6 Sheets—Sheet 1.

H. AITKEN & W. YOUNG.

Process for Manufacturing Illuminating-Gas.

No. 198,725. **Patented Dec. 25, 1877.**

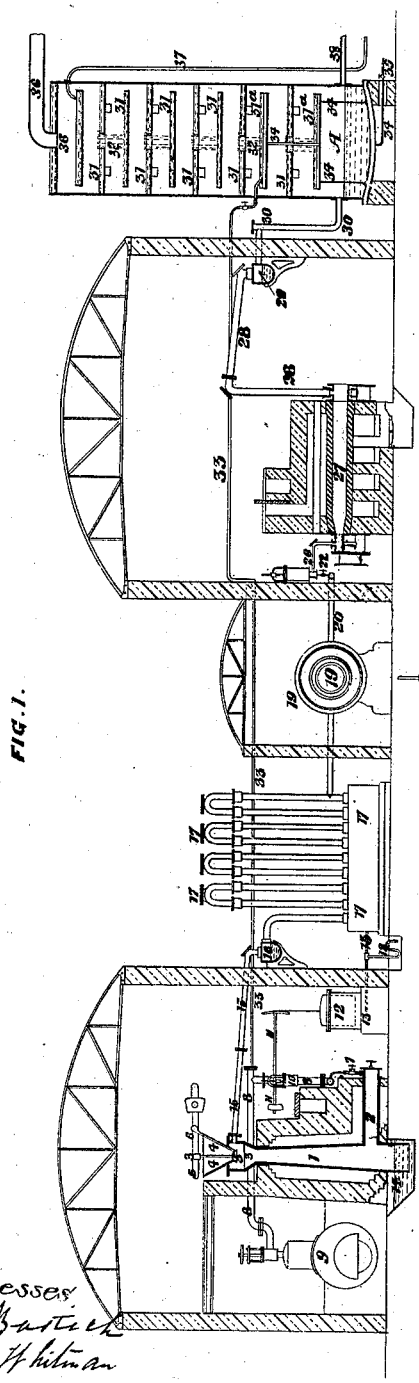


FIG. 1.

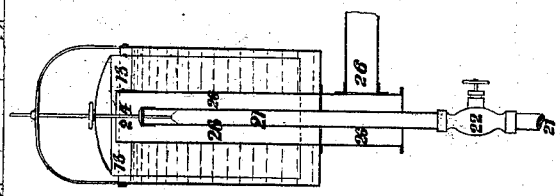


FIG. 2.

Witnesses
Ch. H. Bartlett
L. B. Whitman

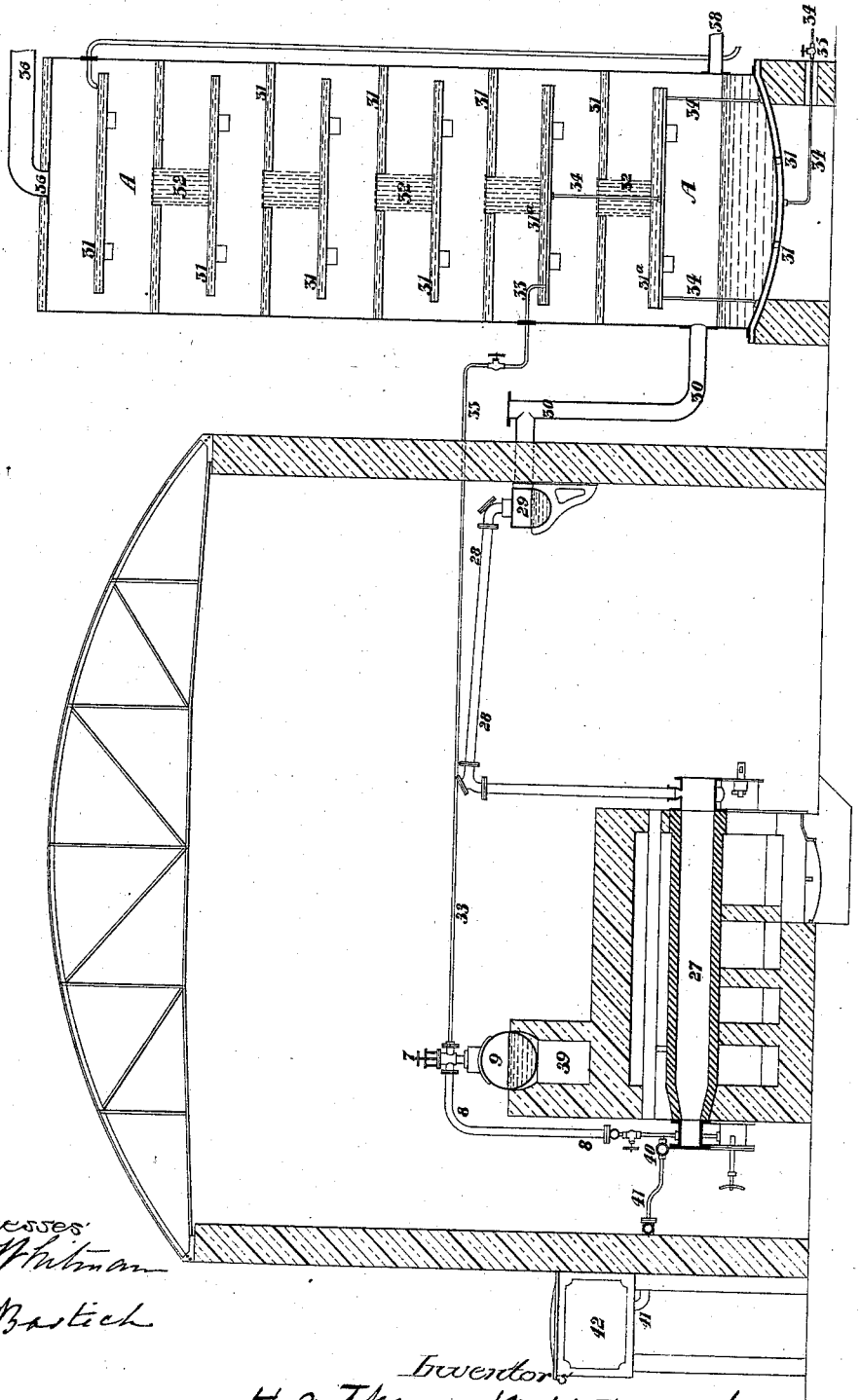
Inventors
H. Aitken
W. Young, by
C. S. Whitman
atty

6 Sheets—Sheet 2.

H. AITKEN & W. YOUNG.

Process for Manufacturing Illuminating-Gas.

