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(54) **HYBRID COMPRESSOR FOR AN AIR-CONDITIONING CIRCUIT**

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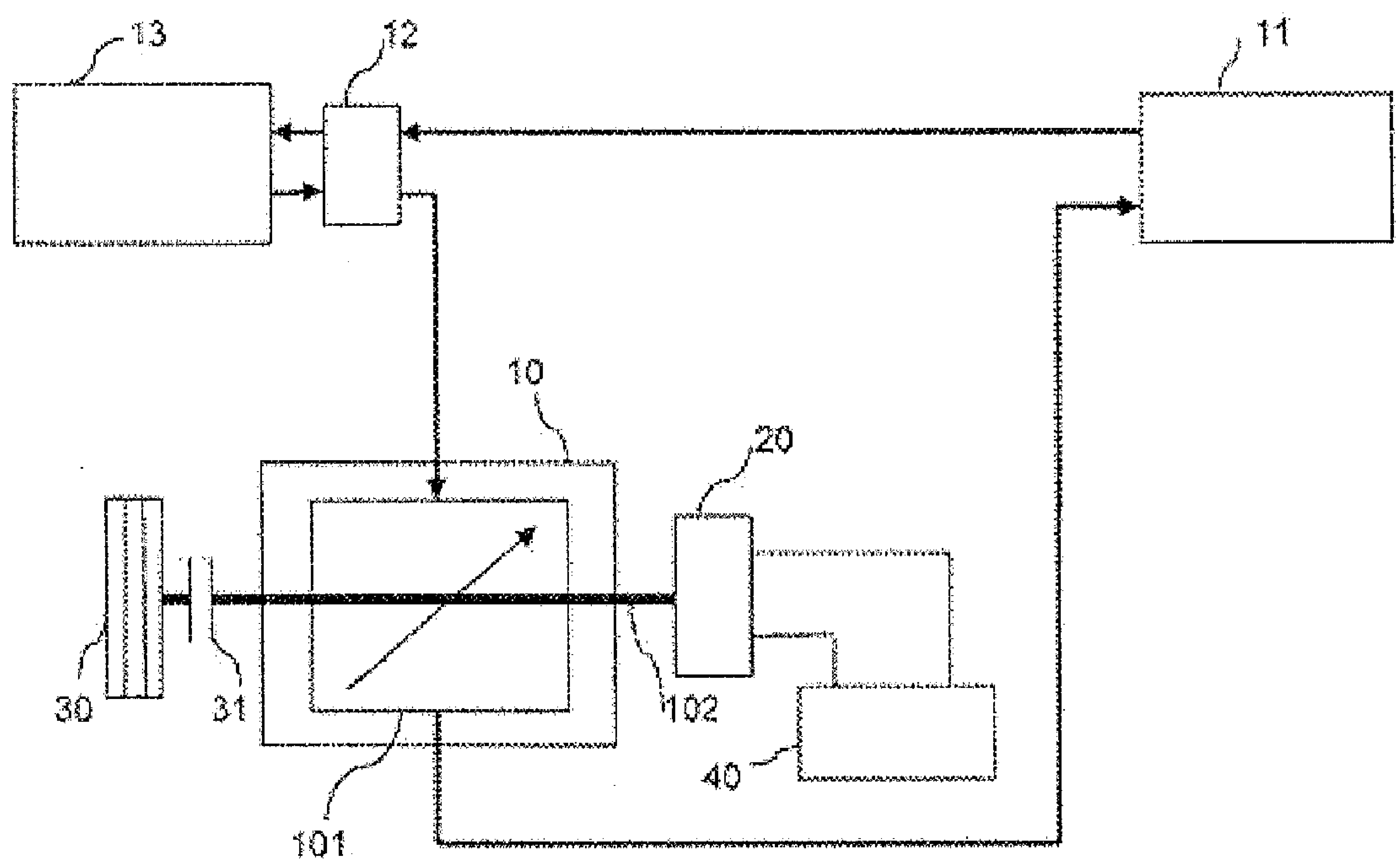
(57) **ABSTRACT**

The invention relates to a hybrid compressor (**10**) for an air-conditioning circuit of a motor vehicle having a heat engine, said hybrid compressor being suitable for being driven, on the one hand, by said heat engine and, on the other hand, by an electric motor (**20**) during phases in which the drive from the heat engine is interrupted. According to the invention, said hybrid compressor (**10**) consists of a compression chamber (**101**) with variable displacement, said displacement being variable in a (variation range having an upper displacement interval in which the compression chamber (**101**) is driven by the heat engine, and a lower displacement interval in which the compression chamber (**101**) is driven by the electric motor (**20**). T*he* invention can be *used* for motor vehicles having a heat engine and provided with an automatic stopping and restarting *system*.



