(No Model.) 3 Sheets—Sheet 1.

C. D. HAUK.

MANUFACTURE OF ILLUMINATING GAS.

No. 572,703. Patented Dec. 8, 1896.

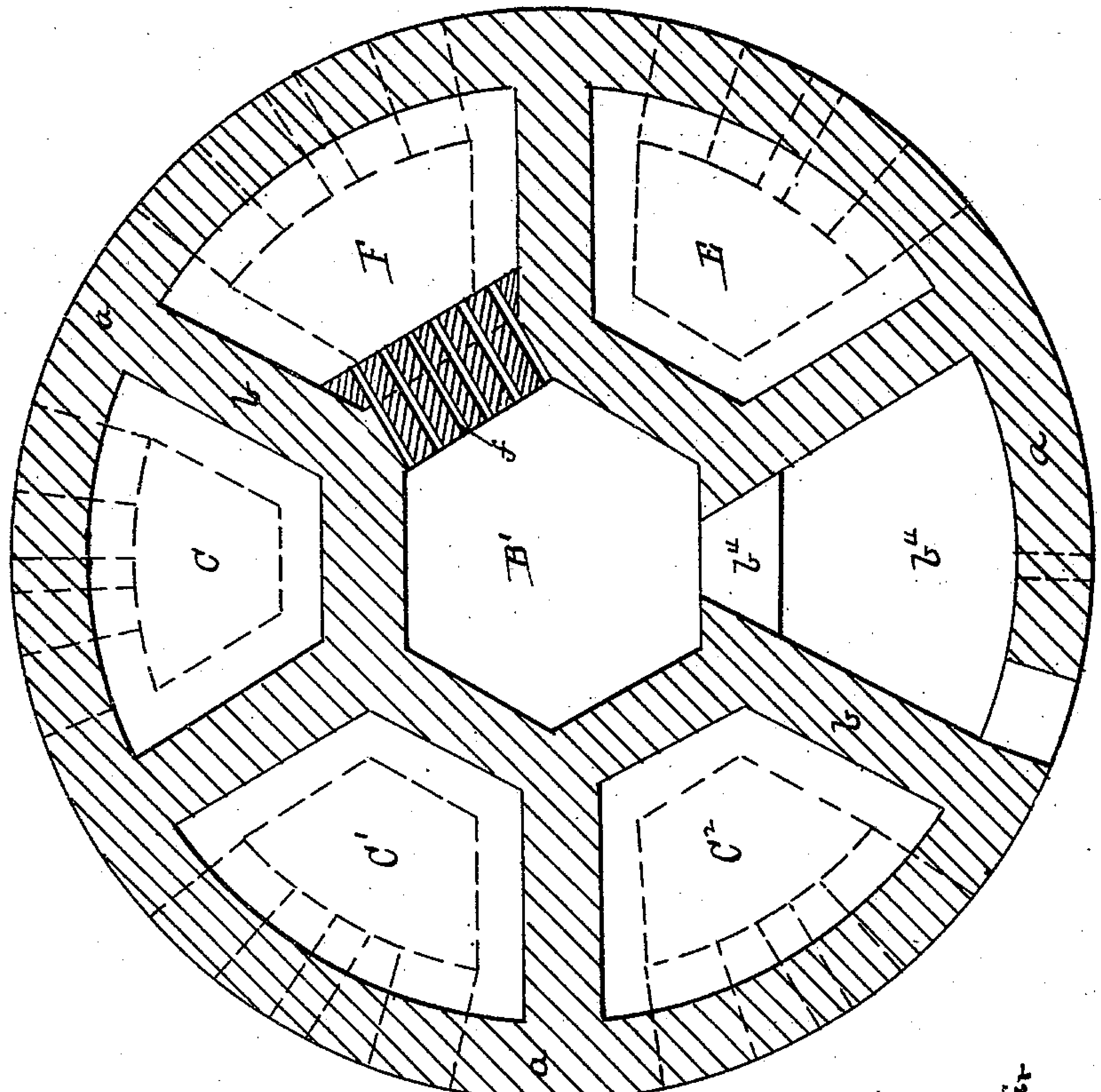

Fig. 3

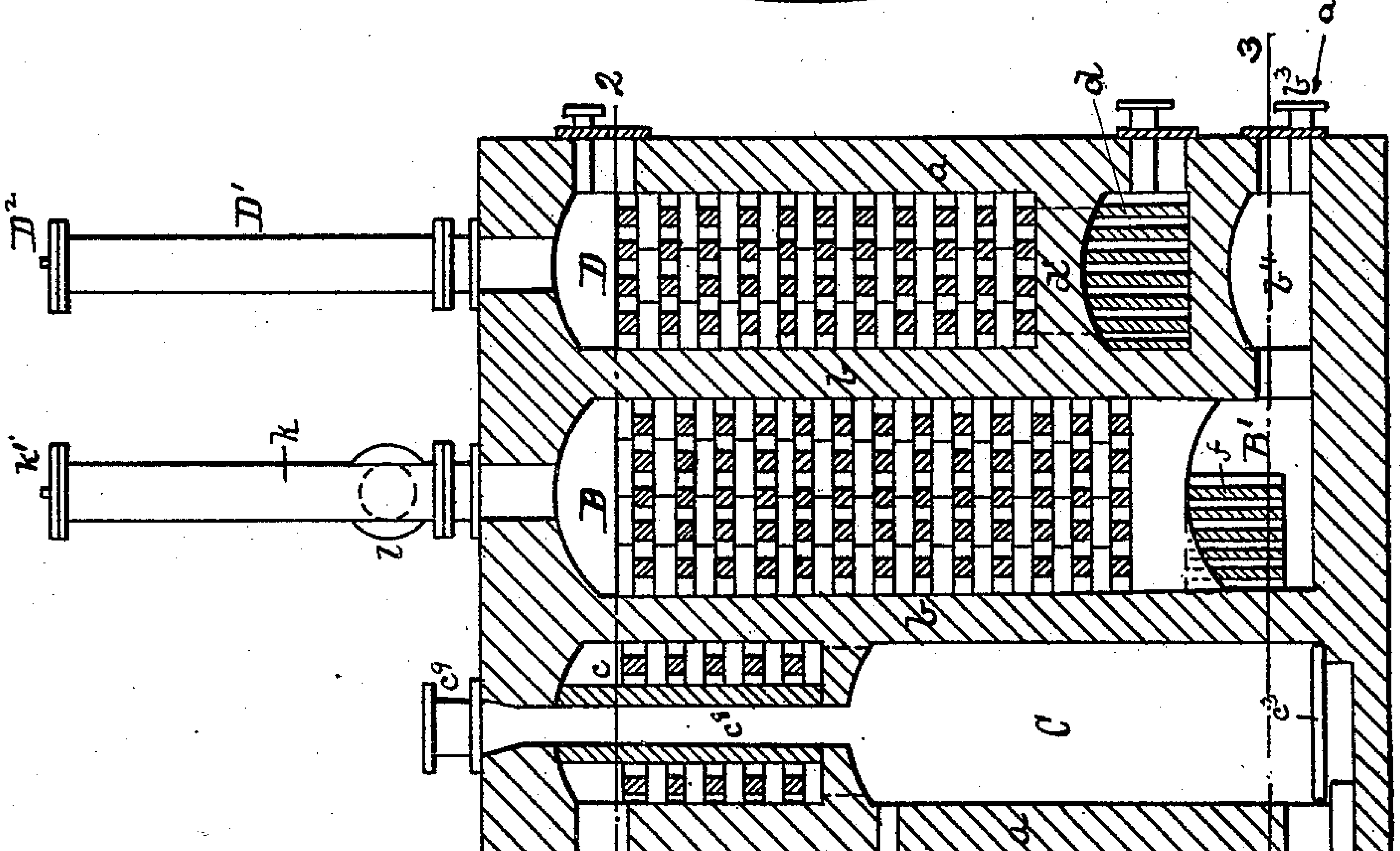

