(No Model.) 3 Sheets—Sheet 1.

# J. L. STEWART.

## APPARATUS FOR MANUFACTURING GAS.

No. 584,713. Patented June 15, 1897.

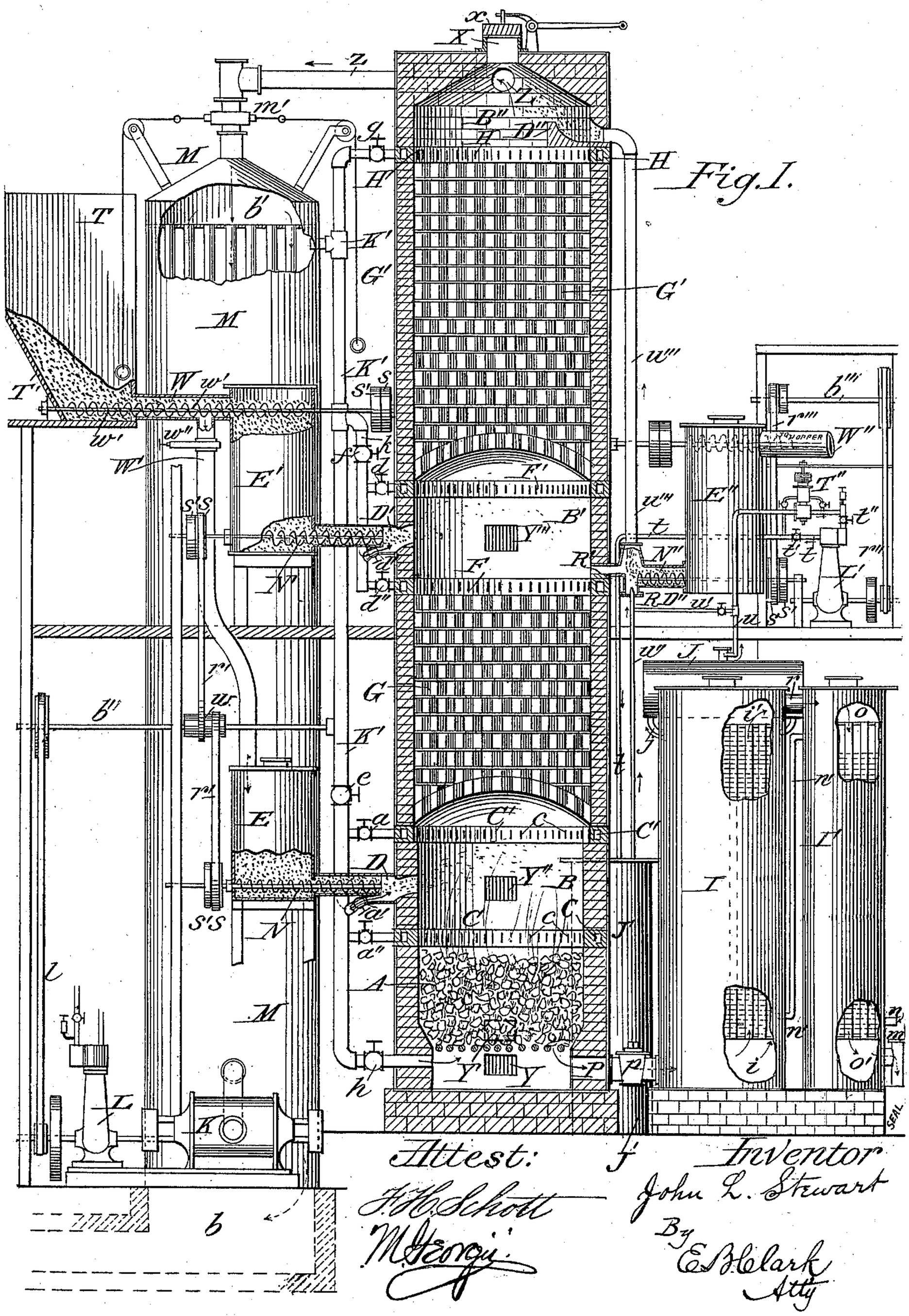


Fig. 1.

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## APPARATUS FOR MANUFACTURING GAS.

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Fig. 2.