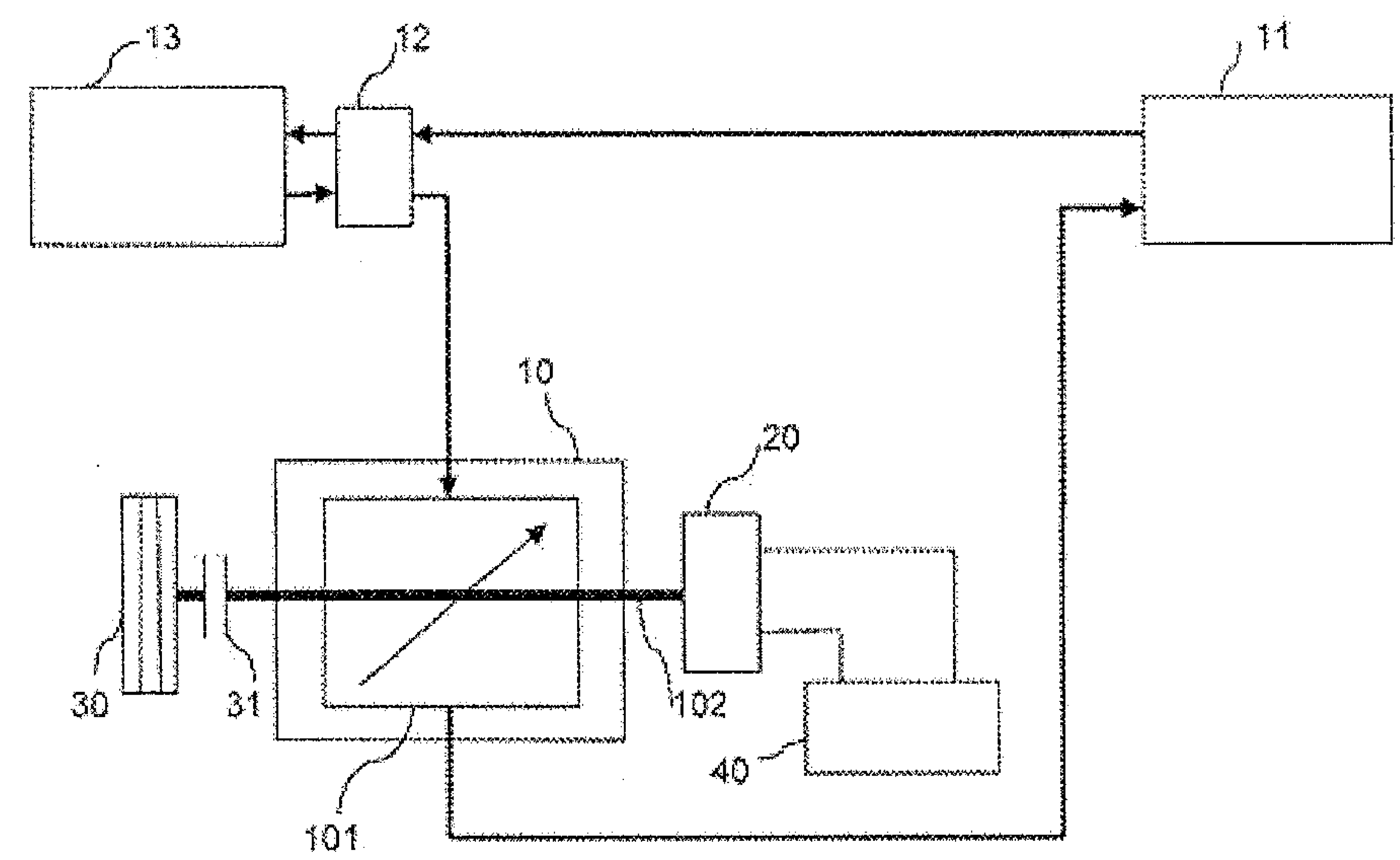

13
12
11
10
20
30
31
102
40
101

FIG. 1

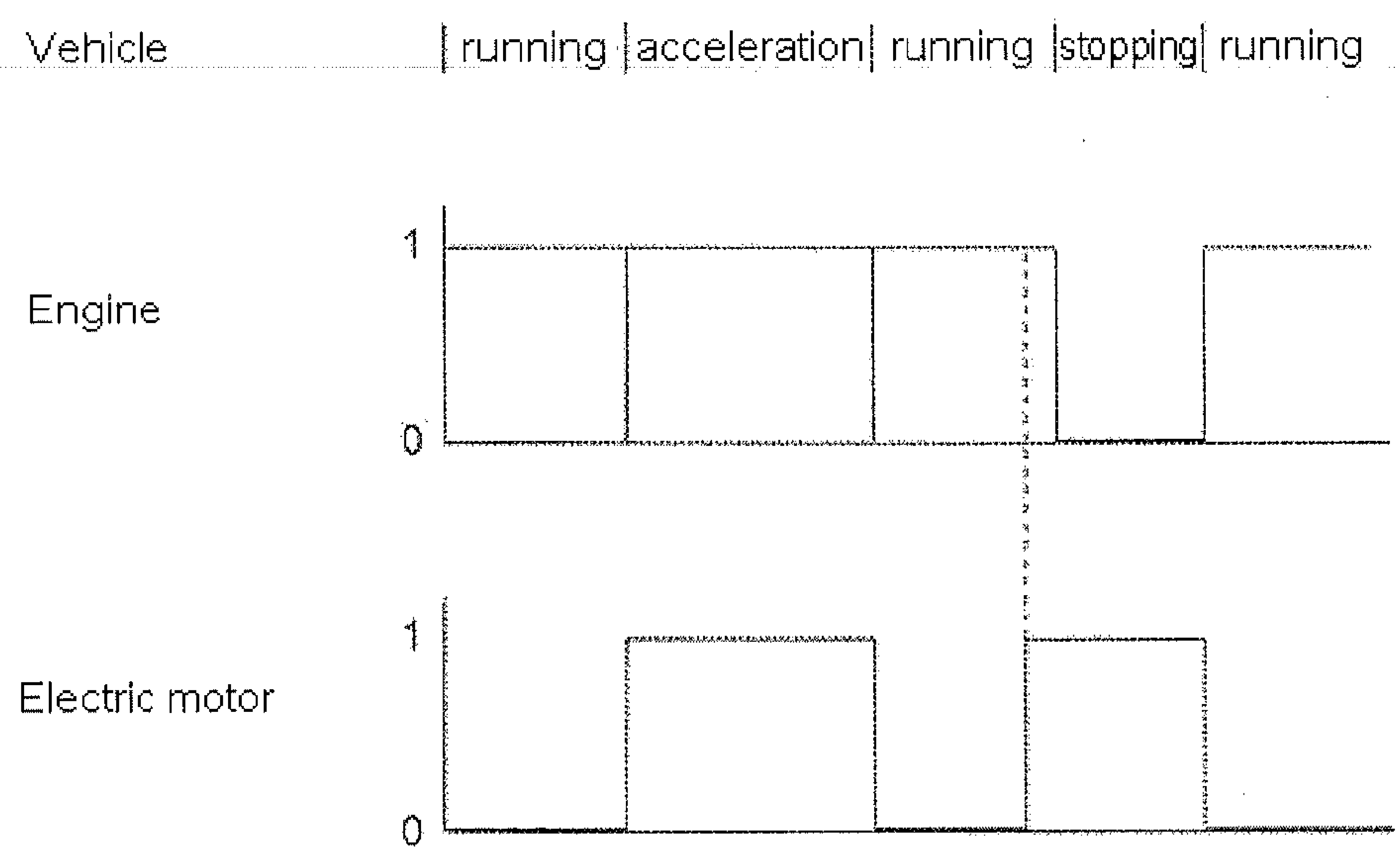

Vehicle
running
acceleration
running
stopping
running
Engine
1
0
Electric motor
1
0

