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(54) HEATER FOR LAB-ON-A-CHIP

(57) A lab-on-a-disc, systems, a method, and a heater attachment which utilize magnetic induction to heat a biochemical testing apparatus. The lab-on-a-disc, including: a biochemical testing apparatus; and an electrically conducting element; wherein, in use, the lab-on-a-disc is rotated relative to one or more magnets, so as to induce an electrical current in the electrically conducting element; wherein, in use, the lab-on-a-disc is rotated relative to one or more magnets, so as to induce an electrical current in the electrically conducting element, thereby heating the biochemical testing apparatus.

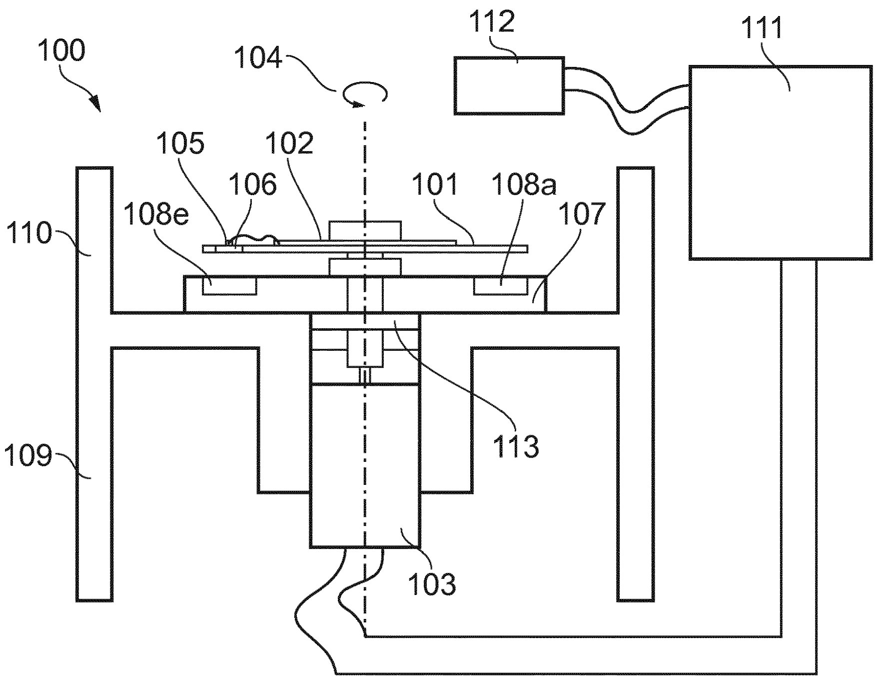

FIG. 1

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Description

Field of the Invention

[0001] The present invention relates to a heater for a lab-on-a-chip technology, and specifically a heater utilizing magnetic induction. It also relates to systems and methods for heating and operating microfluidic chips.

Background

[0002] A recent development of integrated and low cost point of care devices, for rapid diagnosis, has been driven by the miniaturization and automation of analytical protocols in microfluidic systems. One such system is the so-called "lab-on-a-disc" system. In lab-on-a-disc technology, standard compact discs (CDs) are supplemented by channels and chambers for liquids and the pumping of fluids in the microfluidic system thus created is achieved by rotating the disc and thus providing a centrifugal force.

[0003] The lab-on-a-disc was developed as a subsidiary to the growing lab-on-a-chip and microfluidics field. Both of these aim to increase the miniaturisation, portability, accuracy, and cost effectiveness of biochemical analysis with a particular focus on diagnostics. Lab-on-a-disc has a high sample-to-result potential due to its simplicity and ease of integration of several protocol steps of biochemical analysis into a single disc.

[0004] A number of biochemical analytical tests have been implemented in lab-on-a-disc setups in recent years, and it has been recognised as having a high potential in enabling simplification of biochemical tests through their integration in a single platform. An additional requirement for lab-on-a-disc setups is a heater and temperature control, which is required for a number of biochemical tests. However, to date, the rapid and accurate thermal cycling and control of a lab-on-a-disc setup remains challenging.

[0005] As an example, polymerase chain reaction (PCR) is challenging to undertake on a lab-on-a-disc setup due to the number of thermal cycles required (typically between 15 and 40). The reaction chamber temperature needs to be precisely controlled, and alternated between three temperatures (generally between 53°C and 95°C) in each cycle.

[0006] The most widely used heater for PCR systems is the Peltier heater, which uses the thermoelectric effect to convert electrical current into heat. Alternatively, hot-air blowers, infrared light emitters, laser devices, and microwave emitters have been used as a heater in PCR systems. In typical commercial PCR devices, more than 90% of the total time may be due to temperature cycling rather than the underlying amplification process.

[0007] An object of the present invention is to provide a heating mechanism for lab-on-a-disc applications, preferably one which provides for rapid cycling, precise real-time temperature measurement and control, simplicity, portability and/or cost efficiency.

Summary

[0008] At its most general, the disclosure herein provides a heater for a lab-on-a-disc that operates through magnetic induction.

[0009] Accordingly, in a first aspect, the invention provides a lab-on-a-disc, including:

a biochemical testing apparatus; and
an electrically conducting element;

wherein, in use, the lab-on-a-disc is rotated relative to one or more magnets, so as to induce an electrical current in the electrically conducting element, thereby heating the biochemical testing apparatus.

[0010] Such a lab-on-a-disc can be inexpensively produced, and operable to heat to and maintain a present temperature with accuracy and speed. The temperature can either be controlled via the control of the rotational frequency that is inherently integrated in lab-on-a-disc platforms or by adjusting the distance between the rotating lab-on-a-disc and the one or more magnets. No additional heaters are required for thermal cycling. The heating energy is provided through the conversion of mechanical work of the driving motor.

[0011] In a second aspect, the invention provides a system comprising:

a lab-on-a-disc according to the first aspect;
a motor, to which the lab-on-a-disc is releasably attached, such that the lab-on-a-disc is rotatable; and
one or more magnets, located proximate to the lab-on-a-disc, such that when the motor rotates the disc, an electrical current is induced in the electrically conducting element.

[0012] In a third aspect, the invention provides a method of controlling the temperature of a lab-on-a-disc, the lab-on-a-disc comprising a temperature sensor, a biochemical testing apparatus, and an electrically conducting element, the method including:

spinning the lab-on-a-disc, such that one or more magnets located adjacent to the lab-on-a-disc induces an electrical current in the electrically conducting element;
monitoring a temperature on the lab-on-a-disc, using the temperature sensor;
controlling either the rotational frequency of the lab-on-a-disc, or a distance between the one or more magnets and the electrically conducting element, so as to control the monitored temperature.