Fig. 1

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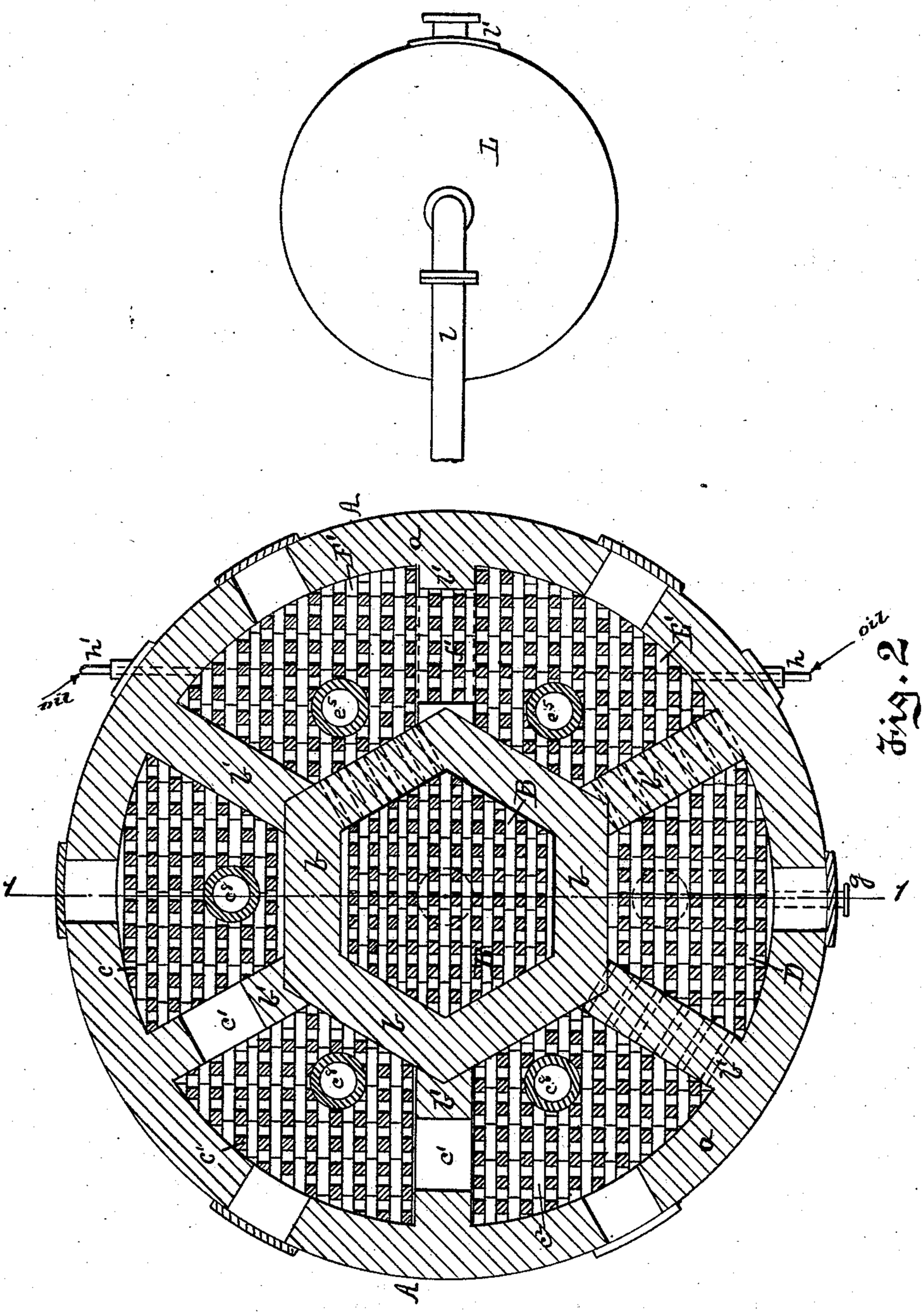
(No Model.) 3 Sheets—Sheet 2.

C. D. HAUK.

MANUFACTURE OF ILLUMINATING GAS.

No. 572,703. Patented Dec. 8, 1896.



Witnesses
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(No Model.) 3 Sheets—Sheet 3.

C. D. HAUK.

MANUFACTURE OF ILLUMINATING GAS.