No. 198,725. **Patented Dec. 25, 1877.**



Witnesses:
R. B. Whitman
A. M. Bostick

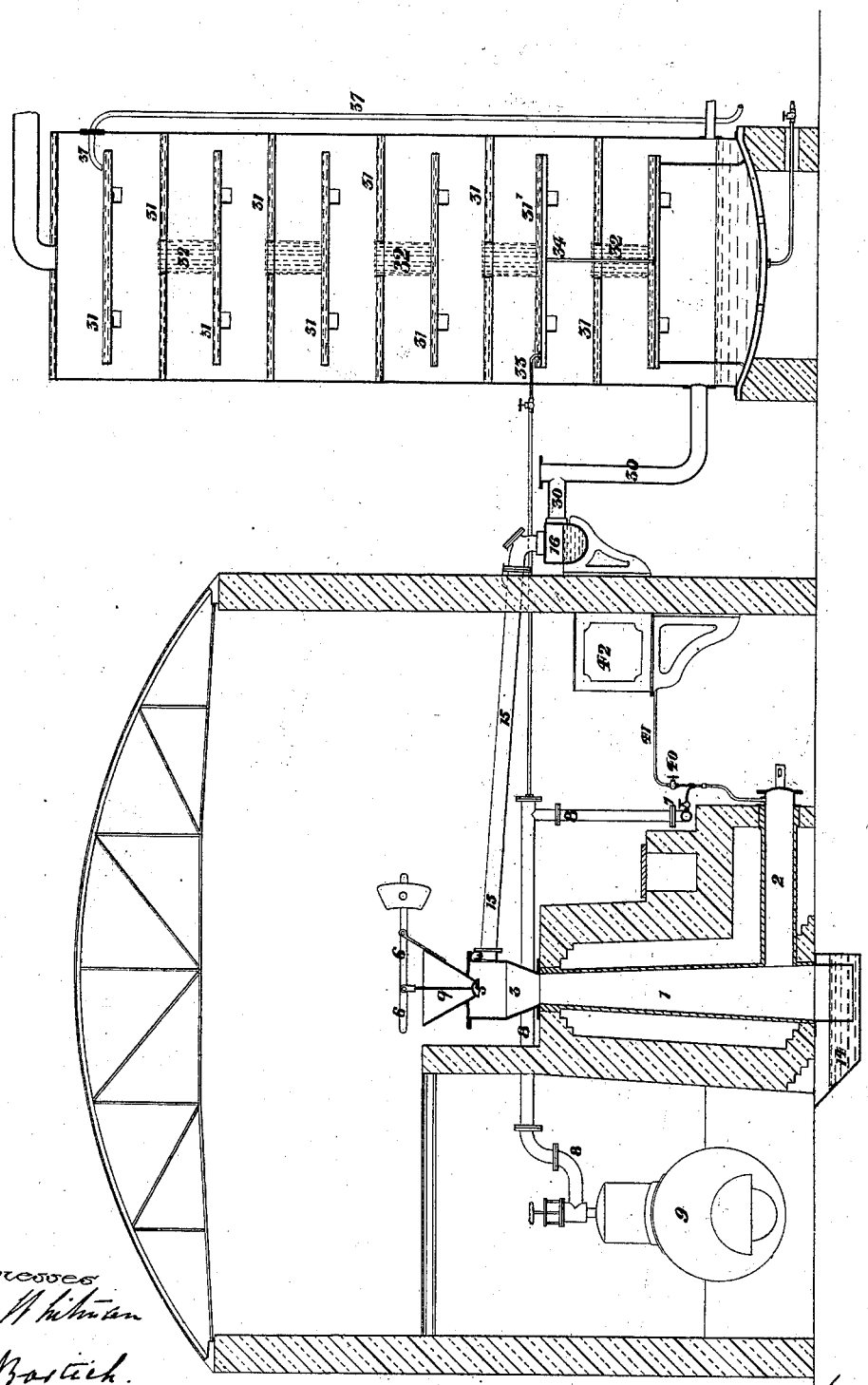
Inventors:
H Aitken. W Young by
C. S. Whitman atty

6 Sheets—Sheet 3.

H. AITKEN & W. YOUNG.

Process for Manufacturing Illuminating-Gas.

No. 198,725. **Patented Dec. 25, 1877.**



Witnesses
A. B. Whitman
M. M. Bostick.

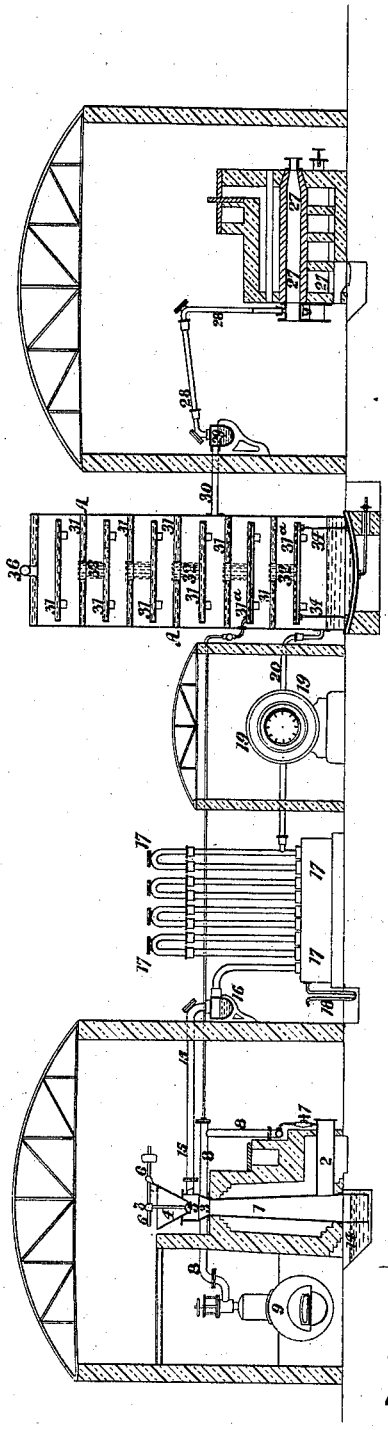
Inventors H. Aitken and W. Young by
C. S. Whitman atty