FIG. 2

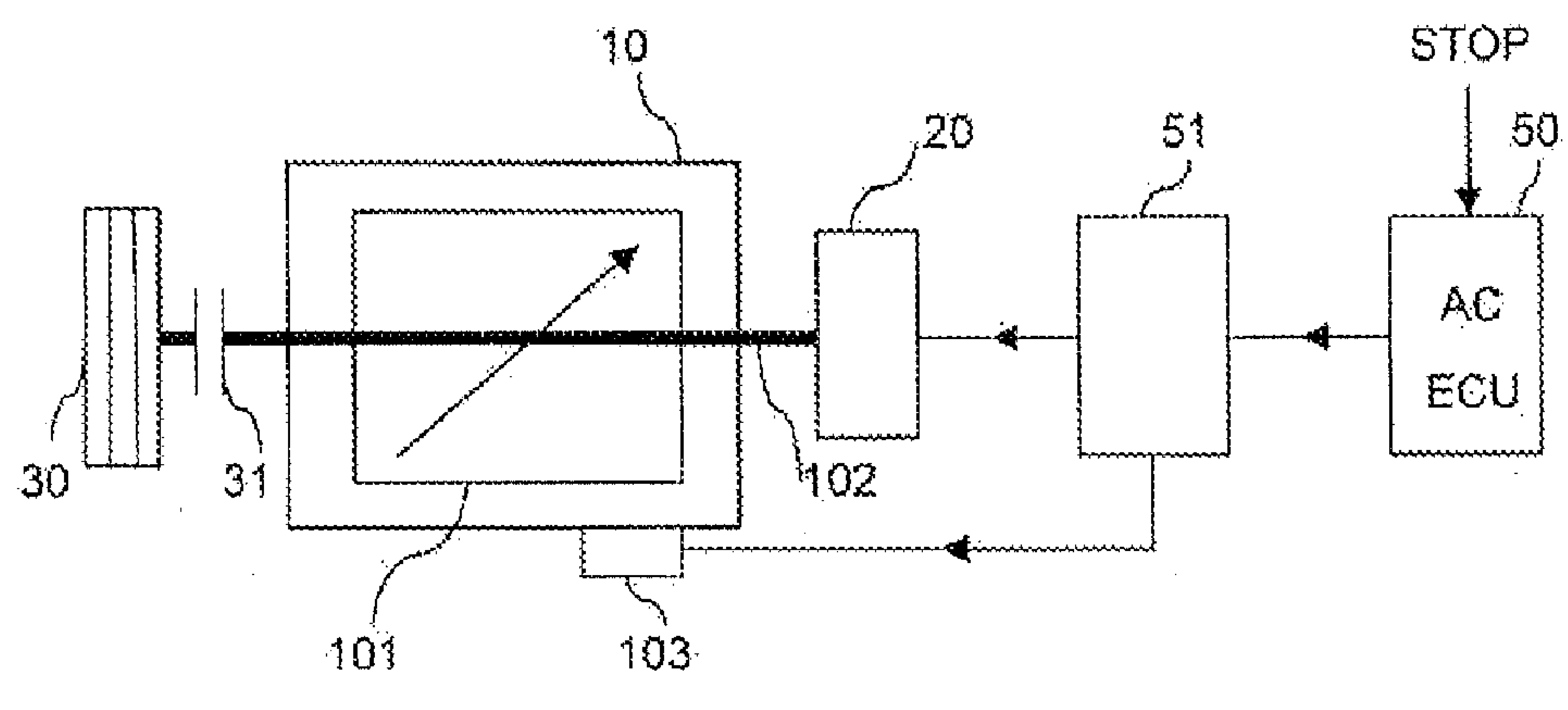


FIG. 3

HYBRID COMPRESSOR FOR AN AIR-CONDITIONING CIRCUIT

[0001] The present invention relates to a hybrid compressor for an air-conditioning circuit of an engined motor vehicle.

[0002] The invention finds a particularly advantageous application in the field of the air-conditioning of engined motor vehicles equipped with an automatic stopping and restarting system, such as the systems able to implement the function known by the term "Stop and Start",

[0003] The "Stop and Start" function consists, under certain conditions, in automatically causing the complete stopping of the engine when the vehicle itself has stopped, and then in automatically restarting the engine following, for example, an action of the driver interpreted as a restart request.