[0013] In a fourth aspect, the invention provides a system comprising:

a motor, including a mounting portion to which a lab-on-a-disc may be releasably mounted and thereby rotated;

one or more magnets, located proximate to the mounting portion, such that when the motor rotates the disc, an electrical current is induced in an electrically conducting element of the lab-on-a-disc thereby heating the electrically conducting element and so heating a biochemical testing apparatus in the lab-on-a-disc.

[0014] In a fifth aspect, the invention provides a kit comprising:

a lab-on-a-disc, the lab-on-a-disc comprising a biochemical testing apparatus, a temperature sensor, and an electrically conducting element arranged such that when an electrical current is induced in the electrically conducting element the electrically conducting element heats the biochemical testing apparatus; and

a communication disc, including a transmitter suitable for connection to the temperature sensor and arranged to transmit the sensed temperature.

[0015] In a sixth aspect, the invention provides a heater attachment for a lab-on-a-disc, the heater attachment comprising:

attachment means, for releasably fixing the heater attachment to a lab-on-a-disc; and

one or more electrically conducting elements, arranged such that when an electrical current is induced in the electrically conducting element the electrically conducting element heats a biochemical testing apparatus provided in the lab-on-a-disc.

[0016] Optional features of the invention will now be set out. These are applicable singly or in any combination with any aspect of the invention.

[0017] The electrically conducting element may be formed of copper. It may be a foil or plate. The element may be permanently fixed or releasably fixed to the lab-on-a-disc.

[0018] The lab-on-a-disc may include a temperature sensor, operable to monitor the temperature of one or more of: the biochemical testing apparatus (or a part thereof), or the electrically conducting element. Temperature control of the biochemical testing apparatus on the lab-on-a-disc is important for many operations. Sensing the temperature of the electrically conducting element may be used as a substitute for sensing the temperature of the biochemical testing apparatus as it may be easier to thermally couple the temperature sensor to the electrically conducting element.

[0019] The lab-on-a-disc may include a transmitter, which transmits the temperature sensed by the temperature sensor, for example to an external controller. In particular embodiments, the transmitter may comprise one or more light emitting diodes, which turn on and off at a frequency which is dependent on the sensed temperature. This can provide a simple approach to transmitting the temperature data in a contactless way which does not require much power to implement. In other embodiments the transmitter may be implemented as an RF transmitter, operable to communicate information to a receiver.

[0020] The lab-on-a-disc may include one or more turns of electrically conducting wire, connected to either or both of the temperature sensor and transmitter, such that in use the temperature sensor and/or transmitter are powered by current induced in the one or more turns of electrically conducting wire. This can reduce or remove the need for a battery or other energy source to be provided on the lab-on-a-disc to power the temperature sensor and/or transmitter. Alternatively or additionally, the transmitter and/or sensor may be powered by a battery, or a capacitor.

[0021] The transmitter may be mounted to a communication disc, and the temperature sensor may be connected to the transmitter. The communication disc may be separable from the lab-on-a-disc. Of course it will be appreciated that the transmitter may also be mounted directly on the lab-on-a-disc.

[0022] The lab-on-a-disc may include a centre spindle hole about which, in use, the lab-on-a-disc rotates.

[0023] The one or more magnets may be located in a plate fixed below the lab-on-a-disc. There may be a plurality of magnets. The plurality of magnets may be disposed equidistantly around a circumference of the plate. Adjacent magnets may have an opposite polarity. The magnets may be fixed or static magnets.

[0024] The one or more magnets may be mounted in a carrier which is itself rotatable relative to the lab-on-a-disc. In such arrangements, the relative speeds of rotation of the magnets and the lab-on-a-disc may be controlled so as to allow control of the heating effect from the relative rotation, whilst rotating the lab-on-a-disc at a speed which is required or desirable for operation of the biochemical testing apparatus.

[0025] The induced currents may be referred to as eddy currents.

[0026] The biochemical testing apparatus may be a reaction chamber. For example, the reaction chamber may be one suitable for PCR reactions and may have a volume of no more than 1000 μL and/or no less than 1 μL. In other arrangements the reaction chamber may have a volume of no more than 1 μL.

[0027] The system may further include a controller, which is configured to operate the motor in response to receiving a temperature sensed on the lab-on-a-disc. In arrangements in which the transmitter transmits the sensed temperature optically, for example using light emitting diodes, the system may further include an optical sensor. For example the optical sensor may be configured to sense the frequency with which the one or more light emitting diodes turn on and off, and thereby derive a temperature sensed by the temperature sensor. The controller may use a closed control loop to control the motor.

[0028] The heater attachment may include a temperature sensor, for sensing the temperature of either the electrically conducting element(s) or, when attached to the lab-on-a-disc, the biochemical testing apparatus. The heater attachment may include a transmitter as discussed above, for example a number of LEDs whose blink frequency is a function of the sensed temperature.

Brief Description of the Drawings

[0029] Embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 shows a cross-sectional schematic view of a system according to an embodiment of the present invention;

Figure 2 shows a top-down schematic view of a lab-on-a-disc;

Figure 3 shows a top-down schematic view of a magnet holder;

Figure 4 shows an electronic circuit diagram of a temperature sensor;

Figure 5 shows an implementation of the circuit shown in Figure 4 on a disc;

Figure 6 shows an electronic circuit diagram of a sensor circuit;

Figure 7 shows a plot of temperature against rotations per minute; and

Figure 8 shows a plot of temperature against time whilst varying the rotations per minute.

Detailed Description and Further Optional Features

[0030] Aspects and embodiments of the present invention will now be discussed with reference to the accompanying figures. Further aspects and embodiments will be apparent to those skilled in the art. All documents mentioned in this text are incorporated herein by reference

[0031] Figure 1 illustrates a cross-sectional schematic view of a system 100 according to an embodiment of the present invention. A lab-on-a-disc 101, which may be for example a CD or DVD, and a communication disc 102 are mounted on a spindle attached to a motor 103. This allows both the lab-on-a-disc and the communication disc to be rotated around axis 104. The motor may be a DC-driven electric motor, or an AC-driven electric motor.

[0032] The lab-on-a-disc 101 in this example includes a temperature sensor 105, an electrically conducting element 106 (here, a copper plate), and a biochemical testing apparatus (not shown in Figure 1). The lab-on-a-disc is discussed in more detail below with respect to Figure 2. The temperature sensor is connected to the communication disc 102 via one or more wires, and in this example is a thermistor. Alternatively, contacts on the communication disc may align with contacts on the lab-on-a-disc. Further alternatively, the components of the communication disc may be integrated with the lab-on-a-disc. The communication disc is discussed in more detail below with respect to Figure 3.