6 Sheets—Sheet 4.

H. AITKEN & W. YOUNG.

Process for Manufacturing Illuminating-Gas.

No. 198,725. **Patented Dec. 25, 1877.**



Witnesses
R. B. Whitman.
A. R. Bostick

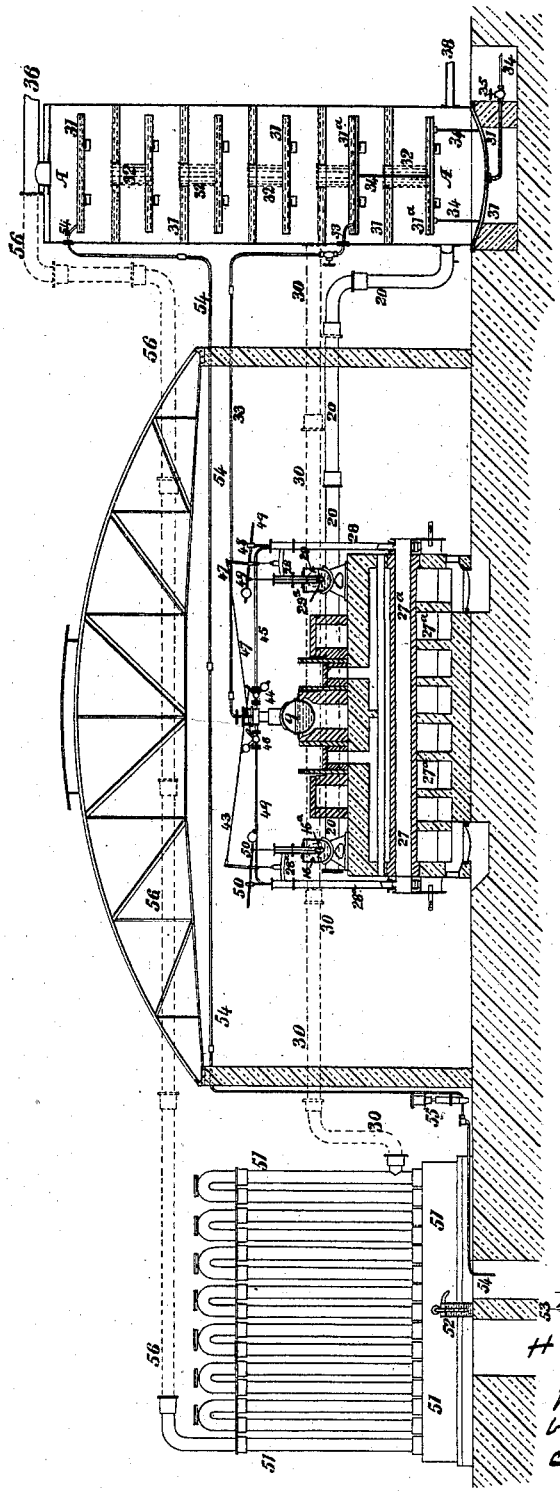
Inventors
H. Aitken
W. Young by
C. S. Whitman
atty

6 Sheets—Sheet 5.

H. AITKEN & W. YOUNG.

Process for Manufacturing Illuminating-Gas.

No. 198,725. **Patented Dec. 25, 1877.**



Witnesses
L. B. Whitman.
M. M. Bostick.

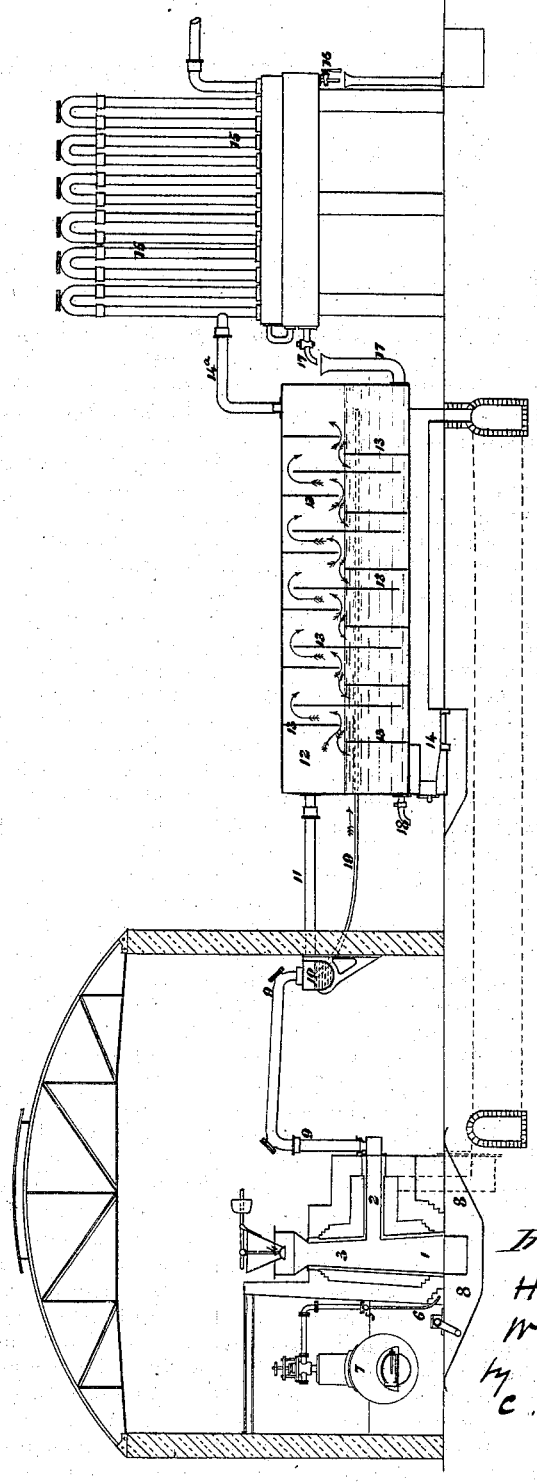
Inventors
H Aitken
W Young
by C S Whitman
atty

