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(54) Heat engine for a vehicle with related control method

(57) A heat engine (1) provided with a plurality of cylinders having at least one inlet valve (3), at least one exhaust valve (4) and an auxiliary valve (6) forming part of a vacuum braking device (5); the valves (3, 4, 6) are controlled by an electronic control unit (8) which, in response to an actuating signal of the vacuum braking device, prevents the injection of fuel into the cylinders (2) and varies the timing sequence from a conventional four-stroke cycle to a two-stroke cycle in which the inlet valve (3) and the auxiliary valve (6) open alternately in accordance with each dead centre of the associated cylinder (2).

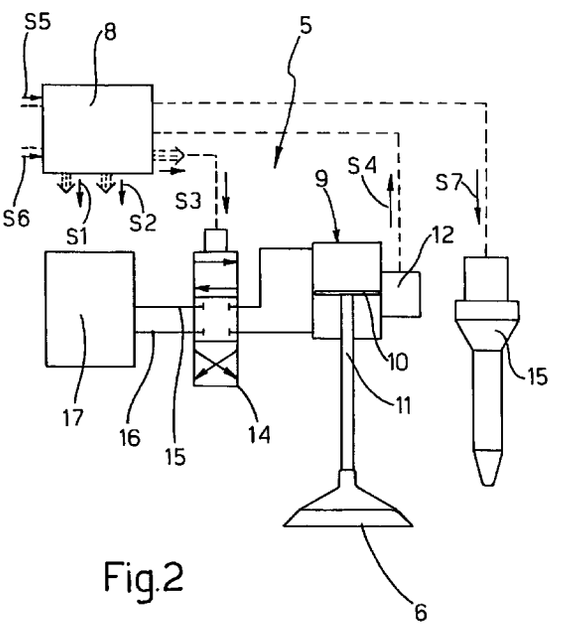

Fig.2

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Description

The present invention relates to a heat engine for a vehicle, in particular a commercial vehicle, and to a method of controlling the engine itself.

Engines provided with a vacuum braking device are known, which device is adapted to discharge from the cylinders the gas compressed during the compression stroke and, at the same time, to prevent the injection of fuel into the cylinders. In this way, the work carried out during the compression stroke is converted into braking torque on the drive shaft and substantially no useful work is produced during the subsequent expansion stroke.

The discharge of the gas compressed at the end of the compression stroke can take place either through the conventional exhaust valves, as described for example in European Patent Application EP-A-0 543 210, in which case the device comprises means for the auxiliary opening of said valves, or through dedicated valves, as described for example in Italian Patent Application No. TO92A 000974 of 30th November 1992.

In any case, in a four-stroke engine the decompression of the cylinders takes place every fourth stroke and the braking action resulting therefrom is basically limited.

The object of the present invention is to devise an engine for a vehicle provided with an improved vacuum braking device which makes it possible to obtain greater braking torque than in the above-described known engines.

This object is achieved by the present invention in that it relates to a heat engine for a vehicle, of the type comprising:

a plurality of cylinders, each of which is provided with at least one inlet valve and at least one exhaust valve;
control means for said valves establishing a first four-stroke timing sequence;
a vacuum braking device which can be actuated so as to dissipate the compression energy in said cylinders;

characterised in that said vacuum braking device comprises means for varying the timing establishing, in response to actuation of the device itself, a second two-stroke timing sequence in which said inlet valve and said exhaust valve are opened alternately in accordance with each of the respective dead centres of the associated cylinder.

The present invention also relates to a method of controlling a heat engine for a vehicle, the engine comprising a plurality of cylinders, each of which is provided with at least one inlet valve and at least one exhaust valve, and a vacuum braking device which can be actuated so as to dissipate the compression energy in said cylinders, said valves being controlled according to a first four-stroke timing sequence,

said method being characterised by varying the timing, in response to actuation of said vacuum braking device, so as to establish a second two-stroke timing sequence in which said inlet valve and said exhaust valve are opened alternately in accordance with each of the respective dead centres of the associated cylinder.

