

Method and device for monitoring plain bearings of a reciprocating piston machine, in particular of an internal combustion engine

5 Technical field

The invention relates to a method for monitoring plain bearings of a reciprocating piston machine, in particular of an internal combustion engine as claimed
10 in the preamble of claim 1, and to a device for carrying out the method as claimed in the preamble of claim 7.

Prior art

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Methods and devices for monitoring plain bearings, in particular of a reciprocating piston machine such as an internal combustion engine, are known from EP-B-0 141 348. A method and a device for monitoring
20 the lubrication at the contact point between two parts which are insulated with respect to one another by means of the lubricating film, move relative to one another and are made of different electrically conductive materials by monitoring the main bearings of
25 a crankshaft of an internal combustion engine are described. The two parts are located in an electric circuit which passes through the actual lubrication point and has a voltage source and an external connection. On the one hand the resistance of the
30 circuit, which is reduced when the lubricating film is torn off, and on the other hand the thermal e.m.f. which occurs at the contact point as a result of the frictional heat when the lubricating film is torn off and which is used as a galvanic voltage source are used
35 to generate the flow of current by means of the external electrical connection of the circuit when there is metallic contact to a large area between the two plain bearing parts which is caused by lack of lubrication and indicates heat damage, said current

flow being used as a control signal or an alarm signal. The connection of the circuit is embodied as a resistor which is electrically matched to the large-area contact point. The voltage drop which occurs at the resistor of
5 the external connection is measured and used to trigger a control signal. The control signal is to be understood here in a wide form, and it can also be used as a switching signal for triggering further actions, for example for stopping the internal combustion engine
10 or triggering an alarm device. The method and the device are expediently embodied in such a way that in the event of briefly occurring voltage peaks the outputting of control signals is suppressed until a previously determined frequency of the voltage peaks
15 over time and/or an increasing tendency of the amplitude occurs.

During the simultaneous monitoring of a plurality of lubrication points or plain bearings which are arranged
20 in one common physical unit or separately it is not possible to determine, by reference to the thermocurrent, which plain bearing the thermocurrent starts from. In order to identify the plain bearings affected it is necessary to provide the individual
25 lubrication points with additional thermal monitoring means and to measure and compare the temperatures occurring at the individual plain bearings in order then to be able to identify which bearing temperature has reached a value which triggers a control signal.
30 Such a measure is relatively complex and is in particular not suitable for plain bearings at which no suitable additional thermal monitoring means can be arranged, such as is the case, for example, for connecting rod bearings and for the piston bolt of a
35 piston.

Summary of the invention

The object of the invention is to further improve a method and a device for monitoring plain bearings of a reciprocating piston machine, in particular of an internal combustion engine.

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The object is achieved according to the invention:

a) with the method specified at the beginning by means of the characterizing features of claim 1;

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b) with the device specified at the beginning by means of the characterizing features of claim 7.

Very detailed information on the bearing status on the one hand and on the location of any damage on the other is obtained by, for example, electronically amplifying and spreading the obtained thermocurrent curve and placing it in a relationship with the angular position of the crankshaft, and searching through the curve obtained for significant symptoms of the plain bearings over an entire working cycle. Such an analysis of the thermocurrent curve can preferably be carried out by means of a computational program which can be generated, for example, by means of trials. The method and the device also supply a means of monitoring which is preferably free of false alarms because no thermocurrent, and therefore no control signal, occurs with satisfactory plain bearings.