[0033] Mounted below the lab-on-a-disc 101, i.e. between the lab-on-a-disc and the motor 103, is a magnet holder 107. The magnet holder includes a plurality of magnets 108a - 108h (although it will be appreciated that any number of magnets, including a single magnet could be used). When the motor rotates the lab-on-a-disc relative to the magnets in the magnet holder, an electrical current is induced in the electrically conducting element 106. This electrical current causes the electrically conducting element to increase in temperature.

[0034] The magnets may be neodymium (nickel plated) disc-shaped magnets with a diameter of 20 mm, a height of 10 mm, and a magnetic strength of around 110 Newton of pulling force. A bearing 113 is used to (i) support the axial load from the lab-on-a-disc and stabilize a rotational axis of the motor against radial loads; and/or (ii) fix the position of the magnet holder 107 relative to the lab-on-a-disc.

[0035] The motor 103 and magnet holder 107 are mounted to a housing 109. Whilst the magnet holder is mounted between the motor and the lab-on-a-disc 101, it will be appreciated that alternatively the lab-on-a-disc could be placed between the magnet holder and the motor. The housing 109 also includes safety protection 110 which encloses the lab-on-a-disc 101. Whilst in this example magnet holder is fixed relative to the housing, it will be appreciated that alternatively the magnetic holder may be mounted to an additional motor which is independent of the motor 103 connected to the lab-on-a-disc.

[0036] The motor 103 is connected to a controller 111, which operates to vary the speed of the motor and therefore the angular frequency of the lab-on-a-disc 101. The motor may operate in accordance with a pre-programmed protocol, or may be instructable via an electrical interface or manual controls.

[0037] In this example, the controller 111 is coupled to an optical sensor 112. The optical sensor senses light emitted from the communication disc 102, and from this light derives a temperature sensed by the temperature sensor 105. In response to this sensed temperature, the controller may vary the speed of the motor. By decreasing the speed of the motor, the angular frequency of the lab-on-a-disc 101 is also decreased. This reduction in angular frequency decreases the current induced in the electrically conducting element 106, which will decrease the temperature of the electrically conducting element. Conversely, increasing the speed of the motor will increase the angular frequency of the lab-on-a-disc. This increase in angular frequency increases the current induced in the electrically conducting element which increases the temperature of the electrically conducting element.

[0038] In a different example, the controller may operate to move the magnet holder 107 relative to the lab-on-a-disc 101 to increase the distance therebetween. This also results in a decrease in the induced current and therefore a decrease in the temperature of the electrically conducting element 106. Conversely, the distance between the magnet holder and the lab-on-a-disc may be decreased which will increase the induced current and therefore increase the temperature of the electrically conducting element.

[0039] Figure 2 shows a top-down schematic view of the lab-on-a-disc 101 shown in Figure 1. As can be seen, the lab-on-a-disc is a generally disc shaped object with a number of elements mounted to or in it. The disc may be, for example, a CD or DVD which has been modified.

[0040] The dimensions of the lab-on-a-disc may substantively match the CD or DVD standard and so have a diameter of 120 mm and a thickness of 1.2 mm. The lab-on-a-disc contains a spindle hole 201, which may have a diameter of 15 mm.

[0041] The lab-on-a-disc 101 includes the electrically conducting element 105 described previously. As can be seen more clearly in this Figure, the electrically conducting element in this example is a copper plate. The temperature sensor 106 is positioned on top of the electrically conducting element. However in some examples it may be located adjacent (i.e. offset in a top-down view) to the electrically conducting element. The lab-on-a-disc also includes a biochemical testing apparatus 202, which is adjacent to the electrically conducting element. Therefore, when the electrically conducting element heats (due to induced currents) the temperature of the biochemical testing apparatus will also increase.

[0042] Figure 3 shows a top-down schematic view of the magnet holder 107 discussed above. The magnet holder in this example includes eight fixed magnets: 108a-108h, disposed equidistantly around a circumference of the magnet holder. As can be seen, adjacent magnets are of an opposite polarity. The magnets are disposed at the same radial distance from a centre of the holder, and periodically around the circumference corresponding to that radial distance. The magnetic holder, like the lab-on-a-disc, may have substantially the same dimensions as a CD or DVD. However, it will of course be appreciated that the magnet holder may take virtually any shape.

[0043] Figure 4 shows an electronic circuit 400 diagram of a transmitter as may be included in the communication disc 102. The transmitter, which may be referred to as a thermistor-based temperature beacon, broadly comprises: a switch 401; an oscillator 402; LEDs 403a - 403c; and a power source 404. The switch 401 in this example is an automatic power switch which closes when the communication disc is rotating. This can help to conserve the energy stored in the battery/capacitor when the disc is not rotating. The oscillator 402 may be provided as a 555 series timer IC, in a stable topology which uses the thermistor 106 of the lab-on-a-disc 101 as the charge-discharge resistor. The oscillator may be tuned to between 1 and 5 kHz at room temperature (between 20°C and 25°C). The range of tuned frequencies allows the desired precision on a circa 1s time scale for measurement. Higher frequencies are not generally required, and may radiate electromagnetic interference. The LEDs 403a-403c in this example share a cathode. The power source 404 may be either (i) a battery, e.g. a 3V lithium button cell; (ii) a capacitor or super capacitor; or (iii) a number of turns of electrically conducting wire which inductively harvest power when the communication disc is rotated.

[0044] In use, the resistance of the thermistor 106 varies the frequency of the output of the oscillator 402. This output is provided to the LEDs 403a - 403c, causing them to flash (i.e. turn on and off) at the same frequency. Light is thus used to transmit the temperature sensed by the thermistor as a frequency of flashing. As an alternative, an RF transmitter may be included in the circuit 400 and used to transmit information (including the sensed temperature) to a receiver.

[0045] Figure 5 shows an implementation of the communication disc 102 including the electronic circuit 400. Like features are indicated by like reference numerals. Notably, it can be seen that the LEDs 403a-403c are disposed circumferentially around a common radius of the communication disc 102. Also, the contacts 501 for connection to the thermistor can be seen as the thermistor in this example is provided on the lab-on-a-disc 101.

[0046] The communication disc 102 may be powered by, for example, 20 turns of electrically conducting wire. At around 2000 RPM, at least 2.5 V of induced voltage can be provided by the 20 turns of wire. This setup allows all components of the communication disc to be integrated into the disc, whereas if a battery is provided this cannot be integrated into the disc and a separate battery holder may be needed as shown in Figure 4.