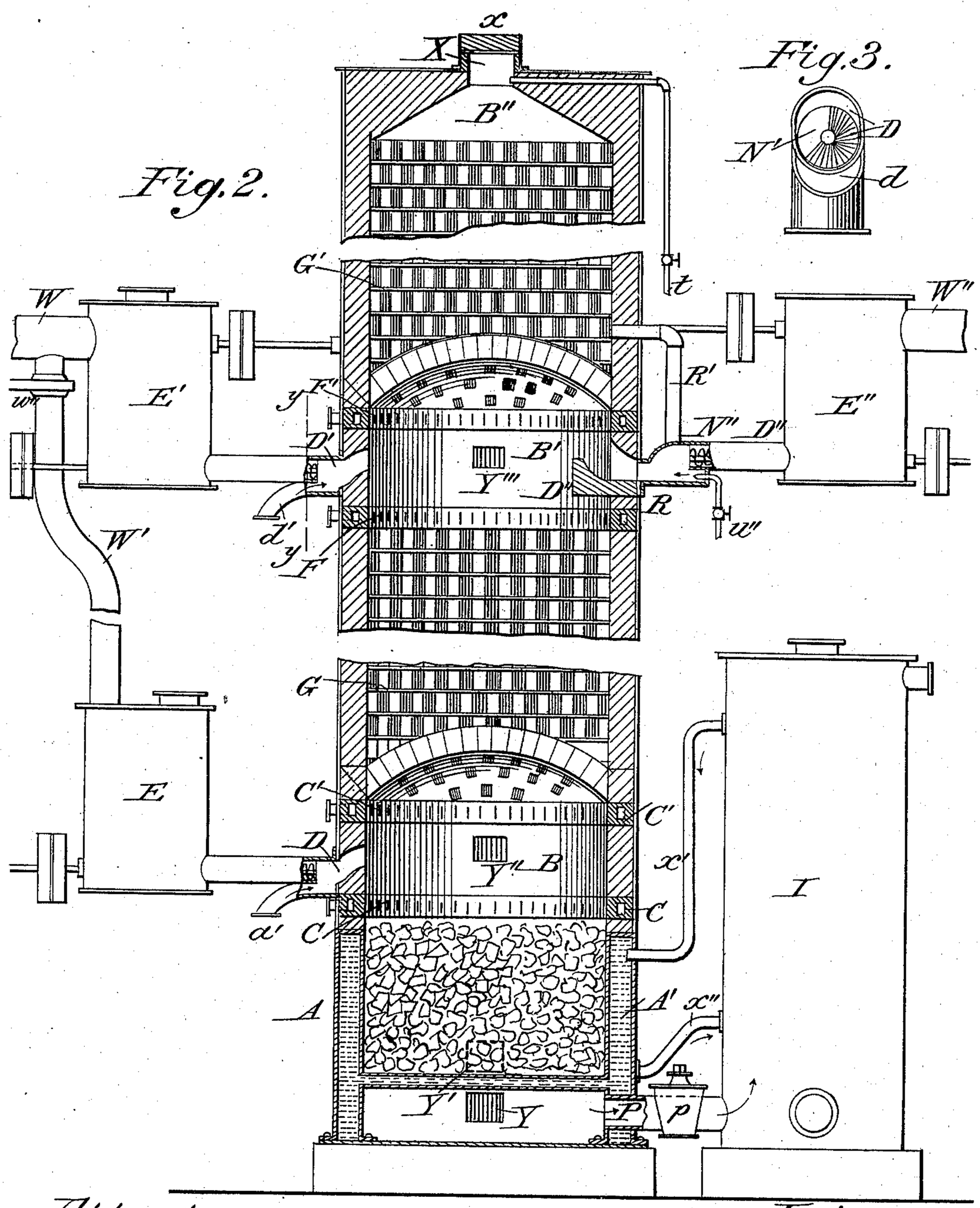


Fig. 3.




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## APPARATUS FOR MANUFACTURING GAS.

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Fig. 4.

