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(54) **SYSTEM FOR PRODUCING COMPRESSED AIR**

(57) The present invention relates to a plant (1) for producing compressed air, for exploitation by a user unit, from a heat source. The plant (1) comprises a compression unit (2) which withdraws in air to be compressed from the environment (A) and generates compressed air (B, C). A first portion (B) of this compressed air is sent to the heating apparatus (5) where it is heated by the heat source, and then is transferred to the expansion unit

(3) as heated compressed air (D). The expansion unit (3) expands the heated compressed air (D), thereby generating as much mechanical power as is required to be transmitted to the compression unit (2). The remaining second portion (C) of compressed air (B, C) is withdrawn by a user conduit (6) and transferred to the user unit (13) as the target product.

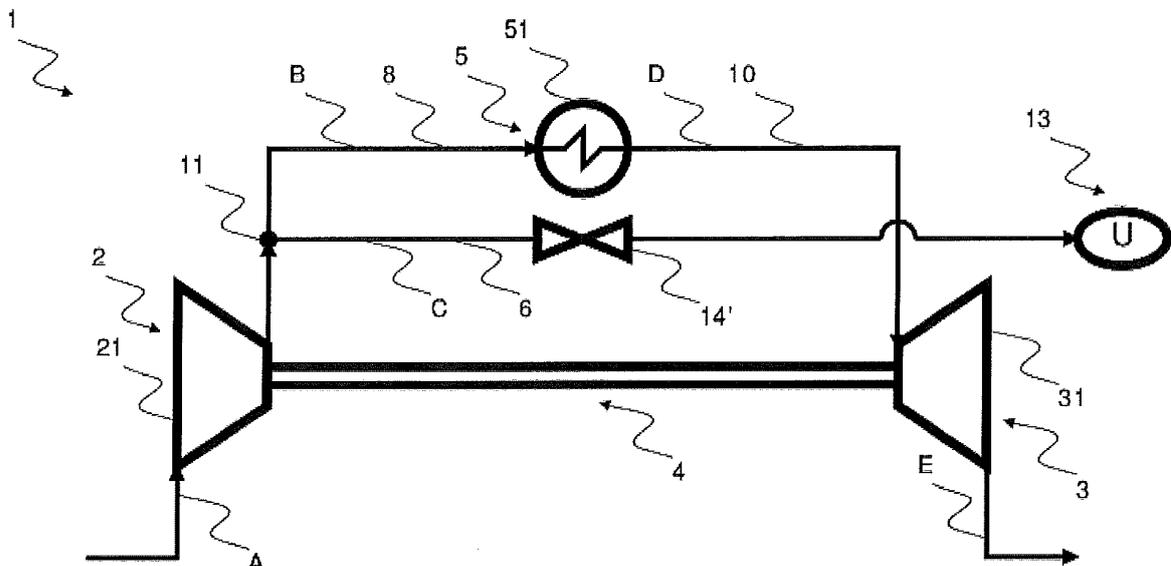


Fig. 1

Description**Field of the invention**

[0001] The present invention relates to a plant for producing compressed air as defined in the preamble of claim 1.

Background art

[0002] Compressed air is a widely used product in many fields, especially including industrial fields. Air, and all gases in general, are compressed in machines known as compressors.

[0003] Compressors are classified into two groups, based on how the fluid is compressed: positive displacement compressors and dynamic compressors (the latter being also known as continuous-flow compressors or turbo-compressors). Positive displacement compressors are particularly suitable for low volumetric flows, while dynamic compressors are suitable for high volumetric flows.

[0004] Expanders are classified in much the same manner as compressors.

[0005] Compressors may be driven by electric motors, internal combustion engines, such as piston engines and gas turbines or microturbines, or anyway other mechanical apparatus such as, for example, steam turbines or gas expanders. Electric drive is the most common solution.

[0006] Nowadays, compressed air has a considerable impact, in terms of percentage, on industrial power consumption, which has in turn a considerable impact on primary energy consumption in all fields.

[0007] Therefore, increased efficiency in compressed air production would be desirable, as it would lead to a considerable reduction in primary energy consumption and pollutant and greenhouse gas emissions, and hence to a more sustainable air compression process.

[0008] Namely, many industrial activities, such as glass, ceramic or metal production, require the use of compressed air and provide considerable amounts of excess heat, which must be consumed or dissipated.

[0009] In prior art techniques, excess heat generated by the aforementioned production processes is used for power generation through a thermodynamic cycle, such as a Rankine cycle using steam or an organic fluid. Part of the power generated is used to supply user units of the production plant, e.g. for compressed air production.

[0010] Therefore, heat may be indirectly used for producing the compressed air required by the desired industrial activity.

Problem of the prior art

[0011] Nevertheless, in this application, compressed air is produced from heat through a number of energy conversion steps, which take place in various plants, and

result in energy losses and hence in overall performance reduction.

[0012] The object of the present invention is to solve the above-described problems of the prior art, thereby affording high-efficiency compressed air production.

[0013] A further object of the present invention is to provide a plant for producing compressed air actuated by a heat source, requiring a small number of energy conversion steps to be carried out in a single plant, thereby also affording advantages in terms of reliability, costs and environmental impact.

