W. F. BROWN.

CONTINUOUS COMBUSTION HEAT ENGINE.

APPLICATION FILED MAR. 23, 1908.

972,504. Patented Oct. 11, 1910.

4 SHEETS—SHEET 1.

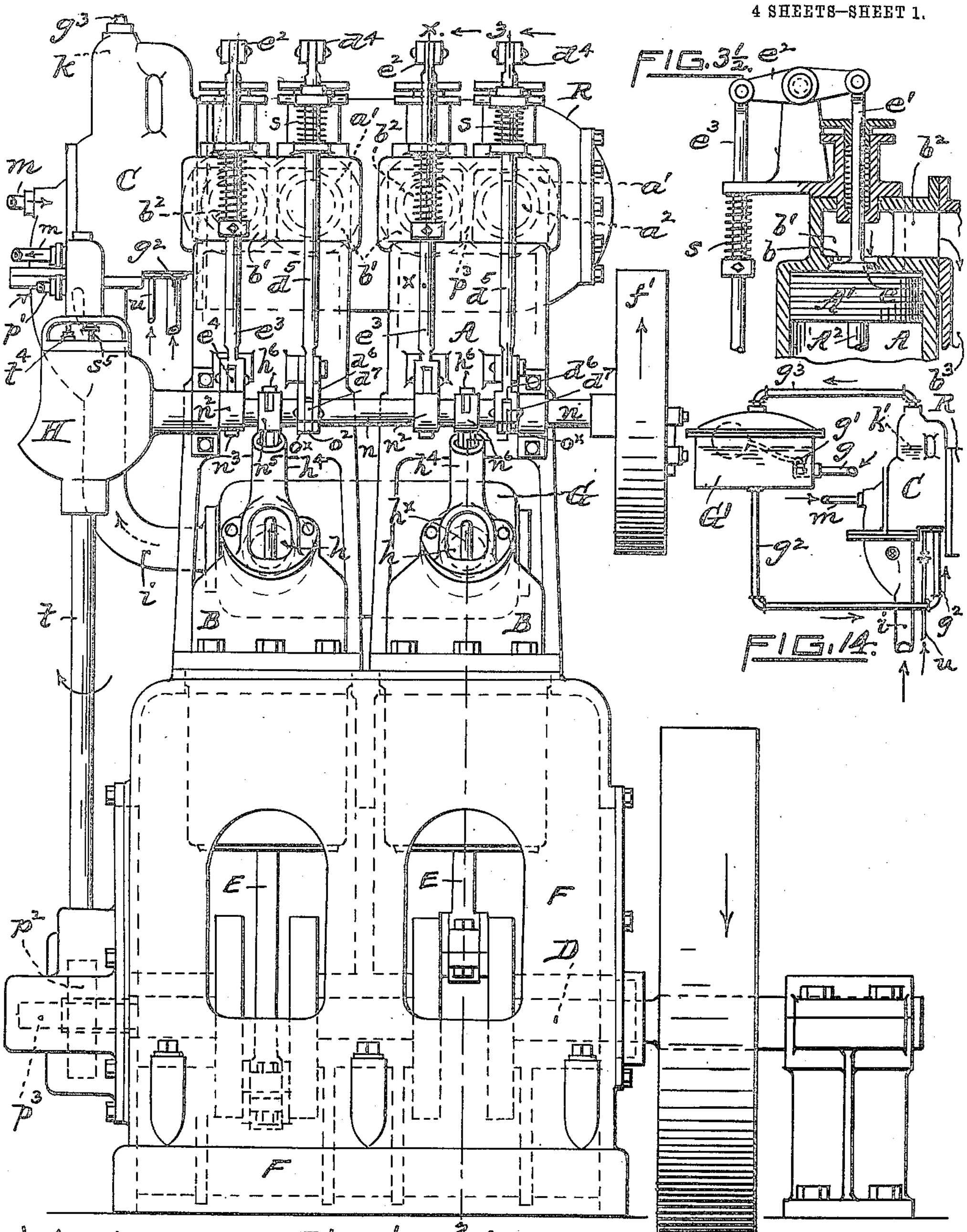

FIG. 3½. FIG. 14.

FIG. 1.

WITNESSES.

C. T. Hannigan.

Calvin H. Brown

INVENTOR.

Walter F. Brown.

By Geo. H. Remington.

Attorney.

W. F. BROWN.

CONTINUOUS COMBUSTION HEAT ENGINE.

APPLICATION FILED MAR. 23, 1906.

972,504.

Patented Oct. 11, 1910.

4 SHEETS—SHEET 2.

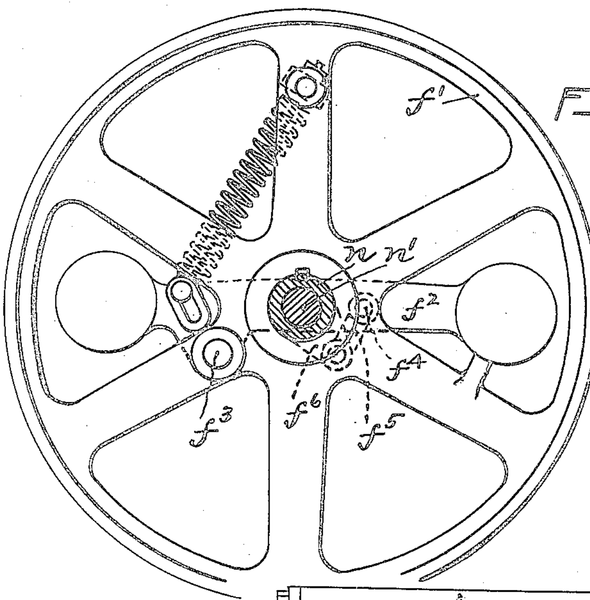

FIG. 12.

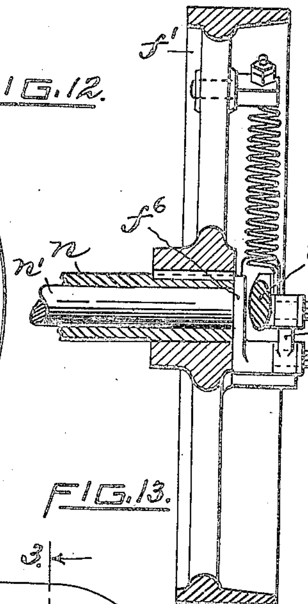

FIG. 13.