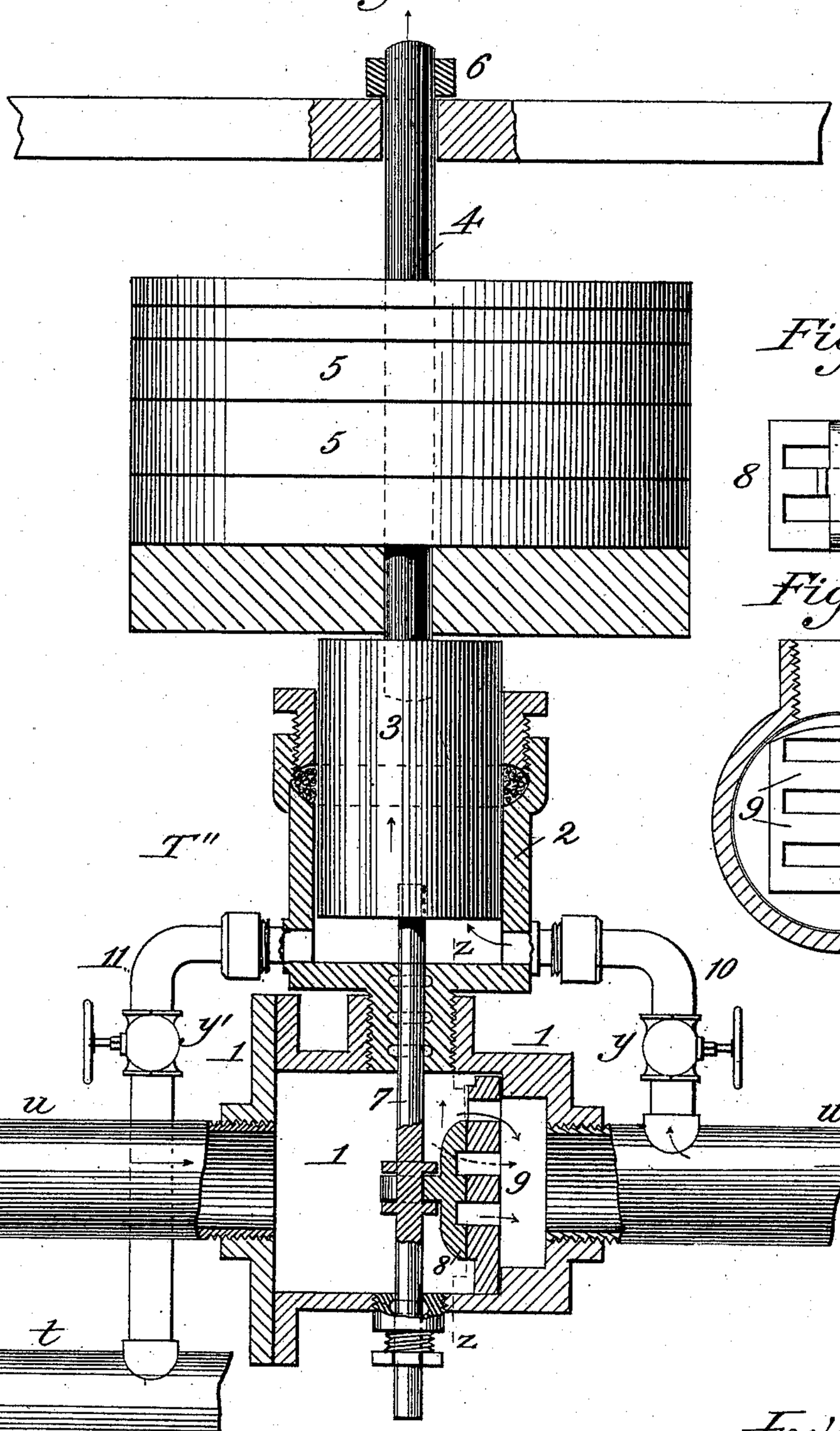
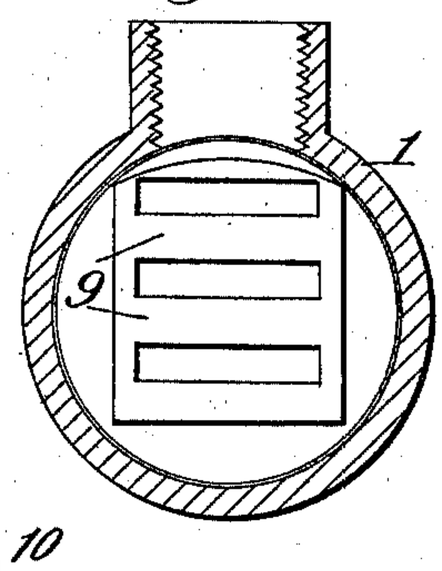



Fig. 5.




Fig. 6.

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# UNITED STATES PATENT OFFICE.

JOHN L. STEWART, OF SAN FRANCISCO, CALIFORNIA.

## APPARATUS FOR MANUFACTURING GAS.

SPECIFICATION forming part of Letters Patent No. 584,713, dated June 15, 1897.

Application filed April 19, 1890. Serial No. 348,644. (No model.)

*To all whom it may concern:*

Be it known that I, JOHN L. STEWART, a citizen of the United States, residing at San Francisco, in the county of San Francisco and State of California, 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 the manufacture of heating and illuminating gases by means of low-priced carbonaceous fuel in the form of dust or slack or cheap hydrocarbon oil in a cupola-generator provided with numerous brick flues.

My present invention embraces certain improvements on the processes and apparatus described and claimed in my former applications for the manufacture of gas—viz., Serial No. 227,537, filed February 14, 1887, and Serial No. 247,605, filed August 22, 1887. These improvements relate more particularly to the methods and means for supplying the cupola-generator with properly proportioned and regulated quantities of air and carbon-dust for heating up the brickwork flues of the cupola; also for supplying properly proportioned and regulated quantities of steam and carbon-dust to the heated decomposing-chambers of the cupola for generating water-gas.

The object of the invention is more particularly to supply the carbon-dust and air in such proportions and quantities as to secure perfect combustion and heat the cupola most economically and in the shortest time; also to supply the carbon-dust and steam to the heated decomposing-chambers in such proportions as to secure perfect decomposition of the steam into water-gas without waste of carbon-dust.

The matter constituting my invention will be defined in the claims.

The construction and operation of my improved generator will now be described with reference to the accompanying drawings, in which—

Figure 1 represents a vertical section of a cupola generating-furnace with connecting steam-boiler and water-heater, air-heater, steam-engines, positive air-blower, and carbon-dust-feeding devices partly in section and partly in elevation. Fig. 2 represents a vertical section of a cupola-generator of modified form, showing the connecting steam-boiler and the carbon-dust-feeding boxes, but with the air-heater, engines, and blower omitted. Fig. 3 represents a sectional detail, on an enlarged scale, of the dust-feeding and air-supply pipe. Fig. 4 represents a vertical section of the governor for controlling the flow of steam to the engine and the flow of exhausted steam from the engine to the generator. Fig. 5 represents a face view of the valve. Fig. 6 represents a face view of the valve-seat and ports.