6 Sheets—Sheet 6.

H. AITKEN & W. YOUNG.

Process for Manufacturing Illuminating-Gas.

No. 198,725. **Patented Dec. 25, 1877.**



Witnesses
N. B. Whitman.
Wm. M. Baskirk

Inventors
H. Aitken
W. Young
by C. S. Whitman
atty

UNITED STATES PATENT OFFICE.

HENRY AITKEN, OF FALKIRK, AND WILLIAM YOUNG, OF CLIPPENS, NORTH BRITAIN.

IMPROVEMENT IN PROCESSES FOR MANUFACTURING ILLUMINATING-GAS.

Specification forming part of Letters Patent No. **198,725**, dated December 25, 1877; application filed September 2, 1876.

To all whom it may concern:

Be it known that we, HENRY AITKEN, of Falkirk, in the county of Stirling, North Britain, coalmaster, and WILLIAM YOUNG, of Clippens, in the county of Renfrew, North Britain, oil-works manager, have invented Improvements in the Manufacture of Illuminating-Gas, of which the following is a specification:

This invention, which relates to improvements in the manufacture of illuminating-gas, has for its object as follows: First, to effect the more perfect and complete application for the manufacture of illuminating-gas of the liquid volatile hydrocarbons produced and ordinarily left in the tars when coal, shale, hydrocarbon oils, resin, or other bituminous substances are destructively distilled for the production of illuminating-gas; and, secondly, to effect the economical use of the fixed carbon contained in the coke resulting from the destructive distillation of bituminous substances having combined or mixed with them a large quantity of mineral matter, and also to remove and utilize the carbon deposited in and on the surface of gas-retorts.

The accomplishment of the aforesaid objects constitutes, essentially, the practical working of what is well known to gas-engineers as the "hydrocarbon process," the difficulty hitherto experienced in the practical or commercial working of which has principally been the production of a gas having a uniform illuminating power. This difficulty arises from the want of efficient means for regulating the supply of the hydrogen or other gas necessary to take up the hydrocarbons produced from the bituminous substance as it undergoes distillation.

With any of the forms or arrangements of apparatus hitherto employed it has been essential that the water-gas should be passed into the bituminous retort while the bituminous substance is undergoing distillation, or mingled with the warm crude bituminous gases as they are produced, and in as near as possible the proportion necessary to combine at once with the hydrocarbon vapors as they are produced from the bituminous substance, for, in the event of the water-gas being in too large a quantity, the resulting mixed gases have been deteriorated in their illuminating power by diluting the bituminous gases too much. On the other hand, in the event of the water-gas being deficient in quantity, the hydrocarbons have not been all taken up and diffused through the mixed gases, and have therefore been condensed and removed by the tars. As during the distillation of a charge of coal the hydrocarbons produced suitable for being so taken up by water-gas are constantly altering in quantity, being most abundant at the early stages of the distillation, and gradually diminishing until, in the latter stages, they are almost entirely wanting, it is easily perceived that considerable difficulty occurs in regulating the supply of water-gas.

By the present invention those defects are obviated, or in a great measure modified, and the hydrocarbon process made a valuable one, by utilizing the means hereinafter described.

Figure 1, Sheet 1, is a section, partly in elevation, of an arrangement of apparatus for the manufacture of water-gas, (hydrogen and carbonic oxide,) or other gas having a low illuminating power, in one set of retorts, which is afterward passed through a second set of retorts, in which bituminous coal or other similar substance is being distilled, and the combined gases subjected to the action of the analyzer or practical condensing arrangement.

The retorts 1 and 2, for the production of the water-gas or other poor gas, are set in a vertical position, and heated by a furnace placed at one side, but which is not shown in the drawing. The carbon necessary for the decomposition of the water is introduced by the hopper and valve arrangement 3, by filling the hopper 4 and then opening the valve 5, by depressing the lever 6, when the coke or other carbonaceous matter falls into the retort. The retort 1 is kept at a very high temperature, and steam is admitted thereinto in a regular stream by the valve 7 communicating with the main steam-pipe 8, led from the steam-boiler 9. On this main steam-pipe 8 there is placed a regulating-valve, 10, actuated by the lever 11, connected to a small governing gas-holder, 12, which, being raised or lowered by the pressure of the gas passed by the pipe 13, regu-

lates the quantity to be admitted for the production of the necessary quantity of hydrogen.

The horizontal portion of the retort 2 may be either filled with coke or fire-brick, the purpose of introducing which is more especially to prepare the steam by heating it for after decomposition than to decompose it. The water-trough 14 at the bottom, and into which the retort 1 dips, seals it, and at the same time allows the ashes resulting from the carbonaceous matter introduced into the retort to be removed. The steam, after being heated in the horizontal portion of the retort 2, passes up through the coke or carbonaceous matter into the body of the retort 1, where it is decomposed into water-gas, and is then drawn off by the outlet-pipe 15, and passed to the hydraulic main 16 and condensers 17, wherein any water which may have escaped decomposition is condensed, and removed by pipe 18. Should the carbon employed for decomposing the water contain sulphur, the gas may be also purified to remove sulphur compounds present, and after being so purified it is then passed through the meter 19 to be measured, and thence to the main pipe 20, for supplying the bituminous gas-retorts 27.