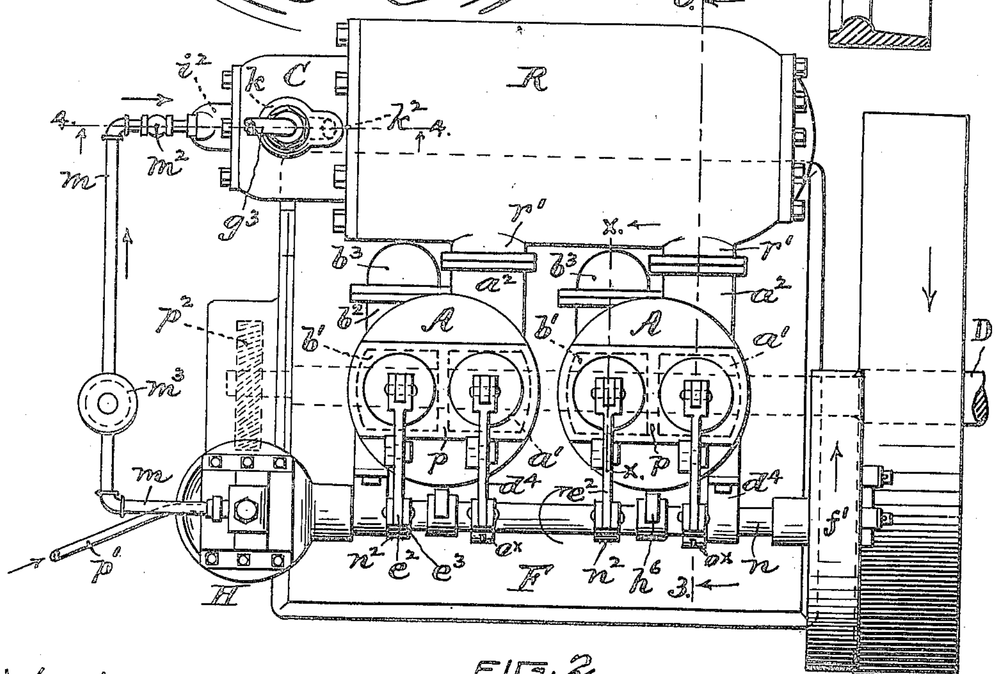

FIG. 2.

WITNESSES.

C. T. Hannigan.

Calvin H. Brown

INVENTOR.

Walter F. Brown.

By Geo. H. Remington.

Attorney.

W. F. BROWN.

CONTINUOUS COMBUSTION HEAT ENGINE.

APPLICATION FILED MAR. 23, 1908.

972,504. Patented Oct. 11, 1910.

4 SHEETS—SHEET 3.

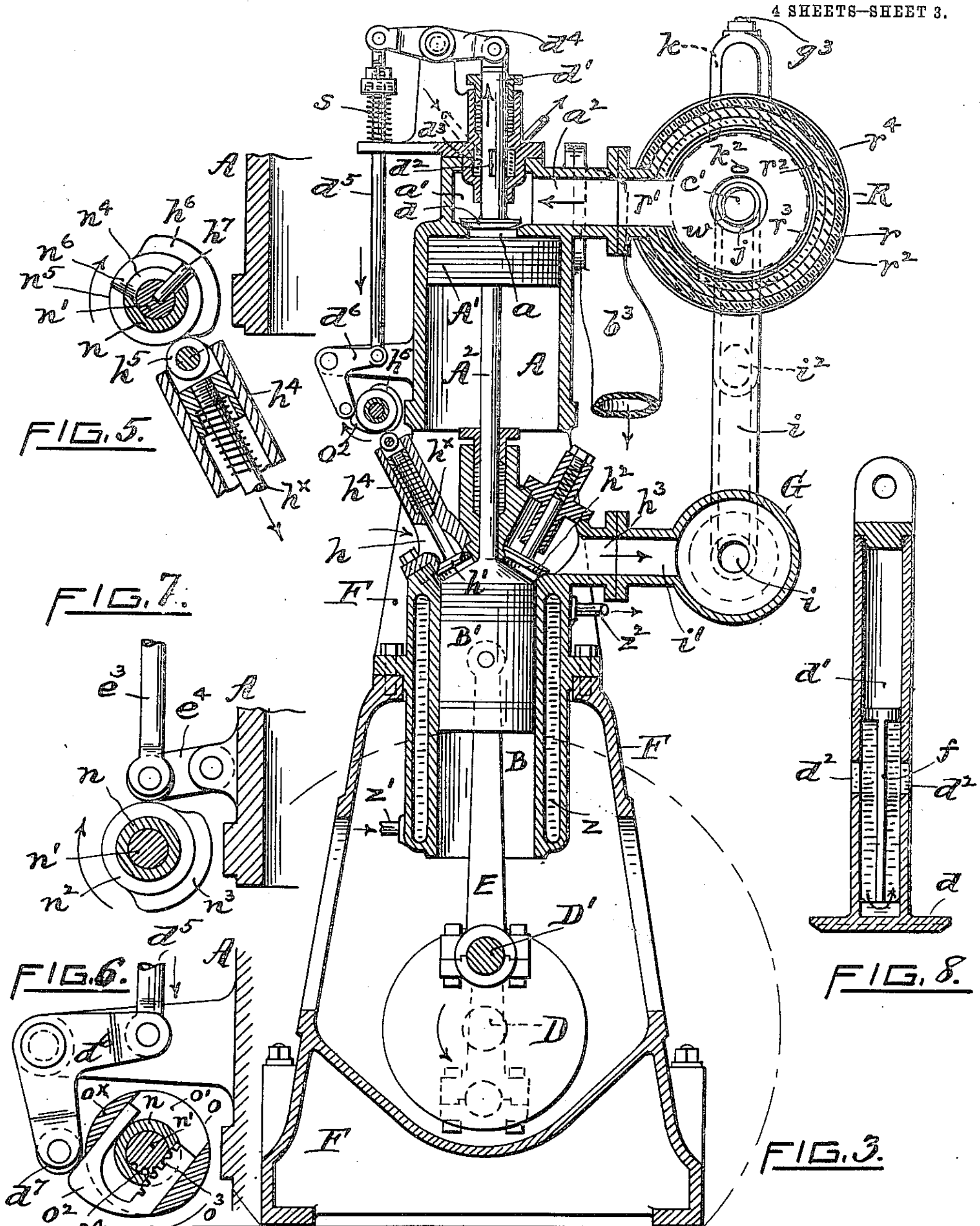

FIG. 5. FIG. 7. FIG. 6. FIG. 3. FIG. 8.

WITNESSES.

C. T. Hannigan.

Calvin H. Brown

INVENTOR.

Walter F. Brown.

By Geo. H. Remington.

Attorney.

W. F. BROWN.

CONTINUOUS COMBUSTION HEAT ENGINE.

APPLICATION FILED MAR. 23, 1908.

972,504.

Patented Oct. 11, 1910.

4 SHEETS—SHEET 4.

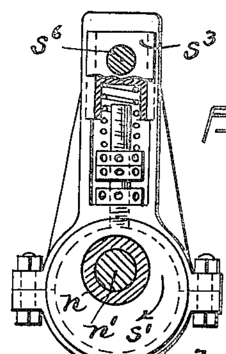

FIG. 11.

