or jackets for supporting the fire-brick lining of the furnace. These tubular projections are hollow, and are kept cool by the circulation of water from space *c*. They can be cheaply constructed, and are readily applied to the jackets for supporting the lining. They may be constructed and applied as shown in Fig. 6; or they may have openings near their bases, and be screwed through the inner jacket, so that their bases shall abut against the inner surface of the outer jacket, as shown in Fig. 13, for staying and strengthening the parts. To secure still greater strength and rigidity of construction, the tubes may be provided with raised screw-threads, be perforated near the base, and have their outer ends closed by screw-plugs b^2, as shown in Fig. 14. With this construction openings are made in both jackets and screw-threaded and the tubes screwed in from the outside of the furnace. The gas-outlet pipe I leading from the ash-box is provided with a valve-box, *m′*, having a hollow perforated valve, *j′*, connected to a hollow stem, *j*, passing through a stuffing-box. Stem *j* connects at its upper end, by a jointed or flexible pipe, with a steam-pipe, k^4, whereby the valve may be kept cool by steam, as described and claimed in a separate application filed by me. Air-blast pipe V connects with pipe I below the valve-box, or at other convenient location. Gas-pipe I′ leads from the valve-box to the top of water-heater G, and such pipe has at its lower end a pendent drip-chamber, *q*, having at the bottom a hand-hole, *q′*, and, if desired, a trap escape-pipe. Pipe I′ is also provided with a wrought-iron water-jacket, O, and the water-space thus formed is connected at the top with heater G by pipes *o o′*, and at the bottom with the water-space *c* of the furnace by pipe O′. The advantage of this construction is that it equalizes the expansion between the generator, stand-pipe, and water-heater. Gas-pipe N′ connects wash-box N with the base of the scrubber U, and small pipe *u″* conducts water from the scrubber into the wash-box. This generator embodies about the simplest and best construction and arrangement for the manufacture of fuel-gas. Having but one gas-outlet, the waste products of combustion pass out at the rear end of the boiler, while the water-gas passes out at the base of the fuel-chamber. A low pressure of steam only is required in the boiler, as the steam is superheated in passing down through the superheater before entering the fuel. Illuminating-gas could also be made by blowing in oil-vapor, either over or into the middle portion of the fuel, as hereinafter fully described.

The apparatus may be operated in a number of different ways, or at least with modifications in the details of procedure for carrying out my improved process for manufacturing gas.

In heating up the apparatus shown in Figs. 1 to 4 a fire is kindled on the grate and fuel is gradually fed in. Then the air-blast is admitted by pipe V below the grate, cap *x* be-

ing removed from passage y' at the end of the boiler, and as combustible gases or products are given off from the fuel the air-blast is admitted through pipe V^2, for causing complete combustion of the gaseous products, and thus generating steam in the boiler. The air-blasts are continued till a deep body of fuel is raised to incandescence and a suitable pressure of steam raised in the boiler, when the air-blasts are shut off and smoke-passage y' closed by cap x. Steam is now decomposed by passage either up or down through the fuel, resulting in pure water-gas composed of hydrogen and carbonic oxide. The apparatus shown in Fig. 2 being in use, the valve in take-off pipe I below the grate-bars is opened, and steam is admitted through pipe K' above the fuel, and is passed down through the fuel, where it is decomposed, and the resulting gas passes through pipe I, box L^2, pipes I' and I^3 into the top of heater G, then down through the tubes of such heater, through wash-box N, up through the scrubber, and by outlet-pipe T to the purifier or holder. If thought desirable, steam may be admitted at the ash-pit and decomposed by passage up through the fuel, and the resulting gas passed off through pipe H and the other parts of the apparatus, as above described.

In the apparatus shown in Fig. 4 the water-gas is passed off through the boiler, valve n' being open, then through the heater, wash-box, and scrubber. The generation of water-gas is continued till the fuel is reduced to the proper temperature for the generation of hydrocarbon gas, when the steam is shut off from either the top or bottom of the generator, and oil-vapor is admitted at such portion of the fuel as found most desirable.