[0004] A typical situation for implementing the "Stop and Start" function is that of stopping at a red light. When the vehicle stops at the light, the "Stop" mode of the "Stop and Start" function causes the automatic stopping of the engine, and the vehicle then enters the "Start" mode which allows the engine to restart automatically without it being necessary to use the means for initial starting of the motor, such as a contact key for example. When the light turns green, the "Start" mode automatically restarts the motor, especially by means of an alternator-starter, following the detection by the command system upon the starting of the vehicle of the depression by the driver of the clutch pedal, of the accelerator pedal, or else of any other action that can be interpreted as the driver's desire to restart his vehicle. The benefit of the "Stop and Start" function is understood in terms of energy saving and pollution reduction, particularly in urban surroundings.

[0005] Moreover, it is known that an air-conditioning circuit of an engined vehicle comprises a refrigerant fluid compressor which is driven by the shaft of the crankshaft of the engine by way of a belt and a pulley linked mechanically to the rod of the compressor. Stated otherwise, the air-conditioning circuit of the vehicle can only operate if the engine is running. Consequently, during the vehicle stopping phases in the context of the "Stop and Start" function, the air-conditioning does not operate. It follows from this that in the course of these stopping phases the setpoint temperature inside the cabin may not be maintained, hence a feeling of discomfort felt by the passengers of the vehicle.

[0006] To ensure maintenance of the temperature in the cabin during the engine stopping phases, it is proposed to replace the usual compressor driven by the engine of the vehicle by a hybrid compressor consisting of two separate compression chambers, constituting, on the one hand, a so-called mechanical compressor whose rod is driven by the engine in the same manner as the usual compressor and, on the other hand, a so-called electric compressor whose rod is driven by an auxiliary electric motor. The rods of two compression chambers are independent.

[0007] When the engine is running, outside of the stopping phases induced by the "Stop and Start" function, the refrigerant fluid circulates in the air-conditioning circuit through the mechanical compressor driven by the shaft of the crankshaft of the motor, while the electric compressor is turned off. Conversely, during the stopping phases of the "Stop and Start" function, the refrigerant fluid is directed toward the electric compressor, which is then driven by the electric motor. Thus, by virtue of the electric compressor, the continuity of operation of the air-conditioning circuit and the maintaining of the comfort temperature in the cabin are carried out when the engine has stopped.

[0008] However, hybrid compressors of this type exhibit the drawback of being voluminous and therefore difficult to integrate. Moreover, they require a system of complex valves which is intended to manage the communication of the refrigerant fluid between the two compression chambers when switching from one compressor to the other.

[0009] Hence, an aim of the invention is to propose a hybrid compressor for an air-conditioning circuit of an engined motor vehicle, said hybrid compressor being able to be driven, on the one hand, by said engine, and, on the other hand, by an electric motor during phases of interruption of driving by the engine, which would be much more compact, easier to integrate and simpler to use when switching over from one drive mode, thermal or electrical, to the other.

[0010] This aim is achieved, in accordance with the invention, because said hybrid compressor consists of a compression chamber with variable capacity, said capacity being variable in a span of variation exhibiting a higher interval of capacities, in which the compression chamber is driven by the engine, and a lower interval of capacities, in which the compression chamber is driven by the electric motor.

[0011] Thus, the hybrid compressor according to the invention comprises only a single compression chamber instead of two for the hybrid compressor of the prior art described above. It is therefore much less voluminous and therefore easier to integrate. Moreover, there is no need to provide a system of complex valves for the passage of the refrigerant fluid from one chamber to another during changes of drive mode, since, in the invention, the compression chamber is single and comprises only one intake orifice and one exit orifice for the refrigerant fluid.

[0012] Preferably, said higher and lower intervals of capacities are distinct.

[0013] Under normal operating conditions of the air-conditioning circuit, the capacity of the compression chamber is chosen in the higher interval, the driving of the rod of the compressor being ensured by the engine.

[0014] On the other hand, during the phases of interruption of driving by the engine, especially the engine stopping phases imposed by the "Stop and Start" function, the cabin is in general already conditioned to comfort conditions, so that the refrigerative power to be provided by the electric motor in order to maintain these conditions for a duration limited to a few tens of seconds is markedly lower, at least by a factor of 2 to 3, than the power that must be provided by the engine. If then suffices to reduce the capacity of the compression chamber to a value lying in the lower interval and to turn on the electric motor until the engine is restarted by the "Stop and Start" function.

