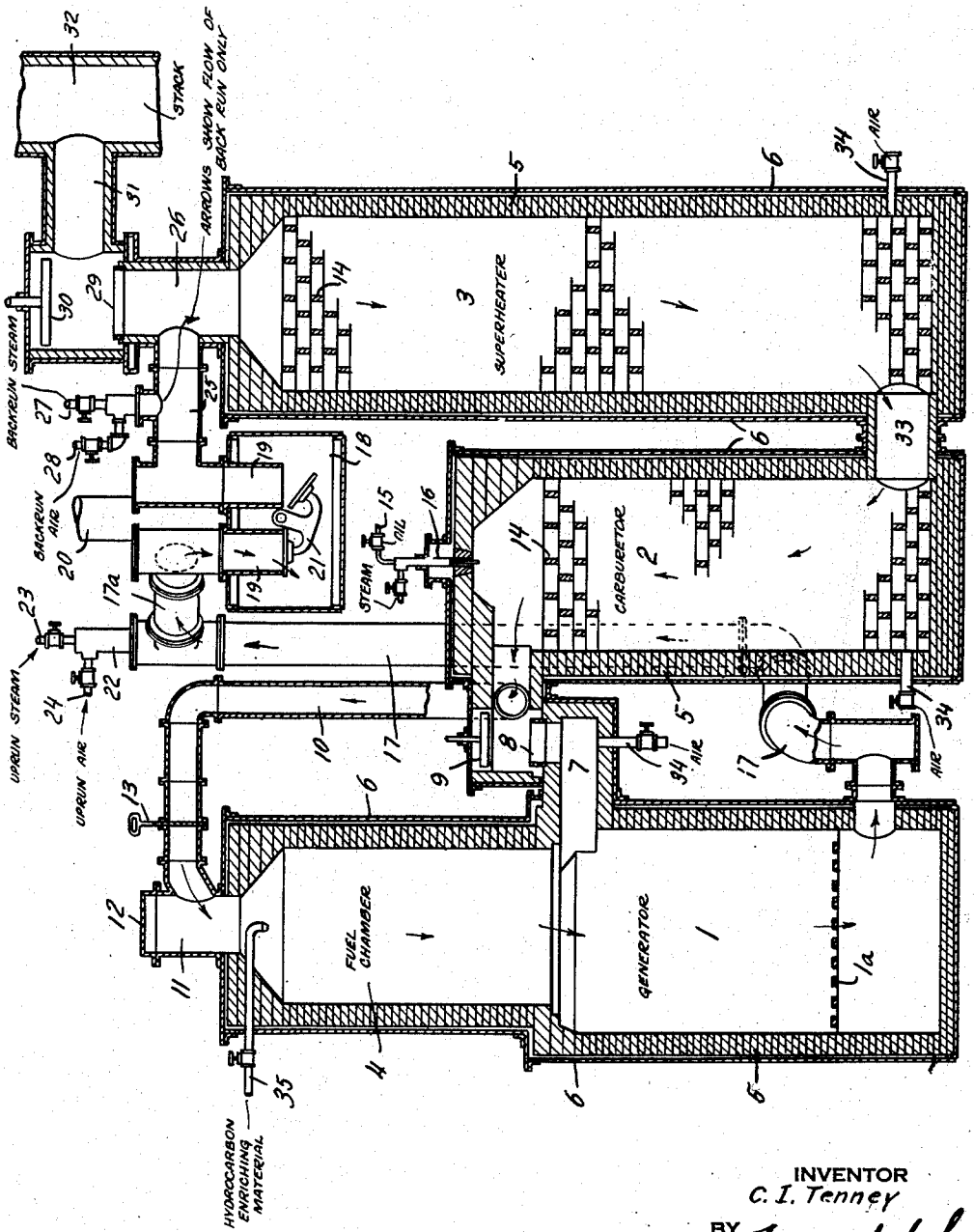
Dec. 23, 1941. C. I. TENNEY 2,267,434

METHOD OF MAKING COMBUSTIBLE GAS

Original Filed May 18, 1925



INVENTOR
C. I. Tenney
BY
ATTORNEY

Patented Dec. 23, 1941

2,267,434

UNITED STATES PATENT OFFICE

2,267,434

METHOD OF MAKING COMBUSTIBLE GAS

Charles I. Tenney, Minneapolis, Minn., assignor to Semet-Solvay Engineering Corporation, New York, N. Y., a corporation of New York