During the operations of heating up and decomposing steam, oil-vapor is generated in the still and stored under pressure, so that it may be admitted in the desired volume to the fuel when ready for making illuminating-gas. If a light oil or benzine having a low boiling-point is used, the vapors may be admitted near the base of the fuel and the resulting gas conducted off at the top, or the vapors may be admitted at the top and the resulting gas conducted off at the bottom. The oil-vapor may be blown into the fuel by a small jet of steam, or by a jet of water-gas under pressure, or directly from the oil-still, the fuel having been opened by the insertion of a bar through pipe h, as described with reference to Fig. 7. The hydrocarbon gas is to be conducted through the heater, wash-box, scrubber, and purifiers to a holder, where it is mixed with the desired quantity of water-gas, or stored separately, as preferred. In case a heavy oil having a high boiling-point is used, it is preferable to use a deep fire or fuel bed and discharge the hydrocarbon vapor near the central portion of such fuel body and pass it up or down, or first one way and then the other, so that it will be decomposed and converted into fixed gas before reaching either the boiler-flues or ash-pit. The oil-vapors are passed upward till the upper portion of the fuel is reduced too low in temperature to produce a fixed gas. Then the upper valve is closed and the lower valve is opened, and the vapors are passed downward till the lower portion of the fuel is in like manner reduced in temperature, when the oil-vapor must be shut off and the generator must be reheated, as above described. An important advantage in this process is that I can commingle water-gas with the hydrocarbon vapor from the still in the generator in the following manner: The body of fuel in the generator is first raised by means of the air-blast to incandescence, when the air is shut off and steam admitted and water-gas generated and conducted off till the fuel is reduced to the proper temperature to receive the hydrocarbon vapors. Part of the current of steam is then shut off and the hydrocarbon vapor admitted near the center of the body of fuel. The reduced current of steam may be admitted over the fuel, and in passing downward will be decomposed into hydrogen and carbonic oxide by the time it reaches the central portion of the generator, which gases mix with the hydrocarbon vapors, and all are converted into a fixed gas in passing through the lower portion of the fuel, and such gas is passed off by the lower valve and outlet-pipe. The direction of the flow of steam and oil-vapor and gas can at any moment be reversed by closing the lower and opening the upper gas-valve and shutting off the steam above and admitting it below the body of fuel.

In using bituminous coal it would be more profitable to generate all the gas by a downward current, as by that method all the volatile hydrocarbons being distilled from the surface coal in the generator would be carried down and converted into a fixed gas by the hot fuel below.

The apparatus represented in Figs. 8, 9, and 11 is to be heated up substantially as above described with reference to Figs. 1 to 4, though an additional air-blast is employed above the superheater or fixing chamber B, and gaseous products rising from the fuel, when the air-blast is on at the base thereof, are partially burned at the top of the fuel-chamber for heating chamber B to the proper temperature, and the combustion completed above such chamber for heating the boiler C. Gas-outlet pipes H, H', and I being closed and cap x at the rear of the boiler being open, the waste products of combustion are passed through the boiler and out of passage y'. Either heating or illuminating gas may be passed out through any of the pipes H, H', or I, into a hydraulic-seal box, and then into the top of heater G; or either kind of gas may be passed through the boiler-flues into seal-box L^4, and thence by pipe C' forward to the top of heater G.

The operation above described for manufacturing heating and illuminating gas may be carried out in this form of apparatus, and, in addition, the steam may be superheated pre-

paratory to decomposition by passage through the heated brick-work in chamber B. For instance, steam is superheated by passage down through chamber B, then decomposed by passage down through the incandescent fuel and the resulting high-grade heating-gas passed off through pipe I leading from the ash-pit, then when the apparatus is reduced to the proper temperature, shutting off the steam, or the main current of it, and spraying oil or oil-vapors into the top of the superheating-chamber, or into the fuel-chamber below the superheater, converting the vapors into a fixed hydrocarbon gas by passing them through such chamber, and, if necessary, through the fuel. The gas is passed off from the fuel-chamber either by pipe H′ or pipe I. Of course after decomposition of steam, oil-vapor might be admitted through pipe *g″* and inlets *h′* to the central portion of chamber A, then passed up through the fuel, up through fixing-chamber B, and the resulting fixed hydrocarbon gas passed out either through pipe H or through the boiler, and thence by pipe C′ into the top of heater G. The refractory material in chamber B and the fuel in chamber A being at the proper temperature, hydrocarbon liquid may be sprayed, by means of water-gas under pressure, into contact with the heated refractory material, thereby vaporizing such liquid, and the mixed vapor and water-gas are converted into a fixed gas by passing them down through the body of heated fuel.

In the manufacture of fuel-gas it is best to admit the steam above the hot fuel or above the superheater and pass it down through the fuel, especially if bituminous coal is used as fuel in the generator, as then all the volatile hydrocarbon vapors distilled from the surface coal during the time gas is being made will pass down with the steam through the incandescent fuel, where it is decomposed, and will combine with the water-gas resulting from the decomposition of the steam, thereby greatly enriching the latter as a fuel-gas.

If it is desired to decrease the per cent. of carbonic oxide usually produced, then a fire of less depth may be used or the steam introduced midway in the heated fuel, so that the principal products of the decomposed steam will be carbonic-acid and hydrogen gases, the carbonic acid being removed by lime purification.

The method of converting hydrocarbon vapor, together with water-gas or a small per cent. of steam, into fixed illuminating-gas by passing them through heated carbonaceous fuel is believed to be advantageous, as carbonic acid present in the water-gas is thus converted into carbonic oxide by taking carbon from the fuel, or carbonic oxide, produced by the decomposition of the steam, is formed by the union of the oxygen with the highly-heated carbon of the fuel, for the reason that such carbon is much hotter than the hydrocarbon vapor, and thus causes decomposition more readily; whereas in the usual process of decomposing hydrocarbons in a heated chamber containing refractory brick-work, lime, stone, &c., the carbonic acid, or any portion of it, present in the accompanying water-gas will be changed into carbonic oxide at the expense of the oil-vapor, thus consuming a large quantity of oil and making the process more expensive.