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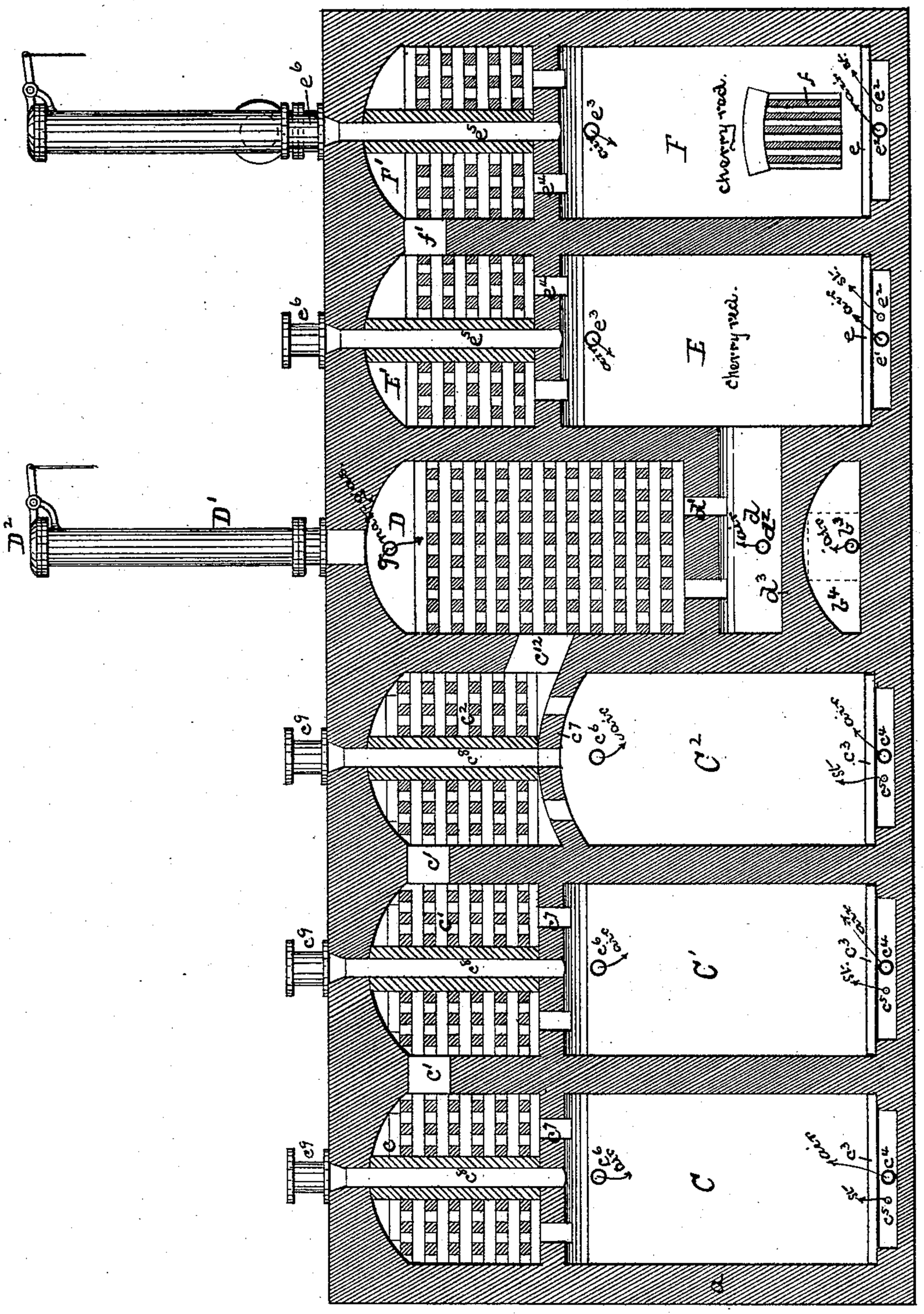

Fig. 4.

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UNITED STATES PATENT OFFICE.

CHARLES D. HAUK, OF CHICAGO, ILLINOIS.

MANUFACTURE OF ILLUMINATING-GAS.

SPECIFICATION forming part of Letters Patent No. 572,703, dated December 8, 1896.

Application filed April 8, 1895. Serial No. 545,018. (No model.)

To all whom it may concern:

Be it known that I, CHARLES D. HAUK, a resident of Chicago, in the county of Cook and State of Illinois, have invented a new and useful Improvement in the Manufacture of Illuminating-Gas; and I do hereby declare the following to be a full, clear, and exact description thereof.

My invention relates to the manufacture of illuminating-gas, and has special reference to the employment of natural gas as the base of the illuminating-gas.

Natural gas, wherever obtained, has been found to be composed very largely of marsh-gas containing eighty-five per cent. or more of this marsh-gas, and, while having high heating powers, burns as an illuminant with a blue flickering flame having very low illuminating powers. The reason for this is believed to be that there is not present sufficient free hydrogen to give toughness thereto and to maintain a steady flame, or sufficient carbon held in suspension to give proper illuminating power by its incandescence.

The object of the present invention is to provide a process of treating natural gas and combining it with other gases in such way as to form a fixed illuminating-gas of high candle-power.

The process may be briefly described as heating and expanding natural gas and intermingling and combining it with gas generated from coal and passing the combined gases through a body of heated carbon, so as to enable the gases to continue the reaction or chemical change between the expanded natural gas, and the nascent coal-gases while in the presence of the heated carbon also take up with the gases particles of carbon in suspension, then introducing hydrocarbon into the combined gases and fixing the gases, such as by passing them through another body of heated carbon, and, if desired, finally through a body of heated refractory material.

My invention also comprises certain steps in the manufacture of the gas as well as certain improvements in the apparatus for the manufacture of the same, all of which will be hereinafter described and claimed.

To enable others skilled in the art to practice my invention, I will describe the same more fully, referring to the accompanying drawings, in which—

Figure 1 is a vertical section of the apparatus on the line 1 1, Fig. 2. Fig. 2 is a cross-section on the line 2 2, Fig. 1, showing also in plan view the eduction-pipe and thermal storage-tank. Fig. 3 is a cross-section on the line 3 3, Fig. 1; and Fig. 4 is a vertical sectional view of the outer chambers arranged consecutively to more clearly illustrate the apparatus and the gas-making process.

