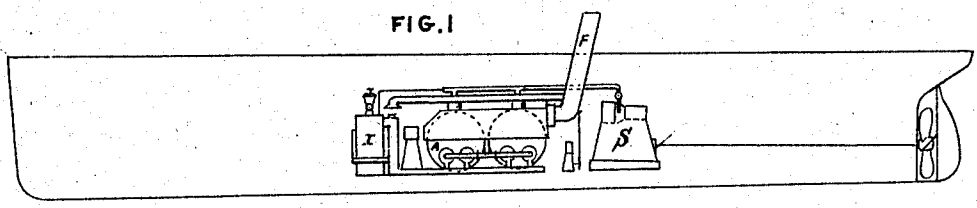
No. 835,531. PATENTED NOV. 13, 1906.

R. M. HUNTER.

PROCESS AND APPARATUS FOR GENERATING STEAM, &c.

APPLICATION FILED JAN. 20, 1897.

FIG. 1



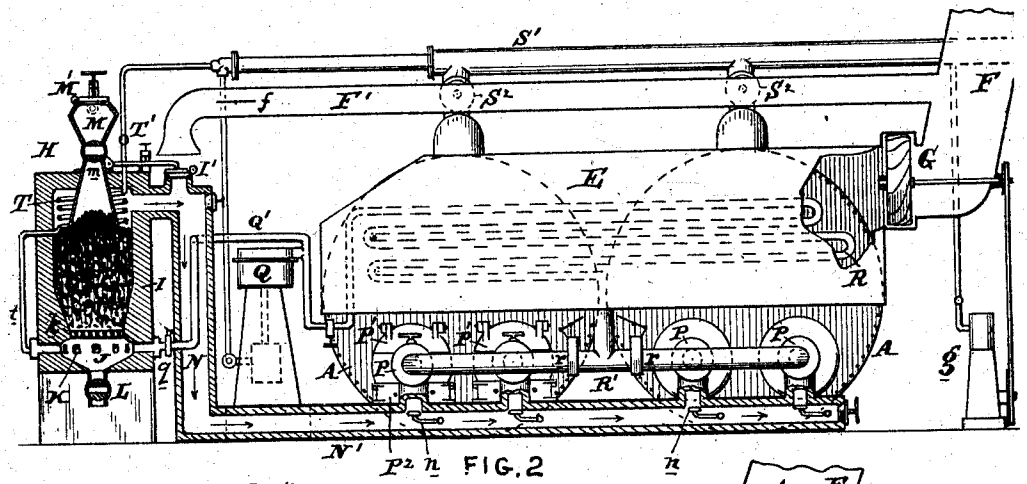


FIG. 2

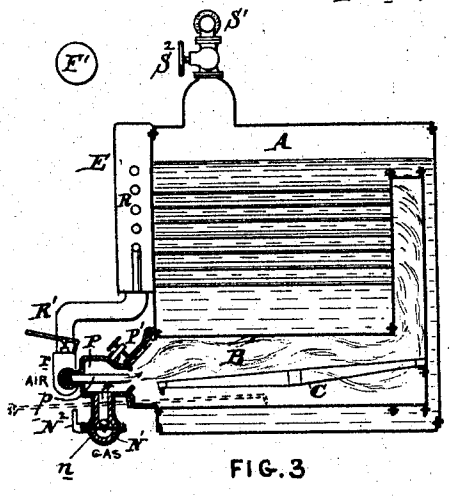


FIG. 3

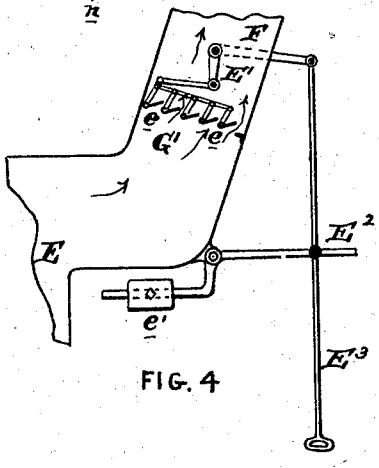


FIG. 4

Attest

Inventor

UNITED STATES PATENT OFFICE.