The cupola-generator is built of brick with a lining of fire-brick, covered with a tight iron jacket and resting upon a suitable foundation in the usual manner. The cupola is provided at the bottom with the fuel-chamber A, having the usual grate and ash-pit. Above the fuel-chamber is provided a combustion-chamber B, having in its walls the two annular air-supply flues C C′, having narrow slits or ports *c c* opening into the interior of chamber B. The supply-pipe D for mixed carbon-dust and air also connects with chamber B between the flues C C′. Above chamber B is provided a decomposing-chamber G, containing numerous flues formed of refractory material, and above such chamber I provide a second combustion-chamber B′, provided with annular air-flues F F′, having ports opening into chamber B′. The supply-pipe D′ for mixed carbon-dust and air also connects with chamber B′ between the flues F F′. The second brickwork decomposing-chamber G′ is constructed above chamber B′, and above such chamber G′, at the top of the cupola, I provide the third combustion-chamber B″, having in its wall an annular air-flue H, provided with ports opening into the chamber B″. The cupola is provided at the top with the main outlet-opening X, having lid *x*.

The ash-pit, the fuel-chamber, and the combustion-chambers B B′ are provided with openings and doors Y Y′ Y″ Y‴, as shown. The top chamber B″ is provided with an opening Z, connecting by a pipe *z* with the air-heater M. The ash-pit of the cupola is connected by a pipe P, having valve *p*, with the

base of the tubular boiler I, having boxes *i i'* at bottom and top. The steam-drum J connects by pipe *j* with the top of boiler I. The pipe *r* connects the top box *i'* of boiler I with the box *o* of water-heater I', and the pipe *m* leads from the bottom box *o'* of such heater to the usual seal-box. A water-supply pipe *n* connects with the lower part of heater I', and a pipe *n'* leads from the upper part of such heater to the boiler I.

The positive air-blower K, operated by an engine L, forces air into the tubular air-heater M. The blower connects with the shell of heater M, above its bottom smoke-box *v*, so that the air to be heated shall circulate around and between the tubes. The heater is provided at the top with a smoke-box *b'*, which is connected by pipe *z* with the top of the cupola, and such pipe *z* is provided with a slide-valve *m'*, which may be operated by chains or ropes passing over pulleys, as shown. The pipe K' for heated air leads from the top of air-heater M and extends downward to near the base of the cupola, being provided with numerous branch pipes provided with valves for supplying air to the ash-pit and combustion-chambers. A branch pipe *k*, having valve *f*, leads from pipe K' for supplying combustion-chamber B' with hot air, and branch pipes provided with valves *d d' d''* lead from such pipe *k* into the annular flues F F' and into the dust-supply pipe D'. A valve *e* controls the flow of hot air to combustion-chamber B and ash-pit. Branch pipes having valves *a a''* lead into the annular flues C C', and branch pipe *a'* leads into the dust-supply pipe D. A branch pipe having valve *h* leads into the ash-pit.

The feed-boxes E E' E'' for carbon-dust are mounted at the proper height, as shown, and are provided with spiral screw conveyers N N' N'', arranged at their lower ends and projecting outward into the dust-supply pipes D D' D''. These dust-supply pipes D D' are elliptical in cross-section and are arranged with their greatest diameters in a vertical position, as shown in Fig. 3. The air-supply pipes connect at their under sides, and the two pipes open into a common chamber, so that as the dust is conveyed forward by the conveyer it is caught by the air-blast entering below and carried directly into the combustion-chamber. The shafts of the screw conveyers N, &c., extend out through the sides of boxes E and are journaled in suitable supports, and are also provided with fast and loose pulleys *s s'*. The belt *l* connects a pulley on the shaft of the engine with a pulley on the shaft *b''*, which is also provided with a driving-pulley *w*, which is connected above and below by belts *r'* with the pulleys on the shafts of the spiral conveyers in boxes E E'.

A large storage-tank T, Fig. 1, having inclined bottoms T', is provided for supplying carbon-dust to the boxes E E'. The tank T is provided with a spiral conveyer *w'* in its bottom, extending out through the pipe W, which connects directly with the top of dust-box E' and by means of a pipe W', having a valve *w''*, with the top of dust-box E. The shaft of the spiral conveyer *w'* may extend through the top of box E and be journaled in a suitable support. It is provided with fast and loose pulleys *s s'*. A similar storage-tank (not shown) is also to be provided for supplying carbon-dust to box E'' and in practice would connect with the top of such box by means of pipe W''. The storage-tanks T may be located outside of the generator-building and provided with suitable covers. When it is desired to fill the boxes E E' with dust, the valve *w''* may first be opened and the conveyer *w'* started in motion, when the dust will pass down through pipe W'' first into box E until it is filled. Then the continued operation of the conveyer will carry the dust into box E' until it is filled, after which the belt is shifted onto the loose pulley. The storage-tanks T are kept supplied with carbon-dust by means of an endless chain or belt provided with buckets similar to those used in grain-elevators.