Original application May 18, 1925, Serial No. 31,028, now Patent No. 1,900,961, dated March 14, 1933. Divided and this application November 1, 1932, Serial No. 640,593

2 Claims. (Cl. 48—205)

This invention relates to a method for manufacturing artificial illuminating or heating gas. This application is a divisional of my copending application Serial No. 31,028, filed May 18, 1925, now Patent No. 1,900,961, issued March 14, 1933, and also bears a divisional relationship to application Serial No. 194,065, filed March 5, 1938, issued as Patent No. 2,129,248 on September 6, 1938. Artificial heating and illuminating gases commonly known in the art as "water gas" and "carburetted water gas" have heretofore been commonly made in an apparatus comprising a generator, carburetor, and superheater.

It is an object of this invention to provide a method for making an artificial heating or illuminating gas using a generator, carburetor and superheater such as heretofore used, together with an auxiliary fuel chamber or retort.

It is another object of the invention to provide a method of making such artificial illuminating or heating gas comprising carrying out an air blast run through the generator, carburetor and superheater and simultaneously partially heating the fuel in an auxiliary chamber, and then passing air in a reverse direction through the superheater, carburetor, said auxiliary chamber, and generator.

It is still another object of the invention to provide a method of making said artificial illuminating and heating gas which consists in carrying out a blast run, as set forth in the preceding paragraphs, and subsequently passing steam in a reverse direction through the superheater, carburetor, said auxiliary chamber, and generator.

These and other objects and advantages of the invention will be fully set forth in the following description made in connection with the accompanying drawing in which the different parts are designated by reference characters, and in which the single view is, for the most part, a vertical section through the apparatus, some parts thereof being shown in side elevation.

Referring to the drawing, a gas generator 1 is shown, as well as a carburetor 2, a superheater 3, and an auxiliary fuel chamber 4. While these various elements may be of any well-known and suitable construction, in the embodiment of the invention illustrated, they are shown as comprising vertically disposed cylindrical chambers having walls 5 of fire brick or other refractory material surrounded by suitable casings 6. The generator 1, as usual, has a grate 1—*a* therein and said generator has an open top portion communicating with the lower open end of an auxiliary fuel chamber or retort 4. It will be seen that the diameter of the auxiliary fuel chamber 4 is somewhat less than that of the generator 1. A passage 7 leads from the top of generator 1 to the top of carburetor 2 and a hot valve comprising a ring 8 and a vertically reciprocable plate 9 co-operating therewith is disposed in the passage 7 and adapted to close the same to shut off communication between the generator 1 and the carburetor 2. While any suitable or well-known type of hot valve may be used, the one illustrated is of the type shown in the copending application of Charles I. Tenney and Paul W. Thayer, filed April 24, 1924, Serial No. 708,704 now Patent No. 1,593,855, issued July 27, 1926. A conduit 10 communicates with the passage 7 on the side of the valve 9 toward the carburetor 2 and communicates at its other end with a passage 11 leading from the top of the auxiliary chamber 4. The passage 11 is formed by a cylindrical casing extending upwardly from the opening in the top of chamber 4, and is provided with a removable cover 12 which may be moved in any suitable way for the purpose of charging fuel into generator 1 and chamber 4. The conduit 10, preferably, is adapted to be opened and closed by a valve 13 shown as disposed adjacent the passage 11. The carburetor 2 and the superheater 3, as usual, are substantially filled with openwork brick or checkerbrick 14 and the carburetor 2 has projecting into its top at the central portion thereof, an oil pipe 15 and a steam pipe 16 which will be connected to suitable oil and steam supply, respectively, which pipes are provided with controlling valves. A conduit 17 leads from the bottom of generator 1 below the grate 1—*a* therein preferably upwardly to a seal pot or hydraulic seal 18. The latter is shown as comprising a cylindrical tank having conduits 19 with open lower ends projecting thereinto, and a conduit 20 leads from the top thereof. The lower ends of pipe 19 project below the surface of a body of water or other liquid maintained in the pot or seal 18 and these ends are adapted ordinarily to be opened and closed by a double swinging valve 21 mounted on a shaft extending at one side of the seal 18. It will be seen that the conduit 17 is connected to one of the pipes 19 by a horizontal portion 17—*a*. A smaller pipe or conduit 22 extends upwardly from the upper end of conduit 17 to a T connection with which communicates a valve-controlled steam pipe 23 and a valve-controlled air pipe 24. The other pipe 19 is connected by a horizontal pipe or con-

