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(54) **GRINDING SYSTEM COMPRISING A GRINDING WHEEL AND A GRINDER WITH MOVABLE DATA TRANSCIVER SYSTEM**

(57) The present invention concerns a grinding system, comprising a grinding wheel and a grinder. The grinder (30) comprising an actuating arm (30) adapted to receive an abrasive grinding wheel (1), an actuator (33) coupled to the actuating arm (31) to rotatably drive or translate it along a driving axis, and a transceiver unit (39) adapted to receive and transmit electromagnetic signals. The abrasive grinding wheel (1) is fixed to the actuating arm (31) of the grinding machine (30), the grinding wheel (1) comprising a body (10) which has at least one abrasive surface (13) intended to come into contact with a workpiece to be machined, and an electronic unit (20) coupled to the body (10). The transceiver unit (39) is located in the grinder (30) so as to be separated from the

abrasive grinding wheel (1) and comprises at least one resonant circuit (391), while the electronic unit (20) of the grinding wheel (1) comprises a further resonant circuit (271) having a resonance frequency equal to or more or less 15% different from the resonance frequency of the at least one resonant circuit (391) of the transceiver unit (39). The grinder further comprises a movement means suitable for moving the transceiver unit (39) along an axis parallel to the driving axis of the actuating arm (31), so as to maintain the at least one resonant circuit (391) of the grinder and the further resonant circuit (271) of the grinding wheel (1) aligned during a translation of the actuating arm.

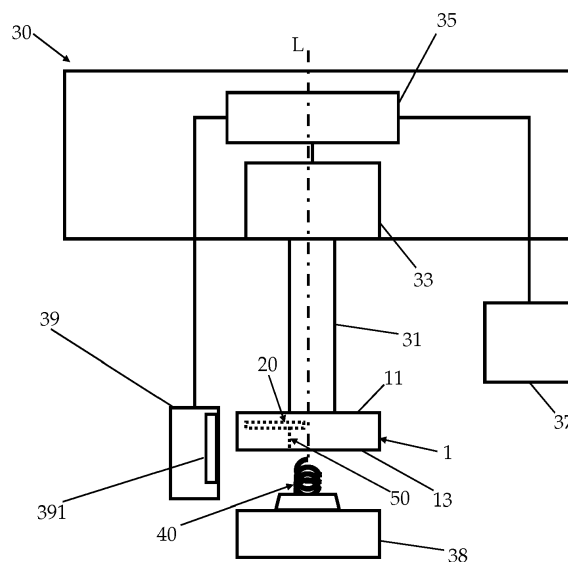


Fig.2

Description

TECHNICAL FIELD

[0001] The present invention relates to the field of tools and tool machines. In particular, the invention relates to a grinding system comprising a grinder and a grinding wheel, and a method to exchange information between the grinder and the grinding wheel of the grinding system.

BACKGROUND

[0002] In the production of mechanical products, the finishing processes of the product - such as deburring, grinding, sharpening and lapping - are fundamental in determining the quality of the same.

[0003] These processes are typically implemented by means of dedicated tool machines, called grinders or grinding machines. In detail, a grinder uses a tool, called grinding wheel, to carry out the finishing process. The grinding wheel has an abrasive surface, typically comprising a mixture of abrasive granules and a binding material. In use, the grinding wheel and a workpiece to be machined are placed in contact with each other and one, or both, are placed in motion. In this way, friction is generated by rubbing between the abrasive surface of the grinding wheel and the product being machined which causes an erosion of the grinding wheel and the desired finish of the product.

[0004] The friction between grinding wheel and product generates heat which can, in some cases, damage the grinding wheel and/or the machined product. To avoid this problem, grinding wheels have been proposed equipped with electronic devices designed to acquire information on the operation of the grinding wheel, for example a working temperature of the grinding wheel, and transmit it to a control unit of the grinder.

[0005] However, the operating conditions of the grinding wheel cause considerable complications in the exchange of signals between the grinding wheel and the grinder. In particular, the work environment is typically saturated with dust and noisy due to the interactions between grinding wheel and product being machined. In addition, during operation the grinding wheel rotates at high speeds and can be displaced along one or more processing axes, as well as being subjected to mechanical stresses of varying intensity due to the interactions between the grinding wheel and the product being machined.

[0006] Therefore, these working conditions make it difficult to implement in a simple and/or economical way efficient communication systems that provide for the transmission of signals by cable, or by optical or sound signalling.

[0007] The United States Patent no. US 7,840,305 describes an abrasive tool for chemical-mechanical polishing (cmp), comprising a substrate with two main opposite surfaces, and an abrasive material superimposed on at

least one of the two main surfaces. Furthermore, the tool comprises a means, for example an RFID tag or a sensor, adapted to provide information on the cmp process to a transmitter positioned near the substrate. The transmitter is adapted to receive cmp information via wireless communication and transmitting it to a remote receiver.