If no thermocurrent curve occurs at all, this therefore means "satisfactory overall bearing state". A constant thermocurrent curve at a low level indicates non-damaging mixed friction. Deflections in the curve which occur briefly and disappear again can indicate temporary damage (hot spots), such as the breaking off of parts of the bearing shells, which can however repair themselves again as a result of melting of the broken-off parts. If, on the other hand, individual high deflections in the curve continuously occur, this

is an indication of a damaged plain bearing whose position can be identified, for example, by reference to the angular position which the deflection of the curve is in and/or the shape of the curve. Certain changes in the curve during a load change and/or when rotational speeds or loads vary can also provide indications of specific symptoms of the plain bearings. For example, a rise in a basic curve at a relatively high rotational speed, and in particular at a relatively high output power, can be an indication of increased mixed friction, which can be attributed to a poor lubricating film, that is to say unsuitable lubricant and/or overloading of the machine. The latter is problematic in particular if the symptoms already occur below the predefined continuous output rating.

The method can be applied in all reciprocating piston machines in which the power cycle, and thus also the bearing cycle and load profile during the working cycle is not constant. Such reciprocating piston machines are, for example, piston pumps and in particular internal combustion engines which operate with a reciprocating piston in a cylinder. The reciprocating piston machines can have one or more cylinders and operate according to the two-stroke working cycle (corresponds to one revolution of the crankshaft, that is to say 360° angle of rotation) or four-stroke working cycle (corresponds to two revolutions of the crankshaft, that is to say 720° angle of rotation). This applies in internal combustion engines regardless of the fuel used, which can be, for example, diesel or heavy oil, petrol, gas or the like.

In order to evaluate the thermocurrent curve, numerous parameters which provide more precise information or additional parameters can be used as is clear, inter alia, from the dependent claims.

The angular position in which the lubricating film thickness is at a minimum during the normal operation of the plain bearing is advantageously selected according to claim 2 as parameter for determining the position of the plain bearing. At this point, the volume resistance of the lubricating film is also at a minimum and may correspond to the galvanic conductivity so that it is possible to detect a thermocurrent at this angular position. Furthermore, the probability that damage to the bearing can occur there earliest is greatest. A suitable parameter for this is, according to claim 3, the displacement path of the bearing journal of a plain bearing.

In particular also the dead center positions and/or the combustion phase according to claim 4 are suitable for determining the position. According to claim 5, further parameters can also be the torque and/or the rotational speed. In the case of internal combustion engines, the ignition sequence is, according to claim 6, also an important parameter.

In order to evaluate the data determined, a common control unit, to which means for sensing the angle of rotation of the crankshaft are connected, is expediently selected for evaluating the data which is determined. According to claim 8, means for sensing the dead center positions of each piston are also connected to the control unit.

According to claim 9, the device is expediently equipped with a transfer unit for the thermocurrent. According to claim 10, this contains, for example, a rotary sensor for sensing the angular position and the rotational speed of the crankshaft. In order to permit the thermocurrent to be transmitted with as little interference and as low an impedance as possible, the transfer unit according to claim 11 is provided with a collector with a plurality of sliding contacts

distributed over the circumference of orbits. The evaluation possibilities can be expanded by means of an acceleration sensor according to claim 12. So that disruptive oscillations of the crankshaft do not have a disadvantageous effect during the transmission, the device is expediently embodied, according to claim 13, with a flexible coupling device which is preferably configured in accordance with claim 14.

10 Modern combustion engines already have an extensive control unit in which the operating data such as rotational speeds, ignition time and the like is already processed so that such control units can be combined with the control unit for the monitoring of
15 plain bearings.

Brief description of the drawings

Exemplary embodiments of the invention are described in
20 more detail below with reference to the drawings, in which:

Figure 1 shows the layout of a three-cylinder internal combustion engine in a vertical section;

25 Figure 2 shows a vertical section through a main bearing of the crankshaft of the internal combustion engine in Figure 1 on an enlarged scale;

30 Figure 3 shows the scheme of conductive continuity by means of the arrangement of cylinder, piston bolt, connecting rod bearing and main bearing as a function of the crank angle;

35 Figure 4 shows the diagram of the occurrence of a thermocurrent at various plain bearings of the internal combustion engine in Figure 1 as a function of the crank angle;

Figure 5 shows a journal displacement diagram for a connecting rod bearing in polar coordinates;

Figure 6 shows the longitudinal section of a transfer unit fitted on a crankshaft;

Figure 7 shows a detail of a flexible coupling device of the transfer unit, partially in section; and

Figure 8 shows a collector of the transfer unit in the transverse view with respect to the shaft axis.

