

June 27, 1939.

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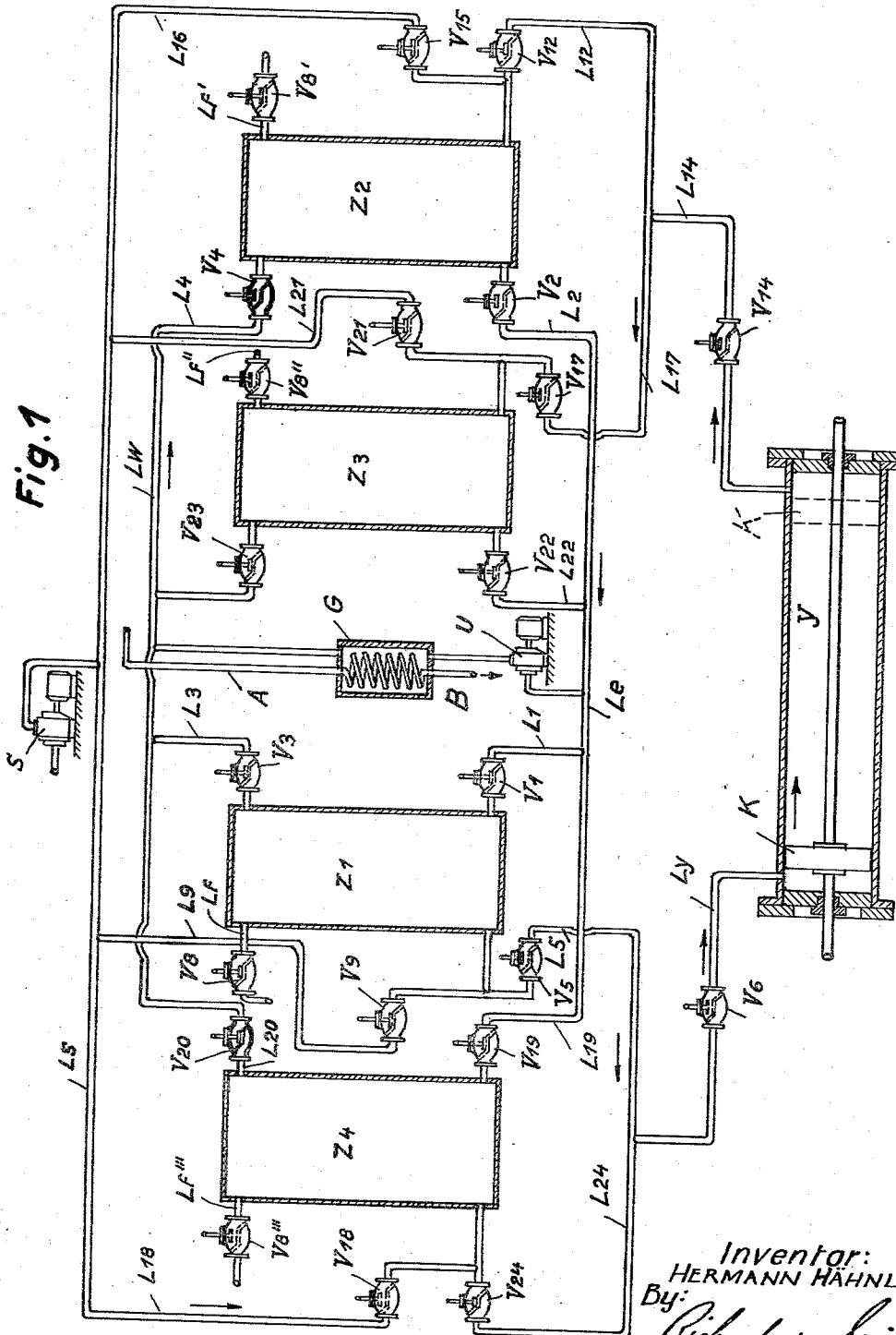
2,164,134