duit 25 to a passage 26 leading from the top of the superheater 3. The pipe 25 has a connection secured thereto from which extends a valve-controlled steam pipe 27 and a valve controlled air supply pipe 28. At the top of the passage 26 is another hot valve similar to that in the passage 7 and comprising a sharp-edged ring 29 and a reciprocating plate 30 cooperating therewith. A passage 31 is adapted to connect the passage 26 to a stack 32 when the valve comprising parts 29 and 30 is in open position, as shown in the drawing. The lower end of the carburetor 2 is connected to the lower end of the superheater 3 by a passage 33 and auxiliary air supply pipes 34 are shown as communicating with the bottom of the carburetor 2 and the superheater 3, which latter pipes will be valve-controlled. An auxiliary air supply pipe also extends into the passage 7 and this pipe also will be valve-controlled. A valve-equipped pipe 35 extends into the top of chamber 4, through which tar may be run or sprayed into the fuel in said chamber.

In operation, the fuel, consisting of bituminous or other coal, will be charged into the generator 1 and the auxiliary chamber or retort 4. This fuel will be charged into the generator 1 and chamber 4 through passage 11, cover 12 being removed for this purpose. The process of this invention contemplates the use of low grade fuel in a finely divided state. It will be noted that the chamber 4 is of somewhat smaller diameter than chamber 1 so there will be some space about the top of the chamber 1. After the fuel has thus been charged, the passage 11 is closed by its cover 12, the valve 13 closed, the hot valve 9 is opened, and the stack valve 30 is opened. The fuel is now ignited in the usual way and the air blast turned on in the pipe 24. The fuel will be heated and a blast or blow run made by passing air upwardly through the fuel and generator 1, the resulting gases passing through passage 7 down through the carburetor 2 and up through the superheater 3 to the stack 32. Additional air may also be forced into the passage 7 and into the carburetor and superheater through the pipe 34. When the fuel in the generator 1 has been brought substantially to incandescence and the checkerbrick in the carburetor 2 and superheater 3 highly heated by the combustion of the gases from the fuel, the air blast will be turned off. During the blast run the fuel in the auxiliary fuel chamber 4 will be heated somewhat by the heat in generator 1 but substantially no volatile matter or products of combustion will be driven off or taken from such fuel owing to the fact that the member 4 is normally closed save for its communication with generator 1. The hot valve 9 will now be closed, valve 13 opened, and the stack valve 30 closed. Valve 21 will also be moved to close pipe 19 communicating with the pipe 25 and open pipe 19 communicating with pipe 17. It may be here stated that the pipes 27 and 28, during the blast run just described, are closed and will remain closed.

After the run just described, which is the ordinary blast or blow run, a reverse run is made through the apparatus with air. This air is supplied through the pipe 28 and passes down through the superheater 3 and up through the carburetor 2, and owing to the fact that valve 9 is closed, up through the pipe 10 and down through the chamber 4 and generator 1. From the generator 1 the resulting gas will pass out through pipe 17 to the seal 18. During the blast run the checkerbrick in the superheater has been very highly heated, especially at the upper part thereof. When the reverse run with air is made the air becomes very highly heated in passing through the superheater and through the carburetor. The carbon and tar deposited on the checkerbrick in the superheater or carburetor during the blast run will be burned off by the air in the reverse run. The heated air passes downwardly through the fuel in chamber 4, heating the same, and some combustion will take place in this chamber and carbon monoxide with some carbon dioxide will be formed. The hot air passing through the chamber 4 will also carry off a large amount of hydrocarbons and the resulting gas will pass down through the coke in the generator 1 and out through the pipe 17. By this passage of air the temperature in chamber 4 is greatly raised and the coke in the generator is maintained at high temperature. The operation acts in effect to transfer some of the heat from the highly heated upper end of the superheater to the chamber 4 and the lower part of the generator. The latter is thus kept in a highly heated condition clear to the bottom thereof.

After a reverse run made with air, as described, pipe 28 will be closed and a reverse run will be made with steam through the apparatus, steam being supplied through pipe 27. The steam will pass downwardly through the superheater 3 and upwardly through the carburetor 2, and owing to the fact that the checkerbrick in the carburetor and superheater are still at a high temperature the steam will be superheated and will pass from the carburetor up through the pipe 10 and down through the fuel in retort 4 and generator 1. The fuel in the chamber or retort 4 has now been brought to quite a high temperature by the reverse run of air, and as the steam passes therethrough and through generator 1, water gas, or carbon monoxide and hydrogen, will be formed. At the same time, this gas will carry off more of the hydrocarbons from the fuel 4, which hydrocarbons will pass down into the hot generator chamber where they will be dissociated. The reverse run of steam will result in transferring some of the heat from the superheater and carburetor to the chamber 4 and the generator 1.