15 Embodiments of the invention

The present invention is based on the state of knowledge of EP-B-0 141 348.

20 Figure 1 shows the layout of a reciprocating piston internal combustion engine which has, for example, three cylinders and operates according to the four-stroke principle, that is to say an entire working cycle runs over two revolutions of the crankshaft or
25 720° angle of rotation. The internal combustion engine contains a crankshaft 1 of a crank drive for the three cylinders Z_1 , Z_2 , Z_3 . The crank drive is mounted in plain bearings, which are referred to as main bearings 2, in which in each case bearing journals 2a rest in
30 bearing shells 3, as is clear in particular from Figure 2. In order to achieve good sliding properties, the bearing shells 3 are lined on their side which bears against the bearing journal 2a with, for example, a white metal layer 4, a lubricating film 5 which is
35 present between this white metal layer 4 and the bearing journal 2a preventing the plain bearings from running hot. The bearing shells 3 are supported by bearing blocks 6 which are integral with a common housing 7.

The crankshaft 1 contains, for each cylinder Z_1 , Z_2 , Z_3 , a crank journal 8 which to a connecting rod 9 is connected via a connecting rod bearing 10. The connecting rod 9 is connected via a further plain bearing 11 to a piston bolt 12 of a piston 13, which is guided up and down in the cylinder Z_1 or Z_2 or Z_3 . The connecting rod bearing 10 and the plain bearing 11 of the piston bolt are of the same design as the main bearing 2 of the crankshaft 1.

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In order now to sense the thermocurrent produced at any main bearing owing to an interrupted lubricating film, the resulting heating and finally the pairing of different metals on the plain bearing, the internal combustion engine is equipped with a control unit 14 which contains a display device 15. The control unit 14 is electrically conductively connected to the housing 7 via a connecting line 16, on the one hand, and to the crankshaft 1 via a connecting line 17 and a collector 18, on the other. In parallel with the control unit 14, the connecting lines 16, 17 are short-circuited via a low-impedance resistor 19. As a result of the thermal e.m.f. which is generated galvanically in a plain bearing, a thermocurrent I flows in the low-impedance circuit 16, 17, 18, 19 and triggers a voltage drop U at the resistor 19. This signal is processed in the control unit 14 and fed to the display device 15.

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The control unit 14 is equipped with means 20 for sensing the angle of rotation of the crankshaft 1. To do this, these means 20 have, for example, a pulse disk 21 which is connected to the crankshaft 1 and whose angle-dependent signals, for example barcodes distributed on the circumference, are sensed by a sensor 22 and fed via a line 23 to the control unit 14. In addition, the control unit 14 is equipped with means 24 which determine the ignition sequence at the cylinders Z_1 , Z_2 and Z_3 . For this purpose, for example, a line 25 is used which is connected to an ignition

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distributor 26 which feeds the ignition current to individual spark plugs 28 via ignition cables 27. The means 20 for sensing the angle of rotation or the means 24 for sensing the ignition sequence can also be
5 obtained by an electronic control device of the internal combustion engine, the latter in particular if the internal combustion engine is a diesel engine which does not have any spark plugs but is instead equipped with a fuel injection system.