[0008] The United States patent application US 2018/158707 describes a system for semiconductor chip processing equipped with apparatus for detecting, authenticating and tracing processing components comprised in the system. In particular, a chemical mechanical polishing system (CMP) is illustrated which comprises a plurality of remote communication devices (RFID) incorporated in a polishing disc and configured to communicate with one or more interrogation devices of a plurality of interrogation devices integrated in or coupled to CMP system components.

[0009] Although it allows overcoming some of the problems indicated above, the solutions proposed in the United States patent US 7,840,305 and in the United States patent application US 2018/158707 do not explain how to solve the problems related to the variability of the intensity of the signals exchanged between TAG and the RFID reader or one of the RFID readers. The movement of the grinding wheel when grinding a workpiece, and the consequent variation in the distance between TAG and the RFID reader, as well as the presence in variable amounts of dust and processing scraps, in particular metal scraps, affect the quality of the transmitted signal and make therefore a correct transmission of data between grinding wheel and grinder difficult.

OBJECTS AND SUMMARY OF THE INVENTION

[0010] An object of the present invention is to overcome the disadvantages of the prior art.

[0011] In particular, it is an object of the present invention to present a grinding system comprising a grinder and a grinding wheel which guarantees an exchange of information between grinding wheel and grinder that is reliable and robust.

[0012] It is also an object of the present invention to present a grinding system which comprises a communication system between grinding wheel and grinder which is simple to make but at the same time robust to interferences and insensitive to disturbances due to the working conditions of the system.

[0013] Furthermore, it is a further object of the present invention to present a method for transmitting information between the grinder and the grinding wheel in a simple and reliable manner.

[0014] These and other objects of the present invention are reached by a system and a method incorporating the characteristics of the appended claims, which form an integral part of the present description.

[0015] A first aspect of the invention concerns a grinding system, comprising a grinding wheel and a grinder. The grinder comprising an actuating arm adapted to re-

ceive an abrasive grinding wheel, an actuator coupled to the actuating arm to rotatably drive or translate it along a driving axis, and a transceiver unit (hereinafter also referred to as PickUP) adapted to receive and transmit electromagnetic signals. The grinding wheel is fixed to the actuating arm of the grinder and comprises a body which has at least one abrasive surface intended to come into contact with a workpiece to be machined, and an electronic unit (hereinafter also referred to as TAG) coupled to the body. Advantageously, the transceiver unit is located in the grinder so as to be separated from the abrasive grinding wheel and comprises at least one resonant circuit, while the electronic unit of the grinding wheel comprises a further resonant circuit having a resonance frequency equal to or close to (within a range going from -15% to +15%, or better going from -10% to +10%) the resonance frequency of the at least one resonant circuit of the transceiver unit. This allows information to be exchanged between the electronic unit of the grinding wheel and the transceiver unit of the grinder. The grinder further comprises a movement means suitable for moving the transceiver unit along an axis parallel to the driving axis of the actuating arm, and for maintaining the at least one resonant circuit of the grinder and the further resonant circuit of the grinding wheel aligned during a translation of the actuating arm.

[0016] This solution allows a good communication to be obtained between the devices despite the fact that the grinding wheel is translated along a driving axis to compensate for wear of the abrasive material.

[0017] In one embodiment the movement means is integral with the actuating arm. This allows the resonant circuits of the grinding wheel and the grinder to be maintained always aligned on a same plane transverse to the driving axis, guaranteeing a high electromagnetic coupling. At each rotation of the grinding wheel, therefore, PickUP and TAG are able to communicate for a time interval Δt dependent on the rotation speed of the grinding wheel.

[0018] In one embodiment, the grinder further comprises an electronic control unit suitable for supplying the transceiver unit with power, the electronic control unit being fixed and connected to the transceiver unit by sufficiently long cables to maintain the connection during the movement of the receiver unit between two end-of-travel ends.

[0019] This allows the electronic control unit to be maintained fixed and only the transceiver unit to be moved. This offers several advantages: firstly, the electronic unit can be supplied with power in a simple way, secondly the electronic unit can be used for other functions of the grinder, so this solution makes it possible to upgrade an existing grinder by simply reconfiguring or replacing the existing electronic unit and connecting a mobile transceiver unit thereto.

[0020] Advantageously, in one embodiment the transceiver unit further comprises a signal processing module, connected to the at least one resonant circuit and to a

switching element. The signal processing module is configured to switch, as a function of the value of a bit to be transmitted, the switching element from a first condition in which the at least one resonant circuit is connected to an oscillator module, to a second condition in which the at least one resonant circuit is connected to a ground potential. The signal processing module is configured to control the switching of the switch as a function of a value of the bit to be transmitted.

[0021] This solution allows implementing a communication protocol based on the amplitude modulation of a resonance signal that is generated when the resonant circuits of the grinding wheel and the grinder are coupled.

[0022] In a preferred embodiment, the signal processing module of the PickUP is configured to monitor the amplitude variations of at least one resonance signal (sn) sensed at said at least one resonant circuit and to switch the aforesaid switching element after detecting a first amplitude variation of said at least one resonance signal (sn).