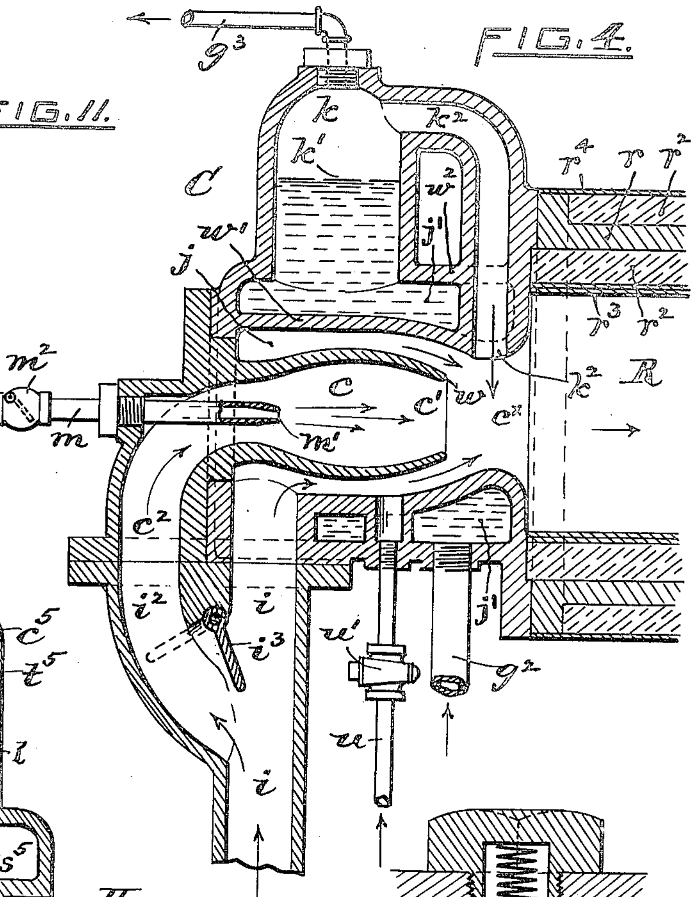

FIG. 4.

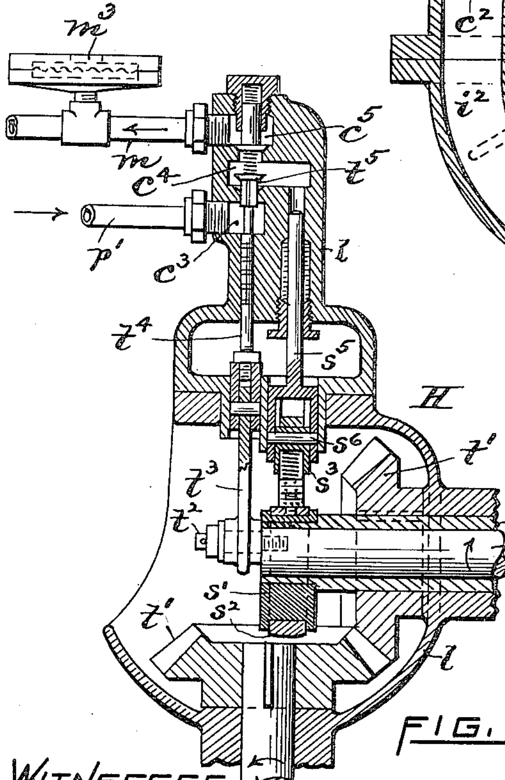

FIG. 9.

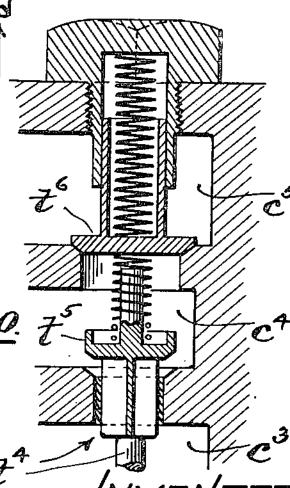

FIG. 10.

WITNESSES.

C. T. Hannigan.
Calvin H. Brown

INVENTOR.

Walter F. Brown.
By Geo. H. Remington.
Attorney.

UNITED STATES PATENT OFFICE.

WALTER F. BROWN, OF WORCESTER, MASSACHUSETTS.

CONTINUOUS-COMBUSTION HEAT-ENGINE.

972,504. Specification of Letters Patent. Patented Oct. 11, 1910.

Application filed March 23, 1908. Serial No. 422,630.

To all whom it may concern:

Be it known that I, WALTER F. BROWN, a citizen of the United States of America, and a resident of Worcester, in the county of Worcester and State of Massachusetts, have invented certain new and useful Improvements in Continuous-Combustion Heat-Engines, of which the following is a specification.

My invention relates to novel improvements in heat-engines, so-called, and more particularly to the type of engines or motors in which the working-medium, introduced into and expanded in the working-cylinder of the engine, is produced by the continuous combustion in an inclosed chamber of a fuel, such for example, as a suitable gas, oil, or other hydrocarbon, combined with compressed-air to complete the combustion.

The invention forming the subject of this application for patent consists, essentially, in certain new and novel features of construction and in the arrangement and manner of operation of the same, all as more clearly and fully hereinafter set forth and claimed.

It is assumed that in general the art of converting a gas or liquid fuel into a heated gaseous medium or working fluid under pressure and the subsequent conversion of the resulting heat-energy into mechanical energy is well understood.

Among the objects sought to be attained by my present invention are the following:

To produce a heat-engine, employing the "Joule" cycle, so-called, in which the applied heat energy of the gaseous working medium, having certain temperature and pressure, is converted into useful work with a materially greater degree of efficiency and economy, as compared with other heat engines of the continuous combustion type using a working medium having the same temperature and pressure.

To produce a self-contained heat-engine of the type referred to having an air-compressor and a working cylinder, and having means for converting the fuel into a gaseous working medium under pressure in an internal combustion chamber, a governor actuated by the engine for automatically controlling the admission of air into the compressor and also for automatically varying the point of cut-off of the working medium in the power cylinder, corresponding with the load upon the engine.

To produce a central internal combustion chamber connected with the fuel supply having means for automatically varying the quantity of fuel fed to the chamber and provided with means for supplying a continuous flow of compressed air into and around the chamber to mingle with the fuel and convert it into the working medium, the volume of said air entering the chamber being variably controlled by the engine itself.

To produce an internal combustion air-jacketed chamber having the fuel and compressed air supplied thereto substantially as stated above, and having the air-jacket surrounded or enveloped by a water-circulating jacket for reducing the temperature of the air-jacket's wall and for reducing the temperature of the gas resulting from the combustion, the steam or vapor generated from the jacket-water at the same time also mingling with and imparting entropy to the gaseous products of combustion.

To provide means for automatically varying the normal stroke or displacement of the continuously actuated fuel-feeding device so as to vary the volume of fuel fed to the combustion-chamber from the source of supply corresponding with the load upon the engine, thereby preventing the feeding of an excess quantity into the chamber.

To provide means connected with the water-jacket of the combustion-chamber element for supplying water from any suitable source to replace in the jacket water converted therein into steam or vapor and mingled with the products of combustion to produce a gaseous working medium, said means being operatively controlled by variations in the normal level of water in the jacket or by changes in the temperature of said working medium.

To provide a heat-protected receiver connected to and communicating with the combustion-chamber element and working cylinder of the engine, said receiver having its walls covered both interiorly and exteriorly with non-conducting material, as asbestos, and means for retaining the latter in position on the receiver.