METHOD AND MEANS FOR OBTAINING POWER OUTPUTS

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6 Sheets-Sheet 1

Fig. 1



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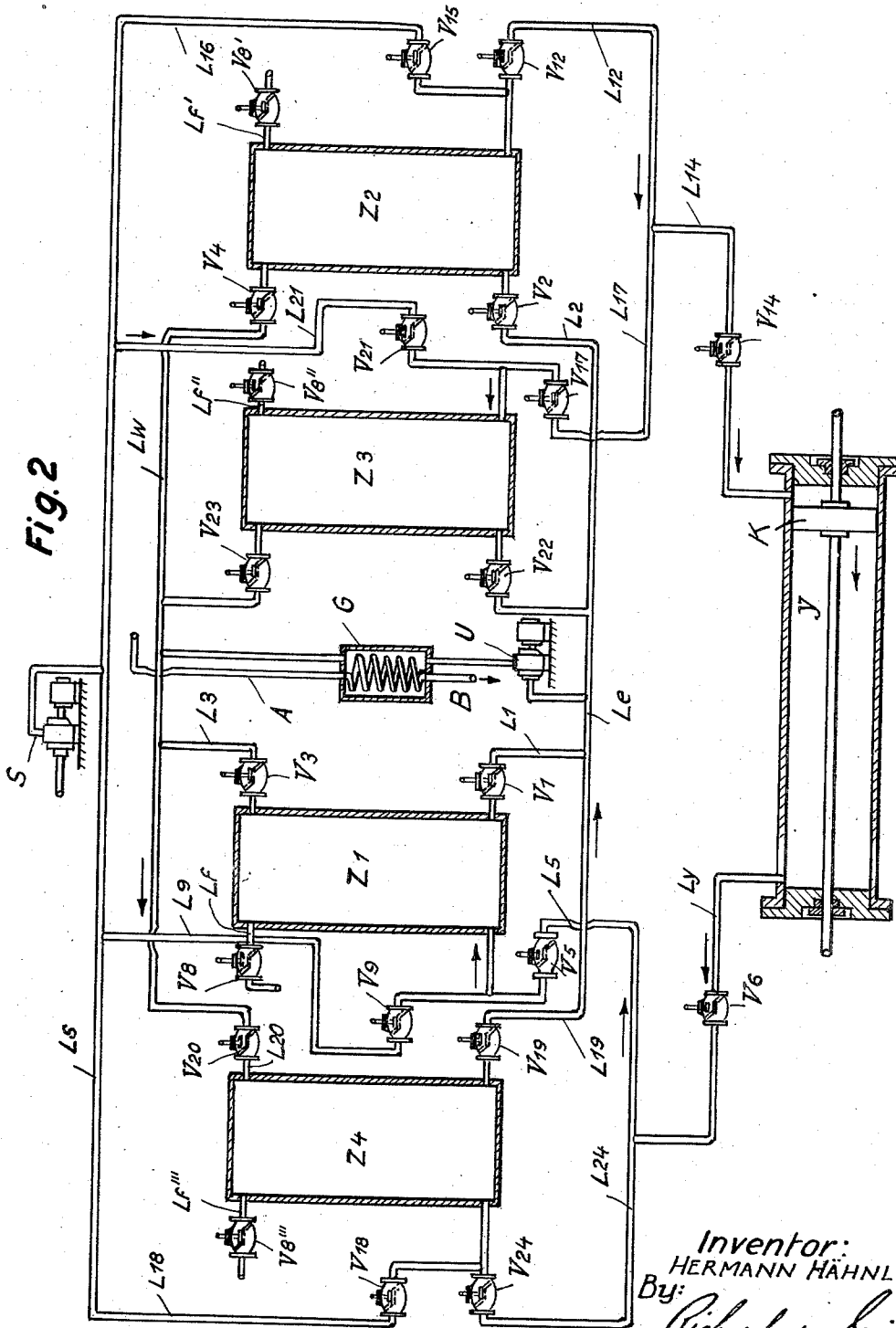
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METHOD AND MEANS FOR OBTAINING POWER OUTPUTS