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PROCESS AND APPARATUS FOR GENERATING STEAM, &c.

No. 835,531. Specification of Letters Patent. Patented Nov. 13, 1906.

Application filed January 20, 1897. Serial No. 619,993.

To all whom it may concern:

Be it known that I, RUDOLPH M. HUNTER, of the city and county of Philadelphia and State of Pennsylvania, have invented an Improvement in Processes and Apparatus for Generating Steam, &c., of which the following is a specification.

My invention has reference to processes and apparatus for generating steam, &c.; and it consists of certain improvements which are fully set forth in the following specification and shown in the accompanying drawings, which form a part thereof.

This application comprehends the employment of solid and gaseous fuel for generating steam or for heating purposes generally where intense temperature is required with a minimum consumption of coal.

My invention is especially useful as a means for generating steam for ocean vessels, and particularly for battleships, cruisers, ocean, passenger, and mail ships, &c., where high speed with small coal consumption is desired. The advantage of lessening the amount of coal required is that with the same coal a greater distance can be traveled without recoaling, less cost for fuel, less tonnage, increased capacity for carrying freight, and less labor necessary to maintain the power.

The object of my invention is to secure all of the above results and at the same time greatly lessen the danger to the furnace-hands from over heat, which is great in the methods heretofore in practice, wherein the temperature of the furnace-room seldom falls below 145° Fahrenheit and at times reaches 200°.

In carrying out my improvements I first convert the solid fuel (coal) into gaseous fuel at a high temperature and then burn the said gas in the furnaces under pressure. As the heat intensity varies with the density of a given gas, it is apparent that by burning the gas under a high pressure a greater density is secured during combustion, with the resulting increase in temperature. To secure this increased density, two things are requisite and necessary—namely, to generate or supply the gas and air to the furnaces under the desired pressure and to provide means to secure a back pressure in the chimney or escape-flue to control the said furnace-pressure. By varying the initial pressure of the gases, or the degree of back pressure, or both, the pressure of the gases in combustion within the furnace proper may be varied. It is essential to the proper carrying on of the process that the air to produce the combustion within the furnace shall have a pressure equal to or greater than that of the gases undergoing combustion to insure the proper supply of oxygen to secure complete and perfect combustion. As an example of the efficacy of this method of burning fuel experiment shows that the temperature of hydrogen burned at atmospheric pressure is only 5° more in temperature than carbonic oxid burned at atmospheric pressure and that if the hydrogen be burned under a pressure that makes its density equal to the density of the carbonic oxid at atmospheric pressure the temperature or intensity may be increased thirty times that of carbonic oxid burned under atmospheric pressure. My invention comprehends the employment in commercial apparatus of this system of consuming fuel, and since it is not possible to treat the fuel while in the solid condition it becomes necessary to first convert or transform it into gas. The gas is generated in a continuous manner under high pressure and is produced by treating coal or coke in a gas-tight chamber with compressed air with or without steam. This gas produced is a fixed highly-heated combustible product and may have an initial pressure of about seventy-five pounds per square inch. It is admitted to the furnaces with an adequate supply of compressed air, preferably superheated, at or about the same pressure. This pressure is reduced in the furnace by an amount equivalent to the difference between the initial and back pressure—that is to say, if the back pressure is fifty pounds per square inch the reduction would be twenty-five pounds—but the pressure under which the combustion takes place would never fall below fifty pounds per square inch. The effect of this is to not only increase the intensity, but to reduce the liability of the boiler bursting internally. In a system of this kind it requires no constant attendance at the furnaces proper, as the valves may all be worked from a cooler position. Furthermore, the work of operating the gas generator or producer is very simple and requires neither great exertion nor protection against excessive heat.

My improvements will be better understood by reference to the accompanying drawings, in which—

Figure 1 is a diagram in elevation illustrating my improvements applied to a steamship. Fig. 2 is an elevation, with part in section, of my improved apparatus. Fig. 3 is a cross-section of same through one of the boilers and furnaces, and Fig. 4 is a sectional elevation of a modified apparatus for producing a back pressure.

