## CLAIMS

1. Heat engine (200) configured for attaining a thermal cycle, the heat engine operating with a thermal fluid and comprising:

- a drive unit (1) comprising:
  - a case (2) delimiting at least one operative chamber (3) at its interior and having:
    - a first inlet (4) in fluid communication with a first inlet duct (14) in order to receive therefrom a flow of said thermal fluid being suctioned into said at least one operative chamber (3);
    - a first outlet (5) in fluid communication with a first outlet duct (15) in order to send thereto a flow of said thermal fluid under compression exiting from said at least one operative chamber (3);
    - a second inlet (6) in fluid communication with a second inlet duct (16) in order to receive therefrom a flow of said thermal fluid being loaded, to be expanded in said at least one operative chamber (3);
    - a second outlet (7) in fluid communication with a second outlet duct (17) in order to send thereto a flow of said thermal fluid being discharged, exiting from said at least one operative chamber (3);
  - members for transforming the energy of said thermal fluid, movably housed within said at least one operative chamber (3) and configured for transforming the energy of said thermal fluid into mechanical energy, according to an operative cycle;
  - an output shaft (8) operatively connected to said energy transformation members and configured for receiving said mechanical energy and providing a rotary motion at the outlet, preferably at constant angular speed;
- a drive circuit (10) extended between said first inlet (4) and second inlet (6) and said first outlet (5) and second outlet (7) and comprising said first inlet duct (14), said first outlet duct (15), said second inlet duct (16) and said second

outlet duct (17), said drive circuit (10) attaining a continuous cycle of thermal fluid flow through said at least one operative chamber (3) of the drive unit, wherein:

- said second outlet duct (17) starts from said second outlet (7) of the case (2) of the drive unit and terminates by being continuously connected with said first inlet duct (14), the latter terminating in said first inlet (4) of the case (2) of the drive unit, the second outlet duct and the first inlet duct attaining a first closed branch (11) of the drive circuit (10);
- said first outlet duct (15) starts from said first outlet (5) of the case (2) of the drive unit and terminates by being continuously connected with said second inlet duct (16), the latter terminating in said second inlet (6) of the case (2) of the drive unit, the first outlet duct and the second inlet duct attaining a second closed branch (12) of the drive circuit (10);

- a heater (41) that is operatively active, along said second closed branch (12) of the drive circuit (10), between said first outlet duct (15) and said second inlet duct (16), configured for heating the thermal fluid circulating in the second branch (12) of the drive circuit.

2. Heat engine (200) according to claim 1, comprising:

- a condenser (43) that is operatively interposed along said first closed branch (11) of the drive circuit (10), between said second outlet duct (17) and said first inlet duct (14), configured for cooling the thermal fluid circulating in the first branch (11);
- a condensation separator (93), placed downstream of the condenser (43) along said first inlet duct (14), where the water present in the thermal fluid is condensed and separated from the air, before the thermal fluid reaches said first inlet (4) for suctioning into said at least one operative chamber (3);
- a pump (94), configured for drawing the condensation water previously extracted from the air by means of the condensation separator (93) and for

sending it into a vaporization pipe (20) flowing into said second branch (12), at a point of said first outlet duct (15) upstream of said heater (41);

- a vaporizer (95), situated in the heat engine in a manner such to intercept, on a high-temperature side thereof, said second outlet duct (17) downstream of the drive unit (1) and upstream of the condenser (43) and, on a low-temperature side thereof, said vaporization pipe (20), the vaporizer (95) being configured for heating and vaporizing the condensation water circulating in said vaporization pipe (20) before it flows into said second branch (12);

- an injector (97), placed at the end of said vaporization pipe (20) and configured for injecting into the second branch (12), upstream of the heater (41), a predefined quantity of water vapor, capable of increasing the unit power of the drive unit (1) and of ensuring the lubrication of said energy transformation members movably housed in said at least one operative chamber (3).

3. Heat engine (200) according to claim 2, wherein the vaporizer (95) is operatively interposed, on the low-temperature side thereof, between said pump (94) and said injector (97), and is operatively interposed, on the high-temperature side thereof, between the second outlet (7) of the drive unit (2), which expels spent thermal fluid, and the condenser (43), in a manner such that the vaporizer acquires residual energy-heat from the spent thermal fluid and uses it for preheating the thermal fluid moving towards the heater (41).