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6 Sheets-Sheet 2



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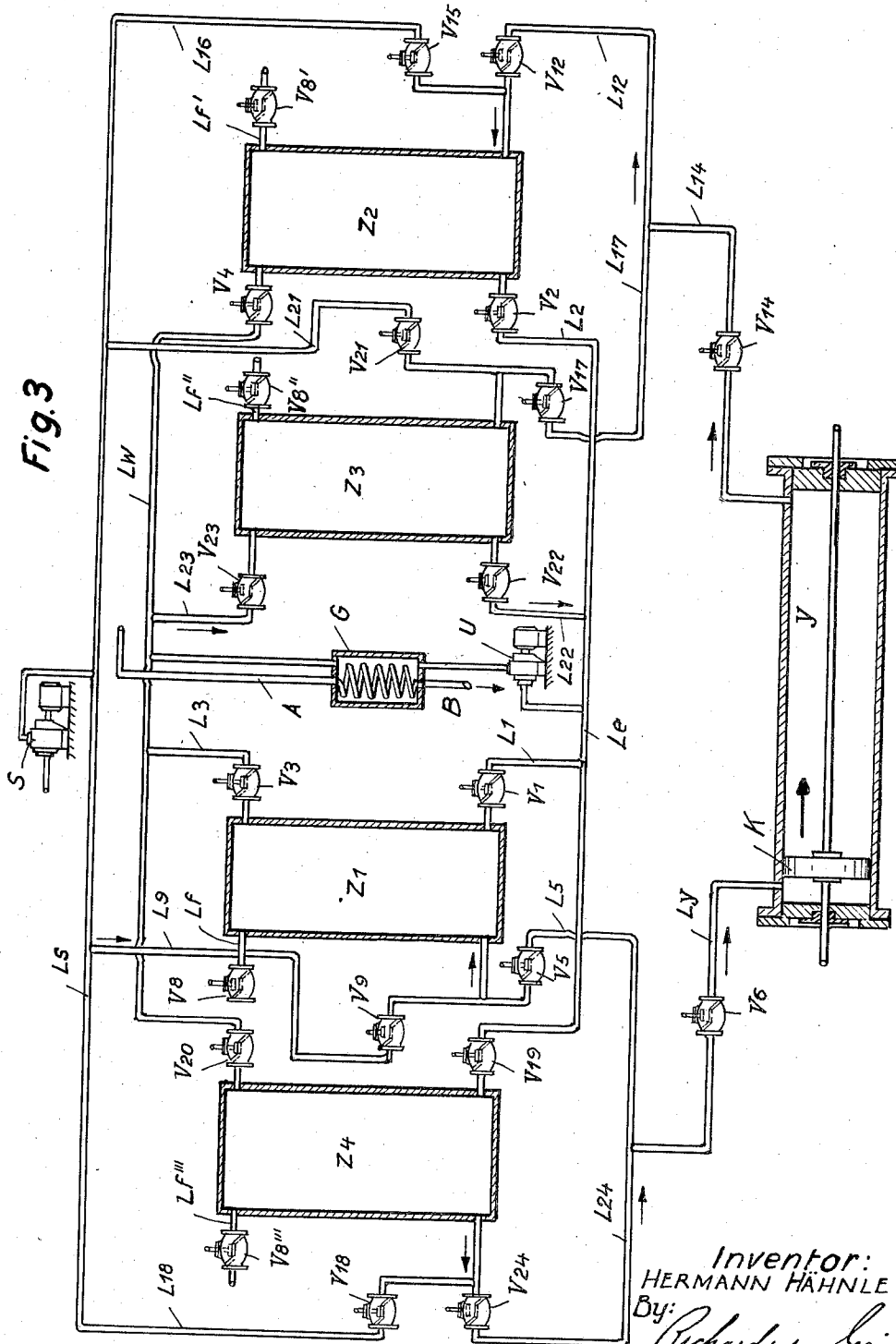
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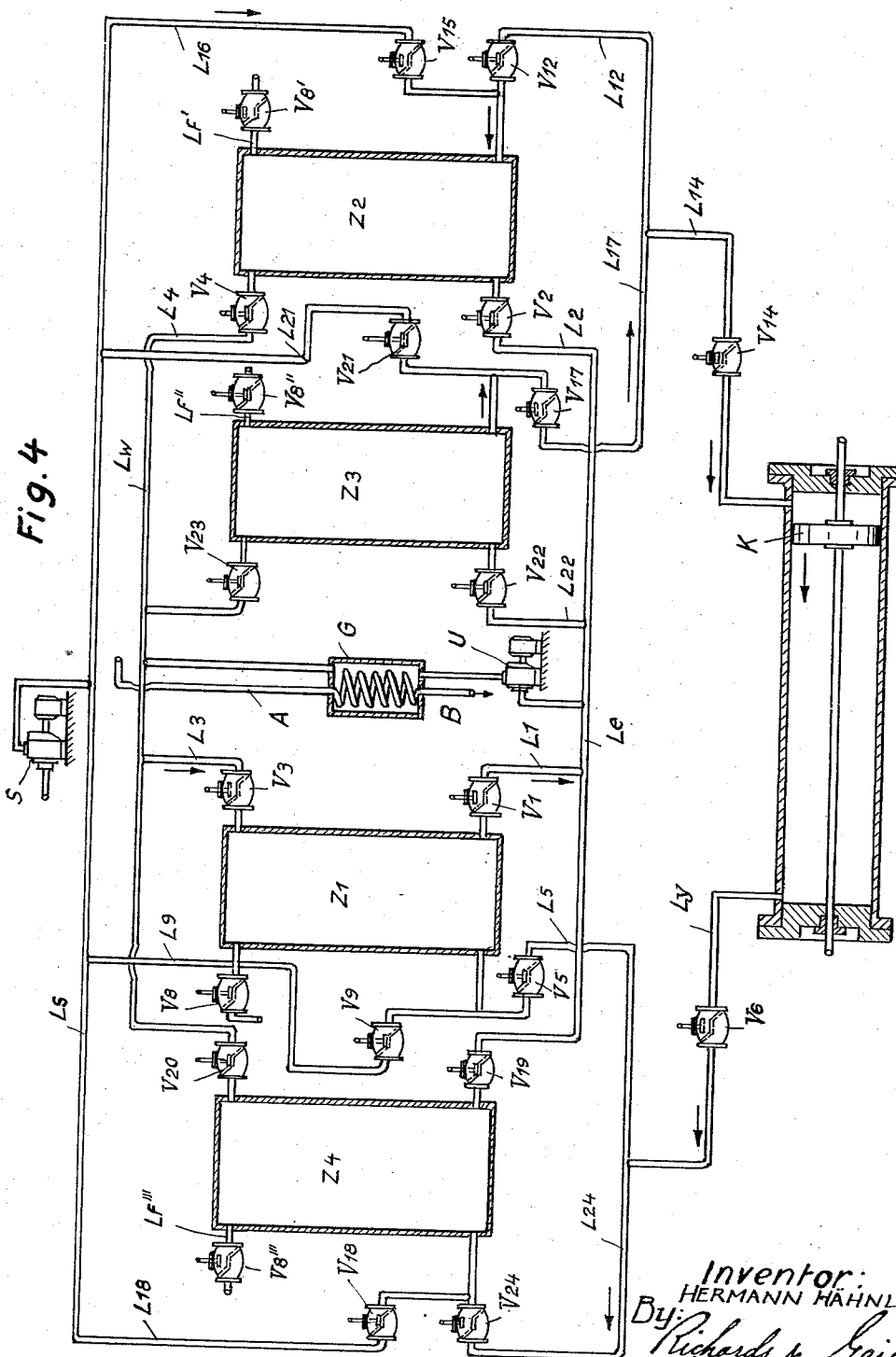
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METHOD AND MEANS FOR OBTAINING POWER OUTPUTS