Advantages of the invention

[0014] These and other objects are fulfilled by a plant for producing compressed air for exploitation by a user unit as defined in any of the accompanying claims.

[0015] Advantageously, the plant is not driven electrically, but it is driven by a generic heat source, and this, on the one hand, will avoid high power generation losses and, on the other hand, will afford integration in generic thermal processes such as those commonly available in industry, for example recovery of thermal power that would be otherwise dissipated in the environment, i.e. the process known in the art as thermal recovery or heat recovery. The plant can thus achieve remarkable efficiencies in compressed air production.

Brief description of the figures

[0016] Further features and advantages of the plant for producing compressed air of the present invention will be apparent from the following description of one preferred embodiment thereof, which is given by way of illustration and without limitation with reference to the accompanying figures, in which:

- Figure 1 shows an exemplary diagram of a plant according to a first embodiment of the present invention;
- Figure 1A shows an exemplary diagram of a plant according to a second embodiment of the present invention;
- Figure 2 shows an exemplary diagram of a plant according to a different embodiment of the present invention;
- Figure 3 shows an exemplary diagram of a plant according to another embodiment of the present invention.

DETAILED DESCRIPTION

[0017] Referring to the accompanying figures, numeral 1 designates a plant assigned to the production of compressed air, which is adapted to be used by a user unit 13 that is external to the plant.

[0018] The user unit 13 consists, for example, in a pneumatic drive, a glass blowing station, or the like.

[0019] The plant 1 comprises:

- a compression unit 2, which is configured to receive air to be compressed A, to perform a compression work on such air to be compressed A and to eject compressed air B, C;
- a heating apparatus 5 configured to receive a first portion of such compressed air B, to provide heat to such first portion of compressed air B, and to eject heated compressed air D,
- an expansion unit 3 configured to receive such heated compressed air D, to generate an expansion work, and to eject expanded air E,
- a transmission apparatus 4, configured to receive such expansion work generated by the expansion unit 3 and drive the compression unit 2.

[0020] In one aspect, the heating apparatus 5 is configured to transfer heat from a heat source to the first portion of compressed air B ejected by the compression unit 2, to thereby eject heated compressed air D.

[0021] Particularly, with the plant operating in steady-state conditions, the heat from the heat source is substantially the only energy that is withdrawn from the outside by the plant and that is used for operation thereof. The heat source may consist, for instance, of excess heat generated by an industrial activity, e.g. by glass, ceramic or metal melting furnaces.

[0022] In one aspect, the compression unit 2 is configured to receive, or suck in, air to be compressed A, preferably ambient air, possibly after filtration by appropriate filters (not shown).

[0023] Referring to the accompanying figures, it shall be noted that, in order to provide fluid communication between the compression unit 2 and the heating apparatus 5, the plant 1 comprises a first connection conduit 8, which is configured to receive at least the first portion of compressed air B from the compression unit 2, and to convey it to the heating apparatus.

[0024] As described in greater detail hereinafter, the first connection conduit 8 may receive either the first portion only of compressed air B or both the first portion of compressed air B and a second portion of compressed air C, from the compression unit 2. In any case, only the first portion of compressed air B is conveyed to the heating apparatus 5.

[0025] Still referring to the annexed figures, it shall be noted that, in order to provide fluid communication between the heating apparatus 5 and the expander unit 3, the plant 1 comprises a second connection conduit 10.

[0026] As it is known, the compression unit 2 must be driven to be able to operate. Particularly, the compression unit 2 requires a power that is substantially equal to the compression work, or equal to the compression work less a power fraction that is lost to keep the compression unit 2 rotating.

[0027] For this purpose, the plant is designed in such a manner that the power for driving the compression unit

2 will be generated by the expansion unit 3, and transmitted to the compression unit through the transmission apparatus 4.

[0028] Therefore, the expansion unit 3 expands the heated compressed air D, thereby generating as much power (e.g. mechanical, electric, hydraulic, pneumatic or magnetic power) as is required to be transmitted to the compression unit 2 by the transmission apparatus 4.

[0029] It shall be noted that the expanded air E ejected by the expansion unit 3 is introduced into the environment.

[0030] Therefore, the plant 1 operates an open thermodynamic cycle. Namely, the expanded air E may be introduced into the environment directly, as shown in Figures 1 and 3, or indirectly, as shown in Figure 2 and as described in greater detail hereinbelow.

[0031] In one aspect, the transmission apparatus 4 is configured to receive the expansion work generated by the expansion unit 3, and particularly to apply a resistant torque to the rotation of the expansion unit 3.

[0032] Therefore, the transmission apparatus 4 is configured to drive the compression unit 2, and particularly to apply a driving torque to the compression unit 2.

[0033] In a preferred embodiment, the transmission apparatus 4 may consist of a mechanical transmission. The mechanical transmission may comprise a single transmission shaft, as shown in Figures 1, 1A and 3, or multiple transmission shafts, as shown in Figure 2. The mechanical transmission may also comprise gears, for maintaining a constant ratio between the speed of the compression unit 2 and the speed of the expansion unit 3.