4. Heat engine (200) according to any one of the preceding claims, wherein the heater comprises a burner (40) with enclosed combustion chamber (40A), said burner being adapted to be power supplied with a plurality of fuel types and being configured for supplying the heater (41) with the thermal energy necessary for the operation thereof,

and/or wherein said heater (41) comprises a containment body (50) provided with an inlet for comburent air (51), drawn from the environment, and housing both said burner (40), operatively active along said second closed

branch of the drive circuit, and said condenser (43), operatively active along said first closed branch (11) of the drive circuit, in a manner such that the heat drawn from said first branch by means of the condenser is transferred to the comburent air before this reaches the burner (40), facilitating the process of combustion and heating of the thermal fluid in the second branch (12).

5. Heat engine (200) according to any one of the preceding claims, comprising a superheater (96) positioned downstream of said burner (40) in order to remove energy from the hot combustion fumes of the burner, and configured for intercepting said vaporization pipe (20) in a position downstream of said low-temperature side of the vaporizer (95) and upstream of said injector (97),

said superheater (96) being configured for transferring the energy removed from the hot combustion fumes of the burner to the condensation water vaporized at the outlet from the vaporizer (95), in a manner such to overheat it before it reaches the injector (97).

6. Heat engine (200) according to any one of the preceding claims, provided with a closed cooling circuit (60), separate from said drive circuit and comprising:

- a first heat recuperator (98), situated in the containment body (50) of the heater (41) in a position downstream of the condenser (43) and upstream of the burner (40), with respect to the direction of the comburent air flow in the heater;
- a cooling unit (interspace 2R) operatively associated with the case of the drive unit (1);
- a plurality of cooling pipes connecting in series, to form a circular path, said first heat recuperator (98) and said cooling unit (2R), said cooling pipes carrying a quantity of cooling fluid (preferably water) and being arranged in the heat engine in a manner such to:

- interact with said cooling unit (2R), where the low-temperature cooling fluid draws heat from the case of the drive unit, cooling it, and consequently it is brought to high temperature, and

- interact with said first heat recuperator (98), where the high-temperature cooling fluid transfers heat to the comburent air flow, heating it, and consequently returns to low temperature;

- a cooling pump (99), placed in said cooling circuit and operatively active on a pipe of said plurality of cooling pipes for determining a circulation of said cooling fluid in the cooling circuit.

7. Heat engine (200) according to the preceding claim, wherein said cooling circuit comprises a second heat recuperator (100), situated in the containment body of the heater in a position downstream of the burner (40), and preferably downstream of said superheater (96), along the outlet path of the hot combustion fumes of the heater, and wherein said plurality of cooling pipes connects in series, in said circular path, said first heat recuperator (98), said cooling unit (2R) and said second heat recuperator (100), the latter being interposed downstream of the cooling unit (2R) and upstream of the first heat recuperator (98), along the travel direction of the cooling fluid, in a manner such that:

- in said cooling unit (2R), the low-temperature cooling fluid draws heat from the case of the drive unit, cooling it, and consequently it is brought to high temperature;

- in said second heat recuperator (100), the high-temperature cooling fluid acquires heat from the hot combustion fumes, cooling them, and consequently undergoes a temperature increase;

- in said first heat recuperator (98), the high-temperature cooling fluid transfers heat to the comburent air flow, heating it, and consequently returns to low temperature.

8. Heat engine (200) according to any one of the preceding claims, provided with an auxiliary hydraulic circuit comprising:

- an auxiliary recuperator (101), situated in the containment body of the heater in a position downstream of the burner (40), and preferably downstream of said superheater (96), along the outlet path of the hot combustion fumes of the heater;

- a plurality of auxiliary pipes configured for traversing said auxiliary recuperator (101) and for being connected with one or more auxiliary uses, preferably space heating utilities and/or sanitary hot water production units;

- an auxiliary pump (104), placed in said auxiliary hydraulic circuit and operatively active on a pipe of said plurality of auxiliary pipes for determining a circulation in said auxiliary circuit;

wherein said auxiliary recuperator (101) is configured for recovering energy from the combustion fumes and for transmitting it to the fluid circulating in said auxiliary circuit, said energy then being available for said auxiliary uses (103).

9. Heat engine (200) according to any one of the preceding claims, wherein said energy transformation members are configured for transforming the energy of said thermal fluid into mechanical energy according to an operative cycle which provides for a sequence of steps of:

- suctioning thermal fluid into said at least one operative chamber;

- compressing the thermal fluid in said at least one operative chamber and pouring the thermal fluid;

- loading thermal fluid in said at least one operative chamber and expanding the thermal fluid in said at least one operative chamber;

- discharging thermal fluid from said at least one operative chamber.