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6 Sheets-Sheet 4



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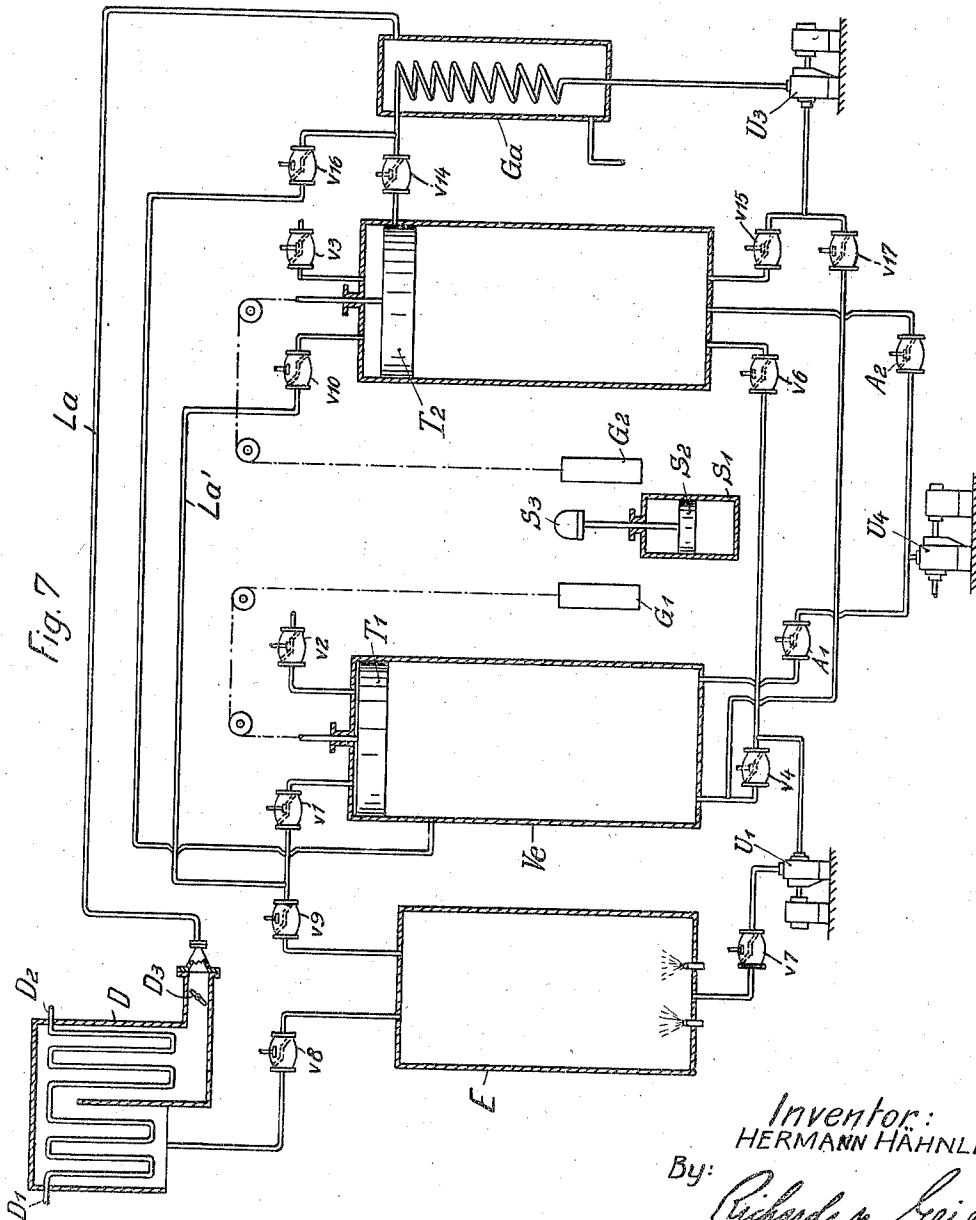
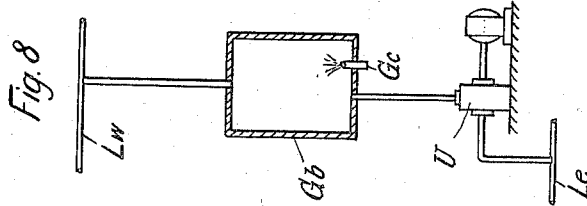
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METHOD AND MEANS FOR OBTAINING POWER OUTPUTS

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6 Sheets-Sheet 6



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UNITED STATES PATENT OFFICE

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METHOD AND MEANS FOR OBTAINING
POWER OUTPUTSHermann Hähnle, Giengen-on-the-Brenz,
GermanyApplication February 17, 1936, Serial No. 64,415
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10 Claims. (Cl. 60—59)

This invention relates to a method of obtaining useful energy, in which an increase in pressure of a gaseous medium is effected by heating it at a constant volume, and in which for the heating either waste gas heat or heat generated by combustion in the gaseous medium itself, hereinafter referred to as live heat, or both may serve.