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It has become apparent now that during a four-stroke working cycle composed of intake stroke T_1 , compression stroke T_2 , working stroke T_3 and expulsion stroke T_4 in the operating chain of a cylinder Z, which is formed
15 from a cylinder bushing (not illustrated in more detail) installed in the common housing 7, the piston 13, the piston bolt 12, the connecting rod 9, the connecting rod bearing 10 and the crankshaft 1, an operating state is established in which the contact
20 resistance in the sliding points has low impedance owing to a thin lubricating film, that is to say is virtually galvanically conductive, and thus the cylinder wall is connected through to the crankshaft. This low impedance, that is to say the galvanic
25 conductivity, occurs in the second stroke in which the compression takes place, in the vicinity of the top dead center OT, preferably directly before the top dead center OT, in which the ignition process also takes place, as is shown by the curve in Figure 3. This is
30 possible because at least one piston ring (not illustrated in more detail) of the piston exhibits virtually no movement at the cylinder wall at the top dead center and therefore no dynamic lubrication occurs either. The piston ring, in this case, penetrates the
35 lubricating film and bears against the cylinder wall. This abutment of the piston ring is promoted by the combustion process during which combustion gases pass behind the piston ring so that the latter is forced, on the one hand, radially outward against the cylinder

5 wall, and on the other hand, onto the underside of an annular groove in the piston by the pressure of combustion gases. It is also assumed that as a result of the fact that the relative speed is small or, when the direction of movement is reversed, non-existent no continuous supporting dynamic lubricating film can build up at the plain bearing 11 of the piston bolt 12 so that here, too, the low impedance, that is to say conductivity, is constant.

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An interruption in the lubricating film, which, given subsequent dry friction, leads to friction heating and gives rise to a galvanic thermocurrent when different materials are paired, can also most likely occur at points where the lubricating film is thin. The diagram in Figure 3 shows the thermal e.m.f. U of such an thermocurrent I for a connecting rod bearing 10 when there is a rupture in the lubricating film and dry friction. This thermocurrent can then flow and thus manifest itself if the abovementioned connecting-through position at the top dead center is established.

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As a rule, owing to mixed friction in the plain bearings, a certain degree of galvanic thermocurrent of a small magnitude is always generated, which generates a low-level basic curve of the basic current. However, if a high thermocurrent is produced in this drive chain as a result of damage to the bearings, it will be evident in this particular phase of the working cycle as a sudden, large deflection of the curve. This means that a thermocurrent in this phase of the working cycle is an indication that the lubricating film of the plain bearing is interrupted in the drive chain, which can lead to damage in this drive chain. The damage here could of course occur in any plain bearing of this drive chain, but it will preferably occur at the connecting rod bearing 10 if the deflection occurs in the abovementioned particular phase of the working cycle. In this phase, there is always conductive

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continuity between the cylinder wall and the piston, on the one hand, and at the piston bolt, on the other, because of the aforementioned low impedance and the associated connecting-through property. By contrast, because of the constant high speed during normal operation, there is a dynamic lubricating film at the connecting rod bearing, which film presents a high resistance to conductive continuity, that is to say would interrupt it, and, on the one hand, becomes low-impedance only when damage occurs and, on the other hand, supplies a continuing galvanic thermocurrent when there is at least partial destruction of the lubricating film in conjunction with the heating and the different bearing materials, which thermocurrent brings about the aforesaid deflection of the thermocurrent curve however only in the region of the top dead center, that is to say the aforementioned connecting-through position.

By way of example, the following considerations arise for the main bearings 2 of the crankshaft 1. The bearing journals 2a are pressed against the lower bearing shell 3 during the greater part of the working cycle, as a result of which, in the event of damage while pressing is occurring, a galvanic thermocurrent is produced which continues, but is interrupted if the bearing journal lifts off from the lower bearing shell, or at least relieves the latter of loading, when the force of the piston 13 is directed upward. Such a reversal of force takes place in the intake phase and leads to the lower bearing shell of the main bearing being relieved of loading, and thus to an interruption in the thermocurrent. Because this brief interruption in the thermocurrent for each main bearing takes place at a specific angular position, this interruption can generally serve as an indication of main bearing damage and as a parameter for a specific main bearing when it occurs at a specific angular position.