[0015] In a preferred embodiment, said compression chamber with variable capacity is a compression chamber with rotary drive. By way of example, said compression chamber is a compression chamber with vanes with adjustable intake volume.

[0016] Advantageously, the invention provides that the driving of the compression chamber by the engine can be disengaged from the engine for capacities lying in said lower interval of capacities. The electric motor is then decoupled from the engine and can ensure the driving of the compression rod under low power because the compression chamber then operates with a reduced capacity.

[0017] It was seen above that said phases of interruption of driving by the engine may be engine stopping phases, and in particular that said engine stopping phases are the stopping phases of a system for automatic stopping and restarting of the engine, such as the "Stop and Start" system.

[0018] However, the electric motor of the hybrid compressor according to the invention may be harnessed in other circumstances, especially when said phases of interruption of driving by the engine are vehicle acceleration phases. It is indeed known that when a vehicle accelerates the air-conditioning circuit is stopped by mechanically decoupling the compressor from the engine, doing so in order to eliminate the resistive torque imposed on the shaft of the crankshaft by the compressor. Under these conditions, the air-conditioning can nonetheless be maintained by setting into operation the electric motor of the hybrid compressor in accordance with the invention.

[0019] In order to facilitate the turning on of the electric motor during the phases of interruption of driving by the engine, provision is made for the hybrid compressor according to the invention to comprise means for setting the electric motor into operation before the commencement of an engine stopping phase. The electric motor is therefore set into operation by anticipation, before the engine actually stops. The electric motor, which, as is known, may be of reduced power, does not therefore have to overcome the diverse variations in refrigerant fluid pressure which generally appear in the air-conditioning circuit following the complete stopping of the air-conditioning circuit.

[0020] In practice, said means for setting the electric motor into operation are means for detecting stopping of the engine of a system for automatic stopping and restarting of the engine. Within the framework of the "Stop and Start" function, these detection means may be extremely varied and generally depend on the strategy chosen by the constructors. It is possible to cite for example the detection of an action on the brake pedal when the speed of the vehicle goes below a given threshold.

[0021] Finally, the invention also relates to an assembly of a hybrid compressor according to the invention and of an electric motor for driving said hybrid compressor, in which the electric motor is supplied by a low-voltage direct current. More specially, said low-voltage direct current is provided by the 12 V network of the vehicle. The implementation of the hybrid compressor in accordance with the invention is then greatly simplified since it does not involve any modification of the onboard electrical network.

[0022] The description which follows with regard to the appended drawings, which are given by way of nonlimiting examples, will elucidate the invention and the manner in which it may be embodied.

[0023] FIG. **1** is a diagram of an air-conditioning circuit comprising a hybrid compressor in accordance with the invention.

[0024] FIG. **2** is a chart illustrating the operation of the hybrid compressor of FIG. **1** for various life situations of a motor vehicle equipped with the "Stop and Start" function.

[0025] FIG. **3** is a block diagram of a control circuit of the electric motor for driving the hybrid compressor of FIG. **1**.

[0026] In FIG. **1** is represented a conventional air-conditioning circuit of an engined motor vehicle, comprising a compressor **10** of a refrigerant fluid which may be an organic, inorganic or eutectic fluid. It is possible to cite as nonlimiting examples supercritical carbon dioxide CO_2, the refrigerants known by the references R134A, 1234yf or else GAR ("Global Alternative Refrigerant"). Downstream of the compressor **10**, the pressurized refrigerant fluid passes through a heat exchanger **11** called a "gas cooler" for carbon dioxide or a "condenser" for R134A since, in this case, the refrigerant initially in the gas phase exits the condenser in liquid form.

[0027] In the example of FIG. **1**, the exchanger **11** may be a water-type exchanger, or an air-type exchanger cooled directly by the outside air.

[0028] The refrigerant fluid is thereafter conducted toward a relief valve **12** so that it is cooled before entering the evaporator **13** where heat exchange then occurs between the cooled refrigerant and air blown toward the cabin of the vehicle.

[0029] The refrigerant fluid, reheated on exit from the evaporator **13**, is then returned to the compressor **10** to perform a new thermal cycle.