[0047] Whilst only a temperature sensor has been discussed, it will be appreciated that further sensors may be included in the lab-on-a-disc 101 and the communication disc 102 may convey the output of these to a controller. For example, a fluorescent fingerprint may be sensed by a sensor on the lab-on-a-disc and provided to the controller. In some examples, the communication disc may provide a structured serial protocol for the transfer of information.

[0048] Figure 6 shows a circuit diagram 600 suitable for detecting the light emitted from the LEDs 403a - 403c of the communication disc, and converting it into a frequency encoded temperature signal suitable for microcontroller readout. Broadly, it includes a photodiode which provides a voltage to a gain stage in response to detecting light from the LEDs.

[0049] Figure 7 is a plot of asymptotic temperature (i.e. the temperature measured after a given period of time, when the temperature stabilizes and is no longer influenced by transition phenomena) against rotations per minute (RPM). As can be seen, the temperature linearly follows the rotation frequency of the disc. At around 1500 RPM, the highest temperature needed for PCR is achieved (around 95°C). With a further increase to 2000 RPM, a temperature over 120°C can be reached.

[0050] Figure 8 is an experimental plot of temperature against time. As can be seen, a temperature of around 90°C was be attained within a few (1 - 5) seconds. The rate of temperature increase seen at around 50 seconds is around 5°C/s. The temperature was maintained for between 30 and 50 seconds, before passive cooling was used by decreasing the angular frequency of the lab-on-a-disc 101. A cooling rate of around 1°C/s was achieved at the interval of thermal cycling temperatures required for a PCR protocol.

[0051] As has been discussed previously, the lab-on-a-disc 101 includes a biochemical testing apparatus. In some examples, the testing apparatus may be usable for amplification and detection of nucleic acids. For example, the testing apparatus may be used for PCR or loop-mediated amplification protocols (LAMP). However the biochemical testing apparatus may also be used to induce endothermic reactions on the lab-on-a-disc, or to induce biological processes where elevated temperature is needed e.g. cell lysis, or thermoporation.

[0052] While the invention has been described in conjunction with the exemplary embodiments described above, many equivalent modifications and variations will be apparent to those skilled in the art when given this disclosure. Accordingly, the exemplary embodiments of the invention set forth above are considered to be illustrative and not limiting. Various changes to the described embodiments may be made without departing from the spirit and scope of the invention.

[0053] The following references may be useful for understanding the present disclosure:

Kellogg, G. J. et al. Centrifugal Microfluidics: Applications. In Proceedings of Micro Total Analysis Systems; van den Berg, A., Olthuis, W., Bergveld, P., Eds.; Kluwer Academic: Dordrecht, 2000; pp. 239-242

Amasia, M. Et al. Experimental Validation of Numerical Study on Thermoelectric Based Heating in an Integrated Centrifugal Microfluidic Platform for Polymerase Chain Reaction Amplification. Biomicrofluidics. 2013, 7, 14106

Martensson, G. et al. Rapid PCR Amplification of DNA Utilizing Coriolis Effects. Eur. Biophys. J. 2006, 35, 453-458.

Sundberg, S. O. et al. Spinning Disk Platform for Microfluidic Digital Polymerase Chain Reaction. Anal. Chem. 2010, 82, 1546-1550.

Burger, J. et al. IR Thermocycler for Centrifugal Microfluidic Platform with Direct on-Disk Wireless Temperature Measurement System. In SPIE Microtechnologies: Smart Sensors, Actuators, and MEMS V; SPIE Proceedings Vol. 8066; Schmid, U., Sanchez-Rojas, J. L., Leester-Schaedel, M., Eds., SPIE: Bellingham, WA, 2011; pp. 80661X-80661X-8.

Chen, X. et al. Wirelessly Addressable Heater Array for Centrifugal Microfluidics and Escherichia coli Sterilization. Conf. Proc. IEEE Eng. Med. Biol. Soc. 2013, 2013, 5505-5508.

US 6,593,143 B1 *titled Centrifuge system for contactless regulation of chemical sample temperature using eddy currents.*

Lab Chip, 2016,16, 1917-1926, Heating blocks are used for isothermal LAMP amplification.

Lab Chip, 2015,15, 3749-3759, Heating in adapted laboratory thermocycler.

Lab Chip, 2015, 15, 406-416, Peltier elements were used

Anal. Chem. 2014, 86, 3841-3848, Laser heating, 30 min to analysis, isothermal amplification,

Lab Chip, 2010, 10, 2519-2526,

JPH02155190(A) - *Magnetic Heater,*

US2013101983 (A1) - *Non contact real time micro polymerase chain reaction system and method thereof,*

CN102042634 (A) - *Magnetic induction heating method and special devices thereof*

GB858179(A) - *Apparatus for converting mechanical energy into heat*

WO2015003450 (A1) - *Column type permanent magnet eddy heating device*

WO2015003448 (A1) - *Permanent magnet eddy heating device*

[0054] All references referred to above are hereby incorporated by reference.

List of Features

[0055]

100	System
101	Lab-on-a-disc
102	Communication disc
103	Motor
104	Axis of rotation
105	Temperature sensor
106	Conducting element
107	Magnet holder
108a-h	Magnets
109	Housing
110	Safety protection
111	Controller
112	Optical sensor
113	Bearing
202	Biochemical testing apparatus
400	Electronic circuit
401	Switch
402	Oscillator
403a-c	LEDs
404	Power source
501	Contacts
600	Circuit diagram

Claims

1. A lab-on-a-disc, including:

a biochemical testing apparatus; and
an electrically conducting element;

wherein, in use, the lab-on-a-disc is rotated relative to one or more magnets, so as to induce an electrical current in the electrically conducting element, thereby heating the biochemical testing apparatus.

2. The lab-on-a-disc of claim 1, wherein the electrically conducting element is formed of copper.

3. The lab-on-a-disc of either claim 1 or claim 2, wherein the electrically conducting element is a foil or plate.

4. The lab-on-a-disc of any preceding claim, further including a temperature sensor, operable to monitor a temperature of one or more of: the biochemical testing apparatus, or the electrically conducing element.

5. The lab-on-a-disc of claim 4, further including a transmitter, which transmits the temperature sensed by the temperature sensor.

6. The lab-on-a-disc of claim 5, wherein the transmitter comprises one or more light emitting diodes, which turn on and off at a frequency which is dependent on the sensed temperature.

7. The lab-on-a-disc of any of claims 4 - 6, including one or more turns of electrically conducting wire connected to either or both of the temperature sensor and transmitter, such that in use the temperature sensor and transmitter are powered by current induced in the one or more turns of electrically conducting wire.

8. The lab-on-a-disc of any of claims 5 - 7, wherein the transmitter is mounted to a communication disc, and the temperature sensor is connected to the transmitter.