Figure 4 now shows the thermal e.m.f. profile for the present three-cylinder internal combustion engine for cases when damage occurs to the various cylinders or connecting rod bearings. Because of the sparking interval between the individual cylinders, which interval is different depending on the design and number of cylinders of the internal combustion engine and is 240° in the present case, the thermal e.m.f. curves which are decisive for the individual cylinders are also offset by 240° so that with a known ignition sequence (here 1-3-2) and the display device it is possible to detect precisely at which cylinder or which connecting rod bearing a thermocurrent occurs, which thermocurrent is an indication of an interruption in the lubricating film and of incipient damage to the corresponding plain bearing.

Figure 5 shows a further possible way of determining a thermocurrent at a specific connecting rod bearing. The parameter used for this is the thickness h of the lubricant which is established in a specific operating state and which is due to the displacement of the journal of the connecting rod bearing during operation. It has in fact become apparent that the bearing forces change continuously in direction and magnitude owing to gas forces and inertial forces as well as the changing load states. Figure 5 illustrates this displacement path of the current journal and the resulting thickness h of the lubricant of a connecting rod bearing in the polar diagram for one working cycle of the four-stroke internal combustion engine as a function of the angle of rotation of the crankshaft. Owing to the periodic profile of this working cycle, a continuous curve is obtained on which in each case the crank position is given in degrees. As a result, a path of the journal center point, what is referred to as the journal displacement path, which is passed through once during each working cycle is produced. The journal changes its position not only in the circumferential direction, but

also in the radial direction. The movement of the journal toward the bearing contact face causes the lubricant to be expelled from the gap h which becomes narrower in the process. If this gap is already small, the resistance of the lubricating film is reduced and a corresponding location is an angular position, suitable as a parameter, for assigning a fluctuating thermocurrent which has been produced to a corresponding connecting rod bearing. Analogous conditions are produced for the main bearing, but with inverted bearing loading, that is to say if, as stated above, the main loading occurs on the lower bearing shell in the case of the main bearing, the main loading takes place on the upper bearing shell in the case of the connecting rod bearing.

Figures 6 to 8 show a transfer unit 30 which is detachably mounted on the crankshaft and which contains the collector 18 for transferring the thermocurrent and the means 20, 20a for determining the angle of rotation. In particular, the transfer unit 30 is constructed as follows:

The transfer unit contains an adapter 31 which is screwed to the crankshaft 1 by means of a screw 32, a conical part 33 on the adapter 31 interacting with a corresponding conical recess 34 on the shaft for initial centering. The adapter has, on the side facing away from the crankshaft 1, a further conical part 35 in which a centering flange 36 engages, said centering flange 36 being screwed via a central screw 37 to the screw 32 which secures the adapter 31 at the crankshaft 1. The centering flange 36 is provided, on the side facing away from the mounting side, with a hollow cylinder 38 which is connected toward the outside with a first fixed housing part 40 via a bearing 39. The bearing 39 is closed off from the adapter 31 by means of a sealing ring 41. On the opposite side, an acceleration sensor 42 which is not illustrated in more

detail but is known is assigned to the bearing 39, which acceleration sensor 42 is composed, for example, of three individual acceleration sensors which can detect the accelerations in all three axes. Arranged in
5 the interior of the hollow cylinder is an elastic coupling device 43 which forms a drive connection between the hollow cylinder 38 and a shaft 44 which is preferably of hollow construction.

10 The flexible coupling device 43 has two hollow cylinders 45, 46 which are arranged coaxially one on top of the other and which each have a plurality of circumferential slots 49, 50 which run, with the exception of a connecting web 47, 48, over the entire
15 circumference. The connecting webs 47, 48 of adjacent circumferential slots 49, 50 of the same hollow cylinder 45, 46 are offset by 180°. In addition, the connecting webs 47, 48 of the two hollow cylinders 45, 46 are offset by 90° with respect to one another. This
20 ensures that irregularities in the running of the crankshaft 1 are as far as possible kept away from the shaft 44.