A portable upright engine L' is set upon the upper floor of the generator-house for operating the dust-conveyer N'' in box E'', and its shaft, having a pulley, is connected by a belt *r''* with shaft *b'''*, having a driving-pulley which is connected by a belt *r'''* with the fast and loose pulleys *s s'* on the shaft of the spiral conveyer N''. The dust-pipe D'', leading from box E'', connects with the steam-jet-injector chamber R, which connects by pipe *u'''* with the chamber B'' at the top of the cupola and by the return or circulating pipe R' with combustion-chamber B'. A steam-pipe *u* leads from steam-drum J to the engine L' and is provided with valve *t''*. A branch steam-pipe *u'*, provided with a valve, connects with pipe *u''*, leading into injector R. The exhaust-steam pipe *t*, provided with valve *t'*, leads from engine L' down to a steam-superheating chamber J', where the steam is superheated, and such steam is returned by pipe *u''* to the injector-chamber R.

In case of a large gas-generator, where it may not be desirable or convenient to furnish all the air by a single blower, two or more blowers may be so connected by means of belts or gear-wheels as to operate together and supply air the same as a single blower for combustion of the powdered fuel, or a separate blower may be connected with each spiral conveyer for independently supplying powdered fuel to each combustion-chamber. In every case the spiral conveyer is adjusted to the speed of the blower and engine, so as to supply a proper proportion of air and carbon-dust. In practice the blower and its engine is provided with a governor such as used with the Roots blowers.

Instead of belts for operating the spiral dust-conveyers I may use gear wheels and pinions properly arranged for such purpose, and I also use a clutch in place of a loose pulley to throw the spiral conveyer into and out

of gear, as required. In some cases the gear wheels and pinions would be preferable, as with them there could be no slipping and failure to act, as in the case of the belts.

In connection with the steam-engine L′ for driving conveyer N″ and supplying the proper proportion of dust and steam to the generator in making water-gas I prefer to use my improved steam-governor T″. (Illustrated in Figs. 4, 5, and 6.) This governor is composed of a valve-chamber 1, the piston-chamber 2, containing the piston 3, and rod 4 for supporting the weights 5, and nut 6, secured to the end of rod 4 above a suitable support, and of the valve and its seat 8 and 9. The piston-chamber 2 is provided with a packing for the piston 3, and a stuffing-box is applied to the bottom of valve-chamber 1 for the passage of the valve-stem 7. A collar (not shown) may be applied to the valve-stem 7 below the stuffing-box for limiting the upward movement of the valve. The valve-seat 9, provided with suitable ports, is arranged across chamber 1, and the valve 8, constructed to register with the ports of the valve-seat, is suitably connected to the valve-rod 7. The pipe *u*, which supplies steam to the engines, is connected on both sides of the valve-chamber 1, as shown. The supply-pipe *u* is connected by pipe 10, having valve *y*, with piston-chamber 2, and the exhaust-pipe *t* is also connected by pipe 11, having valve *y′*, with piston-chamber 2 below the piston 3. In this governor the pressure can be regulated either from the supply or exhaust-steam pipe by opening either of the valves *y* or *y′* and shutting the other one.

In order to operate the generator shown in Fig. 1 for the manufacture of heating-gas, supposing all the valves and doors are closed, I first open the doors Y Y″ and the lid *x* at the top of the cupola and kindle a fire on the grate in chamber A, to which fuel is fed till a good strong bed of ignited fuel is formed. Then the doors Y Y″ are closed. Lid *x* may also be closed and the products of combustion caused to pass through pipe *z* into and through the tubes of the air-heater. The engine L and blower K are now started, the belts all being on the loose pulleys, and the fire urged by the blasts by opening valves *e a″ h*. After the fire is well ignited and chamber B heated I open air-injector valve *a′* and at the same time start the spiral dust-conveyer N by shifting belt *r′* onto the tight or driving pulley and shut off most or all of the air passing through valve *h*. The spiral conveyer conveys the carbon-dust into the injection-chamber D, where it is caught by the air-blast and blown into the combustion-chamber B, in which it is ignited and in descending is met by the streams of heated air admitted through valve *a″*, annular flue C, and ports *c*. Air may also be admitted through the annular flue C′, so as to burn the gaseous products arising in chamber B and thereby heat the flues and refractory material in chamber G above. As soon as combustion-chamber B has been sufficiently heated the valve *f* in pipe *k′* is opened, and also the valves *d d′ d″* in the branch pipes leading into the annular flues F F′ and into the dust-chamber D′. At the same time the belt is shifted onto the tight pulley on the shaft of conveyer N′ in dust-box E′ and carbon-dust fed to the injector-chamber D′, from whence it is sprayed into the combustion-chamber B′ by means of the air-blast passing through pipe *d′*. The dust and air are supplied in regulated quantities and in suitable proportions so as to effect an instantaneous and perfect combustion of the carbon. The operation of feeding and burning the carbon-dust by means of blasts of air is continued until the decomposing-chambers G G′ are heated to the proper temperature for decomposing steam. Then the air-valves *f e h* are closed, entirely shutting off the supply of air to the cupola. The valves *a a′ a″* and *d d′ d″* are in the first instance adjusted to supply the proper volume of air, and after this may be left in such position, as the closing of valves *f e h* entirely shuts off the air from the cupola. Lid *x* at the top of the cupola and also the valve *m′* in pipe *z*, leading to the air-heater, are tightly closed. The belts *r′* are also shifted onto the loose pulleys, so as to stop the feeding of dust to the combustion-chamber. The valve *p* in the gas-take-off pipe P at the bottom of the cupola is now opened and the engine L′ started by opening steam-valves *t′ t″*. The exhaust-steam passes from the engine down pipe *t* to a steam-superheater and returns in a superheated condition through pipe *u″*, passing into the injector-chamber R. I then start the spiral conveyor N″ by shifting the belt *r″* onto the tight pulley *s*, thereby feeding carbon-dust in regulated quantities into the ejector-chamber R, where it is injected by superheated steam passing upward from pipe *u″* and is blown up through pipe *u‴* into chamber B″ at the top of the cupola. The steam is thoroughly carbureted by the carbon-dust, and in the passage of the mixed dust and steam through the heated brick flues of decomposing-chamber G′ the steam is decomposed into hydrogen and carbonic oxid. In case bituminous-coal dust is used a percentage of light carbureted hydrogen is also set free in the decomposing-chambers G′. The mixed gases pass down through chamber G and finally through the bed of fuel in chamber A, where any carbonic acid that may be present is converted into carbonic oxid. The hot gas finally passes off from the ash-pit into and through the tubular steam-boiler and through the tubular water-heater to the seal-box, from which it passes to the washer, scrubber, purifiers, and holder. The pipe R′ admits gases to injector-chamber R, preventing the formation of a vacuum therein by means of the steam-jet. The hot gas passing into the injector-chamber R is again forced up to the top of the cupola and is thereby better mixed with the carbon-dust. A deflecting-