Like letters of reference indicate like parts in each view.

In practicing the invention I employ one or more gas-generators and one or more carbon-chambers for treating and fixing the gas and a highly-heated mass of refractory material, in which the natural gas is first expanded and the nmingled with the coal-gases. I first expand the natural gas by suitable means, and at the same time intermingle and combine therewith nascent coal-gases, preferring to introduce both water-gas and gas distilled from coal obtained in the water-gas generator by passing steam through the incandescent coal and also at intervals dropping small regulated quantities of bituminous coal onto the incandescent mass and so distilling off the hydrocarbons therefrom.

The expanded natural gas and the nascent coal-gases at high heat are thus brought together under conditions which lead to a chemical change thereof, changing the character of the natural gas and increasing its volume and toughness. These combined gases I prefer to intermingle in a mass of highly-heated refractory material, and I then carry them through a mass of heated carbon, such as bituminous coal, after which I introduce into them at one or more points, by a steam-jet or other suitable means, a suitable body of liquid hydrocarbon to unite with the gas resulting from the coal and natural gas, the whole being passed through another body of heated coal or carbon and finally through a highly-heated refractory material. For this purpose any suitable apparatus may be employed, but that illustrated in the drawings has certain advantages, and I will now describe it.

The apparatus is contained within a suit-

able casing, which is circular in form, and, as shown in the several cross-sections, has the lining *a* within the casing A, said lining being formed of brickwork, and within the same the hexagonal cylindrical chamber B, which forms the final fixing-chamber, the walls of which extend from the base of the apparatus to the top wall, forming the hexagonal cylinder *b*, as shown. Extending radially from the angles of said central hexagonal cylinder to the interlining *a* are the walls *b'*, which divide the interior of the apparatus around the central chamber B into six chambers, three of which contain gas-generators C C' C², with superheaters *c c' c²* above them, as hereinafter described, the chamber D forming the natural-gas-heating chamber and the mixing-chamber and being filled with checker-work, the chamber E being one of the coal-treating chambers and the chamber F being the other coal-treating chamber, these coal-treating chambers having above them carbureting-chambers E' and F' filled with checker-work. The three generating-chambers C C' C² and the three superheating-chambers *c c' c²* above them are of the same construction, said several generating and superheating chambers being constructed practically as follows: In the lower part of each generating-chamber, below the grate-bars c^3, are the air-inlet pipe c^4 and the steam-pipe c^5, and in the upper end of the generating-chamber is the air-inlet pipe c^6. Above the chamber is the perforated arch c^7, which supports the checker-work in the superheater, and passing centrally through the superheater is the chute c^8, which passes from the top of the casing down through the same, so as to feed the coal into the generator, the coal-chute having above it a suitable coal-feeder c^9, which can be of any desired construction, so as to provide for the feeding of the coal into the chambers without permitting the escape of the gas.

To form communication between the several superheaters, the ports c^{14} are formed between the upper parts of the superheaters, and the superheater c^2 has a port c^{12} near the arch c^7 at the base of the same, leading into the natural-gas-expanding chamber D. This chamber D is supported upon the perforated arch *d'* and has below it the combustion-chamber *d*, the combustion-chamber having the air-inlet pipe d^2. Below the combustion-chamber is the solid arch d^3, which provides for communication with the central combustion-chamber B' under the final fixing-chamber B, giving access thereto through the passage-way b^4 under the arch d^3, and an air-inlet pipe b^3 for admitting air to the central chamber, communicating with or passing through the passage-way b^4. Above the expansion-chamber D is the relief-pipe D', closed at the upper end by a suitable cap D². Communicating with the upper end of this expansion-chamber is the natural-gas-inlet pipe *g*, and it will be seen that the checker-work in the expansion-chamber D extends some distance above the port c^{12} from the superheater c^2, so that the natural gas is compelled to pass through the body of heated checker-work before it intermingles with the coal-gases in the lower part of the expansion and mixing chamber D.

The chambers E and F are coal-chambers, and they each have below the grate-bars *e* the air-inlet pipe *e'* and the steam-pipe e^2 and in the upper part thereof the inlet-pipe e^3 for the admission of air, while the perforated arch e^4 supports the checker-work in the carbureting-chamber E' or F'. Passing through each carbureting-chamber is the coal-chute e^5, of the same construction as those described above and having a like coal-feeder e^6. In the upper end of the carbureting-chamber E' is the oil-injector *h*, and in the upper end of the carbureting-chamber F' is the oil-injector *h'*. Forming communication between the two carbureting-chambers is the port *f'*. The combustion-chamber *d* below the expansion-chamber D communicates by a grating (preferably formed of a series of pillars) with the coal-chamber E, some distance above the grate-bars *e*, so that the gases can pass therefrom into the coal some distance above the grate-bars, entering the coal where it is not at too high a heat.