[0023] This solution allows implementing a fast and effective communication protocol that does not require identification steps or data exchange prior to communication, as instead occurs in some existing RFID systems. Data transmission occurs, in fact, when the system detects the coupling between the resonant circuits, that is an increase in the amplitude of the monitored resonant signal.

[0024] Advantageously, in one embodiment the electronic unit of the grinding wheel comprises a second signal processing module coupled to a respective further resonant circuit to monitor a second resonance signal sensed at the aforesaid further resonant circuit. The signal processing module is also coupled to a switch element, and is configured to switch, as a function of a value of the bit to be transmitted, the switch element between a closed state, in which it short circuits the resonant circuit, and an open state in which it does not short circuit the resonant circuit. The signal processing module is configured to switch the switch element based on a value of the bit to be transmitted. In particular, the second signal processing module is configured to monitor the amplitude variations of said second resonance signal sensed at said further resonant circuit and to switch the switch after detecting a first amplitude variation of said second resonance signal.

[0025] This solution thus allows the electronic unit (TAG) of the grinding wheel to transmit information to the transceiver unit (PickUP) of the grinder, and accordingly to the latter's control unit, which can thus use the information coming from the grinding wheel to control its operation, for example, change the rotation speed of the actuating arm.

[0026] Advantageously, the control unit of the grinding wheel comprises a logic module, connected to the second signal processing module to exchange data received and to be transmitted, and a measuring circuitry for measuring a temperature of the abrasive surface of the grind-

ing wheel and connected to the logic module for providing a temperature measurement. Preferably, the measuring circuitry comprises a temperature sensor arranged in a seat formed in the grinding wheel body and a probe made of a good heat conducting material. The probe is thermally connected to the temperature sensor and passes through the grinding wheel body from the abrasive surface to the temperature sensor. The second signal processing module switches the switch to transmit a plurality of bits corresponding to the temperature measurement performed by said measuring circuitry.

[0027] In one embodiment, the electronic unit (TAG) of the grinding wheel comprises a battery which supplies electrical energy necessary for the operation of the same electronic unit. Preferably, a switch element is coupled to the battery and is adapted to selectively enable the supply of electrical energy. Advantageously, an enabling assembly is coupled to the switch element to close it at an intensity of the vibrations indicative of an actuation of the grinding wheel or due to the effect of the centrifugal force developed during its rotation.

[0028] Thanks to this solution it is possible to use a battery power supply and therefore to ensure sufficient and substantially uniform electrical energy for the operation of the electronic unit and at the same time to guarantee a consumption of electrical energy limited to the periods of use of the grinding wheel e, therefore, an efficient use of the electrical energy stored in the battery.

[0029] In one embodiment, the electronic unit includes an energy harvesting system. Advantageously, the energy harvesting system is adapted to both generate electrical energy from sources external to the electronic unit such as, for example, vibrations to which the grinding wheel is subjected during operation, and to harvest electromagnetic energy exchanged during the time interval Δt , at which PICKUP and TAG are aligned.

[0030] In this way, it is possible to guarantee at least part of the electrical energy necessary for the operation of the electronic unit thus reducing, or eliminating, a dependence on batteries of the electronic unit.

[0031] Another aspect of the present invention proposes a method for exchanging information between a grinder and a grinding wheel.

[0032] Further features and advantages of the present invention will be more apparent from the description of the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] The invention will be described below with reference to some examples, provided for explanatory and non-limiting purposes, and illustrated in the appended drawings. These drawings illustrate different aspects and embodiments of the present invention and, where appropriate, reference numerals illustrating structures, components, materials and/or similar elements in different figures are indicated by similar reference numerals.

Figure 1 is a perspective view of an abrasive grinding wheel according to an embodiment of the present invention;

Figure 2 is a schematic representation of a grinder according to an embodiment of the present invention. In this figure, the grinder drives the grinding wheel of Figure 1;

Figure 3 is a schematic block representation of a grinding wheel and a grinder according to an embodiment of the present invention;

Figure 4 is a graph showing waveforms of signals transmitted from the grinder to the grinding wheel;

Figures 5A and 5B illustrate a flowchart of a method for the transmission of information from the grinder to the grinding wheel according to an embodiment of the present invention;

Figure 6 is a graph showing waveforms of signals transmitted from the grinding wheel to the grinder, and

Figures 7A and 7B illustrate a flowchart of a method for the transmission of information from the grinder to the grinding wheel according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0034] While the invention is susceptible to various modifications and alternative constructions, some preferred embodiments are shown in the drawings and are described hereinbelow in detail. It is in any case to be noted that there is no intention to limit the invention to the specific embodiment illustrated, rather on the contrary, the invention intends covering all the modifications, alternative and equivalent constructions that fall within the scope of the invention as defined in the claims.

[0035] The use of "for example", "etc.", "or" indicates non-exclusive alternatives without limitation, unless otherwise indicated. The use of "includes" means "includes, but not limited to", unless otherwise indicated.