The bituminous gas-retorts 27 may be of the ordinary horizontal description. The water-gas or other poor gas is admitted to the bituminous retorts by the pipes 21 and 26, leading from the main gas-pipe 20 through the screw-valve 22. To admit the water-gas automatically the apparatus shown on an enlarged scale at Fig. 2, Sheet 1, is employed, this being so constructed that the pressure of the gas on the retort being charged lifts the small gas-holder 23, which actuates the valve 24, covering the pipe 21, and thereby allows the water-gas, which is kept or made under a considerably greater pressure, to pass by the pipe 26 to the bituminous retort. On the pressure being removed from the retort, the small holder 23 at once falls, and shuts off the supply of water-gas.

The mixed bituminous and water gases pass off by the stand-pipe 28 to the hydraulic main 29, and thence by the pipe 30 to the analyzer or fractional condenser A, which may partake of a variety of forms. The analyzer or fractional condenser A shown at Fig. 1 is considered by us to be among the best forms of this apparatus, and it is very similar to the ordinary "Coffey" still-analyzer. This analyzing arrangement consists, as will be seen on referring to the drawings, of a vertical tower or chamber, having tray-diaphragms 31 placed at intervals, and so arranged that the gases in their passage between these trays are caused to travel in a tortuous course, alternately from the sides to the center, the apertures through which the gas has to pass being alternately at the sides and the center of the trays. Hanging from the edges of the central part of the trays, and dipping into the tars in the trays underneath, are tubes of wire-gauze 32. Perforated metal or an equivalent porous arrangement may be adopted. Two of the lower trays 31^a and bottom 31 of the tower are shown cased or double; but more of the trays may also be so constructed; and into this space steam is admitted by the pipe 33, connected to the steam-boiler 9, and the condensed water is drawn off by the pipes 34 and valve 35.

The combined bituminous and water gases or other non-luminous gases, with the suspended crude tars, on entering the fractional analyzer or condenser by the pipe 30, pass under the lowest tray 31^a, and over the surface of the heated tars in the bottom of the analyzer, and so that they are bathed in a large volume of the comparatively volatile vapors of the hydrocarbons given off from the heated tars, which causes the heavy tarry particles suspended in the crude gases to be partially deposited. The gases then travel over the first tray, 31^a, and through the wire-gauze tube 32, hanging from the edges of the aperture in the second tray, 31, which effects a further separation of the mechanically-suspended tars, and at the same time the gases receive lighter hydrocarbon vapors from the tars flowing over the wire-gauze 32 from the second tray. This process is repeated by the passing of the gases through the second wire-gauze and over the surface of the heated tars contained in the third tray, and so on, ascending from tray to tray.

The tars contained in the succeeding trays are successively heated to a less degree. The ascending gases, becoming gradually cooled, deposit heavy hydrocarbon vapors and receive lighter ones, until, by the time they reach the outlet-pipe 36 leading to the scrubbers, they have parted with all, or nearly all, their tarry particles, and only contain those vapors of hydrocarbons diffused through them, most of which remain permanently suspended, a small portion only being removed by the scrubbers, which is again returned by the pipe 37, to be used in carbureting a fresh quantity of gas.

At the same time that the gases are being deprived of tarry particles and receiving volatile vapors the deposited tars and condensed heavy hydrocarbon vapors descend from tray to tray, and, as already described, repart with any absorbed vapors sufficiently volatile to the ascending current of gas, until, by the time the tars reach the bottom, they are almost or practically denuded of volatile hydrocarbons, and pass away by the pipe 38 to the tar-tanks.

The figure on Sheet 2 of the drawings is a section, partly in elevation, showing how the process may be conducted by the alternate production of bituminous gas and water-gas in the same ordinary horizontal retort. When the illuminating or bituminous gas is made from coal or similar solid material, the retort 27 is first charged with the substance, and the destructive distillation completed, or nearly so, the gas passing away by the stand-pipe 28, hydraulic main 29, and pipe 30 to the analyzer

A, heated by the steam-pipe 33, connected to the steam-boiler 9, and there subjected to treatment, as hereinbefore described, only in this case the bituminous gas leaves behind in the condensed tars hydrocarbons which can be taken up by a poor gas. The poor or water gas is made by opening the valve 7 on the pipe 8, connected to the steam-boiler 9, heated by partially-spent heat in the main flue 39. The steam, entering the retort 27, comes into contact with the carbon (graphite) deposited on the surface of the retort, and that contained in the residual coke, and is thereby decomposed into hydrogen and carbonic oxide, which, in turn, is passed by the outlet-pipe 28, hydraulic main 29, and pipe 30 to the analyzer A, and therein, coming into contact with the heated tars contained in the trays, takes up the volatile hydrocarbons left in the tars by the bituminous gases. The deposited carbon (graphite) is thus removed from the retort and utilized, and the retort itself is thus kept clean and effective.

When the bituminous substance employed for the production of the illuminating-gas is a liquid, such as mineral oil, or a solid which may be melted and kept liquid at conveniently low temperatures, such as resin, the process is slightly modified, the retort being charged with coke, broken brick, scrap-iron, or other substances presenting a large surface, and the mineral oil or other bituminous liquid is led into the retort 27 by opening the valve 40 on the pipe 41 connected to the tank 42. The oil, as is well known, on entering the retort, is immediately volatilized, and in its passage through or among the highly-heated solid matter in the retort is decomposed and converted into crude illuminating-gas, solid carbon being at the same time deposited on the surface of the hot solid substance and on the surface of the retort. The oil-gas passes away to the analyzer, where the condensable portion is removed. At intervals the admission of oil is stopped, and steam admitted, as before, from the boiler 9. This steam is decomposed by the carbon deposited from the oil, and the resulting gases passed through the analyzer to take up the surplus hydrocarbons condensed from the rich oil-gas. Both gases are afterward blended or mingled in the gas-holder; and instead of introducing steam ready formed into the retort, water may be run in directly and converted into steam inside the retort; but it is preferable to pass in the steam ready formed.