After the reverse steam run above described, the valve 21 will again be moved to open the pipe 19 communicating with pipe 25 and to close the pipe 19 communicating with pipe 17. An uprun will now be made through the apparatus by supplying steam to the bottom of the generator from pipe 23 through pipe 17 and this steam will pass upwardly through the hot fuel in generator 1 and in chamber 4 where water gas or carbon monoxide and hydrogen will be formed, and some hydrocarbon will be distilled from the uncarbonized fuel. This gas will pass from chamber 4 downwardly through pipe 10, downwardly through the carburetor 2 and upwardly through the superheater 3. The carburetor 2 and the superheater 3 are still at sufficiently high temperatures to efficiently fix this gas and the gas will be enriched with oil sprayed through the pipe 15. The gas will pass from superheater 3 through pipe 25 and pipe 19 into the seal 18 and will be conducted to storage in the usual manner. A very short purging run with air will now be made by turning air into the pipe 17 through pipe 24, which air will pass upwardly through generator 1 and through chamber 4 downwardly through pipe 10 and carburetor 2 and upwardly through the superheater 3, the gas formed during

this short run passing into the seal through pipe 25 and pipe 19 communicating therewith. After this cycle of operations the valve 13 will now be closed, hot valve 9 opened, and stack valve 30 opened, valve 21 also being swung to close pipe 19 communicating with pipe 25. Another blast or blow run will now be made by blowing air up through the generator 1, which air will be supplied by pipe 24 through pipe 17. The blast run will be made as before up through the generator through valve 8, downwardly through the carburetor and upwardly through the superheater 3 to the stack 32, the chamber 4 being by-passed during this run, as in the previous blast run. During the successive runs the fuel in chamber 4 will gradually be coked and will pass downwardly into the generator 1. Any tar which may be supplied through pipe 35 for enriching the gas in the reverse steam or air runs will be decomposed and the hydrocarbons thereof will be carried off with the gas while the carbon residue will become coked with the coal in chamber 4 and will pass down into generator 1. The fuel charged into chamber 4 will be sufficient for carrying out the cycle of runs for eight or ten hours and this fuel will be very efficiently used in the manufacture of the gas. Practically all of the calorific value in the fuel will be transferred to the resulting gas formed and a great saving will be effected by the use of the low grade fuel in supplying the hydrocarbon and carbon to the gas. There are approximately 10,000 cubic feet of 600 B. t. u. gas in each ton of bituminous coal used. There is also in addition to this gas content about 4 or 5 per cent of the weight of the coal in a tar product, which tar is of the same general character as the gas oil or naphtha used in enriching gas. There are about 10 gallons per ton, therefore, of this tar product. As approximately four gallons of gas oil are usually used to enrich 1000 cubic feet of gas from 300 B. t. u. to 600 B. t. u. per cubic foot, the 10,000 cubic feet of 600 B. t. u. coal gas furnishes the equivalent of about 40 gallons of oil for enriching said quantity of gas.

Applicant's process really takes the place of two prior processes. First, of putting the bituminous coal into a retort burning up 20 per cent of the total coke produced used in heating the retort; then taking the remaining coke from the retort, quenching the same with water and thus losing about 5 per cent of the energy in this process; then secondly, taking the coke and putting it into a straight water gas machine and buying expensive oil to enrich this blue water gas. In applicant's process the coking out of the coal is done, the coal gas is mixed with water gas by the reverse run of steam, the tar is partly picked up and carried into the hot generator where it is converted into coke and hydrogen and is also partially used in enriching the gas during the gas-making upruns through the retort chamber. Consequently, there is almost a complete utilization of or gasification of all of the coal with an efficiency in thermal value of the gas equal to about 85 per cent of the thermal value of the ordinary coal.