[0030] As may be seen in FIG. **1**, the compressor **10** of FIG. **1** is a hybrid compressor comprising a compression chamber **101** with variable capacity whose rod **102** may be driven, either by an electric motor **20**, or by the shaft of the crankshaft of the engine (not represented) of the vehicle via a belt and a pulley **30** able to be linked mechanically to the rod **102** by way of a clutch **31**.

[0031] During nominal operation, the rod **102** of the compression chamber **101** is driven by the engine, the pulley **30** being coupled to the rod **102** by the clutch **31**. The capacity of the compression chamber is then chosen in a higher interval of values close to the maximum capacity, from 90 to 110 cm^3 for example. Under these conditions, the hybrid compressor **10** is capable of ensuring an optimal comfort level inside the cabin of the vehicle, whatever the outside temperature, the sunshine and the degree of relative humidity.

[0032] However, it can happen, in certain circumstances, that the air-conditioning compressor is no longer driven by the engine of the vehicle and that, consequently, the air-conditioning circuit ceases to operate and no longer ensures maintenance of the comfort temperature inside the cabin. Such is the case especially during the engine stopping phases imposed by a system for automatic stopping and restarting of the engine able to implement the "Stop and Start" function of vehicles equipped with this function.

[0033] In order to ensure continuity of air-conditioning, the electric motor **20** is set into operation during these stopping phases so as to maintain the circulation of the refrigerant fluid in the air-conditioning circuit. Stated otherwise, it may be considered that the electric motor then substitutes itself for the engine. Of course, the latter is, preferably, disengaged from the compression rod **102**.

[0034] The block diagram of FIG. **3** shows how the switchover of the driving of the compressor **10** from the engine to the electric motor **20** is performed in practice.

[0035] When it receives an engine stop cue STOP from the automatic stopping and restarting system, the electronic control unit **50** of the air-conditioning circuit transmits a signal for engaging the electric motor **20** to a power module **51**. In response to this signal, the module **51** actuates an auxiliary electric motor **103** making it possible to modify the capacity of the compression chamber **101** from the value of the higher interval where it was before the interruption of the driving by the engine to a value of the lower interval, between 20 and 40 cm^3 for example. Next, after decoupling of the pulley **30** by the clutch **31**, the power module **51** dispatches to the electric motor **20** the power necessary to maintain, during the engine stopping phase, the operation of the compressor **10** at a sufficient level, having regard to the initial air-conditioning conditions before the stopping of the engine.

[0036] Indeed, at the moment at which the electric motor **20** takes over from the engine upon stoppage, the cabin of the vehicle is in principle already at the comfort temperature, so that, having regard to the fact that the duration of the stopping phases is generally limited to a few tens of seconds, the refrigerative power to be provided by the electric motor **20** is relatively low. By way of example, in a conventional manner, a refrigerative power of 6 kW is necessary in order to guarantee comfort in the cabin of a vehicle exposed to a high temperature of 25 to 45° C. under sunshine of 1000 $W.m^2$ and a relative humidity of 50 and 60%. However, when the vehicle is already conditioned to the comfort temperature, the refrigerative power to be provided lies between 1 kW and 3 kW depending on the segment of the vehicle. An electrical power of the order of 500 to 800 W to be provided by the power module **51** is then sufficient to maintain comfort in the cabin.

[0037] Consequently, the capacity of the compression chamber **101** may be reduced, with respect to the nominal operating conditions, to values lying in a lower interval of capacities of about the minimum capacity, from 20 to 40 cm^3 for example, distinct from the higher interval defined above.

[0038] Of course, the higher and lower intervals of capacities may be simply reduced to the maximum and minimum capacities alone. The compression chamber **101** then switches in a binary manner between these two capacities depending on whether the motive drive for the rod of the chamber is the engine or the electric motor.

[0039] Having regard to the fact that the power requested of the electric motor is relatively low, it is possible to envisage the use of an electric motor, with or without brushes, supplied by a low-voltage direct current provided, in particular, by the 12 V network of the vehicle, it being possible for the electric current source to be a battery **40** or an extra unit furnished or not with a storage capacitor.

[0040] In a practical manner, the compression chamber **101** with variable capacity may be embodied by a compression chamber with rotary drive, especially a conventional compression chamber with vanes whose intake volume, corresponding to the capacity, can be adjusted between the minimum value of 20 cm^3, for example, and the maximum value of 110 cm^3, for example, by varying the position of the intake orifice in the chamber.