The figure on Sheet 3 is a section, partly in elevation, of an arrangement where the process is conducted by the simultaneous production of bituminous and water gas in one retort, but which may also be modified, so as to produce these gases intermittently. This arrangement is more particularly designed for the distillation of coal, shale, and similar substances containing a large percentage of ash, but which give a gas of considerable illuminating power. The retort is similar to that already referred to with reference to Sheet 1 for the production of water-gas, having a vertical limb or portion, 1, and a horizontal limb or portion, 2. The latter is quite filled with coke, and the former to the extent of two-thirds, or thereabout.

The bituminous shale, coal, or other substance is charged by the hopper 3 and valve 5 into the remaining or upper third part of the vertical portion of the retort, and is there distilled into crude illuminating-gas. At the same time steam is admitted into the horizontal limb or portion of the retort 2 by opening the valve 7 on the pipe 8 leading from the steam-boiler 9. This steam, in its passage through the highly-heated coke, is decomposed, producing water-gas, which combines and mingles with the rich bituminous gases as they are produced from the shale, coal, or analogous substance contained in the upper third part of the retort.

The combined gases pass by the outlet-pipe 15 to the hydraulic main 16, and thence by the pipe 30 to the analyzer, and are therein subjected to the treatment hereinbefore described.

As soon as the first charge of shale or other bituminous substance is nearly worked off some of the ash is drawn from the bottom of the retort in the water-trough 14, and a fresh charge of shale introduced. The coke of the exhausted shale or other bituminous substance now supplies the carbon for the decomposition of the water into hydrogen and carbonic oxide, and thus the coke of shales and other bituminous substances, which is otherwise almost valueless, is economically utilized.

This last arrangement of apparatus may be also advantageously employed for the manufacture of illuminating-gas from resin, mineral oil, and similar liquid hydrocarbons by leading into the retort the oil in a stream above and passing water-gas up, and commingling it with the oil-gases as they are produced, using the deposited carbon from the oils for the production, or to assist in the production, of this water-gas, or by making the process intermittent by shutting off the steam by the valve 7 from the horizontal portion of the retort, and admitting oil by opening the valve 40 connected by the pipe 41 with the oil-tank 42. The oil, on entering the horizontal portion of the retort, is volatilized, and decomposed in passing up through the heated solid matter charged into the vertical limb or portion 1 for the purpose. So soon as the interstices between the highly-heated solid substances become so far closed as to impede the flow and production of the oil-gas, the oil is shut off, and the steam again admitted, which is decomposed and removes the carbon deposited by the decomposition of the oil. In both cases the gases are subjected to treatment in the analyzing arrangement A, in the manner described. In practical working this process is repeated, alternately admitting oil and steam.

The figure on Sheet 4 of the appended draw-

ings is a section, with parts in elevation, showing an arrangement for the production in separate retorts of the bituminous and non-luminous gases, and for the simultaneous and separate treatment of both gases in a combined analyzing arrangement. The water-gas and bituminous gas-retorts and the analyzer are similar in construction to those hereinbefore described in reference to Sheet 1, and similar numbers refer to similar parts of the apparatus. The gases are also produced in a similar manner; but, instead of combining the different gases in the bituminous retorts, they are kept separate and carried into the analyzer in two separate currents, the crude bituminous gases and tars being introduced, as shown, by the pipe 30 between the fourth and fifth tray from the bottom of the analyzer A. At the same time the water-gas or other poor gas is introduced by the pipe 20 at or near the bottom of the analyzer. Both gases pass upward from where they are admitted. The bituminous gases, as they enter from the hydraulic main 29 by the pipe 30, are warm, and are further raised in temperature by the heat of the water-gas rising up from below. The mingled gases are thus subjected to the analyzing action, hereinbefore described, in their tortuous passage through the higher trays and wire-gauze tube in the analyzer. At the same time the tars and condensable heavy vapors deposited from the gas in the upper portion of the analyzer fall back from tray to tray until they drop through into the trays 31^a in the lower part of the analyzer, wherein they are heated by the steam, as before described. At this place the heated tars are acted upon by the incoming current of water-gases or other poor gases, and any traces of hydrocarbons which may remain in the tars, and which are sufficiently volatile, are taken up by the gas, and the tars pass away denuded, as far as practicable, by the pipe 36 leading to the tar-tank.

The figure on Sheet 5 shows an arrangement of double-ended or through retorts, by which the process of making illuminating-gas according to this invention may be conducted in several ways. By one mode the retorts 27 and 27^a are charged to the extent of one half with the bituminous substance, the other half being filled with coke. The hydraulic valve 29^a in the stand-pipe 28, leading from the end of the retort filled with coke, is lifted and closed, and the hydraulic valve 16^a on the pipe leading from the opposite end of the retort is lowered and opened. At the same time the lowering of the valve 16^a actuates the rod 43, connected to the valve 44, which admits steam from the steam-boiler 9 by the pipe 45 and stand-pipe 28 into the end of the retort 27^a filled with coke. The steam, in passing over the coke, is decomposed into hydrogen and carbonic oxide. This gas then passes over and through the bituminous substance, distilling on the other end of the retort 27, and the mixed bituminous and water gases pass away by the stand-pipe 28^a to the hydraulic main 16, and thence by the pipe 20 to the analyzer, to be there subjected to treatment in the manner hereinbefore described. So soon as the first charge of bituminous substance is exhausted the valve 16^a is closed and the coke removed from the end previously employed to make the water-gas, and replaced by a charge of the bituminous substance. The valve 29^a, being now lowered, opens the valve 46 and admits steam from the boiler 9 to the opposite end of the retort 27, which contains the coke from the previous charge of bituminous substance, and by which the steam is at once decomposed into water-gas. This water-gas, in turn, passes over the fresh charge of bituminous substance in the end of the retort 27^a, and by the stand-pipe 28 to the hydraulic main 29, and thence by the pipe 20 to the analyzer. This process is repeated, alternately charging the reverse ends of the retort with the bituminous substance, and using the coke on the opposite end, derived from the previous charge of bituminous substance, to decompose the water for supplying the water-gas to take up the surplus hydrocarbons that would be left in the analyzer by the bituminous gases.