In my improved heat-engine the same is constructed and adapted to be operated on the "Joule" cycle, or system. The heat energy generated and later converted into mechanical energy is continuously produced in an internal chamber by the combustion therein of a suitable fuel combined with the oxygen of heated compressed air continuously supplied thereto and the mingling with the products of combustion of steam or vapor from the water-circulating jacket, thereby giving to the thus produced working medium a greater degree of entropy or thermo-dynamic properties. When in use the compressed air supplied to the highly heated combustion chamber and the air-circulating jacket enveloping the latter not only supplies oxygen to the fuel to effect its perfect combustion but it at the same time protects the walls of the chamber against excessive heating and produces a partial reduction of temperature of the products of combustion while in the chamber, the air also mingling later with the products of perfect combustion. At the same time, too, the temperature of the latter is further reduced by the presence of the steam or vapor from the water-jacket.

It may be added that the temperature of the products of combustion may be reduced or tempered by the use of compressed air alone, but in such case an excessive volume of the air would be required, thereby to a great extent reducing the available power of the engine and obviously decreasing its economy. Therefore in order to overcome the disadvantages or objections just referred to I provide the combustion-chamber with independent air and water jackets, as before stated, by means of which construction the gaseous working medium may be supplied with steam or vapor so as to impart to it a greater degree or percentage of entropy or heat-carrying capacity than can be obtained by the employment of air alone.

Gas engines in general are normally rated nearly up to their ultimate power because they are more economical and efficient when running under full load. In an automatic cut-off steam engine, however, the normal rating is much less than its maximum horse-power; or in other words, the latter engine has a very much greater overload capacity than is possessed by gas or elastic heat-engines. In heat-engines adapted to work on the "Otto" cycle system the maximum power developed may somewhat exceed the normal rating.

My improved heat-engine is capable of producing a much greater percentage of expansibility and overload capacity than has been attainable in heat-engines heretofore devised. In fact its action is quite analogous to that of a steam engine, in that the volume of air admitted to the compressor as well as the volume of working medium entering the working-cylinder of the engine are automatically controlled by the governor, corresponding with changes in the load, and not by variations in temperatures and pressures.

In the accompanying four sheets of drawings Figure 1 represents a front side elevation of a vertical self-contained heat-engine embodying my improvements. Fig. 2 is a corresponding top plan view. Fig. 3 is a vertical sectional view taken substantially on lines 3 3 of Figs. 1 and 2. Fig. 3½ is a vertical sectional view taken on line x x of Figs. 1 and 2, showing the upper portion of the power cylinder and its exhaust-valve and connections. Fig. 4 is a longitudinal sectional view of the combustion-chamber element and some of its connections, in enlarged scale; the section being taken on line 4 4 of Fig. 2. Fig. 5 is a detached sectional view, in enlarged scale, showing governor-actuated means for variably controlling the opening of the intake-valve of the air-compressor. Fig. 6 is a similar view showing analogous means for variably controlling the inlet-valve for the admission of the working-medium into the power or working cylinder. Fig. 7 is a similar detached sectional view showing means for opening the exhaust-valve for the escape of the waste gases from the power cylinder after the working medium has been expanded and converted into useful work. Fig. 8 is a detached longitudinal central sectional view of the said inlet-valve and its stem, enlarged. Fig. 9 is a similar sectional view showing means for supplying and controlling the volume of fuel fed to the said combustion chamber. Fig. 10 is a vertical sectional view showing in further enlarged scale yieldingly mounted valves which open and close the passages or ports through which the fuel is fed. Fig. 11 is a front elevation, in partial section, representing an eccentric connection provided with means adapted to vary the stroke of the fuel-feed-pump. Fig. 12 represents an end elevation of a positively driven automatic governor of well-known construction for actuating and controlling the movements of the valves of the air-compressor and power cylinder. Fig. 13 is a corresponding transverse sectional view, and Fig. 14 is a side elevation, in greatly reduced scale, showing means for automatically maintaining a substantially constant water-level in the water-jacket of the combustion-chamber element.

The following is a more detailed description of my improved heat-engine and including the manner of its operation: The air-compressor B and its piston B^1; the power-cylinder A and its piston A^1 are as drawn disposed in alinement with each other; the pistons being rigidly connected together by the interposed piston-rod A^2, thus insuring concurrent movement when in action. The force developed in the power-cylinder is transmitted to a connecting-rod E jointed to piston B^1 and crank-pin D^1 of a crank or main-shaft D. All the elements thus far referred to are or may be mounted and supported in a suitable stationary frame or housing, as F, in a well-known manner. As drawn, the working area of each power-cylinder is 100 per cent. greater than that of the corresponding air-compressor's plunger or piston. Obviously other proportions and sizes may be employed as determined by the designing engineer. The lower or air-compressing cylinder is provided with a jacket z for the circulation of a cooling medium, as water; the inlet and outlet passages communicating with the jacket being indicated at z^1 and z^2, respectively. See Fig. 3.

I prefer to make the upper end or head of the compressor and its piston cone-shape. The intake and outlet ports are oppositely disposed in said head and provided with valves h^1 and h^2, respectively, seated therein; and having the valve-rods or stems extending from each other in divergent directions and provided with springs to render the valves self-closing. The outlet passage or nozzle h^3 is in open communication with the nozzle i^1 of the compressed-air reservoir G, in turn connected by a pipe i to the combustion-chamber C, soon to be described. The stem $h^\times$ of the inlet-valve h^1 extends upwardly through the tubular hub or bearing h^4 of the bonnet and carries a small roll h^5 arranged to be engaged by a positively revoluble cam h^6, which latter is also capable of independent movement in a reverse direction at the same time by the action of a governor-controlled central shaft n^1 mounted in the suitably supported continuously revoluble tubular shaft or quill n. See Fig. 5. The cam h^6 is represented as fixed to a radial pin h^7 passing downwardly through peripheral slots n^6 and n^4 of collar n^5 and said quill, respectively, and secured to or in the shaft n^1. As thus devised the cam may be turned rearwardly an angular distance, as determined by the governor, thereby varying in a mechanical manner the time and length of the valve's opening for the admission of air, via port h, into the compressor to correspond with variations in the work developed in the engine. The valve h^1 is automatically closed by its spring when the said cam moves away from the roll. It may be added here that as drawn the shaft n is positively driven at the same rate of speed as the engine-shaft D.

The power-cylinder A has its upper head provided with independent inlet and exhaust-chests, a^1 and b^1, having valve-controlled ports a and b, respectively. See Figs. 3 and 3½. The inlet-chamber has a nozzle a^2 in continuous opening communication with a nozzle r^1 of the receiver R, later described. The stem d^1 of inlet-valve d extends upwardly through the chest's bonnet and stuffing-box and is jointed to an end of the short swinging beam d^4; its opposite end being jointed to a guided downwardly extending spring-pressed rod d^5, in turn jointed to an arm of a pivoted knee-lever d^6. The valve-stem d^1 is hollow (see Fig. 8), its lower portion being provided interiorly with a plug having wings f extending nearly to the bottom. The wall of the stem is apertured at d^2 at a point below the plug's head. When in service a cooling medium, as water, is circulated in a chamber d^3 formed in said bonnet, the water also circulating in the stem itself, since the openings d^2 thereof are always in open communication with the water in said chamber d^3. See Fig. 3.