[0041] In the chart of FIG. **2** have been represented the operating states of the engine and of the electric motor **20** for driving the hybrid compressor **10** of a motor vehicle equipped with the "Stop and Start" function, the value 0 corresponding to the stopping of the motor and the value 1 to its operation.

[0042] As may be seen in this figure, when the engine is stopped by the "Stop and Start" function, the electric motor **20** is set into operation, in accordance with the invention, so as to ensure maintenance of comfort in the cabin during the engine stopping phase. However, it may be noted that the setting into operation of the electric motor **20** is performed with anticipation, that is to say before the commencement of an engine stopping phase triggered by the "Stop and Start" function.

[0043] The advantage of this setup is that the electric motor does not have to provide the additional torque which would be necessary in order to overcome the resistive torque induced by the rearrangements of refrigerant fluid pressure in the air-conditioning circuit which could occur at the moment of the stopping of the engine. The power of the electric motor **20** can therefore be rated accordingly.

[0044] To carry out this anticipation of the electric motor, it is possible to use the means implemented by the "Stop and Start" function to detect whether the engine stopping conditions are satisfied and decide as to the stopping of the engine. As soon as the "Stop and Start" function decides to stop the engine, the electric motor **20** is immediately set into operation before the actual stopping of the engine. The conditions of automatic stopping of the engine depend on the strategy adopted by the vehicle constructor. It is possible to cite, inter alia, an action on the brake pedal when the vehicle is traveling at low speed, less than 5 km/hour for example.

[0045] FIG. **2** shows another circumstance in which the electric motor **20** may be set into operation so as to guarantee continuity of the comfort temperature during a stoppage of the air-conditioning circuit. In this circumstance, the stopping of the air-conditioning circuit is not due to a stopping of the engine, but to the decoupling of the drive pulley **30** from the rod **102** of the compression chamber **101**. This situation can occur during acceleration of the vehicle for example, so as to apply a maximum torque to the shaft of the crankshaft and afford the best response to the acceleration request.

[0046] In this case, the electric motor **20** is set into operation as soon as the engine is decoupled from the compression rod **102**.

1. A hybrid compressor for an air-conditioning circuit of an engine motor vehicle, said hybrid compressor being able to be driven by said engine and by an electric motor during phases of interruption of driving by the engine, the hybrid compressor comprising:

- a compression chamber with variable capacity, said capacity being variable in a span of variation exhibiting a higher interval of capacities, in which the compression chamber is driven by the engine, and a lower interval of capacities, in which the compression chamber is driven by the electric motor.

2. The hybrid compressor as claimed in claim **1**, wherein said higher and lower intervals of capacities are distinct.

3. The hybrid compressor as claimed in claim **1**, wherein the driving of the compression chamber by the engine is disengaged from the engine for capacities within said lower interval of capacities.

4. The hybrid compressor as claimed in claim **1**, wherein said compression chamber with variable capacity is a compression chamber with rotary drive.

5. The hybrid compressor as claimed in claim **4**, wherein said compression chamber is a compression chamber with vanes with adjustable intake volume.

6. The hybrid compressor as claimed in claim **1**, wherein said phases of interruption of driving by the engine are engine stopping phases.

7. The hybrid compressor as claimed in claim **6**, wherein said engine stopping phases are the stopping phases of a system for automatic stopping and restarting of the engine ("Stop and Start").

8. The hybrid compressor as claimed in claim **1**, wherein said phases of interruption of driving by the engine are vehicle acceleration phases.

9. The hybrid compressor as claimed in claim **1**, further comprising means for setting the electric motor into operation before commencement of said interruption of driving by the engine.

10. The hybrid compressor as claimed in claim **9**, wherein said means for setting the electric motor into operation are means for detecting stopping of the engine of a system for automatic stopping and restarting of the engine ("Stop and Start").

11. An assembly comprising a hybrid compressor as claimed in claim **1** and an electric motor for driving said hybrid compressor, wherein the electric motor is supplied by a low-voltage direct current.

12. The assembly as claimed in claim **11**, wherein said low-voltage direct current is provided by the 12 V network of the vehicle.

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