10. Heat engine (200) according to any one of the preceding claims, wherein said drive unit is a two-stroke engine or a four-stroke engine, or a reciprocating

engine, or a rotary engine, and/or wherein said drive unit is a heat engine comprising a compressor, performing said suction and compression steps, and an expander, for example a turbine, performing said expansion and discharge steps.

11. Heat engine (200) according to any one of the preceding claims, wherein said at least one operative chamber (3) comprises:

- a first chamber (3A), provided with said first inlet and with said first outlet, in which the suction of the thermal fluid and the compressing of the thermal fluid occur;

- a second chamber (3B), separate from said first chamber, provided with said second inlet and with said second outlet, in which the loading of the compressed thermal fluid, the expanding of the thermal fluid and the discharge of the thermal fluid occur,

and wherein said drive unit is a drive unit with intermittent flow, where:

- said first chamber is an operative chamber with variable volume, configured for operating a fluid suction and a fluid compression;

- said second chamber is an operative chamber with variable volume, configured for operating a fluid expansion and a fluid discharge,

or wherein said drive unit is a drive unit with continuous flow, where:

- said first chamber is structured for attaining a compressor, configured for operating a fluid suction and a fluid compression;

- said second chamber is structured for attaining a turbine, configured for operating a fluid expansion and a fluid discharge.

12. Heat engine (200) according to any one of the preceding claims, wherein said thermal fluid is a mixture comprising a gas and water vapor or water, wherein said gas is preferably air and/or helium and/or other gaseous fluid compatible with the water vapor or the water, and said thermal cycle attained by the heat engine is a combined thermal cycle, and/or wherein the heat engine

comprises an electric generator (G), e.g. an alternator, connected with said output shaft in a manner such to receive said rotary motion preferably at constant angular speed and generate electric current intended to power supply an external utility.

13. Method for attaining a thermal cycle, the method operating with a thermal fluid and comprising the steps of:

- arranging a heat engine (200), preferably according to one or more of the preceding claims;
- executing the following steps:
  - starting said drive unit (1), moving said members for transforming the energy of said thermal fluid;
  - activating said heater (41) for heating the thermal fluid in said drive circuit (10);
  - activating an operative cycle comprising the steps of:
    - suctioning said thermal fluid into said at least one operative chamber (3) through said first inlet (4);
    - compressing said thermal fluid in said at least one operative chamber (3) and pouring said thermal fluid out from said first outlet (5);
    - heating the thermal fluid circulating in said second branch (12) of the drive circuit (10) by means of said heater (41);
    - loading said thermal fluid into said at least one operative chamber (3) through said second inlet (6) and expanding said thermal fluid in said at least one operative chamber (3);
    - discharging said thermal fluid from said at least one operative chamber (3) through said second outlet (7);

wherein said steps of the operative cycle of suctioning, compressing, loading and discharging the thermal fluid determine a transformation of the energy of said thermal fluid into mechanical energy;

- transferring said mechanical energy generated by said transformation members to said output shaft (8), which provides a rotary motion at the outlet, preferably with constant angular speed.

14. Method according to claim 13, comprising the following steps:

- the thermal fluid exiting from said second outlet (7) of the drive unit (1) moves into the second outlet duct (17) of the first branch (11) of the drive circuit (10) and traverses the high-temperature side of the vaporizer (95);

- the thermal fluid continues into the first branch (11) and reaches the condenser (43) where it is cooled;

- the thermal fluid continues into the first branch (11) and reaches the condensation separator (93) where the water present in the thermal fluid is condensed and separated from the air, before the thermal fluid reaches said first inlet (4) of the drive unit (1);

- the condensation water previously extracted from the air by means of the condensation separator (93) is drawn and sent into a vaporization pipe (20) flowing into said second branch (12), at a point of said first outlet duct (15) upstream of the heater (41);

- the condensation water circulating in the vaporization pipe (20) traverses the low-temperature side of the vaporizer (95), where it is heated and vaporized before it flows into said second branch (12) of the drive circuit;

- a predefined quantity of water vapor is injected into the second branch (12), upstream of the heater (41), by means of the injector (97), said water vapor quantity being capable of increasing the unit power of the drive unit (1) and of ensuring the lubrication of said energy transformation members movably housed in said at least one operative chamber (3).