A device for variably controlling the movements of the inlet-valve d is represented in Fig. 6. A collar $o^\times$ secured to said tubular shaft n has a transverse opening o^1 therethrough in which a U-shaped cam member o^2 is slidably mounted; one arm of the cam passes freely through a transverse slot formed in the shaft and is provided with gear-teeth o^3, constituting a rack, engaging teeth o^4 of the governor-actuated central shaft n^1. The portion of said member o^2 extending through the collar and forming the cam proper is adapted to engage a roll d^7 mounted in the free end of the lower arm of lever d^6 to vibrate the latter. The angular distance traversed by the lever is determined by the extent of the cam's projection beyond the collar $o^\times$ in coöperation with the governor-actuated shaft n^1 for varying the position of the cam, thereby correspondingly changing the point of cut-off or closure of the inlet-valve.

The exhaust valve e is seated in the port b (Fig. 3½) of the chest b^1. The stem e^1 of said valve extends upwardly through a suitable stuffing-box and is jointed to a pivoted beam e^2 operatively connected to a rod e^3 jointed at its lower end to a link e^4, Fig. 7. This rod carries a roll adapted to be engaged by a cam n^3 fast to a collar secured to the said continuously revoluble tubular shaft n. A spring s serves to keep the valve normally seated. The exhaust gases pass from the chamber b^1 via nozzle b^2 into the exhaust-pipe b^3. As thus devised and arranged the cam n^3 is positioned so as to positively open and close the exhaust-valve at predetermined points in the piston's movement or back stroke.

The governor is driven by suitable means, as for example, by a pair of meshing spiral-toothed gears, indicated by dotted lines in Fig. 1; one, p^2, is secured to the crank-shaft, the other, p^3, being fixed to a suitably supported vertical shaft t having a miter-gear t^1 fast to its upper end. A fellow gear, t^1, is secured to the adjacent end of the horizontally mounted tubular shaft n (Fig. 9), the latter having fixed thereto at its opposite end a heavy wheel or pulley f^1 carrying the governor device proper. See Figs. 12 and 13. The governor has a spring-connected weighted bar f^2 pivoted at f^3 to the wheel. A link f^5 jointed at f^4 to said bar and also to a short crank f^6 fixed to the adjacent end of the shaft n^1 is adapted to rotate the latter short variable angular distances by the centrifugal force of the governor in a direction contrary to the normal direction of the shaft n while at the same time rotating bodily in unison with the last-named shaft. The said varying changes in the governor are due, as is well-known, to temporary variations in the load upon the engine, the governor's action being employed to automatically change the position of the devices before described for admitting the air and working medium into the respective cylinders and to correspondingly vary the volume of said air and working medium antecedent to their introduction.

The following more particularly relates to and is a description of improved means or devices for continuously converting the products of combustion generated from a suitable fuel, as gas or hydrocarbon oil, into a heat energized working medium capable of being converted into mechanical energy: I employ a combustion chamber element C (Fig. 4) provided with a suitably shaped inner combustion chamber proper, c, into which the fuel and compressed air are supplied, the resulting products of combustion flowing or being discharged into a heat-protected receiver R, later described. As drawn, the inlet end of the chamber c has a nozzle c^2 in open communication with a by-pass i^2 communicating with the discharge-pipe i leading from the said compressed air reservoir G. A manually-controlled valve i^3 may be employed for varying the volume of compressed air entering the chamber c. A space surrounding the walls w of the chamber and being in open communication with the compressed air supply-pipe i constitutes an air-circulating jacket, j, for reducing the temperature of said walls, thus preventing to a considerable extent the radiation therefrom of the high degree of heat generated in the chamber. The discharge end c^1 of the chamber c and also that of the air-jacket open freely into a common outlet $c^{\times}$, in turn opening directly into the receiver R. The outer wall w^1 of the jacket j is enveloped by a substantially concentric space j^1 constituting a jacket for the circulation therein of a suitable cooling medium, as water. The wall, w^2, forms the exterior of the element C, as clearly shown. The top of the latter is provided with a hollow dome-like vertical extension k integral with the jacket j^1 in which dome-space the water is maintained at a substantially uniform level k^1. The space above the water-level forms a small reservoir for the steam or vapor generated from the water. k^2 indicates a duct or passage in open communication with the dome-space and with said outlet $c^{\times}$. As thus devised it will be apparent that the pressure of the gaseous working medium is substantially the same in both the jackets and receiver.

In order to automatically supply water into the jacket j^1 to compensate for the loss due to the generation therein of steam and vapor carried along with the working medium into the working cylinder A, I may employ means, substantially as represented in Fig. 14 of the drawings, in which a well-known form of trap or tank G^1 is provided with a water-supply pipe g and a float-valve g^1, the latter automatically opening to supply water to the tank whenever the water therein drops below the normal or predetermined level; the latter corresponding with the level k^1 in the said water-circulating jacket through the medium of the open pressure-equalizing pipe g^3, uniting the upper portions of the dome and tank. A corresponding pipe, g^2, uniting the bottom of the tank and jacket provides communication for supplying water into the latter. See arrow directions.

The following described means for supplying and automatically controlling the volume of fuel, as for example, liquid-fuel, fed to the combustion chamber. See Figs. 1, 2, 9, 10 and 11; the three last-named figures representing details of construction: H designates the fuel-feeding device as a whole, the same, as drawn, has a short-stroke valve-opening rod t^4 actuated by means of a connection t^3 mounted on a crank-pin t^2 secured in the end of the governor-actuated shaft n^1, arranged whereby said rod in its upward stroke is adapted to engage and force open the spring-pressed foot-valve t^5 to allow fuel (delivered into chamber c^3 via pipe p^1 leading from the source of supply) to flow upwardly into the intermediate chamber c^4. Thus it will be seen that the opening of the valve t^5 is automatically timed and effected by the governor. The fuel is forced from chamber c^4 by a variable-throw pump into the upper discharge-chamber c^5, in turn communicating via pipe m with the fuel-delivery nozzle m^1 positioned in the combustion chamber proper, c. See Fig. 4. The said pump is represented (Fig. 9) as having a suitably packed and vertically guided plunger s^5. The several parts above named as also the said pair of miter gears t^1 are suitably mounted in a casing l as clearly shown. The said plunger s^5 is actuated through the medium of an eccentric s^1 secured to the adjacent end of the positively driven tubular shaft n, the latter as before stated also rotating the governor and other devices fixed thereon. A guided strap, s^2, is mounted on and adapted to be reciprocated in a vertical direction by the eccentric. An independently movable spring-pressed block or cross-head s^3 is adjustably mounted in said strap (Fig. 11) and is jointed to the pump plunger s^5 by a pin s^6 passing transversely through the block and the head of the plunger. This latter is in continuous communication with said intermediate chamber c^4, the device being so constructed and arranged that when in normal action the volume of fuel displaced per stroke is equal to the cross-sectional area of the plunger multiplied by the "throw" or stroke of the eccentric, thereby forcing more or less of the fuel through the upper spring-pressed delivery-valve t^6 into the chamber c^5 and its discharge-pipe m, as before stated. In the event, however, that the pressure upon valve t^6 temporarily exceeds that of the moving plunger some of the fuel may be forced back by the latter into the chamber c^3 and pipe p^1, assuming the lower valve t^5 to then be open. Otherwise when the pressure of the plunger upon the fuel in chamber c^4 is exceeded by the downward pressure upon valve t^6 the plunger itself will then automatically yield in a rearward direction owing to the presence of the said spring-pressed or resilient blocks s^3 slidably mounted in the upper part of the eccentric-strap s^2, no fuel then being displaced. In fact the conditions may temporarily be such that no plunger movement whatever takes place, although the eccentric and strap at the same time be normally working.