The coking of the fuel is done in the generator chamber 1. The generator is at all times full of the proper coked fuel for making water gas and this fuel feeds down into the generator from retort chamber 4. In the prior methods where gas is discharged directly into the generator, with intermittent charging, the capacity of the apparatus is limited and large quantities of CO_2 are developed as a result of the unequal depth of the fuel in the generator and blow holes caused by massing of the fuel, particularly during the blast run in heating the generator. Furthermore, a large portion of the volatile constituents of the fuel are carried off with the blast gases. In applicant's process there is no passage of the blast gases through the retort chamber, consequently the volatile portion of the coal is saved for the enriching of the water gas. The reverse run of air burns off the deposit on the checkerbrick in the carburetor and superheater. The reverse run of steam acts to cool off the superheater and carburetor and prevent the overheating of the checkerbrick. This heat is taken up by the steam which is thus superheated and a transfer of the heat is made to the other end of the apparatus.

As disclosed in applicant's original application, Serial No. 31,028, filed May 18, 1925, now Patent No. 1,900,961 issued March 14, 1933 (page 8 of the specification as filed) the tar introduced into the backrun of steam may be the tar always obtained as a by-product in the gas making industry, namely, water gas tar. Abraham, on page 303 of his recognized work, "Asphalts and Allied Substances," third edition, published November 1929, by D. Van Nostrand Company, Inc., points out that water gas tars "consist principally of aromatic hydrocarbons" and contain substantial amounts of the hydrocarbon oils benzene, toluene, xylene, naphthalene and anthracene.

Instead of carrying out the cycle of runs above described, good results may also be obtained by making the runs in slightly different order. After the first blast run, through the generator, carburetor and superheater, the valve 13 may be closed, as will also be the valve 9 and the valves 29 and 30, valve 21 being left in the position shown in the drawing. The uprun may then be made by passing steam upwardly through the generator 1, which steam will be supplied from pipe 23 through pipe 17. This steam will pass upwardly through the generator and through the fuel in chamber 4 and will then pass downwardly through pipe 10, carburetor 2, and upwardly through superheater 3 and then through pipes 25 and 19 to the seal, from which it will be led, as usual, to a suitable scrubbing and storing apparatus. The steam entering the hot coked fuel in the generator will be dissociated and water gas, or carbon monoxide and hydrogen will be formed, which gas will be at a high temperature. The fuel in chamber 4, particularly that in the lower part of the chamber, has already been somewhat heated and this fuel will be still more highly heated by the hot carbon monoxide and hydrogen passing therethrough. This hot water gas will, in passing through the chamber 4, carry off a large quantity of hydrocarbons from said fuel and said gas will thus be enriched. The coking process will now be begun. The gas will be fixed, as usual, in the carburetor 2 and superheater 3. After this gas making uprun, the valve 21 will be swung to close the pipe 19 communicating with pipe 25 and open the pipe 19 to communicate with pipe 17. A reverse run of steam will now be made, the steam being supplied through pipe 27. This steam as indicated by the arrows in the drawing will pass downwardly through superheater 3 and will be highly superheated therein. The steam will pass upwardly through carburetor 2 and through pipe 10 and then downwardly through the heated fuel

in chamber 4 and the heated fuel in generator 1. Water gas will be formed in chambers 4 and 1 and the gas will be enriched with hydrocarbons taken from the comparatively green fuel or fresh coal in chamber 4. The resulting gas will pass out at the bottom of the generator through pipe 17 and will pass upwardly therein and to the seal 18 from whence it will be conducted as usual to suitable cleaning or scrubbing apparatus and to storage. After the reverse steam run, a reverse air run will then be made, air being supplied through pipe 28, which air will pass downwardly through superheater 3 upwardly through carburetor 2 and through pipe 10. This air will be highly heated in the superheater and carburetor and will pass downwardly through the fuel in retort 4 and in generator 1. Any carbon or tar which has been deposited on the checkerbrick in carburetor 2 and superheater 3 will be effectively burned and cleaned therefrom by the passage of air, this combustion resulting in the formation of carbon monoxide and some carbon dioxide. These gases with the heated air pass, as stated, downwardly through chamber 4 and some combustion will take place in this chamber. The resulting gas will consist principally of carbon monoxide and nitrogen. There will also be a considerable amount of hydrocarbons taken from the fuel in chamber 4, so that the gas is enriched. The gas passing down through the fuel in generator 1 will be heated and fixed and the resulting gas will pass out through pipe 17 and upwardly to the seal 18, as before. If necessary, the gas formed during the reverse runs, particularly the reverse run of steam, may be enriched by tar supplied through the pipe 35. This may be necessary after the operations have been carried on for several hours and the hydrocarbons from the green fuel or fresh coal in chamber 4 largely used up and said fuel largely coked. After the reverse air run through the apparatus, the valve 13 will again be closed and valve 9 and valve 30 opened. Valve 21 will be again swung to close the pipe 19 communicating with pipe 25. The apparatus will then be ready for another blast run. If desired, a short purging run with air will be carried out by passing air upwardly through the generator 1, chamber 4 and onward through the apparatus before changing the valves for the blast run. With the cycle of runs last described, the fuel in the bottom of the generator 1 will be cooled by the first gas-making uprun and this fuel will again be somewhat reheated in the reverse runs.