[0036] Figure 1 is a perspective view of an abrasive grinding wheel 1 according to an embodiment of the present invention. The grinding wheel 1 comprises a typically disc-shaped body 10, which has a first main surface 11 and a second main surface, or abrasive surface 13, mutually opposite and separated by a side wall 15. In the example considered, the surfaces 11 and 13 are substantially circular with corresponding areas, and have a diameter greater than the distance separating them, that is the height of the side wall 15.

[0037] The body 10 of the grinding wheel 1 is at least partially made of abrasive material. In particular, the body 10 comprises a portion of abrasive material which ex-

tends from the abrasive surface 13 towards the first main surface 11. In one embodiment, this portion of abrasive material can correspond to the entire body. The abrasive material is suitable for use in subtractive manufacturing techniques, such as deburring, grinding, sharpening, lapping and the like. Typically, the abrasive material comprises a mixture of abrasive granules - having a hardness selected according to the material to be machined - and a support material, adapted to act as a binder in order to keep the granules joined in a predefined form.

[0038] Furthermore, the grinding wheel 1 comprises a connecting element 17, for example a through hole or a hub, preferably with a longitudinal axis coaxial to an axis L which corresponds, in use, to the axis of rotation of the grinding wheel 1.

[0039] In the example of figure 1, the connecting element 17 is a through hole that joins the centres of the surfaces 11 and 13. By means of this through hole, the grinding wheel 1 can be connected to a grinder 30, shown in Figure 3 and described below. For example, the grinder 30 can be provided with an arm that fits into the through hole 17; the through hole is fitted into the arm until abutting against an abutment surface of the arm and is fixed in position by means of a nut screwed on the free end of the arm.

[0040] In an alternative embodiment (not shown), the first surface can be fixed to a flange of the grinder by means of nuts embedded in the mixture of the grinding wheel. Said flange comprises or is connected to the connecting element 17 mentioned above in order to be mechanically connected to the grinder 30.

[0041] An electronic unit 20 is integrated in the grinding wheel 1, for example it is housed inside a seat which opens onto the side surface 15 of the body 10. Advantageously, as shown in Figure 2, the seat of the electronic unit 20 is arranged in proximity of the first main surface 11 and, therefore, distal to the abrasive surface 13 which is intended to come into contact with one or more products or workpieces 40 to be machined. In the aforementioned alternative embodiment, in which fixing nuts are embedded in the body of the grinding wheel, the housing seat of the electronic unit is positioned in the body portion 10 comprised between the first main surface 11 and the nut that is the furthest from this first main surface 11. In this way, the useful abrasive portion of the body 10 is maximized.

[0042] In detail, as it is visible in Figure 3, the electronic unit 20 (hereinafter also referred to as TAG) comprises a logic module 21, adapted to control the operation of the entire electronic unit 20, a power supply circuitry 23, adapted to supply electrical energy necessary for the operation of the components of the electronic unit, a measuring circuitry 25, adapted to measure a temperature of the grinding wheel 1, a communication circuitry 27, adapted to exchange data with the grinder 30, and optionally an RFID module 29 adapted to store and transmit data concerning the grinding wheel 1. Furthermore, the logic module 21 is connected to the communication cir-

cuitry 27 and to the RFID module 29 for exchanging data therewith, and to the measuring circuitry 25 for receiving temperature measurements.

[0043] The logic module 21 can comprise one or more from among a microcontroller, a microprocessor, an ASIC, an FPGA, a memory and, possibly, one or more ancillary circuits, such as a circuit for generating a synchrony signal (clock), amplifiers for input/output signals, etc.

[0044] The power supply circuitry 23 comprises a battery 231, a switch element, for example a transistor, 233, a piezoelectric sensor 235 and a conditioning module of the piezoelectric signal 237. The battery 231 is connected through a first terminal to the remaining components of the electronic unit 20, while a reference terminal (or ground) is selectively connected to a second terminal through the transistor 233. A control terminal of the transistor 233 is connected to the conditioning module of the piezoelectric signal 237 to which the piezoelectric sensor 235 is also connected. Briefly, the transistor 233, the conditioning module of the piezoelectric signal 237 and the piezoelectric sensor 235 form an enabling assembly which allows the electronic unit 20 to be supplied with power only when the grinding wheel 1 is used. In particular, the piezoelectric sensor 235 generates an electrical voltage proportional to the mechanical stresses to which the grinding wheel 1 is subjected. The conditioning module of the piezoelectric signal 237 is designed to adapt this electrical voltage so that, for a predetermined intensity of the vibrations - corresponding to an actuation of the grinding wheel (1), the transistor 233 enters into conduction, thereby allowing the battery to supply electrical energy to the other components of the electronic unit 20. As an alternative to the piezoelectric sensor 235, a switch device activated by the centrifugal force developed during the rotation of the grinding wheel can be advantageously used.