The pressure upon the fuel pumped into the pipe m which supplies the combustion chamber may be equalized or prevented from undue pulsations in discharging into the latter by means of a suitable diaphragm, m^3, disposed in the pipe in a well-known manner. A check-valve, m^2, may also be located in the pipe m to prevent back-flow into the latter from the combustion chamber. The orifice of said discharge-nozzle m^1 may be arranged or constructed so that its lower side will lie horizontally or even drop a little, thus preventing the retention of fuel therein, substantially as shown in Fig. 4.

The receiver R for supplying the working-cylinders of the engine with the working medium produced in the combustion chamber is closed at one end, its opposite end being secured to the combustion chamber element C and also being in direct open communication with the outlet c^x thereof, see Fig. 4. The receiver is provided with two lateral nozzles r^1 secured to the open inlet-nozzles a^2 of the inlet-valve chambers a^1 of the two cylinders A, as clearly shown. The metal walls r of the receiver are protected against heat-radiation by means of suitable non-conducting material, as prepared asbestos, applied to and covering its entire inner and outer surfaces, as indicated at r^2. Thin layers of suitable binding material, r^3, may be applied to the inner lining r^2 for securely holding the latter in place; a thin casing, r^4, being similarly employed for the outer covering.

It may be stated that in order to provide auxiliary means for initial ignition of fuel supplied to the internal chamber member c antecedent compressed air having a proper degree of heat may be conducted by a pipe u from a suitable independent source of supply into the air-jacket j (see Fig. 4), thereby both heating the walls w of the chamber and supplying compressed air to the fuel to create combustion. After normal action has been established in the combustion chamber the said heated auxiliary compressed air supply may be shut off by means of a cock or valve u^1.

I claim as my invention and desire to secure by United States Letters Patent:—

1. In a heat-engine of the continuous combustion type, having means for converting heat energy or products of combustion into mechanical energy, the combination therewith of means, including an air and water jacketed combustion-chamber adapted to receive mingled fuel and air and generate or convert the same therein into said heat-energized medium, arranged whereby when in use air from the air-jacket and steam or vapor from the water-jacket surrounding the combustion-chamber mingle with the said products of combustion or working medium issuing from the chamber so as to reduce its temperature before it is converted into mechanical energy.

2. In a heat-engine of the continuous combustion type provided with a working cylinder in which heat energy is converted into mechanical energy, the combination of an air and water-jacketed combustion-chamber, means for supplying mingled fuel and air thereto to be converted into said heat energy or products of combustion without passing the same through a cooling medium, as water, means for reducing the temperature of the products of combustion by mingling the same with air and vapor from said jackets, and means for automatically controlling the volume of fuel and air supplied to the combustion-chamber corresponding with changes in the load upon the engine.

3. In a heat-engine of the continuous combustion type, having means for converting heat-energy or products of combustion into mechanical energy, the combination therewith of a combustion-chamber, means for supplying fuel and compressed air to the chamber to generate therein the products of combustion, a jacket surrounding the walls of the chamber communicating with the latter's outlet for the circulation of air so as to reduce the temperature of said walls, and an exterior jacket surrounding the air-jacket for the circulation of a medium, as water,

having a capacity for latent heat, arranged whereby when in use steam or vapor therefrom and air from said air-jacket mingle with the products of combustion to materially reduce its temperature before it is converted into mechanical energy.

4. In a heat-engine of the continuous combustion type, having a working-cylinder and means for automatically controlling the admission of heat-energized gas or working medium under pressure into the cylinder and exhausting it therefrom, the combination therewith of a combustion-chamber communicating with the cylinder, means for supplying fuel and compressed air to the chamber to generate said gas, a jacket surrounding the walls of the chamber and communicating with the latter's outlet for the circulation of air so as to reduce the temperature of said walls and the products of combustion, and an exterior jacket surrounding said air-jacket for the circulation of a cooling medium, as water, having capacity for latent heat, arranged whereby steam or vapor therefrom mingles with the gas to reduce the latter's temperature before it passes to the working cylinder.

5. In a heat-engine of the continuous combustion type, a working-cylinder provided with valved inlet and exhaust-chambers, and a receiver protected against radiation open into said inlet-chamber, in combination with a combustion chamber connected to and adapted to discharge into said receiver provided with independent surrounding air and water-circulating jackets communicating with the discharge end of the center or combustion-chamber proper, means for supplying fuel and compressed air directly into the latter and mingling the same therein to produce a gaseous working medium whose temperature is reduced by mingling with air and vapor from said jackets before entering the receiver, and means actuated by the engine for automatically controlling the volume of said fuel and air supply to correspond with variations in the load upon the engine.

6. In a heat-engine of the continuous combustion type, a working-cylinder provided with valved inlet and exhaust chambers, in combination with a combustion-chamber communicating with said inlet-chamber provided with independent surrounding air and water-circulating jackets communicating with the center or combustion-chamber proper, means for supplying fuel and compressed air into the combustion-chamber without the intervention of a water-seal to produce a gaseous working medium, and means actuated by the engine for automatically controlling the volume of said fuel and air supply to correspond with variations in the load upon the engine.

7. In a heat-engine of the continuous combustion type, provided with means for converting heat energy into mechanical energy, the combination therewith of a combustion-chamber having independent surrounding air and water-circulating jackets in continuous open communication with the center or combustion-chamber proper, means for supplying fuel and compressed air into the latter to produce a gaseous working medium, said medium as it passes from the chamber instantly mingling with air and vapor from said jackets to reduce its temperature, and means actuated by the engine for automatically controlling the volume of said fuel and air supply to correspond with variations in the load upon the engine.

8. In a heat-engine of the continuous combustion type, the combination of a working cylinder, an air-compressing cylinder, connected pistons movably mounted in said cylinders and operatively connected with the crank-shaft of the engine, self-closing valved inlet and outlet-ports disposed in each cylinder, a combustion-chamber communicating with both the said cylinders having independent surrounding air and water-circulating jackets arranged whereby air and vapor from said jackets mingle directly with the products of combustion to reduce its temperature without passing through a water-seal, means for supplying fuel to the combustion-chamber, and means actuated solely by the engine for automatically controlling the volume of said fuel and air supply into said chamber and also for changing the point of cut-off or closure of the intake-valve of the power-cylinder to correspond with variations in the load upon the engine.