A A are two boilers of any known type and are provided with furnaces B.

F is the smoke-stack, which communicates with the breeching E of the boilers.

G is a blower arranged in the smoke-pipe to produce a counter-draft, so as to put a back pressure upon the combustion taking place in the furnaces. This blower may be of any suitable construction and operated at at any speed desired by an engine *g*. Any other means for producing a back pressure may be employed.

I is a gas-generator and consists of a strong iron case lined with fire-brick and having near its bottom a grate *k*. Below the grate is the ash-pit J, having a discharge-valve L, and provided with blast-twyers K, through which air alone or mixed with steam may be passed. The top of the generator is provided with a feeding-hopper M and valve *m*.

M′ is a gas-tight lid, which is closed tightly when the valve *m* is opened at time of charging the generator with coal.

A pipe N leads from the top of the generator and communicates at the bottom with a horizontal gas-main N′, leading to the burners of the furnaces.

I′ is a gas-tight chimney-valve, which may be opened when first starting the fire in the generator. When this is done, the smoke passes into flue F′, leading to the smoke-stack F. A valve or damper *f* may be used to close the flue F′ when not in use. If desired, this chimney-valve I′ may be dispensed with, as the generator may secure its draft through the furnaces.

The steam-boilers connect with the steam-pipe S′, leading to the marine engines S for driving the screw or other machinery. S^2 represents valves for shutting off either boiler from this steam-pipe. Steam may be led from this pipe S′ by a steam-pipe T, which enters the upper part of the generator, so as to be superheated and then delivered to the twyers K by pipe *t*. A valve T′ may be employed to vary the supply of steam to the generator when used.

Q is an air-compressor and designed to compress the air to a pressure of seventy pounds, more or less, and approximately equal to the pressure under which the gas is generated. Air under pressure is led from this compressor Q by pipe Q′ to the twyers K of the generator and may be regulated by a valve *q*. As shown, the pipe Q′ is passed through the gas-flue N, so that the hot gases shall heat the air before it enters the twyers.

The front of each of the furnaces B is provided with a burner P, consisting of a chamber into which gas is delivered from the gas-main N′ and from which it is blown into the furnace, together with air from a blast-nozzle *p*, preferably on the injector principle. (See Fig. 3.) The air-blast is supplied from pipe R′, which in turn receives the air under pressure from the compressor by the pipe R, leading through the breeching, so as to become superheated. The air to the furnaces may be controlled by valves *r* of any suitable construction. The gas supplied to the burners P is also regulated by valves *n*, controlled by hand-levers N^2. Perfect combustion may be secured by properly adjusting the valves *n* and *r*. The general arrangements of the gas-burners may be greatly varied without departing from the operation desired, that shown being illustrated as an example of one manner of constructing them.

As it is desirable to provide means for generating steam for operating the compressor at the starting of the apparatus, I provide one of the boilers with grate-bars *c*, so arranged as not to interfere with the gas-burner, and, further, provide the front of the furnace with coaling-doors P′ and ash-doors P^2, adapted to be made gas-tight, except when first getting up steam. In this manner the apparatus may be started without more delay than to secure motive power sufficient to compress the air. Of course it is evident that a small auxiliary boiler might be used; but such is not necessary when the boiler is provided with auxiliary grate-bars and gas-tight doors.

In place of the means for producing a back pressure shown in Fig. 2 that shown in Fig. 4 may be employed. In this case the smoke-stack is provided with a series of valves G′. The several blades or valves *e* are connected and moved by a lever E′. A rod or handle E^3 connects the lever E′ with a weighted arm E^2, which has an adjustable weight *e′* to tend to close the valve against the pressure of the gases leaving from the furnaces. By adjusting the weight *e′* any degree of back pressure may be secured.