With a view to a better understanding of the present invention two preferred embodiments will be described non-restrictively by way of example below, with reference to the accompanying drawings, in which:

Figure 1 is schematic, partial view of an engine designed in accordance with the present invention;
Figure 2 is an operating diagram of a vacuum braking device of the engine in Figure 1, and
Figure 3 is comparative diagram illustrating various timing sequences of the engine in Figure 1.

Referring now to Figure 1, the reference numeral 1 generally denotes a heat engine 1 for a commercial vehicle.

The engine 1 comprises a plurality of cylinders 2, each of which is provided with a pair of inlet valves 3 communicating with an inlet manifold 3a and a pair of main exhaust valves 4 communicating with an exhaust manifold 4a.

The engine 1 is also provided with a vacuum braking device 5 illustrate schematically in Figure 2. Said device substantially comprises one auxiliary exhaust valve 6 per cylinder, which valve communicates with a bleed manifold 7 for compressed air, which is connected in known manner, for example as illustrated in Italian Patent Application No. TO92A 000974, to a pneumatic installation of the vehicle (not shown).

The valves 3, 4 and 6 are of the so-called active type and are operated by an electronic control unit 8. In particular, as illustrated in Figure 2 with reference to an auxiliary valve 6, each of the valves 3, 4 and 6 is associated with a double-acting hydraulic actuator 9 having a piston 10 rigidly connected to a stem 11 of the respective valve. The actuator 9 is controlled by a respective servo-valve 14, for example of four-way, three-position, closed centre type, which is adapted to connect selectively the chambers of the actuator itself with a delivery duct 15 and with a return duct 16 of a hydraulic unit 17. The control unit 8 is connected to each of the servo-valves 14 and generates control signals designated s1, s2 and s3 respectively for the valves 3, 4 and 6 of the engine 1.

The actuators 9 are provided with respective position sensors 12 which are connected to the control unit 8 and transmit signals s4 correlated with the position of the respective valves.

The unit 8 also receives, in known manner, a plurality of further input signals correlated with operative variables of the engine and of the vehicle, which include an input signal s5 for identifying the timing of the cylinders, and a signal s6 for activating engine braking, which is generated for example by a potentiometer (not shown)

connected to the brake pedal of the vehicle (also not shown).

Finally, the control unit 8 is connected to the injectors 15 of the engine 1 and is adapted to generate signals s7 for controlling the injectors themselves.

The control unit 8 is adapted to control the valves 3, 4 and 6 in accordance with a first four-stroke timing sequence of normal type, when the signal s6 is inactive (i.e. the brake pedal is released). This first sequence is illustrated in the diagram a) in Figure 3, with reference to a given cylinder, as a function of the angle of rotation of the drive shaft; the angular intervals at which the valves are opened are indicated by a thickened line.

In particular, the inlet valve is opened in advance with respect to the top dead centre preceding the induction stroke, is held open during the entire stroke itself and reclosed after the bottom dead centre (bdc). Analogously, the exhaust valve is opened in advance with respect to the bottom dead centre preceding the exhaust stroke, is held open during the entire stroke itself and reclosed with delay after the subsequent top dead centre (tdc).

The injectors are controlled in a conventional manner in accordance with control maps stored in the control unit 8, on the basis of input signals received from the unit itself.

When the signal s6 is active, or assumes a value above a predetermined threshold level, the control unit 8 controls the valves 3, 4 and 6 in accordance with a different timing sequence which is illustrated graphically in Figure 3, diagram b).

In particular, the main exhaust valves 4 are held closed; the inlet valves 3 are opened for a short time around each bottom dead centre and the auxiliary valves 6 are opened for a short time around each top dead centre in accordance with a two-stroke cycle. Additionally, the unit 8 prevents the injection of fuel into the cylinders 2.