9. In a heat-engine of the continuous combustion type, the combination with a ported working-cylinder, a ported air-compressor, a crank-shaft, and pistons mounted in said working-cylinder and compressor operatively connected to the crank-shaft, of a combustion-chamber element, communicating with both the said cylinder and compressor, in which the working medium is generated having independent surrounding air and water-circulating jackets arranged whereby air and vapor from said jackets mingle directly with the products of combustion to reduce its temperature, means for supplying fuel to said chamber, means actuated by the engine for positively opening the intake and exhaust-ports of the working-cylinder and the intake-ports of the compressor, and a device actuated by the engine for automatically cutting off the said working medium and air supply to the cylinder and compressor respectively at various points in the working strokes corresponding with changes in the load and working pressure.

10. In a heat-engine of the continuous

combustion type, a working cylinder having valved inlet and exhaust ports, an air-compressor having valved inlet and discharge-ports, a crank-shaft, a speed-controlling governor, and means operatively connected with said elements for transmitting power developed in said cylinder to actuate the crank-shaft, in combination with a combustion-chamber suitably connected to the working cylinder, means for supplying fuel to said chamber, means, including a by-pass connection, for supplying air under pressure from said compressor into said chamber and around its walls, and means controlled by said governor for automatically varying the point of cut-off or closure of the intake-port of the compressor so as to vary the volume of air to be compressed therein to correspond with the load upon the engine.

11. In a heat-engine of the continuous combustion type, the combination of a combustion-chamber connected to the working cylinder of the engine, independent air and water-circulating jackets surrounding said chamber arranged whereby air and vapor from said jackets mingle directly with the products of combustion to reduce its temperature without passing through a water seal, means for forcing fuel and compressed air into the chamber and converting the fuel into a gaseous product under pressure to be utilized in said cylinder, and a governing device actuated by the engine for controlling the flow of said fuel into the chamber corresponding with variations in the load upon the engine so as to prevent an excess quantity of the fuel from entering the combustion-chamber.

12. In a heat-engine of the continuous combustion type, provided with means for converting heat energy into mechanical energy, an air-compressor, and a speed-controlling governor, the combination therewith of a combustion-chamber surrounded by an air-jacket and an enveloping water-jacket, means for supplying water to the latter, means for mixing steam or vapor, generated in said water-jacket, with the products of combustion constituting the heat energy medium, means for supplying fuel in variable quantities to said combustion-chamber, means, including a by-pass, for supplying air from said compressor into the combustion-chamber and the air-jacket, and means for automatically varying the amount of air admitted to and compressed in the compressor to correspond with the load upon the engine.

13. In a heat-engine of the continuous combustion type, having an air-compressor provided with valved intake and discharge ports, the combination therewith of a combustion-chamber adapted to receive air under pressure from said compressor and for generating therein gaseous products of combustion, independent air and water-circulating jackets surrounding said chamber arranged whereby air and vapor from said jackets mingle directly with the products of combustion to reduce its temperature without passing through a water-seal, and mechanical means for automatically controlling the supply of fuel and compressed air into said chamber in variable quantities or volumes corresponding with variations in the load or work required of the engine.

14. In a heat-engine of the continuous combustion type, a combustion-chamber enveloped in an air-jacket surrounded by a water-jacket, means for supplying water to the latter, a heat-protected receiver for storing therein the products of combustion or working medium, means for converting the heat energy of the latter into mechanical energy, an air-compressor, means for supplying fuel to said combustion-chamber, an engine-driven governor having its action controlled by slight changes in the engine's speed, due to changes in the load, so as to correspondingly vary the supply of fuel and compressed-air to the combustion chamber and air-jacket.

15. In a heat-engine of the continuous combustion type, an air and water-jacketed combustion-chamber, means actuated by the engine itself for automatically supplying fuel and compressed air into the chamber to be converted therein into products of combustion, said air and water jackets being in continuous open communication with the outlet or discharge end of said chamber so that air and vapor from the jackets may mingle directly with and reduce the temperature of the products of combustion, and means for converting the heat of the latter into mechanical energy.

16. In a heat-engine of the continuous combustion type, a combustion-chamber having an air-circulating jacket enveloping the walls of the chamber proper and a water-circulating jacket enveloping said air-jacket, means for supplying fuel to the chamber, means for supplying compressed air from a common source of supply into both the chamber and air-jacket, and auxiliary means for heating the walls of the chamber to produce initial combustion of the fuel.

17. In a heat-engine of the continuous combustion type, the combination of a combustion-chamber, means for supplying fuel and compressed air thereto from a suitable source to be converted into a working medium, means for circulating compressed air from said source around said chamber, and means for circulating water in a jacket surrounding said air-circulation and arranged whereby steam or vapor generated from the water in said jacket mingles with said air and with the products of combus-

tion while the latter is passing from the combustion-chamber and thus tempers the said working medium without passing it through water.

18. In a heat-engine of the continuous combustion type, the combination of a combustion-chamber, means for supplying fuel and compressed air thereto from a suitable source, means for circulating compressed air from said source around said chamber, and means for circulating water in a jacket surrounding said air-circulation and maintaining it at a substantially normal level therein, arranged whereby steam or vapor generated from the water may mingle with and temper the said working medium without passing the latter through water.

19. In a heat-engine of the continuous combustion type, the combination of a combustion-chamber proper having independent air and water-circulating jackets surrounding the same, means for supplying fuel and compressed air into the chamber to produce a gaseous working medium, the latter as generated flowing from the chamber and mingling with vapor and air from said jackets without the intervention of a water-seal, and means actuated by the engine for automatically controlling the volume of said fuel and air supply to correspond with variations in the load upon the engine.

20. In a heat-engine of the continuous combustion type, the combination with a combustion-chamber element provided with independent air and water-circulating jackets surrounding the chamber proper and communicating therewith, of means for introducing and automatically controlling the supply of fuel and compressed air into the chamber proper to produce the working medium for actuating the engine, constructed and arranged whereby the temperature of the products of combustion is reduced by mingling directly with air and vapor from said jackets.

21. In a heat-engine of the continuous combustion type, the combination of a combustion-chamber having independent air and water-circulating jackets surrounding the same and being in communication therewith, means for supplying fuel and compressed air into the chamber to produce a gaseous working medium, the latter as it issues from said chamber having its temperature reduced by mingling directly with air and vapor from said jackets, and means actuated by the engine for automatically controlling the volume of said fuel and air supply to correspond with variations in the load upon the engine.

22. In a heat-engine of the continuous combustion type, the combination of a central combustion-chamber proper having independent air and water-jackets surrounding the same, means automatically controlled by the engine for supplying fuel and compressed air into the said combustion-chamber in variable quantities, corresponding with changes in the load upon the engine, to be converted into the working medium, and having said jackets in open communication with the discharge end of said chamber whereby air and vapor from the respective jackets mingle directly with the said working medium to reduce its temperature before entering the working cylinder of the engine.