sprayer D″ is arranged in front of the opening of pipe $u'''$ in chamber B″ and is so formed as to receive the blast of carbureted steam and spray it over the top surface of chamber B″. After the generation of water-gas has been continued for some time and the temperature is so much lowered that carbonic acid is shown by a suitable test to be present in the gas I stop the spiral dust-conveyer N″ by shifting belt $r'''$ onto the loose pulley and shut off the steam by closing valves $t'$ $t''$, then opening valve $m'$ in pipe $z$, leading to the air-heater, and close valve $p$ in the gas-take-off pipe P. The cupola-generator is then heated up as in the first instance. At first valve $h$ may be opened, admitting air to the ash-pit for heating up the bed of fuel in chamber A, and then such valve may be nearly or quite closed while the carbon-dust is being burned by suitable blasts of air in combustion-chambers B B′ above the fuel. In starting the operation of reheating the cupola, valve $g$ may be opened for a short time, admitting air through annular flue H and its ports for burning any carbon-dust that may have lodged in chamber B″ during the admission of carbureted steam. Such dust having been consumed valve $g$ is closed. After the generator has been again properly heated the mingled dust and air are again shut off and the manufacture of water-gas is resumed by the admission of carbuted steam, as before explained.

The most important and valuable features in my carbureted-steam and dust processes and apparatus are, first, the means for supplying carbon-dust and air in suitable proportions and regulated quantities, and, second, carbon-dust and steam in suitable proportions and regulated quantities for the economical production of cheap fuel-gas from the cheapest kinds of carbonaceous material.

By means of my improved construction and arrangement of parts the horizontal spiral conveyers and air-blower are propelled by the same engine and so geared and adjusted that the proportions of air and dust supplied to the generator continue the same whether the engine be run fast or slow. The speed of the engine L is controlled by the usual governor P so as to maintain a uniform air-pressure on the air-valves, such as one pound to the square inch, more or less, but of sufficient pressure to spray and distribute the dust in the cupola. The revolutions of the spiral conveyers are governed by the speed of the engine and size of pulleys on the spiral-conveyer shafts, counter-shafts, and engine-shafts. These parts are in the first instance adjusted to deliver a certain quantity of dust to each cubic foot of air discharged into the combustion-chambers B B′, of such quantity as can be properly consumed in a given-sized generator. The proper proportions of air supplied through valves $a$ $a'$ $a''$ and $d$ $d'$ $d''$ for the perfect combustion of the carbon-dust having been ascertained, these valves are set in a proper position and are then left open in such position. A stop or check may be fixed to each of the valves, so that in case they are closed they will never open farther than the proper adjustment for the particular kind of carbon-dust being used. Should a change of material or dust be made, a readjustment of the air-valves can be easily made to suit the quality of dust being used. The valves having been properly adjusted there is nothing for the gas-operator in charge to do but to open and close the main air-supply valves, keep the dust-boxes supplied with carbon-dust, and keep the engine and blower running. Through the air-valves $a'$ $d'$ I supply just sufficient air for properly spraying the dust and admit the larger quantity for causing combustion through valves $a$ $a''$ and $d$ $d''$. The air admitted into the annular flues C C′ and F F′ is superheated and then discharged in even streams into the chambers B B′, causing instantaneous and perfect combustion of the carbon-dust without any waste, as is always the case where too much or too little carbon is supplied.

After the generator is fully heated up very little coal needs to be added to the bed of fuel on the grate, but, if desired, the fuel in chamber A may be freely burned in connection with the carbon-dust admitted above.