[0045] The measuring circuitry 25 comprises a temperature sensor 251 connected to a conditioning module of the temperature signal 253. The temperature sensor 251 preferably comprises a thermistor of the PTC type or, alternatively of the NTC type, and is connected to the conditioning module of the temperature signal 253. In turn, the conditioning module of the temperature signal 253 is connected to the logic module 21. During operation, the temperature sensor 251 generates an electrical voltage proportional to the temperature of the grinding wheel 1. The conditioning module of the temperature signal 253 is designed to adapt, for example to amplify or linearise, such electrical voltage so that it is correctly acquired by the logic module 21. Preferably, the temperature sensor 251 is mounted on the electronic board 20 so as to face the abrasive surface 13 when the electronic unit 20 is associated with the grinding wheel 1. The logic module 21 can also contain predictive algorithms that allow anticipating the temperature reading in order to take into account the delay due to the limited thermal diffusivity of the probe 50.

[0046] The communication circuitry 27 comprises a resonant circuit 271, connected in parallel to a switch element 273, which are both connected to a signal processing module 275. The signal processing module 275 is connected to the logic module 21 to exchange data therewith and can comprise signal demodulation circuits, and control circuitry of the switch element 273 for signal modulation. In particular, the signal processing module 275 comprises circuits suitable for modulating in amplitude a signal to be transmitted to the Pickup, and for demodulating in amplitude the signals coming from the Pickup.

[0047] The RFID module 29 comprises a non-volatile memory in which the ID identification data of the grinding wheel 1 such as a model code and/or operating parameters OP, are stored, for example an indication of the hardness of the grinding wheel 1, the dimensions of the abrasive surface 13, the height of the side wall 15, the rotation speed for which the wheel is designed, etc. In one embodiment, the RFID module also stores a threshold temperature value T_{TH} among the operating parameters OP of the grinding wheel 1 indicative of a maximum surface temperature T_s that can be reached by the abrasive surface 13 without incurring damage and/or deformation. In addition or as an alternative, the operating parameters OP of the grinding wheel 1 can comprise a second threshold value T_{MIN} indicative of a limit surface temperature T_s below which the performance and/or the productivity of the grinding wheel 1 is reduced. The ID identification data and the operating parameters OP can be read at any time - for example, during storage, distribution or during the installation of the grinding wheel 1 - also by means of an RFID reader device independent of the grinder 30 without requiring the activation of the rest of the electronic unit 20.

[0048] In a preferred embodiment of the present invention, the electronic unit also comprises a probe 50. The probe 50 extends in the grinding wheel 1 starting from the abrasive surface 13 up to the temperature sensor 29. In particular, the probe 50 is thermally coupled to a detection surface of the temperature sensor 29, that is the thermistor in the example considered. Preferably, a first end of the probe 50 is in contact with the thermistor of the temperature sensor 29, while a second end is flush with the abrasive surface 13.

[0049] Preferably, the probe 50 extends in a direction substantially transverse to the main surfaces 11 and 13 of the body 10 of the grinding wheel 1, therefore substantially parallel to the axis L of the grinding wheel 1. In particular, the probe 50 has an elongated conformation, e.g. like a wire or a stick, with a main dimension substantially greater than the others.

[0050] Advantageously, the probe 50 is made of a material that is a good thermal conductor. The probe 50 transfers the heat which develops at the abrasive surface 13 directly to the thermistor of the temperature sensor 29. Consequently, the temperature sensor 29 detects a temperature corresponding to the surface temperature

T_s of the abrasive surface 13.

[0051] With reference to Figures 2 and 3, in use, the grinding wheel 1 is mounted on an actuating arm 31 of the grinder 30 to form a grinding system adapted to machine one or more products, or workpieces 40. For example, the actuating arm 31 comprises a pin which is inserted in the connecting element 17, and clamping elements which keep the grinding wheel 1 integral with the actuating arm 31.

[0052] The actuating arm 31 is operatively coupled to an actuator 33, for example an electric actuator. Typically, the actuator 33 is configured to impart a rotation about a driving axis of the grinding wheel - corresponding to the axis L - of the grinding wheel 1 mounted on the actuating arm 31, and a translational movement, for example along the same driving axis of the actuating arm 31.

[0053] The grinder 30 comprises an electronic control unit 35, which is configured to control the operation of the grinder 30.

[0054] The control unit 35 of the grinder 30 can comprise one or more from among a microcontroller, a microprocessor, an ASIC, an FPGA, a PLC and, possibly, one or more ancillary circuits, such as a circuit for generating a synchrony signal (clock), amplifiers for input/output signals, power supply circuitry, etc...

[0055] Advantageously, the grinder 30 comprises a user interface 37 provided with input/output elements (not shown, for example a keypad and a screen) and operatively coupled to the control unit 35 to allow an operator (not shown) to check and/or set an operation of the grinder 30.