Instead of making the water-gas in one end of the retort, any substance, such as spent bark, sawdust, peat, or others giving a large proportion of poor gas, may be employed to produce the gas to take up and utilize the volatile hydrocarbons, the bituminous substance being charged at the same time, and the poor gas from the other substance caused to pass over and out by the same stand-pipe, together with bituminous gases.

Another mode of working the process is similar to that already described with reference to the figure on Sheet 3 of the drawings, and it is conducted as follows: The rod 47 connecting the lever 48 of the hydraulic valve 29^a on the stand-pipe 28, and the steam-valve 46 on the pipe 49 leading from the steam-boiler 9, is disconnected. The entire length of the retort is now charged with the bituminous substance, and the crude bituminous gases are passed away by the stand-pipe 28 to the hydraulic main 29, and thence to the analyzer by the pipe 30. (Shown in dotted lines.) So soon as the bituminous substance is exhausted the hydraulic valve 29^a is raised and closed and the hydraulic valve 16^a is lowered and opened. At the same time the steam-valve 44 is also opened by means of the connecting-rod 43 attached to the lever 50 of the hydraulic valve 16^a. Steam is thereby admitted into the retort by the pipe 45 and stand-pipe 28^a, which, coming into contact with the highly-heated coke, is decomposed into water-gas, and drawn off by the stand-pipe 28^a into the hydraulic main 16^a, and thence passed by the pipe 20 into the bottom of the analyzer. The retorts are so worked that about one half of them are producing water-

gas during the time the other half are producing bituminous gas, and the two gases are collected, in the manner described, in the separate hydraulic mains, being afterward separately and simultaneously heated, as hereinbefore described in reference to the figure on Sheet 4, in the combined analyzing apparatus A.

By a third mode of making gas according to this invention, with the apparatus shown on Sheet 5, the bituminous gas may be passed into ordinary condensers, as shown by the dotted pipe 30 and at 51, Sheet 5. The condensed tars are run off by the sealed pipe 52 to the tar-well 53, and the tar is pumped from thence by the pipes 54 and pump 55 to the top of the analyzing apparatus A. At the same time the water-gas is passed by the pipe 20 through the analyzer, and takes up the surplus hydrocarbons contained in the pumped tars from the bituminous gases. The resulting gases may be either kept separate and used separately, or, as shown in the drawing, combined by the connecting-pipe 56, and passed on to scrubbers and purifiers together by the pipe 36.

The drawing on Sheet 6 exhibits an arrangement of gas apparatus which may be in many cases advantageously employed to carry out the process, more especially where it is desired to reduce the tars to a semi or wholly pitched or solid condition, and when the gases are not required to have a very high illuminating power.

The retort shown is specially adapted for the production of gases suitable to be treated by this process from shales, coals, and similar substances, giving by the ordinary process of gas-making a gas of very high illuminating power. The retort consists of three connected limbs or parts, 1, 2, and 3. The bottom limb 1 is kept charged with the coke from shale or other substance distilled. The limb 2 is charged with similar coke or anthracite coal, bricks, or scrap-iron, or any material capable of resisting a high heat and presenting a large surface. The higher limb 3 is charged by the hopper and valve 4 with bituminous substance, the crude illuminating-gases from which pass downward into the limb 2. At the same time steam is admitted into the bottom limb 1 by opening the valve 5 on the pipe 6 connected to the steam-boiler 7. This steam, in passing upward to the limb 2, undergoes decomposition by coming into contact with the carbon contained in the shale or other coke. The two gases (bituminous and water gas) mingle and blend on entering the limb 2, and the undecomposed liquid hydrocarbons contained in the bituminous gas undergo a further decomposition in the presence of the water-gas by coming into contact with the surface of the heated solid material through which they have to pass. As soon as the first charge is exhausted spent ash is drawn from the bottom of the retort resting in the water-trough 8. This empties, or partially empties, the upper limb of the retort, which is again filled with a fresh charge of bituminous shale or other gas-producing material. This process is continuously repeated. The combined gases pass off by the stand-pipe 9 to the hydraulic main 10, and thence by the pipe 11 to the analyzing apparatus 12, which consists of a horizontal still or chamber divided by a series of partitions, 13, in such a manner as to cause the gases and tars to pass in a tortuous manner from one end of the chamber to the other, the tars and gases passing in opposite directions, as shown by the arrows. Underneath this chamber or analyzer is placed a furnace, 14, by which the tars and gases may be heated to the required temperature, according to the quality of pitch desired. The harder the pitch required the higher is the temperature necessary.

The gases enter this analyzing apparatus by the pipe 11, and undergo very similar treatment to that described in reference to the working of the analyzing apparatus shown on the two preceding sheets of drawings. The gases, as they pass from division to division of the apparatus 12, deposit heavy vapors and tar particles, and take up lighter hydrocarbon vapors, until, on leaving the analyzer by the pipe 14^a, they are almost freed of tars proper, and contain only vapors of the more volatile hydrocarbons derived from the tar.

To enable the gases to hold those comparatively-heavy hydrocarbon vapors, they pass from the analyzer more or less heated, and thence through the coolers or condensers 15; or, where the temperature is very high, a second vertical analyzing apparatus may be employed to reduce the temperature of the gases. The condensed matters, ammoniacal liquor, and liquid hydrocarbons are run off, the former into the liquor-tank to supply the scrubbers by the stop-cock 16, and the latter can either be returned by the cock and funnel-pipe 17 to the horizontal analyzer, or disposed of as heavy tar-naphtha direct. The analyzed tars or pitch are from time to time run off from the analyzer 12, by the cock 18, into a sand-bed or other form of mold to be cooled. The tar is led from the hydraulic main 10 into the chamber 12 by the pipe 19.