One of the objects of this invention is the provision of a method in accordance with which the gaseous medium is heated at constant volume so that its pressure is increased, preferably, by being withdrawn by means of a circulating device from a container and passed through a heated heat exchanger and, after being heated therein, is passed to a container which may be the same container from which the medium was withdrawn, the gaseous medium being subsequently allowed to flow out of the said container in a manner substantially free of resistance towards the installation wherein its power is utilized. It is another object of the present invention to provide a method in accordance with which after the pressure and temperature of the gaseous medium have been raised by heating it in the heat exchanger, the gaseous medium is supplied along with a fuel to a combustion chamber and, during the combustion of the fuel, the combustion gas is partly conveyed at a constant pressure to the installation wherein its energy is utilized and in part returned to the container from which it is conducted to a consumer.

The method according to the invention has the advantage, whether or not waste heat or live heat is employed for heating the heat-interchanger, that the pressure of the medium is raised without any mechanical compression work. Thus when for example, the pressure drop is utilized, the power output is practically entirely a useful output, only the small expenditure of mechanical power required to overcome the low frictional resistance of the walls of the circulation-system having to be deducted from the useful output. This loss, however, is so small in practice as compared with the useful output that it can be neglected.

In order to obtain a continuous yield of energy, it is only necessary to withdraw the gaseous medium successively from a plurality of containers and, after passing it through the same heat interchanger, to return it to the respective container, the gaseous medium being subsequently withdrawn successively from the containers the contents of which have been brought up to pressure and heated and delivered to the installation

wherein its power is to be utilized, as will be described hereinafter in detail. The carrying out of this continuous method also does not necessitate any appreciable expenditure of mechanical power, since, in addition to the negligible amount of power required for the circulation work, only a fan drive has to be maintained which likewise does not entail any great expenditure of power, since the fan has only to fill the individual containers with the gaseous medium (fresh air) at atmospheric pressure after the contents thereof have been expanded down and after the containers have been brought into communication with the atmosphere.

The invention is illustrated by way of example in the accompanying drawings which show purely diagrammatically a number of embodiments of apparatus constructed to be operated in accordance with the invention.

In the drawings:

Figure 1 is a diagram illustrating an apparatus constructed in accordance with the principles of the present invention;

Figures 2, 3 and 4 are similar to Figure 1 and show the apparatus during different phases.

Figure 5 is a diagram illustrating a circulation system constructed in accordance with the principles of the present invention.

Figure 6 shows a part of the system illustrated in Figure 5 in a different position.

Figure 7 shows a system used in conjunction with a steam generator.

Figure 8 shows a heat exchanger for the plant illustrated in Figures 1 to 4.

Referring to Figure 1 which shows an apparatus for carrying out the method in such manner that a continuous output of power is obtained with the use of waste gas heat for heating the heat interchanger G, four containers Z1, Z2, Z3, and Z4 are provided for the air serving as working medium, each of said containers being capable of being connected up with the heat interchanger G so as to form a closed circulating system.

The waste gases which, for instance, may come from a Diesel engine are supplied by means of the pipe A through the heat interchanger G which is constructed as a counterflow-flow heater, and leave the latter at B cooled down to the outside temperature. In the phase of the cycle of operations shown in Figure 1, the cooling of the waste gases is effected by withdrawing air at outside temperature from the container Z2, which is filled with air in the manner hereinafter described, the air being drawn through the pipe L2 and the pipe Le, (the valve V2 with which

the pipe L2 is provided being open) by means of the circulating fan U and passed through the heat exchanger G after which the air is returned to the top of the container Z2 through the pipe Lw and the pipe L4, the valve V4 with which the pipe L4 is provided, being open, whereupon the valves V2 and V4 are closed.

At the same time, hot air under pressure constituting the contents of the container Z1, and which has been heated up to the required pressure during a preceding phase in the same manner as that described in connection with the container Z2, is passed through the pipe L5, the valve V5 being open, and through the pipe Ly, the valve V6 being open, into a power cylinder y, on the left hand side of the piston K situated in the left-hand dead-centre position. During this time the valve V14 connected to the right-hand end of the cylinder y and inserted into the pipe L14, is held open as well as a valve V17 provided in a pipe L17 which leads to the lower end of the container Z3. In addition to this a valve V8'' which is provided in a pipe Lf'' leading to the outside air from the top of the container Z3 is held open. The interior of the cylinder to the right of the piston K is thus in communication with the atmosphere and the compressed air supplied to the left hand side of the piston K from the container Z1 displaces the piston to the right, performing work, the piston forcing the contents of the cylinder into the container Z3 and the contents of the latter into the outside air.

After the contents of the container Z1 have been expanded whereby the piston K has moved into its right-hand dead-centre position, the valve V17 is closed, while the valves V6, V14, and V8'' are left open. At the time the above operations are carried out, a valve V18, which is provided in a pipe L18 leading to the bottom of the container Z4 and which is connected up through a pipe Ls with a scavenging fan S, and a valve V8''' which is provided in a pipe Lf''' leading from the top of the container Z4 to the outside is held open. The fan thus fills the container Z4 with atmospheric air, whereupon the valves V18 and V8''' are closed.