[0034] According to other alternative embodiments, the transmission apparatus 4 consists, for instance, of an electric, hydraulic, pneumatic or magnetic transmission.

[0035] The transmission apparatus 4 may further comprise a combination of these types of transmissions, particularly if there are pluralities of compressors 22, 23 and expanders 32, 33, as described below.

[0036] Obviously, power losses may be associated with the transfer of energy by the transmission apparatus 4. For example, a mechanical transmission generally has an efficiency ratio other than one, in certain embodiments higher than 95%, which affects the efficiency of energy transfer between the expansion unit 3 and the compression unit 2.

[0037] In one aspect, the expansion work is only used to drive the compression unit 2. In other words, the transmission apparatus 4 is configured to transfer the entire expansion work provided by the expansion unit 3 to the compression unit 2, to achieve a balanced configuration.

[0038] A characteristic of the plant 1 is that no user units other than the compression unit 2 withdraw power, i.e. are driven by the expansion work.

[0039] In other words no means operating in parallel with the compression unit 2 withdraw power from the expansion unit 3 and/or the transmission unit 4 and transfer it outside the plant 1.

[0040] Particularly, there are no electric generators, driven by the expansion unit 3 and/or by the transmission unit 4, that supply power into a power network external to the plant, namely external to the transmission apparatus 4.

[0041] Furthermore, there are no operating machines, driven by the expansion unit 3 and/or by the transmission unit 4, that provide work to an external user unit, operating in parallel with the compression unit 2.

[0042] In one aspect, the plant 1 comprises a user conduit, which is configured to receive a second portion of compressed air C ejected from the compression unit 2, and to transfer the second portion of compressed air C to the user unit 13.

[0043] This user conduit 6 allows to achieve the desired effect of producing compressed air designed for external use by the plant 1, as it provides the compressed air generated by the compressor unit 2 along a conduit that is distinct and separate from the conduits 8, 10.

[0044] With this arrangement, the second portion of compressed air C, i.e. the portion provided to the user unit 13, will not be reintroduced into the thermodynamic cycle.

[0045] The remaining second portion C of compressed air B, C is withdrawn by the user conduit 6 and transferred to the user unit 13 as the wanted product.

[0046] Particularly, the plant 1 does not comprise means for conveying the second portion of compressed air C from the user unit 13 to the compression unit 2 and/or the expansion unit 3 and/or the heating apparatus 5.

[0047] The compressed air B, C ejected from the compression unit 2 may be split into the first portion of compressed air B and the second portion of compressed air C in various manners and in various locations of the plant 1.

[0048] Generally, also referring to Figures 1 to 3, the user conduit 6 is configured to receive the second portion of compressed air C at a point of withdrawal 11.

[0049] According to one embodiment, as shown in Figures 1, 1A and 2, the point of withdrawal 11 is located at the first connection conduit 8, such that the first and second portions of compressed air B, C will be ejected together, i.e. mixed, from the compression unit 2. Therefore, the first connection conduit 8 receives both the first portion of compressed air B and the second portion of compressed air C and, in the point of withdrawal 11, the user conduit 6 forms a bypass from the first connection conduit 8 to receive the second portion of compressed air C from the first connection conduit 8.

[0050] According to a different embodiment, as shown in figure 3, the point of withdrawal 11 is within the compression unit 2 (i.e. such group consists, for instance, of a multistage compressor 25, as described more in detail hereinafter) and the first and second portions of compressed air B, C are ejected from the compression unit 2 separately or in different locations of the compression unit 2. Thus, in this embodiment, the first connection con-

duit 8 only receives the first portion of compressed air B.

[0051] In one aspect, for the expansion work to be only used, under steady-state conditions, to drive the compression unit 2, i.e. in order to maintain a balanced configuration, the plant 1 comprises flow-rate control means 14', 14" which are configured to control a pressure flow of the first portion of compressed air B and/or a pressure flow of the second portion of compressed air C.

[0052] In other words, the flow control means 14', 14" are configured to control the pressure flows of the first and/or second portions of compressed air B, C, such that the user conduit 6 has therein a slightly higher pressure (e.g. a few percentage points higher, such as 1, 2, 3, 4 or 5% higher) than the pressure value in the user unit 13.

[0053] It shall be noted that the work per mass unit generated by the expansion of the heated compressed air D is greater than the work per mass unit that is carried out to compress the air to be compressed A, due to the heat provided by the heating apparatus 5. As a result, in order to keep the transmission apparatus 4 balanced, the mass flow of air to the expansion unit 3 must be smaller than the mass flow to the compression unit 2. Particularly, the mass flow to the compression unit 2 substantially coincides with the sum of the mass flows of the first portion of compressed air B and the second portion of compressed air C, whereas the mass flow to the expansion unit 3 substantially coincides with the mass flow of only the first portion of compressed air B.

[0054] The flow control means 14', 14" may comprise one or more valves. One valve may be associated, for example, with the user conduit 6 and/or the first connection conduit 8 and/or the point of withdrawal 11.