23. In a heat-engine of the continuous combustion type, the combination of a combustion-chamber having an outer jacket forming a space for the circulation of water and an independent inner jacket forming a space for the circulation of compressed air, means for supplying water and compressed air to said jackets respectively, and having both jackets practically surrounding the walls of the central or combustion-chamber proper and communicating with its discharge, whereby said circulating media, *i. e.*, the compressed air and steam or vapor from the water, are utilized for stepping down or reducing the temperature of the products of combustion or working medium generated in the combustion-chamber, means for supplying and automatically controlling the volume of fuel and compressed air entering the combustion-chamber, and means for automatically maintaining a practically constant water-level in said outer jacket.

24. In a heat-engine of the continuous combustion type, the combination with a combustion-chamber, provided with a central chamber in which the combustion proper takes place, having independent air and water-circulating jackets enveloping the central chamber and having the pressure upon the air and water substantially alike, and means for supplying fuel and compressed air in variable quantities thereto to produce a gaseous working medium, of a device communicating with said water jacket for automatically supplying water and maintaining it at a substantially uniform level therein, said water supply replacing the water converted into steam or vapor combined with the products of combustion or working medium after the latter passes from the chamber.

25. In a heat-engine of the continuous combustion type, the combination of a combustion chamber element, provided with a central chamber in which the combustion proper takes place, having independent air and water-circulating jackets enveloping the said central chamber, means for supplying fuel and compressed air in variable quantities thereto to produce a gaseous working medium, means, for automatically supplying water to the water-jacket in variable quantities for replacing the water converted there-

in into steam or vapor, and having air and vapor from said jackets combined with the products of combustion or working medium after the latter passes from the combustion chamber.

26. In a heat-engine of the continuous combustion type, the combination of a combustion-chamber having independent air and water-circulating jackets enveloping the center portion in which the actual combustion takes place, means for supplying fuel to said chamber, a pipe for supplying compressed air to the chamber, a by-pass connection communicating with said pipe for diverting compressed air from the latter into said jacket, and means for controlling the relative volumes of said air entering said chamber and jacket.

27. In a heat-engine of the continuous combustion type, the combination of a combustion-chamber element provided with a central chamber in which the combustion proper takes place, an independent air-circulation jacket enveloping the central chamber, a water-circulating jacket for preventing radiation of heat from said air jacket, means for supplying fuel to said chamber, and means for supplying compressed-air to the chamber and air-jacket from a common source to produce, when mixed with the fuel, a gaseous working medium.

28. In a heat-engine of the continuous combustion type, the combination with a receiver adapted to be connected to the working-cylinder of the engine and being protected both internally and exteriorly to prevent radiation of heat therefrom, of a combustion-chamber secured to and adapted to discharge into the receiver and arranged for the introduction and admixture of fuel and compressed air, said chamber being provided with a water-carrying jacket and an air-jacket, the latter disposed between the water-jacket and the combustion-chamber proper, and having both jackets in communication with each other and with the discharge leading from said chamber.

29. In a heat-engine of the continuous combustion type, a working cylinder, including a piston and rod movably mounted therein, an air and water-jacketed combustion-chamber, an air-compressor and fuel-pumping means both actuated by and in unison with the engine itself arranged to automatically supply fuel and compressed air into said chamber to be converted therein into an expansible working medium or heated products of combustion, the temperature of the latter being reduced by mingling with the air and vapor of said chamber, in combination with a suitable heat-protected receiver in open communication with the combustion-chamber for receiving from the latter the said working medium, and means for intermittingly admitting said working medium from the receiver into the working-cylinder.

30. In a heat-engine of the continuous combustion type, the combination with a working-cylinder, a governor device, and a combustion-chamber arranged for the generation therein of a gaseous working medium, of a fuel-pumping device having a ported intake-chamber connected with a fuel-supply and a discharge-chamber connected with the combustion-chamber proper, means operatively controlled and timed by the governor arranged for opening the normally closed discharge outlet of the intake-chamber at varying intervals for the outflow of fuel, a mechanically actuated element having a normally uniform movement or fuel-displacement for opening the normally closed inlet-passage of the discharge-chamber and forcing the fuel therethrough and out of said discharge-chamber into the said connection communicating with the combustion-chamber, and a resilient device interposed between said movable element and its actuating means for automatically changing its movement or fuel displacement corresponding with the resistance opposed to it.

31. In a heat-engine of the continuous combustion type, the combination of a suitably mounted air-compressor provided with self-closing valved air-intake and air-outlet ports, a governor device, means for positively opening said air-intake port, means operatively connected with and controlled by the governor for automatically varying the duration of the inlet-port's opening, a plunger mounted in the compressor arranged to be connected to the crank of the usual driving-shaft of the engine, a working-cylinder disposed in alinement with the air-compressor provided with an intake-port and an exhaust-port located in independent chambers, means for intermittingly opening and closing the last-named ports, a driving-piston mounted in said cylinder and connected to the said air-compressor's plunger for moving the latter in unison with it, a heat-protected receiver in communication with the chamber of said intake-port for holding the gaseous products of combustion, a combustion-chamber proper, in which the working medium is generated, opening into said receiver and communicating with the discharge-outlet of the air-compressor, and means for automatically supplying fuel in varying quantities into said combustion-chamber.

32. In a heat-engine of the continuous combustion type, an air-compressor and working cylinder, each provided with suitable intake and discharge ports, a plunger and a piston mounted in said compressor and cylinder respectively, and means for opening and closing all the said ports, the

combination therewith of a heat-protected receiver in open communication with the intake-port's chamber of the working cylinder, a central combustion-chamber proper opening into the receiver, an air-conducting passage or duct connecting the air-compressor and the interior of the combustion-chamber, an air-jacket surrounding the latter, a branch leading from said air passage for supplying air to the last-named jacket, a water-jacket for reducing the temperature of the said air circulation provided with a passage for the flow of steam or vapor from the water-jacket so as to mingle with the products of combustion flowing into the receiver, and means for feeding fuel in variable quantities from a suitable source of supply into the combustion-chamber.

33. In a heat-engine of the continuous combustion type, having a piston-carrying working cylinder and suitable coöperating devices, a combustion-chamber proper, means for supplying to said chamber fuel and air under pressure from independent sources, an air-circulating jacket surrounding the combustion chamber proper and opening into the discharge end of the chamber so that the air may mingle with and reduce the temperature of the outflowing gaseous products of combustion, an outer water-circulating jacket surrounding the said air-jacket adapted to conduct steam or vapor therefrom to combine with said tempered products of combustion so as to complete the heat-energizing working-medium, and means for automatically supplying water to the water-jacket in variable quantities to replace the water converted into steam or vapor.

34. In a heat-engine of the continuous combustion type, a combustion-chamber surrounded by an air-jacket, an exterior water-jacket surrounding the air-jacket, means for supplying the combustion-chamber with fuel and air under pressure, means for by-passing a part of the compressed air through the air-jacket, means for supplying water to the water-jacket, and means for mingling the vapor or steam from the water and the by-passed air with the products of combustion, in combination with means for converting the heat energy of the mixture, *i. e.*, said products of combustion and said vapor and by-passed air, into mechanical energy.

Signed at Worcester, Mass. this 20th day of March 1908.

WALTER F. BROWN.

Witnesses:
ARTHUR S. HOUGHTON,
WINFRED H. WHITING.