All the other valves shown in Figure 1 are held in the closed position during the phase described and during the cycle of operations carried out during this phase. At the end of this phase the functions of the containers Z1—Z4 are interchanged, as shown in Figure 2. The container Z4 which has just been filled with fresh air is connected to the circulating system which includes the heat exchanger G by opening the valve V19 which is provided in the pipe L19 connected to the bottom of the container Z4 and to the pipe Le, and by opening the valve V20 in the pipe L20 which is connected to the top of the container Z4 and to the pipe Lw. The contents of the container Z4 are thus heated and their pressure is increased.

At the same time the valve V12 of the pipe L12 leading from the bottom of the container Z2 to the pipe L14, is opened and as the valve V14 is held open, the hot compressed air passes from the container Z2 to the cylinder y to the right of the piston K. The valve V8 of pipe Lf leading from the top of the container Z1 into the outside air is, however, also open and since the valves V5 and V6 are also held open, the space in the cylinder to the left of the piston K is also in communication with the outside air through the container Z1, the gas under pressure from the container Z2 displacing the piston from right to

left while performing work. The contents of the cylinder y are thus forced into the container Z1 and the contents of the latter into the atmosphere. At the same time the valve V21 of the pipe L21 leading from the pipe Ls to the lower end of the container Z3 is opened and after the valve V8'' of the pipe Lf'' leading from the top of the container Z3 to the outside air has been opened, the container Z3 is scavenged by means of the scavenging fan S and filled with fresh air.

After the termination of this phase the valves V5, V8'', V19, V20 and V21 are closed while the valves V6, V12, V14 remain open (Fig. 3). At the same time, however, the valve V22 of the pipe L22 leading from the bottom of the container Z3 to the pipe Le, the valve V23 of the pipe L23 leading from the pipe Lw to the top of the container Z3, the valve V24 of the pipe L24 leading from the bottom of the container Z4 to the pipe Ly, and the valve V8' of the pipe Lf' leading from the top of the container Z2 to the outside, as well as the valve V9 of the pipe L9 leading from the pipe Ls to the bottom of the container Z1 to the pipe Ls, are opened.

The compressed air from the container Z4 thus drives the piston K in the cylinder y from left to right again, performing work, so that the contents of the cylinder y are forced into the container Z2 and the contents of the latter into the outside air. At the same time the contents of the container Z3 are passed through the heat exchanger G, being thereby heated and brought up to the required pressure. The container Z1 is on the other hand scavenged by the scavenging fan S and filled with fresh air.

When this phase is terminated, the valves V8, V9, V12, V22 and V23 are closed, (Fig. 4). On the other hand the valve V17 of the pipe L17 connected to the pipe L14, the valve V8''' of the pipe Lf''' leading from the top of the container Z4 to the outside, the valve V1 of the pipe L1 which connects the bottom of the container Z1 to the pipe Le, the valve V3 of the pipe L3 leading from the top of the container Z1 to the pipe Lw and the valve V15 of the pipe L16 connected to the pipe Ls and to the bottom of the container Z2, are opened.

The compressed air now passes from the container Z3 to the right of the piston K (broken line position) into the cylinder y and drives the piston K from right to left, performing work and forcing the contents of the latter into the atmosphere. The contents of the container Z1 are circulated through the heat exchanger G, heated and brought up to the required pressure, while the container Z2 is scavenged by the scavenging fan S and filled with fresh air. After the termination of this phase the valves V1, V3, V24, V15 and V8' are closed and the cycle of operations described above is repeated.

The various valves are actuated by any suitable valve-actuating mechanism driven from the piston rod of the piston or operated under the control of the piston rod. No valve mechanism is shown since such valve-operating mechanism does not form any part of the present invention.

The same method can be carried out also by using live heat. For this purpose it is only necessary to heat the heat-interchanger Gb with live heat generated by the combustion of fuel in the burner Gc as shown in Figure 8.

The method can also be carried out in such manner that a final heating of the gaseous medium is performed by the combustion of fuel after preheating it and increasing its pressure

at a constant volume by means of waste gas heat or live heat also generated by combustion of fuel. The method may be carried out suitably in this manner, that the gaseous medium is preheated in the closed circulating system and brought to the increased pressure. This air of increased pressure is conducted into a combustion chamber and, by burning fuel, is caused to flow in part as combustion gas under constant pressure through an opened valve to an installation wherein its energy is utilized, whilst at the same time a part is returned through another opened valve and a corresponding pipe to the container, from which the air has been withdrawn. This may be performed in a continuous process whereby a number of containers may be inserted alternately and in succession into the circulation system of one and the same heat source and of one and the same combustion chamber. This process shall now be more particularly described with reference to Figures 5 and 6.

In these figures E represents a combustion chamber or final heating space, Ve is one of the containers for the air to be heated, W is a second similar heater container, S1 is a storage vessel and H is a heating apparatus heated by the combustion of fuel. These containers can be connected to the heating apparatus H through the blower U2 and with the combustion chamber E by means of the circulating fan U1 through pipes provided with valves in the following manner.