According to the new timing sequence, therefore, the engine 1 acts as a two-stroke compressor. In fact, in accordance with each bottom dead centre air is drawn from the inlet manifold 3a through the inlet valves 3; the air drawn in is compressed during the subsequent upstroke of the piston and is expelled into the bleed manifold 7 through the auxiliary valves 6 in accordance with the top dead centre.

Therefore, during each upstroke of the piston compression work is carried out which is converted into braking torque on the drive shaft; the vacuum at top dead centre prevents a considerable proportion of the work carried out from being recovered as useful work during the subsequent downstroke of the piston.

Figure 3, diagram c), illustrates an alternative timing sequence to that in the above-mentioned diagram b). In this case the behaviour of the inlet valves 3 and outlet valves 4 is substantially identical. However, with regard to the auxiliary valves 6 the control unit 8 effects their opening either in accordance with each top dead centre or after each bottom dead centre, according to a cycle which can be termed "at a single stroke", thus increasing the braking power.

The subsequent opening of the auxiliary valves 6, which commences in the final phase of the opening period of the inlet valves 3, has the purpose of improving the filling of the cylinder, thus allowing the admission of compressed air from the bleed manifold which is at a higher pressure than the inlet manifold. This has the result that the initial compression pressure is higher and, therefore, the compression work and thus the braking torque are increased.

The advantages achieved with the present invention are apparent from a study of the features of the engine and the associated control method in accordance therewith. Above all, the vacuum braking takes place according to a two-stoke cycle; therefore, the vacuum work is dissipated with each revolution of the drive shaft, rather than every two revolutions as happens with conventional devices. The braking torque on the drive shaft is thus increased.

Furthermore, in the solution illustrated with reference to diagram c) in Figure 3 the braking effect is further increased owing to the fact that the internal pressure of the cylinder at the start of compression and thus the compression work are increased by the inflow of compressed air into the cylinder from the bleed manifold.

Finally, it is evident that the engine 1 and the associated control method described can be subject to modifications and variants which do not depart from the protection afforded by the claims.

In particular, the actuators for controlling the valves may be of single-acting type, with spring return; alternatively, the engine can be provided with a timing system of mechanical type, with a suitably designed camshaft and hydraulically acting tappets interposed between the cams and the associated valves and designed to transmit or absorb selectively the actuating forces of the valves; the variation of the timing sequence may be achieved by cyclically switching respective solenoid valves for controlling hydraulic tappets by means of an electronic control unit.

Claims

1. A heat engine (1) for a vehicle, of the type comprising:

   a plurality of cylinders (2), each of which is provided with at least one inlet valve (3) and at least one exhaust valve (4, 6);
   control means (8) for said valves (3, 4, 6) establishing a first four-stroke timing sequence;
   a vacuum braking device (5) which can be actuated so as to dissipate the compression energy in said cylinders (2);

   characterised in that said vacuum braking device (5) comprises means (8) for varying the tim-

ing establishing, in response to actuation of the device itself, a second two-stroke timing sequence in which said inlet valve (3) and said exhaust valve (6) are opened alternately in accordance with each of the respective dead centres (bdc, tdc) of the associated cylinder (2).

2. An engine according to claim 1, characterised in that said cylinders (2) have at least one main exhaust valve (4) and an auxiliary exhaust valve (6).

3. An engine according to claim 2, characterised in that in said second timing sequence of said means (8) for varying the timing are adapted to keep said main exhaust valve (4) closed, to open said inlet valve (3) in accordance with each bottom dead centre (bdc) and to open said auxiliary exhaust valve (6) in accordance with each top dead centre (tdc) of the associated cylinder (2).

4. An engine according to any one of the preceding claims, characterised in that in said second timing sequence said means (8) for varying the timing are adapted also to open said auxiliary exhaust valve (6) after each bottom dead centre (bdc) of the associated cylinder.