The shaft 44 which is embodied as a hollow shaft is
25 mounted in two bearings 51, 52 in a second fixed housing part 53 which is supported in a fixed mount 54. The mount 54 contains a supporting tube 55 which can be attached via external attachment flanges 56 to suitable means, for example the engine housing. The housing part
30 53 is supported on the inner side of the protective tube 55 via a rubber ring 57.

Arranged on the shaft 44 is, on the one hand, the means
20 for determining the angle of rotation which has the increment disk 21 whose series of bars (not illustrated
35 in more detail) distributed over the circumference is sensed by the sensor 22. In the present case, a second means 20a for determining the angle of rotation is preferably arranged, said second means 20a being offset

by 90° with respect to the first means. The second means is used, on the one hand, for safety's sake and, on the other hand, for compensating any fluctuations in the rotary movement of the shaft.

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The collector 18 which has a plurality of sliding contacts 58 distributed over the circumference is also seated on the shaft, said sliding contacts 58 being each connected to the fixed housing part 53 by means of a spring arm 59. There are preferably eight sliding contacts which are distributed over the circumference at different orbits 60, it being preferably possible for in each case two sliding contacts 58 to interact, offset by 180°, with the same orbit 60. This construction of the collector is intended to permit the thermocurrent to be tapped as precisely as possible and with as little disruption or resistance as possible, and to compensate any untrue running of the shaft 44.

20 The fixed housing parts 40 and 53 are formed by a casing tube 61 which is provided over a large part of its length with circumferential slots 62 which are constructed in the same way as the circumferential slots 49, 50 in the hollow cylinders 45, 46 so that
25 untrue running, that is to say oscillations of the crankshaft, can also be compensated here. The casing tube 61 is provided with a flexible protective sheath 63.

30 The conductors (not illustrated here in more detail) of the individual sensors are connected to the connecting lines 17, 23 for the control unit 14 at a connecting part 64.

LIST OF REFERENCE SYMBOLS

1	Crankshaft	40	Housing part
2	Main bearing	41	Seal
2a	Bearing journal	42	Acceleration sensor
3	Bearing shell	43	Coupling device
4	White metal layer	44	Shaft
5	Lubricating film	45	Hollow cylinder
6	Bearing block	46	Hollow cylinder
7	Housing	47	Connecting web
8	Crank journal	48	Connecting web
9	Connecting rod	49	Circumferential slit
10	Connecting rod bearing	50	Circumferential slit
11	Plain bearing	51	Bearing
12	Piston bolt	52	Bearing
13	Piston	53	Housing part
14	Control unit	54	Mount
15	Display device	55	Protective tube
16	Connecting line	56	Flange
17	Connecting line	57	Rubber ring
18	Collector	58	Sliding contact
19	Resistor	59	Spring arm
20	Angle of rotation means	60	Orbit
20a	Angle of rotation means	61	Casing tube
21	Increment disk	62	Circumferential slit
22	Sensor	63	Protective sheath
23	Line	64	Connecting part
24	Ignition sequence means		
25	Line		
26	Ignition distributor		
27	Ignition cable	h	Thickness of lubricating film
28	Spark plug	I	Thermocurrent
30	Transfer unit	U	Drop in thermal e.m.f.
31	Adapter	OT	Top dead center
32	Screw	UT	Bottom dead center
33	Conical part	T1	Intake stroke
34	Conical recess	T2	Compression stroke
35	Conical part	T3	Working stroke
36	Centering flange	T4	Expulsion stroke
37	Screw	Z1	First cylinder
38	Hollow cylinder	Z2	Second cylinder
39	Bearing	Z3	Third cylinder

PATENT CLAIMS

1. A method for monitoring plain bearings of a reciprocating piston machine, in particular of an internal combustion engine, in which, at least in one cylinder (Z_1 , Z_2 , Z_3), a displaceable piston (13) is connected to a crankshaft (1) via a connecting rod (9), a thermocurrent (I), which is produced whenever a lubricating film (5) between bearing parts which move relative to one another and are made of different electrically conducting materials is torn off, on the basis of a temperature gradient at such a plain bearing (2a, 10, 11) being used as a control signal in a control unit (14), characterized in that, in order to differentiate between different plain bearings (2a, 10, 11) and/or bearing states, the curve of the thermocurrent (I) obtained is placed in relationship with the angle of rotation of the crankshaft (1) by amplifying it and spreading it, and in that the curve obtained is interrogated for respective significant symptoms of the plain bearing over at least one entire working cycle.