[0056] Furthermore, the grinder 30 can comprise - or be associated with - a spindle 38 adapted to keep the workpiece 40 to be machined in position, for example a spring. Advantageously, the spindle 38 is positioned so that the second surface 13 of the grinding wheel 1, mounted on the actuating arm 31, faces the workpiece 40 to be machined. The spindle 38 can be replaced by other positioning devices able to keep the workpiece to be machined in position during the interaction with the abrasive surface of the grinding wheel. For example, the spindle can be replaced by a pair of jaws. In an alternative embodiment (not shown), the workpieces to be machined (e.g. springs) are positioned on a workpiece-holder disc able to house different workpieces to be machined. The workpiece-holder disc preferably has an axis of rotation parallel to and spaced from the axis L of the grinding wheel itself. The continuous rotation of the workpiece-holder disc progressively subjects the workpieces to the abrasive action of the grinding wheel.

[0057] The grinder 30 also comprises a transceiver unit 39 operatively coupled to the control unit 35, which allows the exchange of information between the electronic unit 20 of the grinding wheel 1 and the control unit 35 of the grinder 30 as described below.

[0058] The transceiver unit 39 comprises a plurality of series resonant circuits 391 - ten in the non-limiting example of Figure 2 -, an oscillator module 395, a signal

processing module 393 and a switching element 397. In detail, the resonant circuits 391 are arranged in parallel with each other between the reference potential (or ground) of the transceiver unit 39 and a common terminal of the switching element 397. The latter has a second terminal which can be connected alternately to the oscillator module 395 and a third terminal connected to the reference potential. Furthermore, each resonant circuit 391 is connected, via a respective intermediate terminal 3910, to a corresponding reading terminal of the signal processing module 393.

[0059] In turn, the signal processing module 393 is connected to the switching element 397 to control it.

[0060] Finally, the control unit 35 is connected both to the oscillator module 395 to supply it with power, and to the signal processing module 393 to supply it with power and exchange data with the latter.

[0061] In an alternative embodiment, the signal processing module 393 can be implemented in the control unit 35 of the grinder 30 instead of in the transceiver unit 39.

[0062] The transceiver unit 39 is positioned on the grinder 30 so as to be in proximity of the side wall 15 of the grinding wheel 1, when the latter is mounted on the actuating arm 31. Advantageously, the transceiver unit 39 is arranged in the grinder 30 in a side wall thereof in a position radial to the grinding wheel 1; for example, so as to be at a distance d - preferably, in the order of centimetres - from the side wall of the grinding wheel 1 - as shown in Figures 2 and 3. Alternatively, the transceiver unit 39 can be arranged in another position proximal to the grinding wheel 1, for example on the actuating arm. In other words, the transceiver unit 39 is located in the grinder 30 so as to be separated from the abrasive grinding wheel 1 fixed thereon. In particular, the term 'separate' means that the transceiver unit 39 and the abrasive grinding wheel 1 are not in direct contact nor are there any kind of wirings between them.

[0063] In particular, the resonant circuits 391 are arranged aligned - or with at least one of their inductive elements aligned - along a direction parallel to the driving axis of the actuating arm 31 and therefore to the axis L of the grinding wheel 1 coupled thereto. In this way, it is possible to guarantee a reliable electromagnetic coupling between the resonant circuit 271 of the communication circuitry 27 and one or more from among the resonant circuits 391 of the transceiver unit 39, even when the grinding wheel 1 and, therefore, the communication module 27, is displaced parallel to the axis of rotation. In fact, operationally, as the grinding wheel wears out, the grinder lowers the grinding wheel support to keep the abrasive surface 13 in contact with the workpieces to be machined. This involves displacing the resonant circuit in the direction of the workpiece to be machined. As the resonant circuit 271 lowers, it is coupled to a different resonant circuit 391. The transceiver unit 39 comprises a number of resonant circuits 391 suitably arranged so as to ensure an efficient electromagnetic coupling between resonant

circuits 391 and 271 for the entire travel of the grinding wheel 1 in the grinder 30. Summarizing, the resonant circuits of the transceiver unit are arranged so that the resonant circuit of the communication circuitry 27 is electromagnetically coupled to at least one resonant circuit 391 of the transceiver unit 39 along the entire travel allowed, in use, to the abrasive grinding wheel 1.

[0064] The switch element 397 normally connects the oscillator module 395 to the resonant circuits 391 providing them with a carrier signal having a frequency substantially corresponding to the resonance frequency f_R of the resonant circuits 391 and 271. The term substantially corresponding is herein understood to mean that the resonance frequencies of the resonant circuits 391 and 271 differ by a maximum of 15%, or more preferably differ by a maximum of 10%.

[0065] In use, the control unit 35 of the grinder 30 drives the actuator 33 to put the actuating arm 31 and the grinding wheel 1 with it in a rotational and/or linear motion so as to bring the grinding wheel 1 in contact with the workpiece 40 to be machined. In order to effectively machine the workpiece 40, the control unit 35 of the grinder 30 exchanges information with - or at least receives information from - the electronic unit 20 of the grinding wheel 1. The control unit 35 uses this information to adjust the actuation of the actuator 31. Advantageously, the electronic unit 20 of the grinding wheel 1 and the transceiver unit 39 of the grinder 30 exchange information in a reliable and effective manner. The information transmitted by the electronic unit 20 of the grinding wheel 1 is then transferred from the transceiver unit 39 to the control unit 35 and, vice versa, the information provided by the control unit 35 is transmitted to the electronic unit 20 of the grinding wheel 1 from the transceiver unit 39.