The properly proportioned and regulated supply of steam and carbon-dust for the manufacture of water-gas is effected in a manner similar to that employed in the admission of dust and air for heating the cupola. The steam, however, that is eventually used to generate water-gas is first used to operate the engine that works the spiral screw conveyer N″ for delivering dust in the proper proportion to the decomposing-chamber of the cupola. The cupola having been heated and the valves properly arranged for manufacturing water-gas, the engine L′ is started by opening steam-valves $t'$ $t''$ in the supply and exhaust pipes of the engine, the belt $r'''$ is shifted onto the tight pulley of the spiral-conveyer shaft, and the steam and dust are supplied to the decomposing-chamber, as before explained. The proper proportions and quantities of steam and dust are governed by the steam passing through the steam-cylinder of the engine that operates the spiral dust-conveyer, since each stroke of the steam-piston measures a certain quantity of steam under a uniform steam-pressure in such cylinder. The number of revolutions of the spiral conveyer is controlled by the speed of the engine in connection with the counter-shafts, pulleys, and belts above described. The steam-pressure in the steam-cylinder is regulated by the governor T″ to any desired pressure below that in the steam-boiler. For example, suppose that each revolution of the spiral dust-conveyer N″ delivers one pound of carbon-dust into the injector-chamber R, and that twenty pounds of carbon-dust are required to each one thousand feet of gas generated, and that the maximum produc-

tion of gas in the generator is two thousand cubic feet per minute, then the speed of the spiral conveyer is to be forty revolutions per minute. Now suppose the capacity of the steam-cylinder to be one cubic foot, and that the uniform steam-pressure in the cylinder is sixty pounds, and as one cubic foot of steam at sixty pounds pressure is equal to four cubic feet at atmospheric pressure, and as it requires about five hundred cubic feet of steam at the latter pressure to produce one thousand cubic feet of gas, then to produce two thousand cubic feet of gas per minute will require one thousand cubic feet of steam at atmospheric pressure, or two hundred and fifty feet at sixty pounds pressure. As each revolution of the driving-pulley on the engine measures two cubic feet of steam at sixty pounds pressure, then the speed of the engine should be one hundred and twenty-five revolutions per minute. With the above conditions it is easy to calculate the dimensions of the pulleys so as to give forty revolutions to the spiral conveyer to every one hundred and twenty-five revolutions of the engine per minute. These adjustments of parts, like those for air and dust, need to be made only once, after which they require no further attention except to see that the steam-pressure in the boiler is kept above that required for the steam-cylinder of the engine. The speed of the engine is regulated at valve $t''$ by the operator, or, to start with, by the size of the nozzle on the end of pipe $u''$ delivering steam to injector-chamber R.

No matter how fast or slow the engine is run the proportions of steam and carbon-dust continue the same, so that when the flues of the decomposing-chamber are at a high heat, so as to rapidly generate gas, then the desired quantity of carbureted steam can be supplied by simply opening steam-valve $t''$ a little more and gradually shutting off steam as the heat in the generator is lowered, the proportions of steam and carbon-dust continuing always the same. To effect a uniform steam-pressure in the steam-cylinder, I use my improved steam-valve governor connecting together the steam-inlet pipe and the exhaust-steam pipe between the valve $t'$ and the engine, so that the pressure in the exhaust-steam pipe is practically the same as it is in the inlet steam-pipe between governor T'', valve $t''$, and the engine, less the pressure necessary to run the engine and operate the spiral dust-conveyer N'', which difference in pressure would be nearly constant and should not make more than one or two pounds difference per square inch. The steam-pressure in the cylinder can be adjusted or changed by adding to or removing weights from the steam-governor to any desired pressure less than that in the steam-boiler. When, however, the pressure is changed, a readjustment of the speed of the carbon-dust conveyer will be necessary. Supposing the steam-governor be set to maintain sixty pounds steam-pressure in the steam-cylinder, then, for accurate working, it is only necessary to maintain the pressure in the steam-boiler above sixty pounds. The exhaust-steam after passing valve $t'$ may be passed directly into the steam-injector in chamber R, but when the carbureted steam is delivered into the top chamber of the generator I prefer that it be superheated.

It has heretofore been proposed to manufacture gas from steam and carbon-dust in a generating-furnace, but no provision was made for controlling or regulating the relative proportions of such dust and steam, and the dust was therefore liable to be fed at one time in an excessive quantity—that is, a quantity much greater than that required for decomposing the quantity of steam being supplied—resulting in clogging the heating-flues formed in the brickwork and interfering with the regular and systematic manufacture of gas. At another time a deficient proportion of carbon-dust would be fed as compared with the quantity of steam, and such steam would not therefore be properly decomposed. This difficulty is especially present in intermittent water-gas-generating furnaces where the temperature is constantly varying from a high degree at the commencement of each run to a lower and lower degree toward the end of the run. In such generating apparatus steam is always supplied rapidly and in large volume when the heat is high and is gradually reduced in quantity as the temperature is lowered. No provision, however, has heretofore been made for decreasing and regulating the volume or quantity of carbon-dust supplied to such furnaces in proportion to the varying volume of steam supplied thereto.

In my process of generating gas the carbon-dust and steam used are not only supplied to the generator in the proper proportions and quantity when the temperature is high, but the relative proportion of each is maintained substantially uniform, both decreasing in quantity alike as the temperature of the furnace is reduced.