In the lower end of the coal-chamber F, above the grate-bars, is the exit-port *f*, which has a like grating over the same, the gas passing through this exit-port into the central or fixing chamber B. Leading from the upper end of the chamber B is the pipe *k*, having at the upper end thereof a relief-cap *k'*, and leading from this pipe *k* is the eduction-pipe *l*, which leads into the thermal storage-tank L, having at the base thereof the outlet-pipe *l'*, which leads to the scrubbers and finally to the gas-holder. Suitable doors or openings are provided for communication with the several chambers surrounding the central fixing-chamber, which need not be referred to.

To first heat up the apparatus ready for making gas, the following course is preferably followed: Fires are started in the several generating-chambers and coal-chambers, and as soon as well ignited the bodies of coal are built up within said chambers and a blast of air through the air-pipes at the base of the chambers turned on, and the gas so formed is ignited by blasts at the upper ends of the several generator and coal chambers. The relief-cap of the pipe D' above the expansion-chamber D is opened, but the relief-cap of the pipe *k* above the central fixing-chamber is kept closed. The gases from the several generators are then burned within the several superheating-chambers and are carried over into the expansion-chamber D, passing from the port c^{12} upwardly through the same to heat the upper part of the checker-work therein. At the same time air is admitted to the combustion-chamber *d* and the gases

formed in the chamber F are burned to heat the checker-work in the carbureting-chambers F′ and E′ and pass down into the coal in the chamber E and pass with the gases formed in the chamber E into this combustion-chamber *d* and are burned therein and pass upwardly through the lower part of the checker-work in the chamber D. This is continued for a suitable period to heat the expansion-chamber D, and the relief-pipe D′ is then closed and the relief-pipe K above the central chamber B is opened, when all the gases and heated products pass through the chamber D and upwardly through the chamber E and are burned in the upper part thereof and serve to heat up the checker-work in the carbureting-chambers E′ and F′, passing thence downwardly through the body of coal in the chamber F and passing with the gases formed therein through the part *f* and into the central fixing-chamber B. The gases present are then burned in the central combustion-chamber B′, air being admitted for the purpose through the air-pipe b^3, the products of combustion passing through the perforated arch into the fixing-chamber B and escaping through the relief-pipe *k*.

The relief-caps are so manipulated as to provide for the heating of the several bodies of coal and checker-work according as it is found necessary, the coal in the generators being raised to a high heat, the several superheating-chambers being raised to as high a heat as practicable, the checker-work in the expansion-chamber D being raised to a temperature of about 1,200° Fahrenheit, the coal in the carbureting-chambers E F being raised to about a cherry red, the carbureting-chambers E′ F′ brought to the proper temperature for carbureting gases, and the final fixing-chamber being brought to the proper heat for fixing the combined gases. The air is then cut off and steam is then admitted to the generator C^2, forming water-gas therein, which passes over into the expansion-chamber D. At the same time natural gas in proper proportion is admitted to the top of the expansion-chamber D and passes down through the upper part of the checker-work therein and mingles with the water-gas, and as the gas-making continues steam is admitted successively to the generators C′ C, the gases formed passing into the superheaters *c c′* and passing over through the superheaters and thence into the expansion-chamber D, the proportion of natural gas being increased as these gases come over, and it being expected to employ about one-third the volume of natural gas in proportion to the coal-gas formed. The natural gas is expanded to many times its volume in the chamber D, and the superheated coal-gases entering into the chamber D serve to assist in heating and expanding the natural gas and maintaining the heat in the chamber for that purpose.