[0066] In the preferred embodiment, the control unit 35 and the electronic unit 20 exchange information (for example binary data) by exploiting the electromagnetic coupling between the resonant circuit 271 and one or more of the resonant circuits 391. For this purpose, the inductive L_T , the capacitive C_T and the resistive R_T elements of the parallel resonant circuit 271 are dimensioned to resonate at the same frequency f_R at which the inductive L_n , the capacitive C_n and the resistive R_n elements (with $n = [1, 2, \dots, 10]$ in the considered example) of each series resonant circuit 391 resonate.

[0067] The resonant circuits are able to periodically couple to each other for a communication time interval Δt . The periodicity of the coupling is equal to the rotation time T in which the grinding wheel 1 performs a rotation. In detail, during the rotation of the grinding wheel, the resonant circuit 271 periodically passes in a position proximal to the resonant circuits 391. As the grinding wheel rotates, the resonant circuit 271 approaches the resonant circuits 391 and coupled thereto; in these conditions, data transmission is now possible. As the rotation continues, the resonant circuit 271 begins to move away, so that after a communication time Δt the two resonant circuits are sufficiently far away so that they are no longer

coupled. In these conditions, data transmission is not possible.

[0068] The control unit 35, through the transceiver unit 39, and the electronic unit 20 are configured to exchange information, for example an information corresponding to a single binary data, or bit during one or more communication time intervals Δt . Preferably, the control unit 35 is configured to operate as a main or master unit, while the electronic unit 20 is configured to operate as a secondary or slave unit.

[0069] Referring to Figures 4, 5A and 5B, in the case of transmission from the transceiver unit 39a to the electronic unit 20, the signal processing module 393 initially receives (block 601) from the control unit 35 the information to be transmitted, for example a string of one or more bits to be transmitted. In the example considered, the information is transmitted sequentially - for example, a bit Btx at a time-, each during a respective communication time interval Δt .

[0070] As illustrated in Figure 4, when the electronic unit 20 of the grinding wheel 1 passes in proximity of the resonant circuits 391, through the region which from now on we will define as operational, during the communication time interval Δt , one or more resonant circuits 391 resonate with the resonant circuit 271. The electromagnetic coupling between the resonant circuits of the TAG and the Pickup causes an amplitude variation of one or more of the resonance signals s_n (indicated with COIL1, COIL2,...COIL10 in Figure 4) provided by the resonant circuits 391 and a corresponding variation in the amplitude of the resonance signal s_m provided by the resonant circuit 271 of the electronic unit 20.

[0071] The signal processing module 393 of the transceiver unit 39 is configured to select (block 603) at least one resonance signal s_n , provided by a respective resonant circuit 391, to be used. Alternatively, the signal processing module 393 of the transceiver unit 39 is designed to make the sum of the signals s_n coming from the resonant circuits 391, so that, during the transition from a resonant circuit to the other, the amplitude of the demodulated sum signal remains almost constant.

[0072] The signal processing module 393 generates (block 606) a digital signal D_n based on the resonance signal s_n selected, or based on the sum of the resonance signals s_n received as input in the alternative described above. In detail, the signal processing module 393 is configured to demodulate - for example in amplitude - the resonance signal s_n - or the sum of the signals s_n - obtaining a corresponding demodulated signal sd_n . The demodulated signal sd_n is digitized by the signal processing module 393, which converts the crossings of a threshold value A_{thn} of the demodulated signal sd_n into corresponding switchings of the digital signal D_n from a low logic value (for example, the reference voltage) to a high logic value (for example, the power supply voltage) or vice versa.

[0073] Furthermore, the signal processing module 393 is configured to identify (decision block 609) the initial

time instant to of the communication time interval Δt . For example, the signal processing module is configured to detect a switching from a first logic value to a second logic value of the digital signal D_n , corresponding to a (first) crossing of the threshold value A_{thn} by a demodulated signal sd_n . In this embodiment, therefore, the crossing of the threshold value A_{thn} by the demodulated signal sd_n is then considered the start of the communication time interval Δt .

[0074] If the signal processing module 393 detects the start of the communication time interval Δt (output branch Y of the decision block 609 and time instant to in Figure 4), the signal processing module 393 selects (block 612) the information to be transmitted. In the example considered, the signal processing module 393 selects the logic value of a bit of the bit string to be transmitted received from the control unit 35, for example, a logic "zero" in the left portion of Figure 4 and a logic "one" in the right portion of Figure 4.

[0075] The signal processing module 393 is configured to measure an elapsed time of the communication time interval to detect (decision block 615) that a guard time T_p - lower than Δt - has been reached by the time instant to.