2. The method as claimed in claim 1, characterized in that the angular position in which the lubricating film thickness is at a minimum during normal operation is selected as parameter for determining the control signal of a plain bearing.

3. The method as claimed in claim 1 or 2, characterized in that the displacement path of the bearing journal is selected as parameter for determining the control signal of a plain bearing.

4. The method as claimed in one of claims 1 to 3, characterized in that the position of the crankshaft (1) in which the associated piston (13) is located in the vicinity of the top dead center (OT) in the



compression phase is selected as parameter for determining the control signal.

5. The method as claimed in one of claims 1 to 4,
5 characterized in that the torque and/or the rotational speed of the crankshaft (1) are used as parameters for determining the control signal.

6. The method as claimed in one of claims 1 to 5,
10 characterized in that the thermocurrent (I) is placed in relationship with the ignition sequence of the cylinders (Z_1 , Z_2 , Z_3) in an internal combustion engine.

7. A device for carrying out the method as claimed in
15 one of claims 1 to 6, having a control unit (14) which can be connected by means of lines (16, 17) to the housing (7), on the one hand, and to the crankshaft (1) of the reciprocating piston machine, on the other, and which outputs a control signal when a thermocurrent (I)
20 occurs, characterized in that means (20, 20a) for sensing the angle of rotation of the crankshaft (1) are connected to the control unit (14).

8. Device according to claim 7, characterized in that
25 means for sensing the dead center positions of the piston (13) are connected to the control unit (14).

9. Device according to claim 7 or 8, characterized in that it has a transfer unit (30), which can be
30 connected to the crankshaft (1) of the reciprocating piston machine, for the thermocurrent (I).

10. Device according to claim 9, characterized in that the transfer unit (30) has a rotary sensor (20) for
35 sensing the rotary position and the rotational speed of the crankshaft (1).

11. Device according to claim 9 or 10, characterized in that the transfer unit (30) has a collector (18)

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with a plurality of sliding contacts (58) distributed over the circumference and preferably on various orbits (60) which can be coupled to the crankshaft (1), said sliding contacts (58) being connected by means of
5 spring arms (59) to a fixed housing part (53) which surrounds the sensing range.

12. Device as claimed in one of claims 9 to 11, characterized in that the transfer unit (30) has at
10 least one acceleration sensor (42) which can be coupled to the crankshaft (1).

13. Device according to one of claims 9 to 12, characterized in that the transfer unit (30) has an
15 adapter (31) which can be coaxially connected to the crankshaft (1) and which is connected via a flexible coupling device (43) to a shaft (44) which is mounted in a fixed housing (53) to which lines (17, 23) of the transfer unit (30) to the control unit (14) are
20 connected.

14. The device as claimed in claim 13, characterized in that the flexible coupling device (43) has two hollow cylinders (45, 46) which are arranged coaxially
25 one on top of the other and which each have a plurality of circumferential slits (49, 50) which run, with the exception of a connecting web (47, 48), over the entire circumference, the connecting webs (47, 48) of adjacent circumferential slits (49, 50) being offset by 180° and
30 in addition the connecting webs (47, 48) of the two hollow cylinders (45, 46) being offset with respect to one another by 90°, the two hollow cylinders (45, 46) also being connected at one end to one another and at the other end to the adapter (31) on the one hand and
35 to the shaft (44) on the other.



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