At intervals, from time to time, small regulated quantities of coal are dropped through the coal-chutes into the generators, and in passing into the same the hydrocarbons contained therein are quickly distilled from the coal, and the hydrocarbon vapor or gas so obtained passes over with the water-gas into the expansion-chamber, the coal or distilled gases being liberated by the high heat of the coal within the generators as well as by the heat of the walls of the chambers and of the coal-chutes themselves, which are very highly heated. This part of the process is well adapted for the making of distilled or coal gas with water-gas in the process where natural gas is not employed, and is intended to be covered when so employed. As a result, the gases mingling in the chamber D are heated and expanded natural gas, water-gas, and distilled or coal gas, the natural gas being highly heated and expanded and brought into condition to unite with the other gases, while the other gases are in a nascent state, and therefore more ready to unite with the expanded natural gas, and in this expansion-chamber the natural gas, (marsh-gas,) which in its natural state is compressed into less than half the volume of its constituents, is permanently expanded and united with the hydrogen, hydrocarbons, and carbonic oxid of the coal and water gases, so that as the gases are brought together at a high heat and in an expanded and nascent state, and a chemical change takes in all of the gases, the free hydrogen uniting with the carbons of the natural gas and producing a gas which is high in hydrocarbon, while a sufficient body of free hydrogen is obtained for the gases to provide for a steady and regular flame in the resultant gas, a tough and steady gas being thus produced. The gases pass down from the expansion-chamber into the combustion-chamber *d*, and thence pass into the upper part of the coal-chamber E, passing up through the same into the carbureting-chamber E′, and in passing through the body of heated coal therein they take up particles of carbon therefrom and hold them in suspension, so providing for the particles of free carbon, which increase the incandescence of the resultant gas, and at the same time, as the combined gases pass through, the chemical change continues in the body of highly-heated coal, the combination between the nascent and expanded gases being facilitated in the presence of the coal, while any carbonic acid present is converted into carbonic oxid. If the coal in the lower part of this chamber E is highly heated, a small portion of steam may also be admitted there to generate water-gas, which mingles with the other gases. The gases then pass into the carbureting-chamber, into which oil, or other hydrocarbons, is introduced through the pipe *h*, which is quickly vaporized and combines with the gases passing through the chamber and passes over into the second carbureting-chamber F′, into which another portion of oil is introduced in like manner, the hydrocarbon combining with the gases so

formed and enriching the gases, so as to add to their illuminating power, the proportion of hydrocarbon so introduced into the two carbureting-chambers of course depending upon the candle-power desired. The combined gases then pass down through the second body of heated coal in the chamber F, where any steam remaining undecomposed, such as that introduced with the oil, is converted into water-gas, and in which any heavy hydrocarbons are also gasified and mingled with the resultant gas.

To insure the fixing of all the gases, they are passed through the final fixing-chamber B, by which a suitable illuminating-gas is insured. For the making of the gas, however, either the second coal-chamber F or this final fixing-chamber may be omitted, both such chambers being employed simply to insure the formation of a stable fixed illuminating-gas. During the process where the coal in the chambers E and F is at a high heat I may, if desired, introduce at intervals small regulated quantities of coal, so as to distil off the hydrocarbons therefrom and to coke the same, as above described in connection with the gas-generators C C′ C².

The gas is carried from the apparatus through the eduction-pipe *l* and may be taken through the thermal storage-tank and thence through suitable scrubbers to the regular storage-tank.

To reheat the apparatus after it is cooled down, the eduction-pipe is closed and the cap of the relief-pipe D′ is first opened and air is admitted at the bases of the several generators and coal-chambers and at the upper ends of the same as well as at the base of the expansion-chamber D, and in this way burning the gases and passing them upwardly into and through the expansion-chamber, this being continued for a few minutes when the cap of the relief-pipe D′ is closed and the cap of the relief-pipe *k* over the central fixing-chamber is opened and the gases and heated products are passed into and burned again in the central fixing-chamber for a few minutes to heat it, when the air-pipes are all closed, the relief-pipe *k* is closed, and the eduction-pipe opened and gas is made as above described.

The apparatus has the further advantage that it may be employed in the making of gas without the employment of natural gas, in which case I prefer to introduce part, at least, of the oil in the expansion-chamber D, generating the gases in the three generators, carbureting them, and then passing them through the bodies of heated coal, and during their passage through the carbureting-chambers introducing further portions of hydrocarbons, if desired.

In employing natural gas, by expanding it and mixing it with the nascent coal-gases, so that a chemical union therewith is formed through the reaction between the gases, the natural gas is so utilized that the full volume of its constituents, which is more than double of natural gas, is obtained, while the gas is rendered tough and a steady flame obtained therefrom through the hydrogen introduced and the lighter hydrocarbons formed, and a fine illuminant, burning well in the ordinary burner, is obtained, and as about one-third of the volume is formed from the natural gas a very cheap gas can be produced.

While the apparatus described is well adapted for the practicing of the processes above described, other forms of apparatus suitable for the purpose may be employed in carrying out the process or the steps of the process covered.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The process of forming illuminating-gas, consisting in heating and expanding natural gas, generating gas from coal, and superheating the same, and intermingling and combining the natural gas with the coal-gas so obtained, and passing the combined gases through a body of heated carbon, introducing hydrocarbons into the combined gases and then passing the gases and vapors through another body of heated carbon and then through a mass of heated refractory fixing material, substantially as set forth.