5. A method of controlling a heat engine (1) for a vehicle, the engine (1) comprising a plurality of cylinders (2), each of which is provided with at least one inlet valve (3) and at least one exhaust valve (4, 6), and a vacuum braking device (5) which can be actuated so as to dissipate the compression energy in said cylinders (2), said valves (3, 4) being controlled according to a first four-stroke timing sequence when said vacuum braking device (5) is inoperative;

said method being characterised by varying the timing, in response to actuation of said vacuum braking device (5), so as to establish a second two-stroke timing sequence in which said inlet valve (3) and said exhaust valve (6) are opened alternately in accordance with each of the respective dead centres (bdc, tdc) of the associated cylinder (2).

6. A methbd according to claim 5 for controlling an engine (1) provided with at least one main exhaust valve (4) and an auxiliary exhaust valve (6) for each cylinder (2) characterised in that said second timing sequence comprises the phases of keeping said main exhaust valve (4) closed, opening said inlet valve (3) in accordance with each bottom dead centre (bdc), and opening said auxiliary exhaust valve (6) in accordance with each top dead centre (tdc) of the associated cylinder (2).

7. A method according to claim 5 or 6, characterised in that said second timing sequence also comprises the phase of opening said auxiliary exhaust valve (6) after each bottom dead centre (bdc) of the associated cylinder (2).

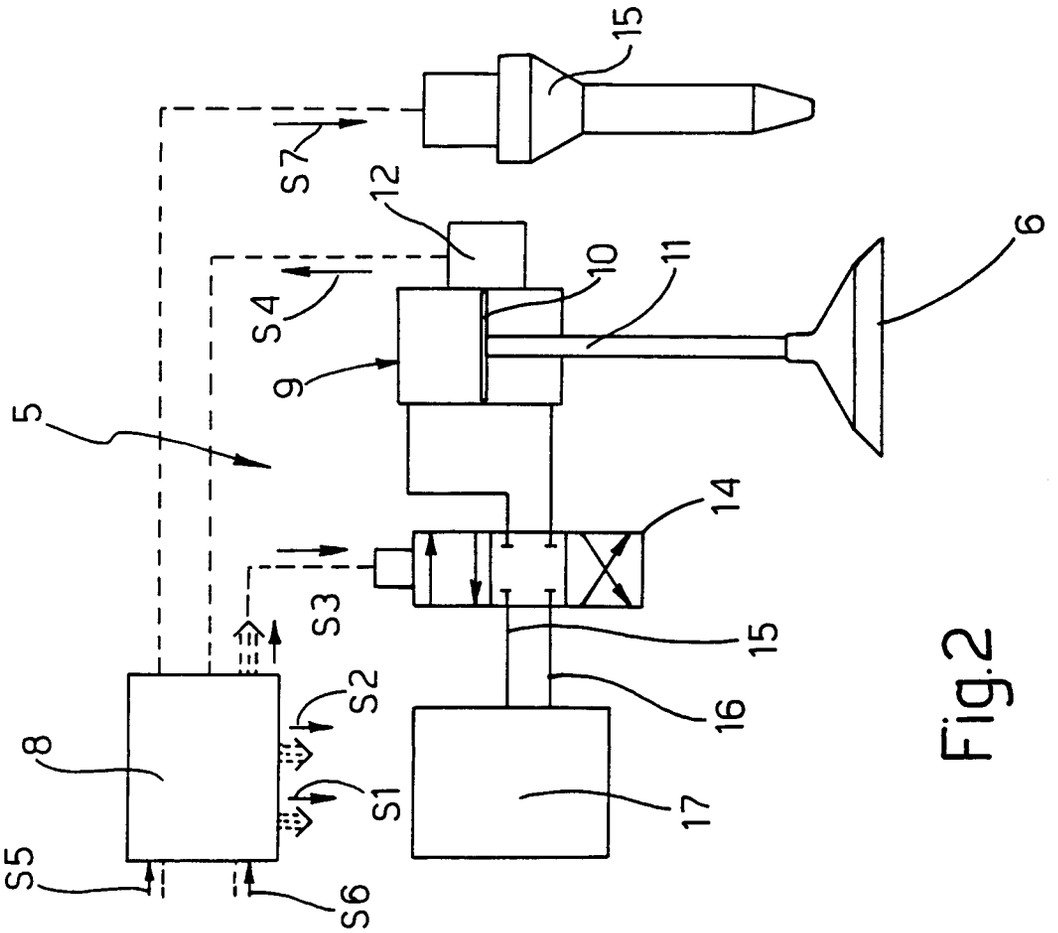
15
S7
12
6
10
11
S4
9
5
14
S3
15
S2
16
8
S1
17
S5
S6