9. A system comprising:

a lab-on-a-disc as set out in any of claims 1 - 10;
a motor, to which the lab-on-a-disc is releasably attached, such that the lab-on-a-disc is rotatable; and
one or more magnets, located proximate to the lab-on-a-disc, such that when the motor rotates the disc, an electrical current is induced in the electrically conducting element.

10. The system of claim 9, further including a controller, which is configured to receive a temperature sensed on the lab-on-a-disc and to control the motor in response to the sensed temperature.

11. The system of either claim 9 or 10, wherein the lab-on-a-disc further includes:

a temperature sensor, operable to monitor a temperature of one or more of: the biochemical testing apparatus, or the electrically conducing element; and
a transmitter, which transmits the temperature sensed by the temperature sensor, wherein the transmitter comprises one or more light emitting diodes, which turn on and off at a frequency which is dependent on the sensed temperature, and the system further includes an optical sensor, which is configured to sense the frequency with which the one or more light emitting diodes turn on and off, and thereby derive a temperature sensed by the temperature sensor.

12. A method of controlling the temperature of a lab-on-a-disc, the lab-on-a-disc comprising a temperature sensor, a biochemical testing apparatus, and an electrically conducting element, the method including:

spinning the lab-on-a-disc, such that one or more magnets located adjacent to the lab-on-a-disc induces an electrical current in the electri-

cally conducting element;
monitoring a temperature on the lab-on-a-disc, using the temperature sensor;
controlling either the rotational frequency of the lab-on-a-disc, or a distance between the one or more magnets and the electrically conducting element, so as to control the monitored temperature.

13. A system comprising:

a motor, including a mounting portion to which a lab-on-a-disc may be releasably mounted and thereby rotated;
one or more magnets, located proximate to the mounting portion, such that when the motor rotates the disc, an electrical current is induced in an electrically conducting element of the lab-on-a-disc thereby heating the electrically conducting element and so heating a biochemical testing apparatus in the lab-on-a-disc.

14. A kit comprising:

a lab-on-a-disc, the lab-on-a-disc comprising a biochemical testing apparatus, a temperature sensor, and an electrically conducting element arranged such that when an electrical current is induced in the electrically conducting element the electrically conducting element heats the biochemical testing apparatus; and
a communication disc, including a transmitter suitable for connection to the temperature sensor and arranged to transmit the sensed temperature.

15. A heater attachment for a lab-on-a-disc, the heater attachment comprising:

attachment means, for releasably fixing the heater attachment to a lab-on-a-disc; and
one or more electrically conducting elements, arranged such that when an electrical current is induced in the electrically conducting element the electrically conducting element heats a biochemical testing apparatus provided in the lab-on-a-disc.