[0055] In one embodiment, also referring to Figure 1, it will be appreciated that the flow control means 14', 14" comprise a two-way valve (14') located at one point along the user conduit 6, the latter operating as a bypass relative to the first connection conduit 8 to receive the second portion of compressed air C.

[0056] In another embodiment, also referring to Figure 1A, the flow control means 14', 14" comprise a three-way valve 14", located at the point of withdrawal 11, which is placed along the first connection conduit 8; also in this configuration the user conduit 6 operates as a bypass from the first connection conduit 8 to receive the second portion of compressed air C.

[0057] It shall be noted that the compression unit 2 may consist of one compressor 21 or multiple compressors 22, 23. Namely, the compression unit 2 may comprise a single compressor 21, as shown in Figures 1, 1A and 3, or a plurality of compressors 22, 23 including any number of compressors, as shown in Figure 2.

[0058] The compressors 22, 23 may be part of different categories or subcategories of compressors. Each of the compressors 21, 22, 23 of the compression unit 2 may be a single-stage compressor 24, as shown in Figure 1, 1A or a multistage compressor 25, as shown in Figure 3. Particularly, a single-stage compressor 24 comprises

a single stage 6, whereas a multistage compressor 25 comprises an input stage 27, an output stage 28 and possibly one or more intermediate stages 29.

[0059] Each compressor 21, 22, 23 of the compression unit 2 is preferably configured to cause adiabatic compression of the air to be compressed A.

[0060] For example, if the compression unit 2 comprises at least one multistage compressor 25, the user conduit 6 may be connected to the multistage compressor 25, for bleeding the second portion of compressed air C from the multistage compressor 25 between the input stage 27 and the output stage 28 of the multistage compressor 25. Here, the flow control means 14', 14" comprise a two-way valve 14' placed at one point along the user conduit 6.

[0061] It shall be noted that the multistage compressor 25 from which the second portion of compressed air C is bled may coincide with the single compressor 21 of the compression unit 2, if the compression unit 2 comprises a single compressor 21, otherwise it may coincide, also referring to Figure 2, with any of the compressors 22, 23 of the compression unit 2, if the compression unit comprises a plurality of compressors 22, 23.

[0062] According to a further embodiment, also referring to Figure 2, the second portion of compressed air C is ejected from the compression unit 2 between two distinct compressors 22, 23 in series arrangement, i.e. the point of withdrawal 11 is located between two distinct compressors 22, 23 in series arrangement.

[0063] It shall be noted that, in the latter two cases, the first portion of compressed air B has a higher pressure than the second portion of compressed air C.

[0064] According to other embodiments, not shown, the plant 1 may comprise multiple point of withdrawals 11 and multiple user conduits 6, situated in different locations in the plant 1 with a cascade control, the priority being assigned to the conduit at the highest pressure.

[0065] Therefore, the point of withdrawal 11 may be situated between stages 27, 28, 29 of a multistage compressor 25 or between the various compressors 22, 23 of the compression unit 2, or downstream from the last single-stage or multistage compressor, and upstream from the heating apparatus 5.

[0066] In one aspect, the heating apparatus 5 comprises a main heating unit 51, which is configured to transfer heat from a heat source to the first portion of compressed air B.

[0067] The main heating unit 51 may comprise, for example, a heat exchanger, which is configured to transfer heat from a heat source to the first portion of compressed air B. This will advantageously afford heat recovery.

[0068] Alternatively, the main heating unit 51 may comprise a combustion chamber. The combustion chamber is configured to inject a fuel into the first portion of compressed air B and start a combustion. Here, the heated compressed air D contains exhaust fumes.

[0069] The expansion unit 3 comprises an expander 31. Like the compression unit 2, the expansion unit 3 may

comprise a single expander 31, as shown in Figures 1, 1A and 3, or a plurality of expanders 32, 33 including any number of expanders, as shown in Figure 2.

[0070] The expanders 31, 32, 33 of the expansion unit 3 may be part of categories or subcategories of expanders differing from each other and from the categories of the compressors 21, 22, 23 of the compression unit 2. The number of the expanders 31, 32, 33 of the expansion unit 3 may be the same as or different from the number of the compressors 21, 22, 23 of the compression unit 2. Each of the expanders 31, 32, 33 of the expansion unit 3 may be a single-stage expander or a multistage expander. Preferably, each expander 31, 32, 33 of the expansion unit 3 is configured to cause adiabatic expansion of the heated compressed air D.

[0071] Each compressor 21, 22, 23 of the compression unit 2 is connected to a respective expander 31, 32, 33 via the transmission apparatus 4.

[0072] For example, in the case of a mechanical transmission apparatus 4, each compressor 21, 22, 23 may rotate at the same speed as or at a different speed from each expander 31, 32, 33 of the expansion unit 3. Furthermore, distinct compressors 22, 23 and/or distinct expanders 32, 33 may rotate at different speeds.

[0073] Possible embodiments of the plant 1 will be now described, which are susceptible of further improving the efficiency of the plant 1 for producing compressed air.