In the phase shown in Figure 5 the valves A1 and v2 are, for a while, opened, whereas the valves A2, H2, v1, v3, v4, v5, and v11 and v12 are closed. The valves v6—v10 are held opened, so that combustion air from the container W, which has been heated, say from 300° C. abs. to 600° C. abs. and brought up to the required pressure of two atm. abs. in a preceding phase in a manner hereinafter to be described, is conducted by means of the circulating fan U1 into the combustion chamber E wherein the temperature may be 1800° C. abs. From this latter two thirds by weight of the contents of the container W flow through the valve v8 under constant pressure owing to the combustion of fuel to an engine (not shown) wherein its power is utilized, while the remaining third is conducted back through the valves v9 and v10 of the pipes L2 and L2' into the container W above the piston T1, which thereby moves from its raised position to its lowered position. The piston weight is nearly balanced by the counter-weight G2. The piston T2 will therefore descend due to the withdrawal of air below the same and the space above the piston T2 will be filled with gas having a temperature of 1800° C. abs. The fan U1 has therefore only circulating work to perform.

The two containers W and Ve are connected alternately to the combustion chamber E. If, as shown in Figure 5, the container W is connected with the chamber E, then the valves v6 and v10 are opened and the valves v12 and v1 closed. If, however, the chamber E is connected with the container Ve, then the valves v12 and v1 are opened and the valves v6 and v10 are closed.

The same occurrences take place in the containers W and Ve, only they are shifted in relation to each other to the extent of one phase. In that moment in which the container Ve is cut off from the chamber E by the closing of the valves v4 and v1 and the container W is connected to the chamber E by the opening of the valves v6 and v10, the piston T2 is in its highest position while the piston T1, the weight

of which is balanced by the counter-weight G1, is in its lowest position. The space above the piston T1 is filled with gas having a temperature of 1800° C. abs., which has flown through the valves v9 and v1, while the container Ve was connected with the chamber E. The gas above the piston T1 is removed from the container Ve by the opening of the valve v2, and then the gas is conducted to a consuming unit having atmospheric pressure, which is not shown in Figure 5.

By this means the pressure above the piston T1 is quickly reduced and as soon as atmospheric pressure has been reached and fresh air is delivered through the open valve A1 by means of the fan Uv into the container Ve, the piston T1 is forced upwardly. Thus the residual gas is rapidly removed through the valve v2 and the container Ve is filled below the piston T1 with fresh air, whereupon the valves v2 and A1 are closed (Fig. 6). The fresh air thus admitted to the container Ve through the valve A1 is then heated during the further utilization of the compressed air from the container W by being circulated by means of the fan U2 through the heating apparatus H and thereby placed under pressure (Fig. 6).

In order to enable the combustion chamber E to operate without interruption, it is necessary that the container Ve be filled with fresh air and that the heating of this air by means of the heating device H to the temperature of 600° C. abs. be completed at the time when the total amount of air situated below the piston T2 is removed from the container W and is transmitted to the chamber E.

If the switching of the two containers can not be accomplished at the same time, then an accumulator is provided which receives the superfluous amounts of air and gives up the needed amount of air, whenever necessary. This accumulator consists of a container S1 having a piston S2 which is connected with a weight S3. The weight S3 is such that it corresponds to the pressure of the heated air, in the present example to two absolute atmospheres.

The container W is switched off by the closing of the valves v6 and v10 after the piston T2 has reached its lowest position and the piston T1 has reached its highest position, while the container Ve is switched on by the opening of the valves v4 and v1. During the discharge of the heated air from the container Ve a rapid expansion of the combustion gases conducted from the combustion chamber E to the container W is obtained by opening the valve v3 and allowing the combustion gases to flow to an installation (not shown) wherein their pressure power or their heating power or both may be utilized. Then the valve A2 is opened and fresh air is introduced into the container W underneath the piston T2 and so forth.

The combustion gases flowing out of the combustion chamber E may also be utilized for delivering their heating power, as for instance, for heating a steam generator.

The preheating of the air may also be effected by waste gas heat in lieu of live heat. Thus, the remaining heat of the utilized combustion gases may, for instance, be used, said gases having been caused to flow out of the combustion chamber E through the valve v8.

In the case of the apparatus shown in Figure 7, the method is carried out in the last mentioned manner in conjunction with a steam gen-

erator. Two-thirds of the combustion gases which are continuously produced in a combustion chamber E are supplied to a steam generator D when the temperature of the air supplied to the combustion chamber E has risen, for instance, to 800° C. absolute. The steam generator consists of a heated coiled pipe, the water being introduced at D1 and the steam being removed at D2. However, the steam generator may be of any other suitable type. A throttle valve D3 is situated at the exit side of the steam generator. The usual final heating surfaces in the steam generator, which are expensive, are dispensed with and the combustion gases are withdrawn from the steam generator through a pipe La and supplied to a heat exchanger Ga, the cost of which is less than that of the final heating surfaces of a steam generator. Thus the heat of the waste combustion gases is transferred in the heat exchanger to fresh air from the containers Ve and W, from which the air is circulated by a circulating pump U3 in the same manner as in the case of the arrangement shown in Fig. 5. It is only necessary to have the valves v14 and v15 open at one time and the valves v16 and v17 open at another time, the method being carried out otherwise in the same manner as described with reference to Fig. 5. Since the cooling of the combustion gases in the steam generator D is carried out at a constant pressure, while the heating of the fresh air is at a constant volume, the combustion gases led through the boiler are sufficient to preheat the entire fresh air again up to 800° C. absolute.