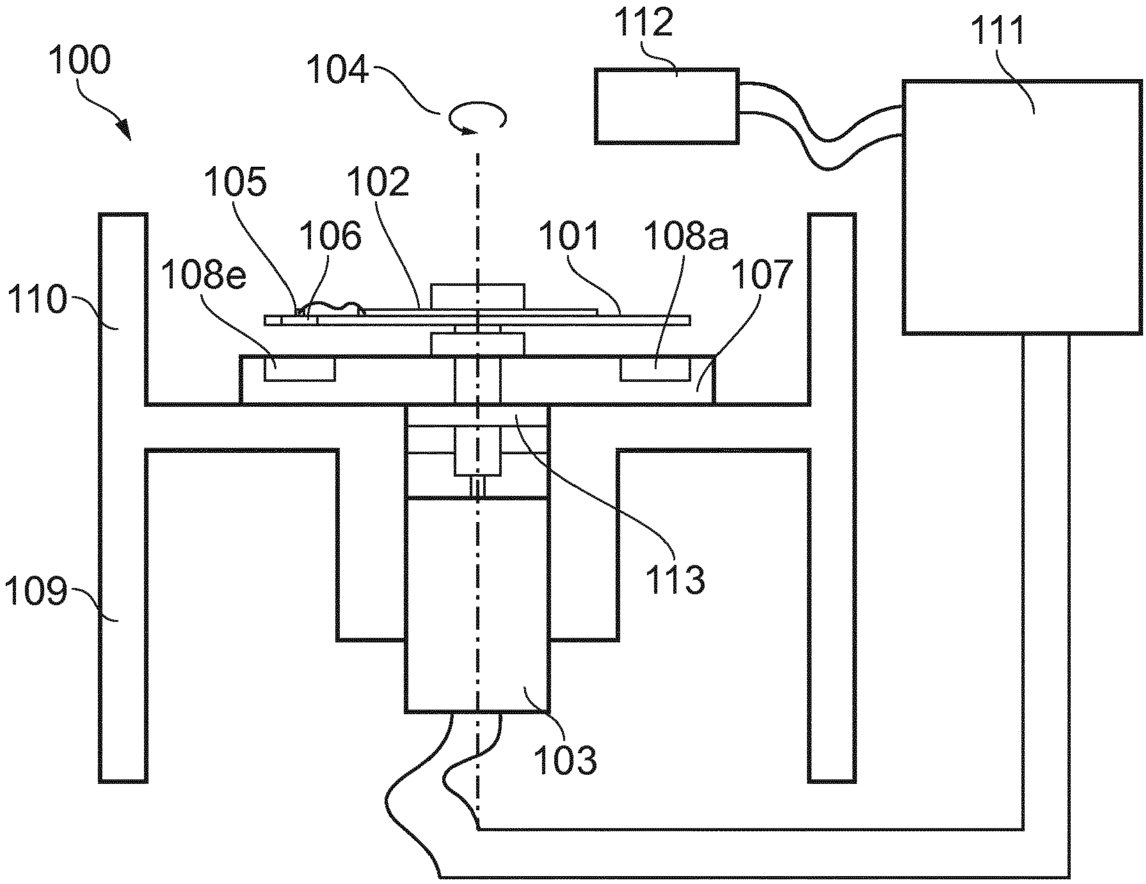

FIG. 1

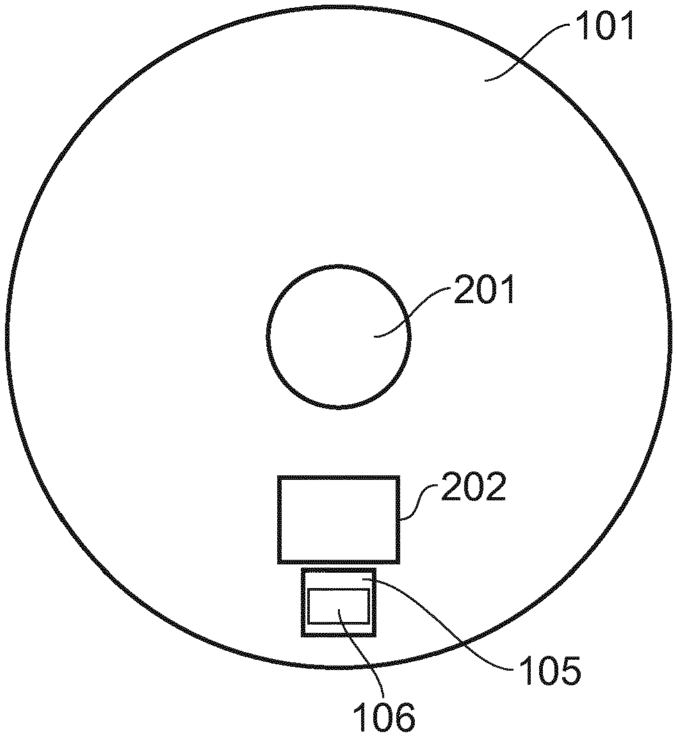
101
201
202
105
106

FIG. 2

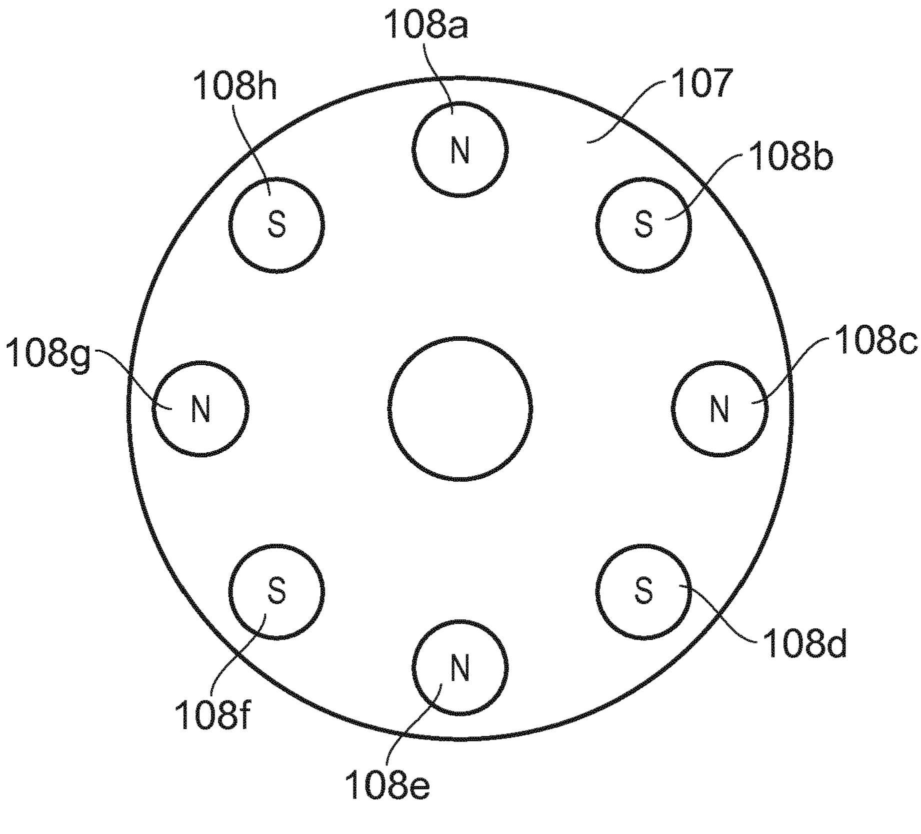
108a
108h
107
108b
N
S
S
108g
108c
N
N
S
S
108d
N
108f
108e

FIG. 3

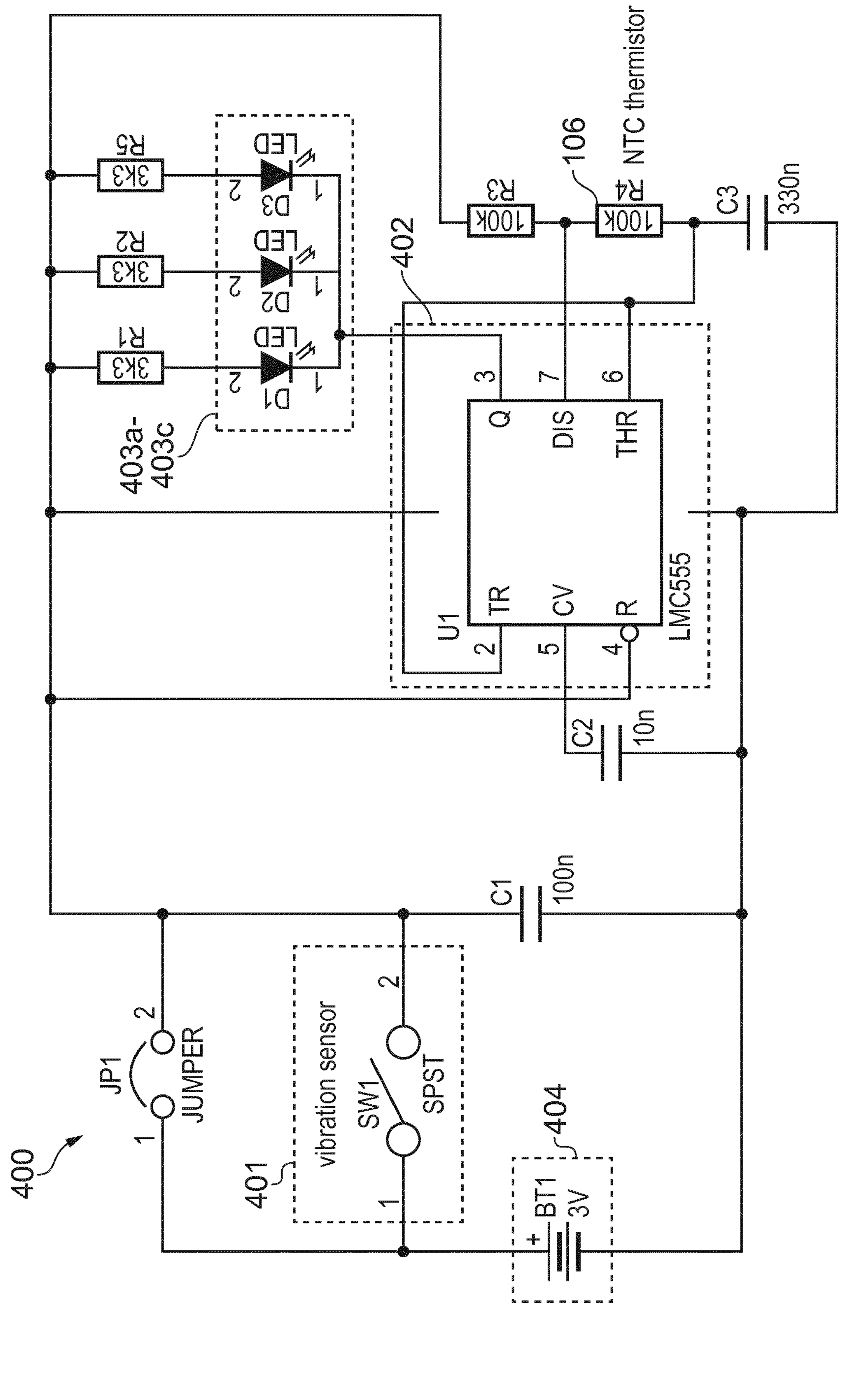
400
JP1
JUMPER
1
2
401
vibration sensor
SW1
SPST
1
2
404
+
BT1
3V
C1
100n
C2
10n
C3
330n
R1
3K3
R2
3K3
R5
3K3
D1
LED
D2
LED
D3
LED
403a-
403c
402
U1
LMC555
TR
CV
R
Q
DIS
THR
2
5
4
3
7
6
R3
100K
R4
100K
106
NTC thermistor