My steam-governor shown in Fig. 4 can also be operated so as to assist in proportioning the steam and carbon-dust supplied to the generator. For instance, supposing the steam-boiler pressure to be one hundred pounds and the governor weighted to fifty pounds, and with this condition that there is too much dust being supplied to the amount of steam, then by adding more weights to the governor, thereby increasing the pressure to sixty pounds, about one-fourth ($\frac{1}{4}$) more steam is supplied to each revolution of the screw conveyer. In a similar manner the proportion of steam may be reduced by removing weights from the governor, thereby decreasing the pressure.

When it is desired to manufacture illuminating-gas, it is only necessary to spray in oil or benzin at any point in the lower portion of the heated flues or over the bed of fuel

toward the latter part of the run after the fire has partially cooled down, or the hydrocarbon oil may be sprayed in with the carbon-dust in sufficient quantities to produce a gas of the required candle-power.

All the steam-pipes connected with the steam supplied from the boiler to the generator must be protected by asbestos or other suitable material, so as to prevent condensation in the pipes.

The cupola-generator shown in Fig. 2 is somewhat modified in its construction and operation as follows: At its lower end it is provided with a water-jacket A′, surrounding the fuel-chamber, which jacket is connected by pipes $x'$ $x''$ with the boiler I. The injector-chamber R and steam-jet pipe $u''$ are arranged to discharge directly into the combustion-chamber B′ at about the middle of the cupola, while the exhaust-steam pipe $t$, leading from the engine, is conducted directly to the top of the cupola and the steam discharged into chamber B″, from whence it passes down through the highly-heated brick flues in chamber G′, where it is highly superheated. This superheated steam combines with the carbon-dust being blown into chamber B′ and the mixture passes down through the highly-heated flues in chamber G, where decomposition takes place, and then the resulting gases pass through the bed of fuel out through the take-off pipe, steam-boiler, and water-heater to the seal-box. By this method of conducting the operation the superheated steam either volatilizes or combines with all the carbon-dust and carries it down to the fuel-chamber. The carbon-dust may also be sprayed into chamber B directly over the surface of the fuel and steam admitted to the top of the cupola.

The stack above chamber B′ can be made of any desired height, so that products of combustion may pass out at the opening X at a temperature but little above that of the steam in the boiler.

Smaller generators suitable for factories, &c., may be constructed with a single fuel-chamber, one combustion-chamber B, and one chamber G, filled with refractory material.

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

1. A gas-generating apparatus comprising in combination a generating-furnace, having a supply-pipe for mingled carbon-dust and steam, a device for feeding carbon-dust, a device for measuring and feeding steam and mechanism connecting said devices for regulating the feed of both the dust and steam in uniform proportions, substantially as described.

2. A gas-generating apparatus comprising in combination a generating-furnace, a carbon-dust-feeding device, an air-feeding device and connecting mechanism for regulating the feed of dust and air in proper proportions for heating the furnace; also a dust-feeding device, a steam measuring and feeding device and mechanism connecting said devices for regulating the feed of dust and steam in uniform proportions for generating gas, substantially as described.

3. In combination with the decomposing-chamber of a cupola gas-generator, a carbon-dust feed-box and conveyer, a connected injector-chamber, an engine connected by suitable gearing with the dust-conveyer, and also connecting by means of its exhaust-steam pipe with the injector-chamber, and a pipe connecting the latter chamber with the cupola, substantially as and for the purpose described.

4. The combination with a cupola-generator, an injector-chamber, having a supply-pipe and conveyer for carbon-dust and a steam-jet pipe, of a dust-pipe leading from the discharge end of the injector-chamber into the cupola and a return or circulating pipe leading from the cupola into the inlet end of such injector-chamber substantially as and for the purpose described.

5. In combination with the combustion-chamber of a cupola-generator the two annular air-distributing flues provided with ports arranged at top and bottom of such chamber, and a carbon-dust-supply pipe with conveyer and blast-pipe connecting directly with the combustion-chamber between the annular air-distributing flues substantially as and for the purpose described.

6. The combination with a cupola gas-generator, a carbon-dust feed-box, a feed-pipe connecting it with the cupola-generator, and a screw conveyer arranged in such box and feed-pipe, of an air-blower, a pipe leading from such blower and connected with the discharge end of the dust-pipe below said screw conveyer, and a steam-engine connected by suitable gearing with both the dust-conveyer and the air-blower for supplying proper proportions of carbon-dust and air to the combustion-chamber of the generator, substantially as described.

7. The combination with a generating-cupola of a carbon-dust feed-box, a dust-conveyer and feed-pipe connecting said box with the cupola, a steam-engine, operating-gearing connecting said engine with said dust-conveyer, a steam-supply pipe to the engine, and an exhaust-pipe leading therefrom to said dust-feed pipe connecting the feed-box with the cupola, and a steam-governor as T″ connecting by separate valved pipes with said steam supply and exhaust pipes of the engine, whereby the relative proportions of steam and carbon-dust supplied to the cupola will be constantly maintained, substantially as described.

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

JOHN L. STEWART.

Witnesses:

ROBERT A. MCCALL,

C. L. GODDARD.