The fuel when reduced to the temperature at which it ceases to produce pure hydrogen and carbonic oxide from the decomposition of steam is at or near the proper temperature for decomposing and fixing the rich hydrocarbons and producing a high-grade illuminating-gas.

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

1. In combination with a fuel and generating chamber, a hydrocarbon-supply pipe connecting with the middle portion thereof, a steam-supply pipe connecting with the upper end thereof, and a gas-discharge pipe leading from the lower end thereof, for the purpose described.

2. In combination with a fuel and generating chamber, a hydrocarbon-supply pipe connecting with the middle portion thereof, a steam-supply pipe connecting with the upper and lower ends thereof, and gas-discharge pipe connecting with its top and bottom, for the purpose described.

3. In combination with a fuel and generating chamber, a hydrocarbon-supply pipe provided with an injector-pipe for steam or water-gas connecting with the middle portion of such chamber, a steam-inlet pipe connecting with one end thereof, and a gas-discharge pipe leading from one end thereof, for the purpose described.

4. In combination with a fuel and generating chamber, the injector-pipe having connections for steam and hydrocarbon connecting with the middle portion and with the upper and lower ends of such chamber and gas-discharge pipe, and pipes leading from the top and bottom thereof, for the purpose described.

5. In combination with a fuel and generating chamber, a hydrocarbon-supply pipe connecting with the middle portion thereof, a steam-supply pipe connecting with one end of the chamber, and a gas-discharge pipe leading from each end of the chamber, for the purpose described.

6. In combination with a fuel and generating chamber, a hydrocarbon-supply pipe and a jet-pipe for steam or water-gas connecting with the middle portion of the chamber, and a gas-discharge pipe leading from each end of the chamber, for the purpose described.

7. In combination with a fuel and generating chamber, an inlet-pipe connecting with the fuel-space of such chamber, having at its outer end a removable plug or stopper, and having a connecting-pipe for hydrocarbon oil or vapor, and a connecting pipe for steam or water-gas, for the purpose described.

8. In combination with a fuel and generating chamber, an inlet-pipe for steam and hydrocarbon oil or vapor, having at its outer end a removable plug or stopper, for the insertion of a bar or rod to open the fuel, whereby the oil or vapor may be better distributed in such fuel.

9. In combination with a fuel and generating chamber, projecting fuel-supports secured at different heights in the walls of such chamber, for assisting in breaking up caked fuel, and sufficiently supporting it to prevent its packing on the grate.

10. In combination with the water-jacket casings of a gas-generating furnace, the hollow tubular projections secured to the inner jacket and open to the water-space, for supporting the fuel and preventing its packing on the grate.

11. In combination with the water-jacket casings of a gas-generating furnace, a circular row of hollow tubular projections secured to one or both jackets and open to the water-space, for supporting the fire-brick lining of the furnace.

12. In a cupola gas-generating furnace, the fuel-chamber provided with stoke-holes at different points in the circumference and height of its walls, from near the grate-bars to near the top of such chamber, in combination with a superheating chamber or boiler placed above the fuel-chamber, for the purpose described.

13. The walls of a fuel and generating chamber provided with stoke-holes at different points in its circumference and height, in combination with fuel-supports secured at different heights to the walls of such chamber, whereby caked fuel may be broken up and kept open sufficiently for the free passage of air, steam, and vapor or gas.

14. The fuel and generating chamber having a gas-outlet pipe at top and bottom, in combination with a horizontal tubular boiler having at its outer end an outlet-passage and cap for the escape of products of combustion.

15. The fuel and generating chamber having a gas-outlet pipe at top and bottom, connecting with the top of a water-heater, in combination with a horizontal tubular boiler having an outlet-passage for products of combustion, and a pipe connecting the rear end or smoke-box of such boiler with the top of the heater.

16. The fuel and generating chamber having two or more gas-outlet pipes leading directly from it, and each connecting with a seal-box, a pipe or pipes connecting such boxes, and a pipe connecting the upper box with the top of the water-heater.

17. A gas-generating furnace or cupola having a fuel-chamber, a fixing or superheating chamber, and a boiler connecting above the fixing or superheating chamber, in combination with gas-outlet pipes leading, respectively, from the ash-pit, the top of the fuel-chamber, and the top of the fixing-chamber, for the purpose described.

18. The combination of a gas-generating furnace or cupola having a water-jacket, a gas-outlet pipe having a water-jacket, a connected water-heater, and pipes connecting the water-jackets and heater, for the purpose described.

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

JOHN L. STEWART.

Witnesses:
H. E. GARSED,
C. DUBREE.