[0074] In one embodiment, as shown in Figure 2, ambient air may be compressed in multiple compressors 22, 23 connected in series with cooling therebetween, i.e. using a process known as inter-refrigerated or inter-cooled compression.

[0075] In detail, in this case the plurality of compressors 22, 23 comprises a first compressor 22 and a second compressor 23. The first compressor 22 and the second compressor 23 are connected in series. The first compressor 22 is configured to receive the air to be compressed A and to perform pre-compression, i.e. to eject pre-compressed air F.

[0076] The plant 1 comprises a cooling device 7 configured to receive the pre-compressed air F output from the first compressor 22, withdraw heat from the pre-compressed air F, and provide cooled pre-compressed air G to the second compressor 23. The second compressor 23 is configured to eject compressed air, and particularly the first portion of compressed air B only, or both first and second portions of compressed air B, C. The plant 1 may comprise any number of cooling devices 7.

[0077] In one embodiment, as shown in Figure 2, the expansion unit 3 comprises a plurality of expanders 32, 33, including a first expander 32 and a second expander 33. The first expander 32 and the second expander 33 are connected in series. The first expander 32 is configured to perform pre-expansion, i.e. to eject pre-expanded air H.

[0078] In this embodiment, the plant 1 comprises an intermediate heating device 9 configured to receive the pre-expanded air H output from the first expander 32,

provide heat to the pre-expanded air H, and provide heated pre-expanded air I to the second expander 33. Therefore, the expansion unit 3 and the intermediate heating device 9 will carry out the process known as expansion with repeated heating. The plant 1 may comprise any number of intermediate heating devices 9.

[0079] In various embodiments, the expanded air E ejected by the expansion unit 3 is introduced into the environment directly or indirectly. For example, in the embodiment as shown in Figures 1 and 3, the expanded air E is introduced into the environment directly.

[0080] In one embodiment, as shown in Figure 2, the heating apparatus 5 comprises a regenerator 52. The regenerator 52 is configured to receive the first portion of compressed air B from the compression unit 2, i.e. from the first connection conduit 8, and to receive the expanded air E from the expansion unit 3. It shall be noted that the first portion of compressed air B and the expanded air E do not mix in the regenerator 52. The regenerator 52 is configured to transfer heat from the expanded air E to the first portion of compressed air B. Thus, the regenerator 52 ensures pre-heating of the first portion of compressed air B and is configured to eject pre-heated compressed air L.

[0081] Here, the main heating unit 51 is configured to receive the pre-heated compressed air L, transfer heat from the heat source to the pre-heated compressed air L, and eject the heated compressed air D. The heated compressed air D is sent to the expansion unit 3 through the second connection conduit 10. In this embodiment, the expanded air E is not introduced into the environment directly from the expansion unit 3, but it is introduced into the environment downstream from the regenerator 52, either directly or indirectly.

[0082] In a further embodiment, as shown in Figure 2, the plant 1 comprises a cogeneration unit 12 having a heat exchange device configured to heat a generic fluid, e.g. water, by recovering thermal power from expanded air E, to be used for other purposes. Particularly, the cogeneration unit 12 receives expanded air E directly from the expansion unit 3 or from the regenerator 52. The air that comes out of the cogeneration unit 12 is introduced into the environment.

[0083] The above description clearly shows that the plant 1 solves the prior art problems as set forth above.

[0084] Those skilled in the art will obviously appreciate that a number of changes and variants as described above may be made to fulfill particular requirements, without departure from the scope of the invention, as defined in the following claims.

Claims

1. A plant (1) for producing compressed air exploitable by a user unit (13), comprising:

- a compression unit (2) configured to receive

air to be compressed (A), to perform a compression work on said air to be compressed (A) and to eject compressed air (B, C),

- a heating apparatus (5) configured to receive a first portion of said compressed air (B), to provide heat to said first portion of compressed air (B), and to eject heated compressed air (D),
- an expansion unit (3) configured to receive said heated compressed air (D), to generate an expansion work, and to eject expanded air (E),
- a transmission apparatus (4), configured to receive said expansion work generated by the expansion unit (3) and to drive the compression unit (2),

characterized in that:

- the plant is not driven electrically, and
- the plant comprises a user conduit (6) configured to receive a second portion of said compressed air (C) and to convey said second portion of compressed air (C) to said user unit (13),
- said expansion work being used, under steady-state conditions, only to drive said compression unit (2).

2. A plant (1) as claimed in claim 1, comprising flow control means (14', 14'') configured to control a pressure of the first portion of compressed air (B) and/or a pressure of the second portion of compressed air (C) to keep said transmission apparatus (4) balanced.

3. A plant (1) as claimed in any of the preceding claims, comprising a first connection conduit (8) configured to receive said first portion of compressed air (B) and said second portion of compressed air (C) from said compression unit (2) and to carry said first portion of compressed air (B) to said heating apparatus (5) said user conduit operating as a bypass from said first connection conduit (8) to receive said second amount of compressed air (C), wherein said flow control means (14', 14'') comprise a two-way valve (14') placed at one point along said user conduit (6) or a three-way valve (14'') placed at one point of withdrawal (11) in said first connection conduit (8).