What I claim is:

1. The device which comprises at least two containers adapted to be filled with a gaseous medium, a heat exchanger of constant dimensions, means supplying heat to said heat exchanger, means connected with said containers and adapted to remove the heated gaseous medium from said containers to carry out useful work, and means connecting said containers with said heat exchanger, and comprising means for supplying fresh gaseous medium in said containers one after the other and therefrom to said heat exchanger, and for removing it from said heat exchanger to one of the containers, whereby the gaseous medium in said containers is caused to flow continuously and consecutively through said heat exchanger and is removed from the device to carry out useful work.

2. The device which comprises at least one container adapted to be filled with a gaseous medium, a heat exchanger of constant dimensions, means supplying heat to said heat exchanger, means connected with said container and said heat exchanger and comprising means for causing a flow of a gaseous medium from said container to said heat exchanger and for causing a return flow of the heated gaseous medium from said heat exchanger back into said container, means constituting a combustion chamber, means connecting said container with the last-mentioned means and adapted to transmit the heated gaseous medium from said container to said combustion chamber, and means for removing the gaseous medium from said combustion chamber to carry out useful work.

3. A device in accordance with claim 2, comprising means connected with the combustion chamber for removing a part of the gas heated in said combustion chamber to carry out useful work, and means for returning another part of

the gaseous medium heated in said combustion chamber back to said container.

4. The device which comprises a heat exchanger of constant dimensions, means supplying heat to said heat exchanger, a plurality of circuits, each circuit comprising a container adapted to be filled with a gaseous medium, means connecting the container with said heat exchanger, and means for causing the gaseous medium in said container to flow consecutively and continuously through said circuits, whereby said gaseous medium is heated in said heat exchanger and returned to its container, means constituting a combustion chamber, and means connecting said containers with said combustion chamber, and comprising means for causing the heated gaseous medium to flow consecutively from said containers to said combustion chamber to be heated therein, and for causing a part of the gaseous medium to flow from said combustion chamber back into its container, and means connected with said combustion chamber to remove another part of the gaseous medium from said combustion chamber to carry out useful work.

5. A device in accordance with claim 4, wherein the means for heating the heat exchanger comprise means for transmitting combustion gases from said combustion chamber to said heat exchanger.

6. A method of obtaining useful energy by means of a gaseous working medium, said method comprising heating a constant volume of the medium and thereby increasing its pressure by passing it through a heated heat exchanger to a container, and expanding it from the container to a working installation and causing it to actuate said installation to remove from another container a medium which has been previously heated at a constant volume by passage through said heat exchanger and expanded from said other container to said installation to actuate the latter.

7. A method as claimed in claim 6, characterized by the feature that the heat exchanger through which the gaseous medium to be heated is passed in a closed circulating system, is heated by means of hot waste gases from the installation wherein the energy of the gaseous medium is utilized.

8. A method as claimed in claim 6, characterized by the feature that after the pressure and temperature of the working medium have been raised by heating it in the heat interchanger, the working medium is delivered together with fuel to a combustion chamber and, during the combustion of the fuel the combustion gas is in part conveyed at constant pressure to the installation where its energy is utilized and is in part returned to the container from which it is conducted to the consumer.

9. A method as claimed in claim 6, characterized by the feature that after the pressure and temperature of the working medium have been raised by heating it in the heat interchanger, the working medium is delivered together with fuel to a combustion chamber and, during the combustion of the fuel the combustion gas is in part conveyed at constant pressure to the installation where its energy is utilized and is in part returned to the container from which it is conducted to the combustion chamber and further characterized by preheating the air of several containers by circulating through one and the same heat interchanger, to which the containers are connected alternately and in succession,

withdrawing the preheated highly compressed air successively in turn from the said containers and, conducting it to one and the same combustion chamber by means of a circulating fan, causing
5 part of the combustion gas to flow out, during the combustion, from said chamber at constant pressure to the installation where it is utilized and returning the other part to the container from which the air is withdrawn.

- 10 10. A method as claimed in claim 6, characterized by the feature that after the pressure and temperature of the working medium have been raised by heating it in the heat interchanger, the working medium is delivered together with fuel
15 to a combustion chamber and, during the combustion of the fuel the combustion gas is in part conveyed at constant pressure to the installation where its energy is utilized and is in part returned to the container from which it is conducted to

the combustion chamber and further characterized by preheating the air of several containers by circulating through one and the same heat interchanger, to which the containers are connected alternately and in succession, withdrawing the preheated highly compressed air successively in turn from the said containers and, conducting it to one and the same combustion chamber by means of a circulating fan, causing part
5 of the combustion gas to flow out, during the combustion, from said chamber at constant pressure to the installation where it is utilized and returning the other part to the container from which the air is withdrawn and in which the working medium is preheated by means of waste
10 gases delivered from the installation to which they are conducted from the combustion chamber in the form of working gases.
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