The operation will now be understood. The generator I being charged and steam being generated in the boiler, the compressor is put into operation after the several parts are made gas-tight. Air is admitted to the generator under high pressure to produce a gas exceedingly rich in heat units. The high pressure of the air admitted to the generator causes the carbon to become porous as a mass and maintained at a high temperature, so that rapid production of fuel-gas is secured. Under the high pressure employed but a small proportion of carbonic-acid gas

is produced, and this is practically eliminated when steam is admitted simultaneously with the air. By admitting superheated steam from pipe *t* simultaneously with the air the gas produced is especially rich in heat units, since it will contain large percentages of hydrogen and hydrocarbons. By the large and forced quantities of air admitted to the generator the carbon therein cannot be cooled or chilled by the steam-supply, so that the process of generation is continuous, and only a small-sized generator is necessary for a large duty. The fuel-gases so produced are led by pipe N′ to the burners of the furnaces, and here they are mixed with additional quantities of superheated air under high pressure and thoroughly consumed within the furnaces. The pressure under which these gases are burned may be equal to or somewhat less than the initial pressure under which they are admitted, and this is regulated by the production of the back pressure. The higher the back pressure consistent with the proper initial pressure the more intense the heating effect.

The advantage of securing high temperature and maintaining it with surety is to enable high steam-pressures to be employed, and thereby with a given engine to secure increased horse-power or to reduce the size of the engines for a given horse-power. The use of high pressure in the combustion-chamber secures quick penetration of heat to the water and rapid steam-generation, thus enabling the size of the boilers to be greatly reduced for a given-sized engine. For a given horse-power not only may the engine be reduced in size, but the boilers also, since the higher pressure secured permits a reduction in size of cylinders, and this reduces the volume of steam necessary. In addition to these advantages the facility with which the process can be carried on and regulated is most important. Furthermore, the labor required is reduced to a minimum, and not more than one-fifth the men heretofore necessary would be required to operate it. The saving in cost of steam-generation is very great as regards coal, since every portion of the carbon is converted into the form of gas capable of giving off the greatest heat units. No smoke is produced in normal operation, producing the greatest cleanliness.

While I have described my invention more particularly with reference to its adaptation to vessels, it is to be understood that I do not limit myself to any particular use, as it is equally adapted to all uses where high temperature is necessary or advantageous—as, for instance, in all metallurgical operations and millwork, such as in reheating-furnaces and soaking-pits.

I do not confine myself to any special form of apparatus, as any or all of the details may be modified as desired. Neither do I limit myself to any particular pressure under which the gases are generated or burned, though they should be generated at over fifty pounds per square inch to secure the most advantageous results.

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

1. In a power apparatus for steamships, &c., the combination of two or more steam-boilers each having one or more gas-tight furnaces, a steam-actuated air-compressor for compressing air to a high pressure, a fuel-gas generator into which air is forced continuously under high pressure, a fuel-gas-supply pipe leading from the generator to all of the furnaces and provided with valve devices for regulating the supply of high-pressure and hot fuel-gas to the furnaces, a compressed-air pipe leading from the compressor to all of the furnaces and provided with valve devices to regulate the supply of high-pressure air to the said furnaces of each of the boilers, a steam-pipe from the boilers to operate the air-compressor, a single chimney-flue connecting with the outlets from all of the furnaces, a back-pressure device in said chimney-flue to retard the escape of the products of combustion by a pressure less than that of the fuel-gas generator to insure the combustion taking place in all of the furnaces under equal high pressure, and steam-actuated power-engines for driving the ship or vehicle.

2. In apparatus for generating heat, the combination of means to generate a fuel-gas under pressure, a compressor for compressing air to high pressure, flues to supply compressed air to the gas-generator in insufficient quantity to produce complete combustion, a closed furnace independent of the generator, valved gas-supply pipes for leading the hot fuel-gas into the closed furnace under pressure, flues for leading additional compressed air at a pressure not greater than that of the fuel-gas into the furnace at place of combustion to secure full combustion of the gas, and a chimney-outlet from the closed furnace having means to create a back pressure exerted to oppose the escape of the products of combustion from the furnace of less resistance than the pressure of the fuel-gas while maintaining a continuous passage for products of combustion.