Fig.2

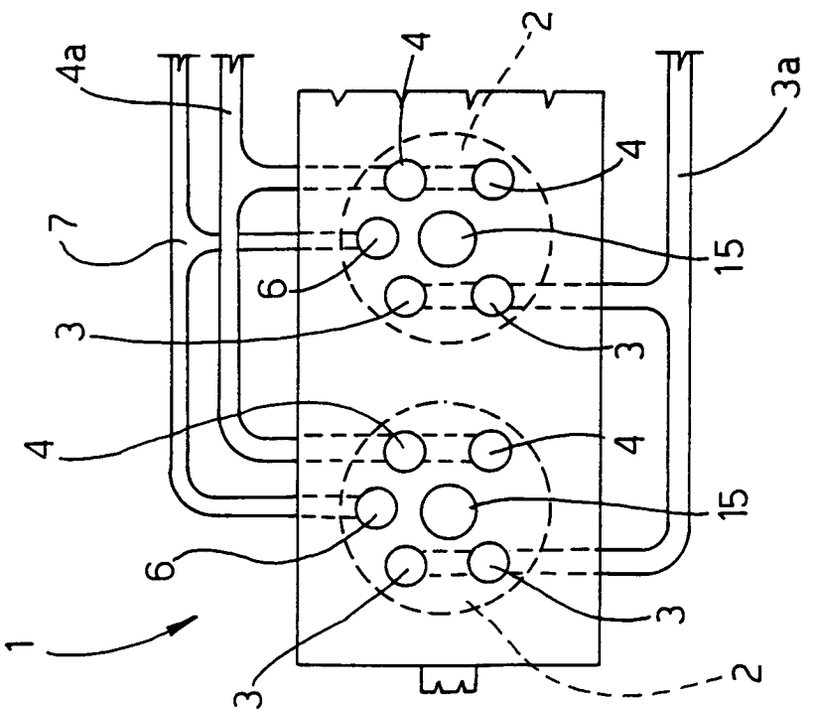
4a
4
2
3a
4
7
15
6
3
3
4
4
15
6
3
1
3
2

Fig.1

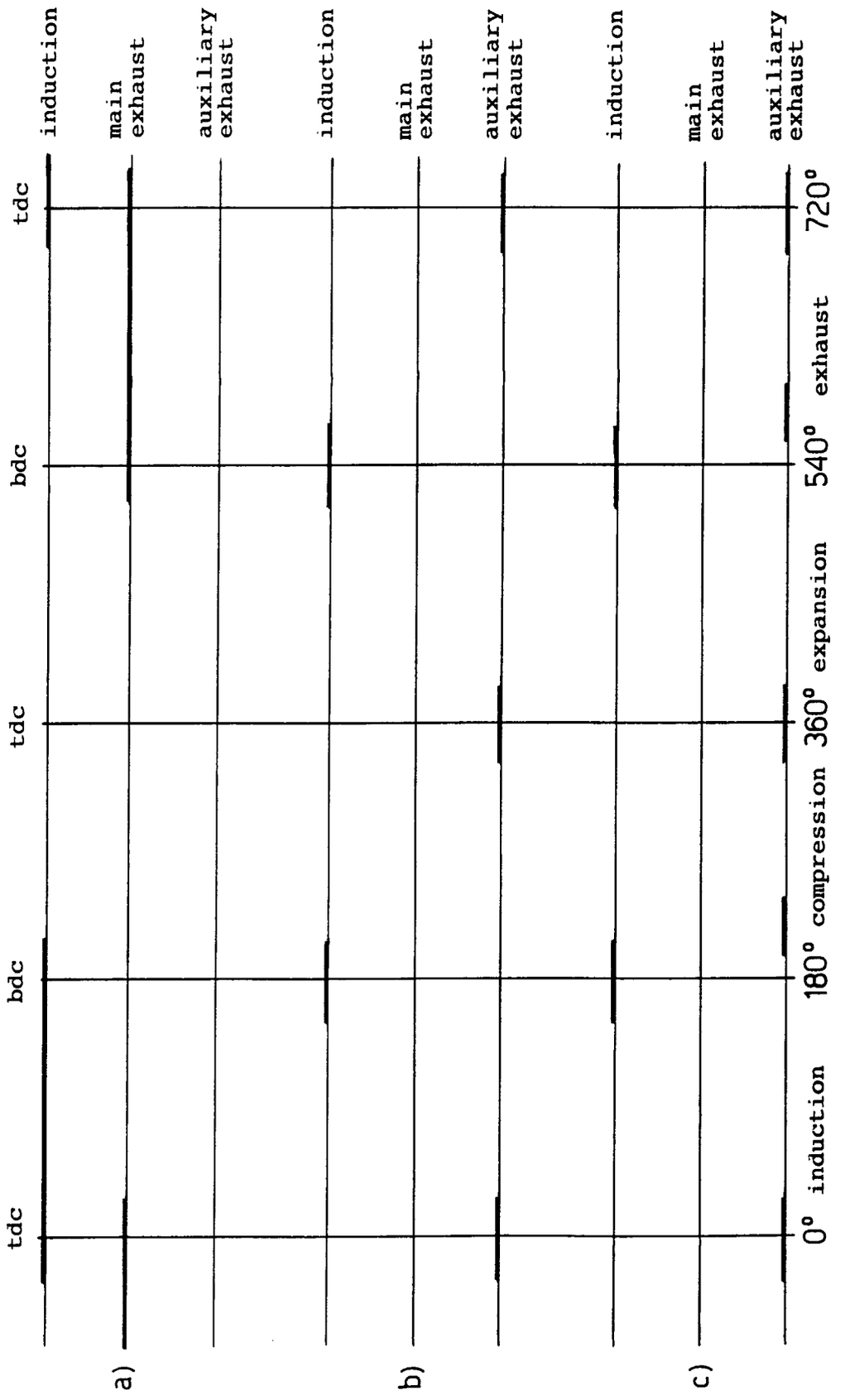
a)
b)
c)
tdc
bdc
tdc
bdc
tdc
0° induction
180° compression
360° expansion
540° exhaust
720°
induction
main exhaust
auxiliary exhaust
induction
main exhaust
auxiliary exhaust
induction
main exhaust
auxiliary exhaust

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 96 11 2814

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	GB-A-307 753 (MOTORWAGENFABRIK BERNA AG) * the whole document *	1,5	F01L13/06
A	DE-C-577 588 (MOTORWAGENFABRIK BERNA AG) * the whole document *	1,5	
A	DE-A-41 25 831 (MERCEDES BENZ AG) * claims; figure 1 *	2	
A	WO-A-90 09514 (AB VOLVO) * page 9, line 33 - page 11, line 8; figures 4,5 *	1,2,5,6	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

F01L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	14 November 1996	Klinger, T

CATEGORY OF CITED DOCUMENTS

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