FIG. 4

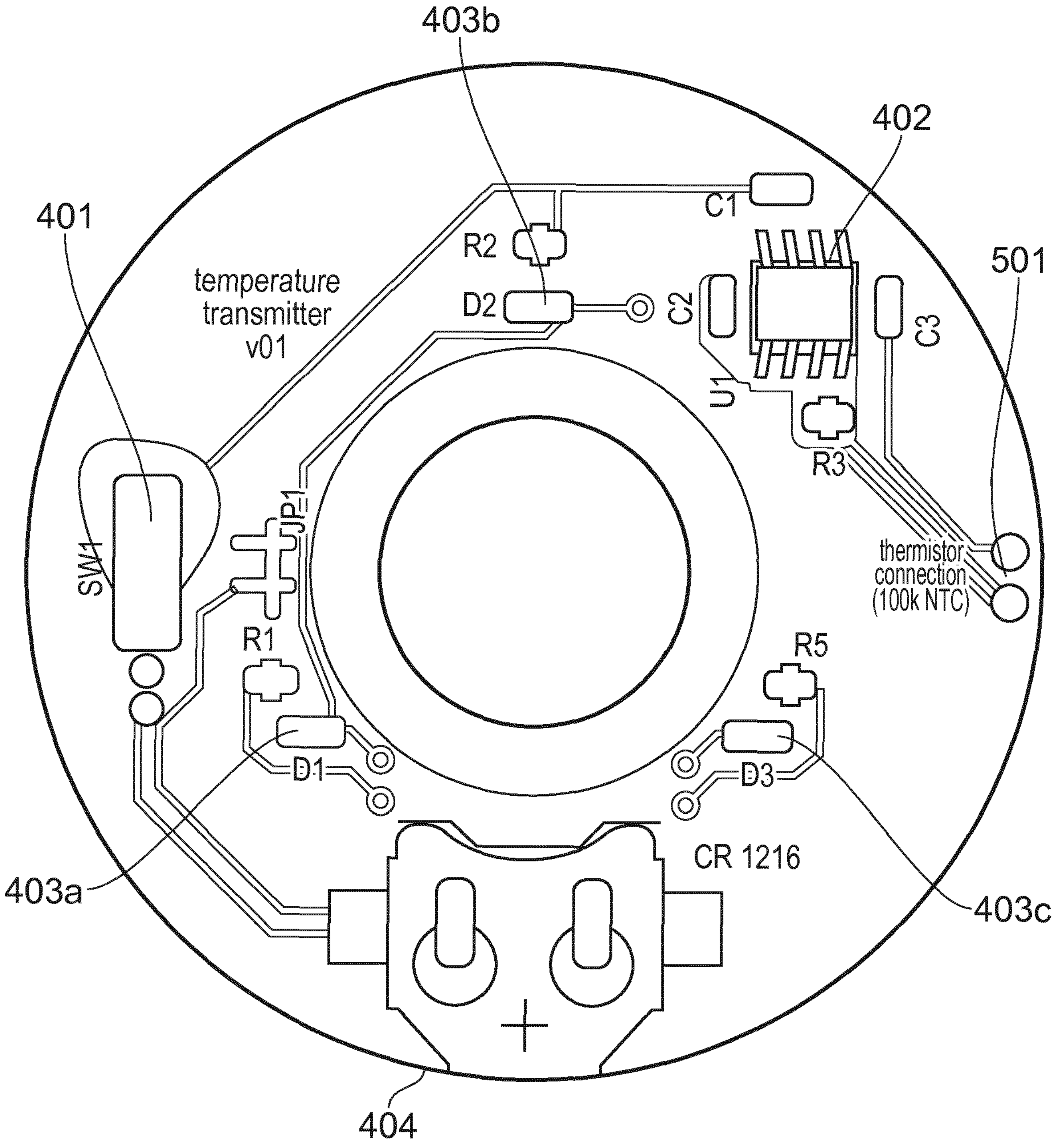
403b
402
401
501
C1
R2
temperature
transmitter
v01
D2
C2
C3
U1
R3
SW1
JP1
thermistor
connection
(100k NTC)
R1
R5
D1
D3
CR 1216
403a
403c
404

FIG. 5

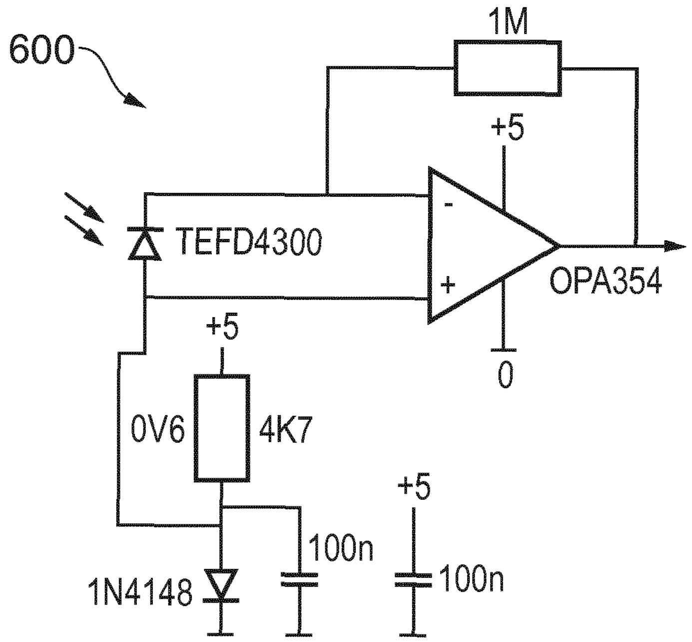
600
1M
+5
TEFD4300
-
+
OPA354
+5
0
0V6
4K7
+5
100n
1N4148
100n