3. In apparatus for generating heat, the combination of a generator containing carbon from which to generate a fuel-gas under high pressure, a compressor for compressing air to high pressure, flues to supply compressed air to the gas-generator in insufficient quantity to produce complete combustion, a closed furnace independent of the generator into which the hot fuel-gas and additional air are admitted under high pressure to secure full combustion of the gas, and a chimney-flue provided with a rotary fan for producing a

draft to oppose the escape of the products of combustion from the furnace.

4. In apparatus for generating heat, the combination of means to generate a fuel-gas by subjecting a body of igneous carbon in a closed chamber simultaneously to air and steam at high pressures, a compressor for compressing air to high pressure, flues to supply compressed air to the gas-generator in insufficient quantity to produce complete combustion, steam-pipes for supplying steam to the gas-generator under high pressure, a valved gas-supply pipe for admitting regulated quantities of fuel-gas into the closed furnace, independent valved air-supply pipes for supplying a regulated quantity of additional compressed air into the furnace to secure complete combustion of the gas, and a chimney-outlet from the closed furnace having means to create a back draft to retard the escape of the products of combustion and insure the gases being burned under high pressure and in the requisite quantities.

5. In apparatus for generating heat, the combination of means to generate a fuel-gas by subjecting a body of igneous carbon in a closed chamber simultaneously to air and steam at high pressure, a compressor for compressing air to high pressure, flues to supply compressed air to the gas-generator in insufficient quantity to produce complete combustion, a closed furnace, a valved gas-supply pipe for admitting regulated quantities of the fuel-gas into the closed furnace, independent valved air-supply pipes for supplying a regulated quantity of additional hot compressed air into the furnace to secure complete combustion of the fuel-gas, means to heat the compressed air prior to entering the furnace, and a chimney-flue provided with a rotary fan for producing a backward draft to oppose the escape of the products of combustion from the furnace and insure the gases being burned under high pressure and in the requisite quantities.

6. In apparatus for generating heat, the combination of a generator in which to generate a fuel-gas, a compressor for compressing air to high pressure, flues to supply compressed air to the gas-generator in insufficient quantity to produce complete combustion, a closed furnace into which the hot fuel-gas and additional air are simultaneously admitted in regulated quantities under high pressure to produce complete combustion of the fuel-gas while under pressure, a chimney-flue provided with a rotary fan for producing a backward or retarded draft to oppose the escape of the products of combustion from the furnace and insure them being burned under high pressure, and power devices for operating the fan at variable speeds to regulate the pressure under which the combustion is carried on in the furnace.

7. In apparatus for generating heat, the combination of means consisting of a generator having steam and air pipes to generate a fuel-gas by subjecting a body of igneous carbon in a closed chamber simultaneously to air and steam at high pressure in which the air is in insufficient quantity to produce complete combustion, a closed furnace into which the hot fuel-gas and hot additional air are admitted in regulated quantities under high pressure to produce complete combustion of the fuel-gas, a compressor for compressing the air to give it the initial high pressure, a chimney-flue leading from the furnace provided with a rotary fan for producing a backward or retarded draft to oppose the escape of the products of combustion from the furnace and insure them being burned under high pressure, and power devices for operating the fan at variable speeds to regulate the pressure under which the combustion is carried on in the furnace.

8. In apparatus for generating heat, the combination of a closed furnace into which the fuel-gas and air are forced under high pressure, and a chimney-flue provided with a rotary fan for producing a backward or retarding draft to oppose the escape of the products of combustion from the furnace and insure them being burned under high pressure.

9. In apparatus for generating heat, the combination of a closed furnace into which the fuel-gas and air are forced under high and constant pressure, a chimney-flue provided with a rotary fan for producing a backward or retarding draft to oppose the escape of the products of combustion from the furnace and insure them being burned under high pressure, and power devices for operating the fan at variable speeds to regulate the pressure under which the combustion is carried on in the furnace.

10. In apparatus for generating heat, the combination of a closed furnace into which the proper proportions of fuel-gas and air are introduced under high pressure to produce complete combustion of the gas, means for supplying fuel-gas under a high steam-pressure to the furnace, a compressor for compressing the air to high and continuous pressure, means to heat the compressed air prior to being admitted to the furnace, independent means for regulating the supply of air and the gas to the furnace in sufficient quantities to produce complete combustion of the gas, and a chimney-flue having means producing a counter-draft to retard the free escape of the products of combustion.