From the above description it is seen that applicant has provided a simple and efficient method and apparatus for making artificial illuminating or heating gas. The process is carried out in one apparatus and all of the gas made by the various runs or steps in the process is delivered to a common storage container. As set forth, a great saving in fuel is effected, both in the cost of the fuel used for coking purposes and the fuel used for enriching the gas. By the reverse run of air the checkerbrick and the superheater and carburetor are very effectively cleaned. By the use of the chamber 4 and the arrangement of the runs therethrough, as described, the gas is discharged to the seal in a comparatively cool condition. In the ordinary use of the three-shell machine, the gas passes through the highly heated fuel in the generator and the highly heated checkerbrick of the carburetor and superheater. The upper part of the superheater is usually heated to a very high degree and it will thus be seen that the gas leaving the superheater will be at a very high temperature. This high temperature of the gas is objectionable as wasteful of the heat. In applicant's process the gas made in the reverse runs will cool off the superheater and the carburetor to some extent and leave the bottom of the generator in a comparatively cool condition. When the gas-making uprun is performed, the checkerbrick in the carburetor and superheater are reduced somewhat in temperature, particularly that at the top of the superheater so that the gas also leaves the superheater in comparatively cool condition. The process therefore makes more efficient use of the heat generated.

The method disclosed is applicable to existing installations of gas-making apparatus by merely adding the auxiliary fuel chamber or retort 4 to the top of the generator and making the proper connections. The additional expense of the apparatus is small when the great saving in fuel is considered.

It will, of course, be understood that various changes may be made in the form, details, arrangement and proportions of the apparatus and in the steps and sequence of steps in the process without departing from the scope of applicant's invention, which, generally stated, consists in such a method and apparatus capable of carrying out the objects above stated, in the novel parts and combinations of parts and steps disclosed and defined in the appended claims.

What is claimed is:

1. In a process of producing carburetted water gas in a set involving a generator having a fuel bed therein and a carburetor and superheater communicably connected therewith, the cycle of steps which comprises blasting the fuel bed with air and burning the resultant blast gases in the carburetor and superheater to heat these chambers, passing steam up through the fuel bed in the generator, introducing the water gas into the carburetor, adding hydrocarbon oil to the water gas passing through the carburetor and withdrawing the resultant carburetted water gas from the superheater, passing steam in a reverse direction through the superheater and carburetor, into the top of the generator, adding hydrocarbon oil to the generator, passing the resultant mixture of hydrocarbon oil vapors and steam through the fuel bed in the generator and withdrawing the resultant carburetted water gas from the generator and passing air in a reverse direction through the superheater and carburetor into the top of the generator, into the fuel bed therein, and withdrawing the resultant blast gases from the generator.

2. The process of making combustible gas in a set involving a generator, carburetor and superheater connected in series and located in separate and detached shells, and a fuel receiving chamber superimposed on said generator and communicating therewith, which comprises charging said generator and chamber with bituminous coal to form a bed of fuel therein, passing air up through the fuel bed in said generator, bypassing the resultant blast gases around the portion of the fuel bed in said chamber and then passing the resultant blast gases into and through the carburetor and superheater and burning them therein to heat said carburetor and superheater; discontinuing the aforesaid air blasting step and passing steam up through the fuel bed in the generator including that portion thereof within said fuel receiving chamber and

passing the resultant combustible gas through the carburetor and superheater; passing steam through the superheater, carburetor, and down through the fuel bed in the generator including the portion thereof within the fuel receiving chamber and withdrawing the resultant combustible gas from the generator; adding hydrocarbon oil, which upon decomposition forms carbonaceous deposits, to the fuel bed in the generator during at least one of said steam gas making runs; passing air through the superheater, carburetor and down through the fuel bed in the generator to consume carbonaceous deposits resulting from the introduction of said hydrocarbon oil, and withdrawing the resultant blast gases from the generator.

CHARLES I. TENNEY.