FIG. 6

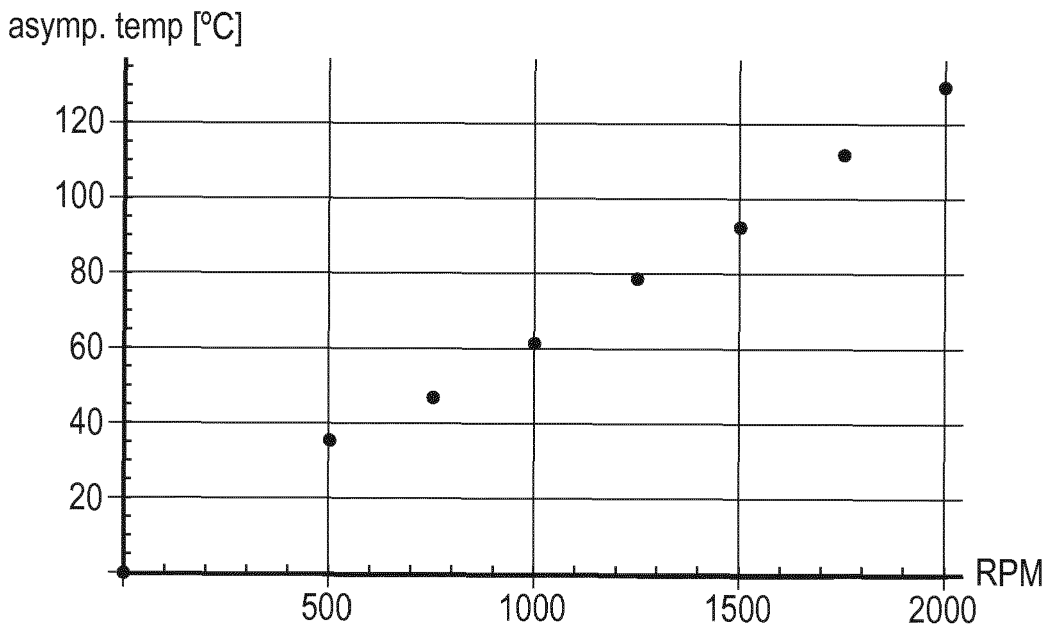
asymp. temp [°C]
120
100
80
60
40
20
RPM
500
1000
1500
2000

FIG. 7

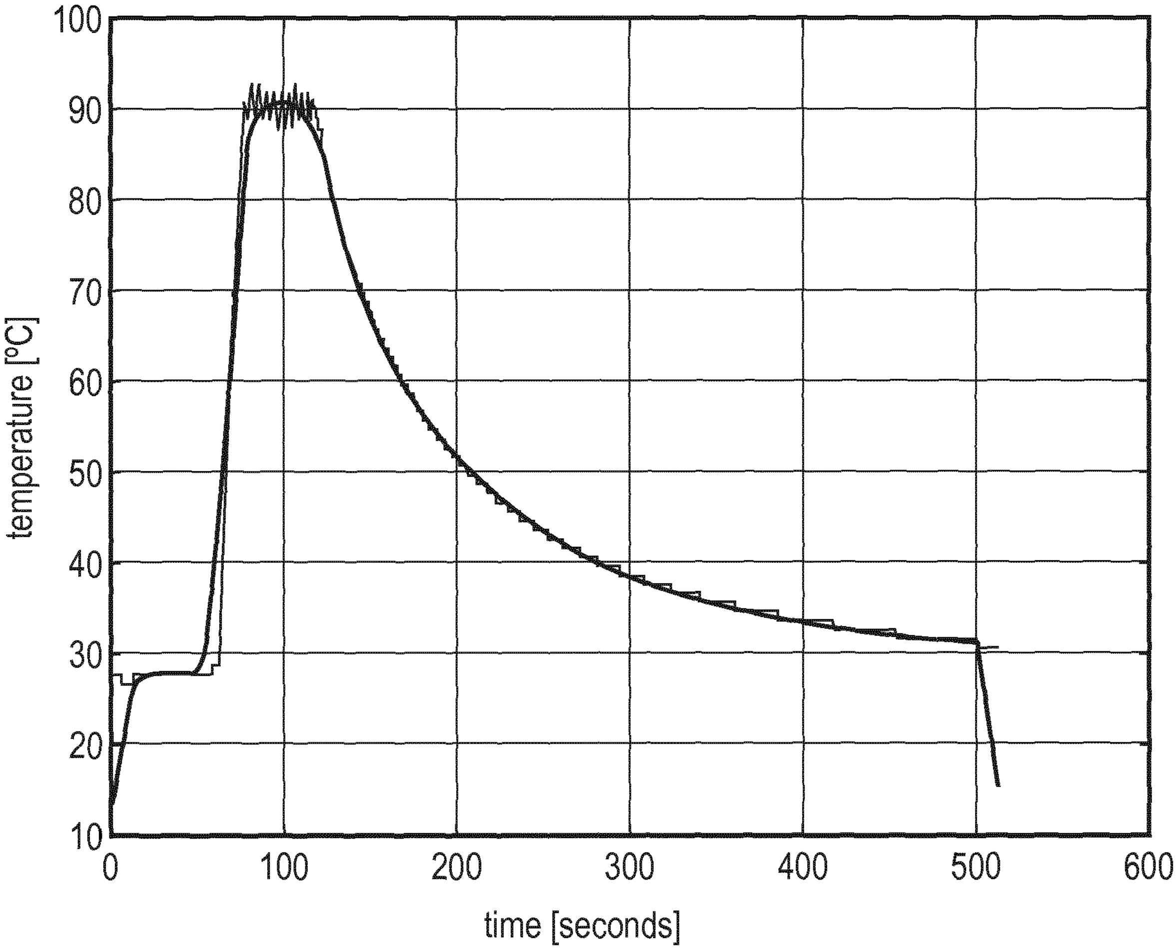
100
90
80
70
60
50
40
30
20
10
temperature [ºC]
0
100
200
300
400
500
600
time [seconds]

FIG. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 19 16 7447

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	23 May 2019	Viskanic, Martino

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