4. A plant (1) as claimed in any of the preceding claims, wherein:

- said compression unit (2) comprises a multi-stage compressor (25) having an inlet stage (27) and an outlet stage (28),
- said user conduit (6) is connected to the multi-stage compressor (25) for bleeding said second amount of compressed air (C) from the multi-stage compressor (25) between said inlet stage (27) and said outlet stage (28),

- said flow control means (14', 14") comprise a two-way valve (14') placed at one point along said user conduit (6).
5. A plant (1) as claimed in any of the preceding claims 1 to 4, wherein:
- said compression unit (2) comprises a first compressor (22) and a second compressor (23), said first compressor (22) being configured to receive said ambient air (A) and eject pre-compressed air (F), and said second compressor (23) being configured to eject said compressed air (B, C);
 - said plant comprising a cooling device (7) configured to receive said pre-compressed air (F) output from the first compressor (22), withdraw heat from said pre-compressed air (F), and provide cooled pre-compressed air (G) to said second compressor (23);
 - said expansion unit (3) comprises a first expander (32) and a second expander (33), said first expander (32) being configured to receive said heated compressed air (D), and eject pre-expanded air (H), said second expander (33) being configured to eject said expanded air (E).
6. A plant (1) as claimed in claim 5, comprising an intermediate heating device (9) configured to receive said pre-expanded air (H) output from the first expander (32), provide heat to said pre-expanded air (H), and provide heated pre-expanded air (I) to said second expander (33).
7. A plant (1) as claimed in any of the preceding claims, wherein said heating apparatus (5) comprises a main heating unit (51) comprising a heat exchanger, configured to transfer heat from said heat source to the first portion of compressed air (B), or a combustion chamber, configured to inject a fuel into the first portion of compressed air (B) and start a combustion.
8. A plant (1) as claimed in an any of the preceding claims 1 to 7, wherein:
- said heating apparatus (5) comprises a regenerator (52) and a main heating unit (51),
 - said regenerator (52) is configured to receive said first portion of compressed air (B) and said expanded air (E), transfer heat from said expanded air (E) to said first portion of compressed air (B) and eject pre-heated compressed air (L),
 - said main heating unit (51) is configured to receive said pre-heated compressed air (L), transfer heat from a heat source to said pre-heated compressed air (L) and eject said heated compressed air (D).
9. A plant (1) as claimed in any of the preceding claims, comprising a cogeneration unit (12) having a heat exchange device configured to receive said expanded air (E) from the expansion unit (3) or from said regenerator (52) and transfer heat from said expanded air (E) to a generic fluid.
10. A plant (1) as claimed in any of the preceding claims, wherein said transmission apparatus (4) consists of a mechanical, electric, pneumatic, hydraulic or magnetic transmission.