11. In apparatus for generating heat, the combination of a gas-tight furnace into which the fuel-gas and air are admitted and burned under high pressure, heating-pipes for superheating the air delivered to the furnace adapted to be heated by the gases burning in the furnace, valved gas-supply pipes

for controlling the fuel-gas fed into the closed furnace, valved air-supply pipes for controlling the supply of compressed and heated air to the furnace whereby complete combustion is insured under a high pressure, and a chimney-flue provided with mechanically-operated means for producing a variable back draft to retard the escape of the products of combustion from the gas-tight furnace.

12. In apparatus for generating heat, the combination of means to generate a fuel-gas under high pressure, a compressor for compressing air to high pressure, two or more gas-tight furnaces each provided with means for supplying air and gas under high pressure, independent means for regulating the supply of the air and gas separately to each of the furnaces from the common generator and compressor, and a chimney-flue common to all the furnaces having means to retard the escape of the products of combustion simultaneously from all of the furnaces to equalize the back pressure in all of the furnaces.

13. In apparatus for generating heat, the combination of means to generate a fuel-gas under high pressure and temperature, a compressor for compressing air to high pressure, two or more gas-tight furnaces each provided with means for supplying air and gas under high pressure, means heated by the products of combustion before being fed to the furnaces to heat the air while under pressure, independent means for regulating the supply of highly-heated air and gas to the furnace to secure complete combustion, and a chimney-flue common to all the furnaces opening to the atmosphere having means to retard the free escape of the products of combustion to the atmosphere to simultaneously equalize the back pressure in all of the furnaces.

14. In steam-generating apparatus, the combination of means to generate a fuel-gas under high pressure and temperature by subjecting a body of igneous carbon in a closed chamber simultaneously to air and steam at high pressure the air being in insufficient quantity to produce complete combustion, two or more furnaces each provided with means for independently supplying gas and additional quantities of air under high pressure to secure complete combustion of the gas, one or more steam-boilers heated by the furnaces, steam-pipes leading from the boilers to the gas-generator, heating-pipes for superheating the air delivered to the furnace heated by the products of combustion of the several furnaces, independent means for regulating the supply of the air and gas to the furnace, and a chimney-flue common to all of the furnaces having means to retard the escape of the products of combustion whereby the back pressure of all of the furnaces is simultaneously controlled and made the same.

15. The herein-described method of generating heat which consists in supplying to a gas-tight furnace fuel-gas and air both under high pressures, burning said gas and air under high pressure to secure complete combustion and to increase the intensity of heat, permitting the products to escape from the furnace into the atmosphere, and acting upon the escaping products of combustion during their escape with an opposing draft to retard their escape and maintain a very high pressure within the furnace.

16. The herein-described method of generating heat which consists in supplying to a gas-tight furnace fuel-gas and air under high pressures, burning said gas and air both under high pressure to secure complete combustion and to increase the intensity of heat, permitting the products to escape from the furnace into the atmosphere, acting upon the escaping products of combustion during their escape with an opposing draft to retard their escape, maintaining a high pressure within the furnace during the combustive process greater than the opposing draft, and varying the opposing draft to regulate the extent of pressure under which the combustion takes place within the furnace.

17. The herein-described method of generating heat, which consists in supplying air under high pressure to a bed of igneous carbon in a closed chamber to generate a continuous supply of fuel-gas under continuous and uniform high pressure, passing the fuel-gas so generated while hot and under the initial pressure into a gas-tight or closed furnace together with a slight excess of superheated compressed air at equally high pressure, regulating the supply of and burning the air and gas within the closed furnace under strong pressure whereby increased intensity of heat is secured by increasing the density of the gases under combustion, and causing the products of combustion from the furnace to escape at a pressure greatly in excess of atmospheric pressures.

In testimony of which invention I have hereunto set my hand.

R. M. HUNTER.

Witnesses:
J. W. KENWORTHY,
WM. L. EVANS.