In working this invention by any of the hereinbefore-described or analogous arrangements of apparatus, the quantity of hydrogen and carbonic oxide or other gases having a low illuminating power necessary to take up the hydrocarbons from the crude gases produced from any given bituminous substance, and to produce a gas of the desired illuminating power, must first be ascertained by trial, through distilling a given weight of the bituminous substance, and adding the water or other gas until the desired illuminating power is attained.

Although, in carrying out this invention, it is not essential that the water-gases and bi-

tuminous gases be made at the same time, because the action of the analyzer upon the gases is such that considerable variations may be made between the proportion of the bituminous and non-bituminous gases at the instant of their production; for, should the quantity of hydrogen or other non-luminous gas be insufficient to take up the whole of the hydrocarbons produced together with the bituminous gas at the time, the surplus falls back into the trays of the analyzer; and, on the other hand, when the hydrogen or other non-luminous gas is more than sufficient to take up the hydrocarbons from the bituminous gases simultaneously produced, then the previously-condensed surplus hydrocarbon vapors contained in the trays serve to supply this deficiency. The variations in the proportions of the gases are in this manner practically balanced by the action of the analyzer. Yet, where it can conveniently be done, it is better that the water-gas should be passed into the bottom of the combined analyzer in as regular a proportion as possible to the bituminous gases, so as to meet the stream of crude tars contained in the surplus hydrocarbons as they drop from the portion of the analyzer in which the bituminous gases are analyzed and condensed; or, where it is desirable to analyze the mixed gases, the water-gas should be passed into the retort containing the bituminous matter, and there mingled with the crude bituminous gases as they are eliminated, as it appears the poor gases serve to shield from over-decomposition the hydrocarbons present in the crude bituminous gases suitable for carbureting the poor gases. Therefore, in adding the poor or water gases ascertained to be necessary to take up the hydrocarbons from the bituminous substance and form the quality of gas desired, the valves for admitting the water-gas, or the steam for its production, or other poor gas, should be regulated to pass as near as possible the average necessary quantity during the distillation of the weighted bituminous substance. A very short time will suffice to do this, checking the quantity added by the meter, measuring the water or other poor gas alone, or by taking the gross quantity of mixed gases passed through the ordinary station-meter.

If desired, the improvements in the manufacture of gas constituting this invention may be worked with a lower temperature of the analyzer by reducing the pressure of the gas or vapors therein to any desired point below that of the atmosphere. This may be effected by the use of an exhauster, steam-jets, or the mechanical equivalent thereof, placed between the analyzer and the scrubbers, regulating-valves being placed between the analyzer and the retorts, to prevent too much reduction of the pressure in the retorts; or a considerable portion of the force or energy required to relieve the gases of the atmospheric pressure may be utilized by passing the hot vapors and gases as they leave the hydraulic main through a supplementary cylinder or cylinders actuating a piston or pistons attached to the driving-gear of the exhauster, the said gases being worked more or less expansively, according to the pressure desired in the retorts.

Under this method of working, the attenuated hydrogen or other gas of low illuminating power that may be used is rendered capable of absorbing a large volume of the hydrocarbons.

Having now described and particularly ascertained the nature of our said invention, and the system, mode, or manner in or under which the same is or may be carried into practical effect under various modifications, we wish it to be understood that we do not confine or restrict ourselves to the precise details or arrangements we have had occasion to describe and delineate, as many variations may be made therefrom without departing from the main or essential features of our said invention. Neither, on the other hand, do we claim as new, or as our invention, the decomposition of water into carbonic-oxide and hydrogen gases by highly-heated carbon contained in gas-retorts; nor do we claim the combining the carbonic oxide and hydrogen so obtained with the crude gases, as they are produced from bituminous substances undergoing distillation, either in the bituminous retort or out of it while warm; nor do we claim the carbureting of hydrogen and carbonic oxide obtained from the decomposition of water by heated carbon or other gas having a low illuminating power with the diffused vapors of hydrocarbons in an isolated form, as we are aware that this has been previously done to some extent for the like purpose to this invention, as we have already stated, by means of what is known as the "hydrocarbon process," and by other means. Neither do we claim all the details of mechanical construction separately which we have had occasion to describe and refer to, (as many of these are already in use,) except in combination with and as forming parts of the essential features, and for the objects or purposes, of our said invention; but

What we consider to be novel and original, and therefore claim, is—

1. The process of manufacturing illuminating-gas by carbureting water-gases, in diffusing them in regulated quantities through independently-controlled or separate retorts, wherein hydrocarbon vapors are being evolved from bituminous substances, thus preventing the deposition of carbon in the retorts, or, if already deposited, utilizing it, substantially as described.

2. In the manufacture of illuminating-gas, the process herein described of diffusing or suspending in and through hydrogen, carbonic-oxide, or other gas or gases having a low illuminating power, the volatile hydrocarbons produced, and ordinarily left in the

tars when coal, shale, hydrocarbon oils, resin, or other similar bituminous substances are destructively distilled for the production of illuminating-gas—that is to say, bringing the said hydrogen, carbonic-oxide, or other poor gases into contact with the tars while in a heated state and spread over large surfaces, or by mingling the said gases with bituminous gases, either in the bituminous retort as they are produced or afterward, and subjecting the mingled gases to fractional condensation or cooling, the condensed tars being kept in a heated state, substantially as hereinbefore shown and described.

In witness whereof we have signed our names to this specification in the presence of two subscribing witnesses.

HENRY AITKEN. [L. S.]
WILLIAM YOUNG. [L. S.]

Witnesses:

DAVID DRYSDALE AUSTIN,
GEORGE MACAULEY CRUIKSHANK.