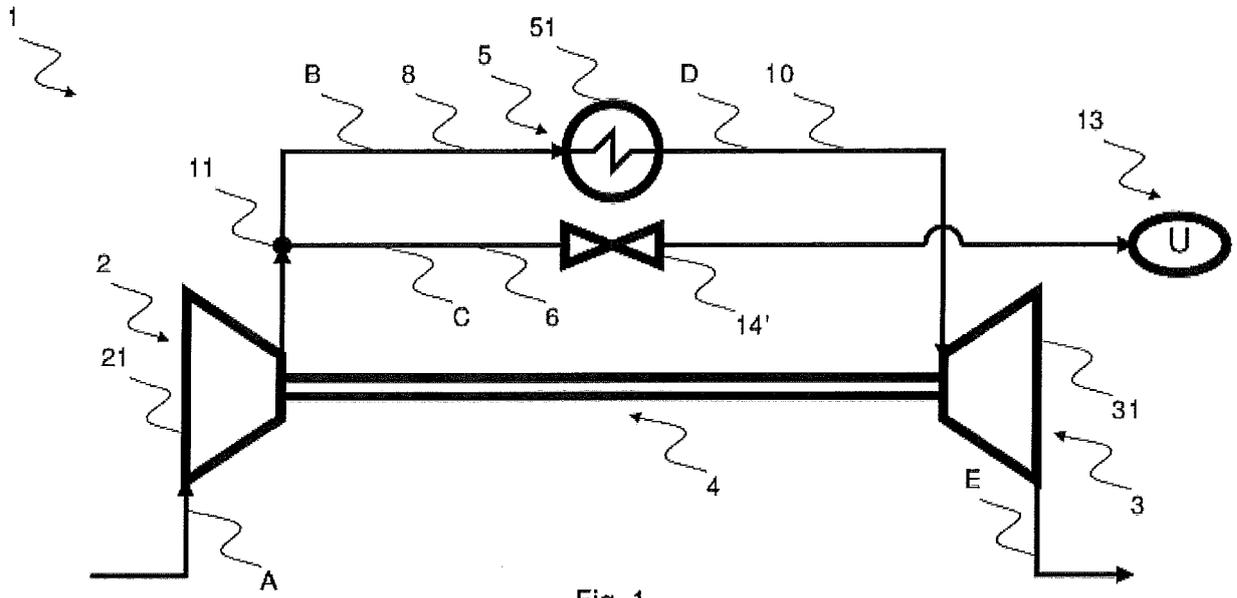


Fig. 1

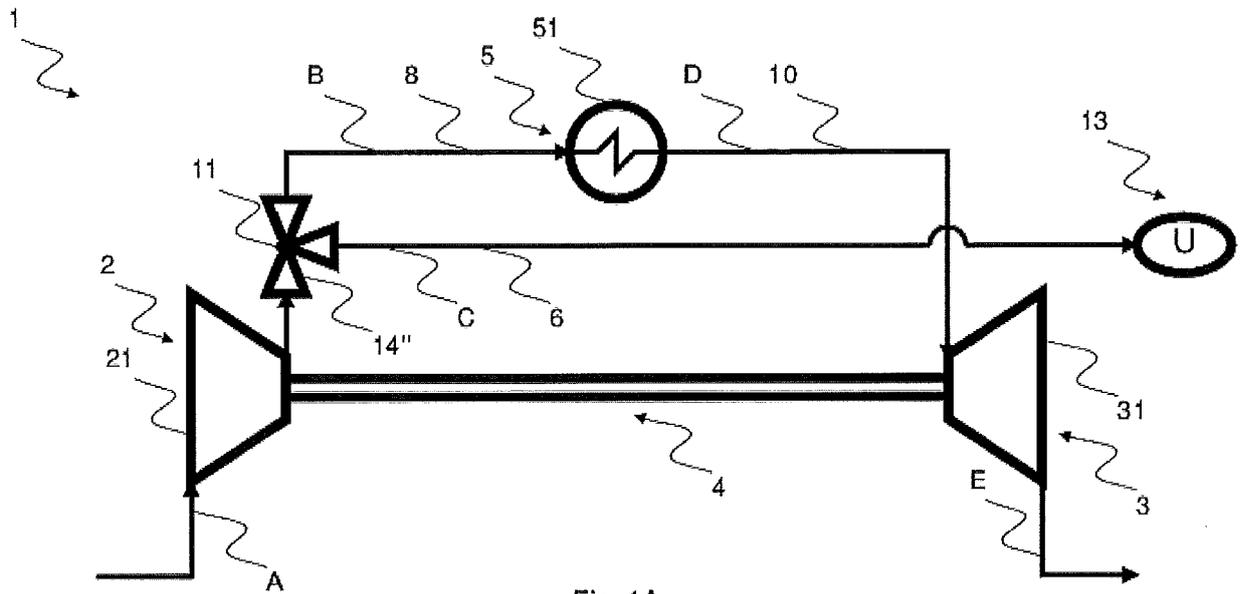


Fig. 1A

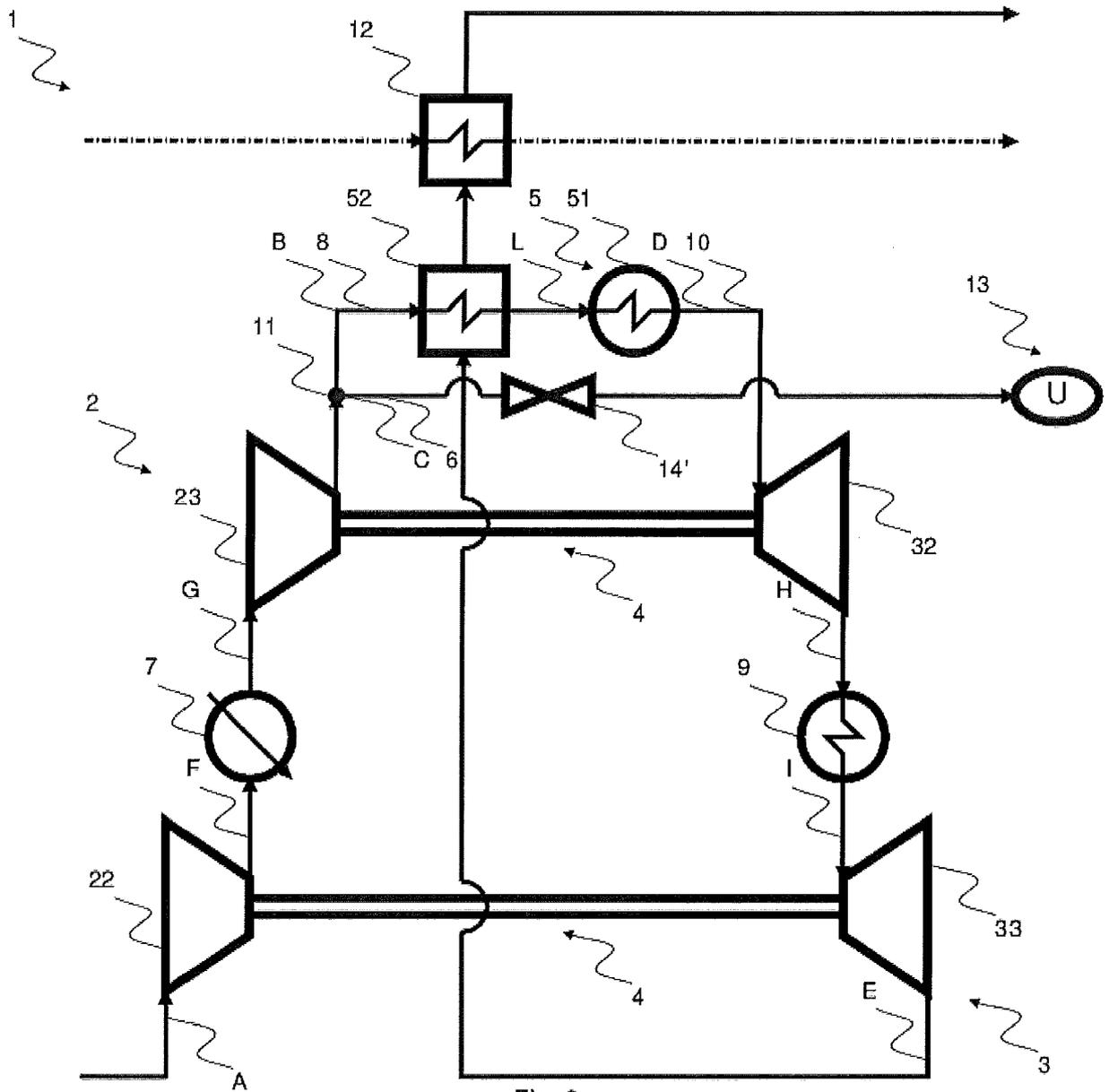


Fig. 2

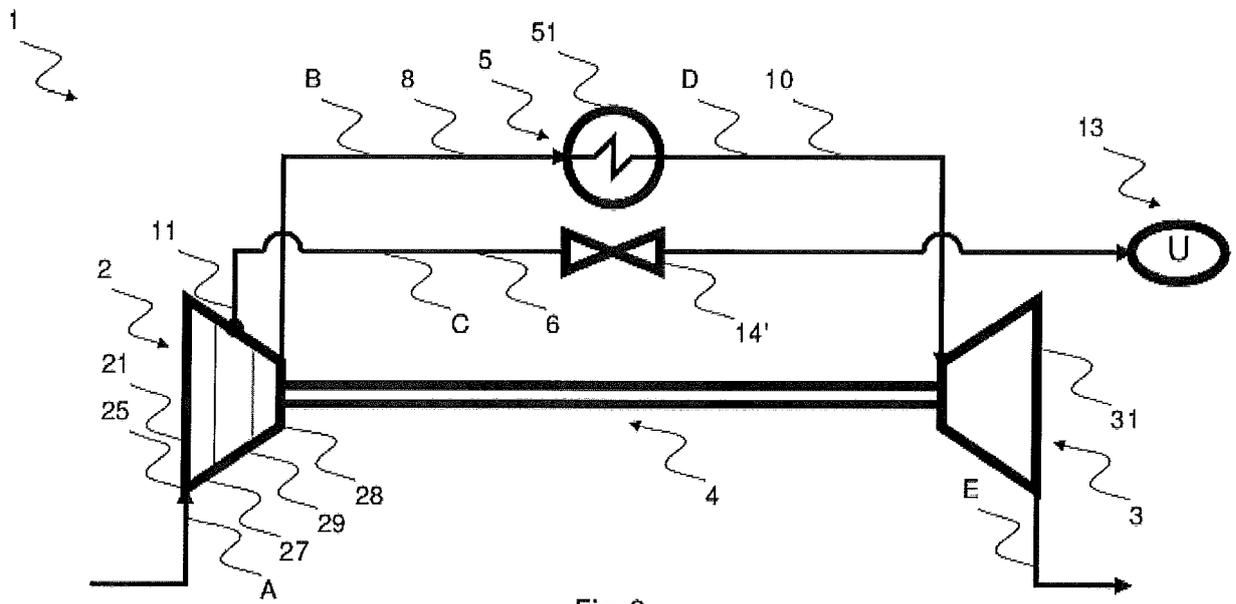


Fig. 3



EUROPEAN SEARCH REPORT

Application Number
EP 17 18 2628

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	DE 44 10 440 A1 (ISRAEL ELECTRIC CORP LTD [IL]) 10 August 1995 (1995-08-10) * the whole document *	1-3,5-7, 10 4,8,9	INV. F01C11/00 F04C11/00
X	US 5 873 250 A (LEWIS RALPH H [US] ET AL) 23 February 1999 (1999-02-23) * column 7, line 66 - column 9, line 6 * * figure 2 *	1	
A	WO 00/06876 A1 (TEXAS A & M UNIV SYS [US]) 10 February 2000 (2000-02-10) * the whole document *	1	
A	WO 2008/049818 A2 (SHELL INT RESEARCH [NL]; SHELL CANADA LTD [CA]; STRAVER ALEXANDER EMAN) 2 May 2008 (2008-05-02) * the whole document *	1	
			TECHNICAL FIELDS SEARCHED (IPC)
			F01C F04C
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 30 November 2017	Examiner Lange, Christian
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