15. Method according to claim 13 or 14, comprising the following steps:

- arranging said cooling circuit, comprising the first recuperator (98), the cooling unit (2R), the plurality of cooling pipes and the cooling pump (99);

- executing the steps of:

- the low-temperature cooling fluid interacts with the cooling unit (2R), where it draws heat from the case of the drive unit, cooling it, and consequently it is brought to high temperature;

- the high-temperature cooling fluid interacts with the first heat recuperator (98), where it transfers heat to the comburent air flow, heating it, and consequently it is cooled and returns to low temperature;

- activating the cooling pump (99) for determining the circulation of cooling fluid in the cooling circuit,

and/or comprising the following steps:

- arranging the second recuperator (100) in the cooling circuit;

- executing the steps of:

- in the cooling unit (2R), the low-temperature cooling fluid draws heat from the case of the drive unit, cooling it, and consequently it is brought to high temperature;

- in the second heat recuperator (100), the high-temperature cooling fluid acquires heat from the hot combustion fumes, cooling them, and consequently undergoes a temperature increase;

- in the first heat recuperator (98), the high-temperature cooling fluid transfers heat to the comburent air flow, heating it, and consequently it is cooled and returns to low temperature.

16. New SEOL thermodynamic cycle, usable with heat engines of the prior art, operating with multiple combined fluids and comprising:

a_ a Compressor (1'), having the object of suctioning ① and compressing ② the circulating gaseous fluid (Air and/or Helium and/or another compatible gas);

b_ a Check valve (6'), having the object of preventing, in any case, the compressed gaseous fluid from circulating in a sense opposite that of normal motion;

c_ a Mixing box (8'), having the object of receiving the compressed gases, coming from the Compressor (1'), in order to then mix them with the overheated water vapor, coming from the recovery vapor Generator (13');

d_ a Superheater (10'), having the object of overheating the mixture coming from the Mixing box (8'), so as to bring the thermal energy "$Q_H$" necessary for determining the autonomous rotation of the Expander (3');

e_ an Expander (3'), capable of receiving the overheated mixture ③ and making it expand ④, removing heat-energy therefrom and producing the useful mechanical work of the cycle "$L_E$";

f_ a recovery vapor Generator (13'), capable of removing most of the residual thermal energy ($Q_R$) contained in the mixture discharged from the expander (3') and using it for generating overheated water vapor to be reintroduced into the cycle;

g_ a Condenser (15'), having the object of dispersing the non-recoverable energy ($Q_{LR}$), so as to complete the condensation of the mixture at low temperature, which is discharged from the recovery vapor Generator (13');

h_ a Separator (17'), having the object of separating the gaseous part of the mixture (Air and/or Helium and/or another compatible gas) from the liquid part (condensation water), so as to render them separately usable in the cycle;

i_ a metering Pump (20'), provided with a flow rate Regulator (21'), having the object of suctioning, from the separator (17'), a predetermined quantity of condensation water and pumping it at high pressure into the recovery vapor Generator (13').

J_ an electric Generator (4'), capable of transforming the mechanical Work "$L_E$" produced by the Expander "ES" into electrical energy, also arranged for performing the function of starting motor in the initial step of starting the heat engine.

17. New SEOL thermodynamic cycle according to claim 16, characterized by the crucial presence of the recovery vapor Generator (13') and by the main

function performed by the same, aimed for recovering the residual thermal energy ($Q_R$) still contained in the mixture discharged from the Expander (3') and for generating overheated water vapor which is then re-introduced into the cycle, bringing the recovered thermal energy and thus increasing both the unit power of the heat engine and the overall thermal yield of the cycle itself.

18. New SEOL thermodynamic cycle according to claim 16, characterized by the secondary function performed by the recovery vapor Generator (13'), represented by the fact that the water vapor produced and re-introduced into the cycle allows the lubrication of the cylinders and pistons of the heat engine, reducing mechanical friction.

19. New SEOL thermodynamic cycle according to any one of claims 16 to 18, characterized in that, for the mechanical conversion of the thermal energy, it uses a rotary engine formed by a multistage Compressor (1') and by a turbine Expander (3'), mechanically connected to each other by means of the drive shaft (2'), as represented in FIG.1.

20. New SEOL thermodynamic cycle according to any one of claims 16 to 18, characterized in that, for the mechanical conversion of the thermal energy, it can use a heat engine, of any already known prior art, formed by a Compressor (1'), performing suction/compression functions, and by an Expander (3'), performing expansion/discharge functions, mechanically independent from each other or connected by means of any one transmission type, suitably modified in order to be able to use the recovery vapor Generator (13'), as described in the present invention application.