2. The process of forming illuminating-gas, consisting in heating and expanding natural gas, passing steam through a mass of heating carbon and forming water-gas and at intervals during the formation of the water-gas dropping small regulated quantities of bituminous coal onto the mass of incandescent coal, superheating the gases so obtained and intermingling and combining them with the natural gas, passing the combined gases through a body of heated carbon, introducing hydrocarbons into the combined gases and then passing the gases and vapors through another body of heated carbon and then through a mass of heated refractory fixing material, substantially as set forth.

3. As steps in the process of forming illuminating-gas, heating and expanding natural gas, generating gas from coal, and superheating the same, intermingling and combining the natural gas with the coal-gas so obtained, and passing the combined gases through a body of heated carbon, introducing hydrocarbons into the combined gases, and fixing the gases and vapors, substantially as set forth.

4. As steps in the process of forming illuminating-gas, heating and expanding natural gas, generating gas from coal, and intermingling and combining the natural gas with the coal-gas so obtained, passing the combined gases through a body of heated carbon, introducing hydrocarbons into the combined gases, and fixing the gases and vapors, substantially as set forth.

5. As steps in the process of forming illuminating-gas, heating and expanding natural gas, generating gas from coal, intermingling and combining the natural gas with the coal-

gas so obtained, passing the combined gases through a body of heated carbon, introducing hydrocarbons into the combined gases, and then passing the gases and vapors through another body of heated carbon, substantially as set forth.

6. As steps in the process of forming illuminating-gas, heating and expanding natural gas, generating gas from the coal interminglingand combining the natural gas with the coal-gas so obtained, introducing hydrocarbons into the combined gases, and then passing the gases and vapors through a body of heated carbon, substantially as set forth.

7. As steps in the process of forming illuminating-gas, passing natural gas through the body of heated refractory material, and generating gas from coal and superheating the same, and carrying the superheated coal-gas into the same body of refractory material with the natural gas to assist in expanding the natural gas and maintaining the heat thereof and to combine therewith, substantially as set forth.

8. A gas apparatus inclosed within a vertical cylindrical casing having a central fixing-chamber provided with a gas-eduction pipe leading through the top body thereof, and around the same a series of gas generating and treating chambers on the same general horizontal plane, said chambers communicating with each other successively, and one of the chambers communicating with the central chamber, substantially as set forth.

9. A gas apparatus inclosed within a vertical cylindrical casing having a central fixing-chamber and around the same a series of gas generating and treating chambers, said chambers communicating with each other successively, and one of the chambers communicating with the central chamber, and a passage-way leading under one of the outer chambers into the base of the central fixing-chamber to give access thereto, substantially as set forth.

10. A gas apparatus inclosed within a vertical cylindrical casing, having a series of generators provided with superheating-chambers above them, containing refractory material, a mixing-chamber with which one of the superheaters communicates and which opens into the side of a heating-chamber for containing carbon, a second such heating-chamber containing carbon, carbureting-chambers above said two chambers communicating with each other and passages leading from the second chamber containing carbon, substantially as set forth.

11. A gas apparatus inclosed within a vertical cylindrical casing having a central fixing-chamber and around the same a series of gas generating and treating chambers, said chambers communicating with each other successively and one of the chambers communicating with the central chamber, and relief-pipes leading from the central fixing-chamber and from one of the gas-treating chambers, substantially as set forth.

12. A gas apparatus, having a series of generators provided with superheaters above them containing refractory material, a mixing-chamber with which one of the superheaters communicates, said chamber containing refractory material, and having a natural-gas inlet at the upper end thereof, and the lower end of said chamber opening into the side of a heating-chamber for containing carbon, substantially as set forth.

13. A gas apparatus having a series of gas-generators provided with superheaters above them, containing refractory material, a mixing-chamber, containing refractory material and having a natural-gas-inlet pipe at the upper end thereof, a port opening from one of the superheaters into the side of the mixing-chamber below the top of the refractory material, substantially as set forth.

14. A gas apparatus having a central fixing-chamber and around the same a series of gas-generators and treating-chambers communicating with each other successively, one of said chambers containing the refractory material and having at the base thereof a combustion-chamber, having a side opening therefrom, and having a passage-way leading under said combustion-chamber into the base of the central fixing-chamber to obtain access thereto, substantially as set forth.

In testimony whereof I, the said CHARLES D. HAUK, have hereunto set my hand.

CHARLES D. HAUK.

Witnesses:

JAMES I. KAY,

ROBERT C. TOTTEN.