[0076] After the guard time T_p (output branch Y of the decision block 615) has elapsed, the signal processing module 393 is configured to modify the amplitude of the resonance signals s_n in order to transmit a bit having the desired value. In the example considered, the signal processing module 393 compares (decision block 618) the logic value of the bit to be transmitted and the logic value of the digital signal D_n with the instant T_p - for example, sampling the digital signal D_n - and determines the need to modify the amplitude trend of the resonance signal s_n based on a discrepancy between these logic values.

[0077] In the case wherein the logic value of the bit to be transmitted and the logic value of the digital signal D_n do not correspond (output branch N of the decision block 618), the signal processing module 393 maintains (block 621) the resonance signal s_n unchanged for the duration of the communication time interval Δt . In particular, the signal processing module 393 maintains the switching element 397 closed between the oscillator module 395 and the resonant circuits 391, thereby transmitting a bit at a first logic value, for example 0 as illustrated in the left portion of Figure 4.

[0078] Otherwise (output branch Y of the decision block 618), the signal processing module 393 is configured to alter (block 624) the resonance signal s_n , thereby transmitting a bit at a second logic value, for example 1, as illustrated in the right portion of Figure 4. In detail, the signal processing module 393 is configured to switch the switching element 397 so that it connects the resonant circuits 391 to the reference potential, rather than to the oscillator module 393, for example by switching a value of a control signal sp of the switching element 397. This quickly cancels out the amplitude of the resonance signal

s_n and, consequently, the resonance signal s_m on the resonant circuit 271 of the communication module 27. Preferably, the signal processing module 393 is configured to maintain the resonant circuits 391 connected to the reference terminal at least until the end of the communication time interval Δt (that is, the closing time is greater than or equal to the difference between Δt and T_p). This causes the resonance signal s_n to remain nil for the remaining part of the communication time interval Δt (that is, $\Delta t - T_p$).

[0079] In parallel, the signal processing module 275 of the communication module 27 is configured to generate (block 627) a digital signal D_m based on the second resonance signal s_m at the ends of the resonant circuit 271. Similarly to what has been described above, the signal processing module 275 of the TAG device is configured to demodulate - for example in amplitude - the resonance signal s_m read at the ends of the resonant circuit 271, obtaining a demodulated signal sd_m . The demodulated signal sd_m is digitized by the signal processing module 393, which converts the crossings of a threshold value A_{thn} of the demodulated signal sd_m into corresponding switchings of the digital signal D_m from a low logic value (for example, the reference voltage) to a high logic value (for example, the power supply voltage) or vice versa.

[0080] Furthermore, the signal processing module 275 is configured to identify (decision block 630) the initial time instant to of the communication time interval Δt for a respective rotation period T of the grinding wheel 1. For example, the signal processing module 275 is configured to detect a switching from a first logic value to a second logic value of the digital signal D_m , that is a (first) crossing of the threshold value A_{thm} by the demodulated signal sd_m , and to consider this logic switching with the start of the communication time interval Δt .

[0081] The signal processing module 275 is configured to measure an elapsed time of the communication time interval in order to detect (decision block 633) that a respective guard time T_T has been reached by the initial instant to of the communication time Δt .

[0082] After the guard time T_T (output branch Y of the decision block 633) has elapsed, the signal processing module 275 identifies (decision block 636) the bit contained in the second resonance signal s_m and records the reception of a bit B_{RX} accordingly to which the high logic value (block 639) or the low logic value (block 642) will be associated. In detail, the signal processing module 275 is configured to determine the logic value of the digital signal D_m . In the case wherein the digital signal D_m has a high logic value, the signal processing module 275 is configured to record in a memory buffer a bit at a low logic value (left portion of Figure 4) or, vice versa, to record a bit at a high logic value if the digital signal D_m has a low logic value (right portion of Figure 4).

[0083] Finally, the signal processing module 275 transfers the bits stored to the logic module 21 of the electronic unit 20 of the grinding wheel 1.

[0084] The method 600 described above is reiterated

(returning to block 603) at each period T until the transmission of the bit string is completed and is implemented each time the control unit 35 transmits a bit string to the transceiver unit 39.

[0085] In a preferred embodiment, the transmission of one or more bits is provided from the electronic unit 20 to the control unit 35 of the grinder 30, preferably upon request of the control unit 35. For example, the control unit 35 is configured to transmit a predetermined bit string to the electronic unit 20 which is interpreted by the logic module 21 as an instruction for the transmission of a datum, for example one or more temperature measurements performed by the measuring circuitry 25.

[0086] The number of bits that can be transmitted is limited by the response speed of the electronic circuits of the involved TAG and PICKUP and by the time Δt available for data exchange. If the rotation speed of the grinding wheel is sufficiently low, it is possible to exchange a complete ASCII character, thereby increasing the rapidity of data exchange by a factor of 8 with respect to the case in which the data exchange is limited to a single bit.

[0087] After that, the transmission of bits from the grinding wheel 1, that is from the TAG, to the grinder 30, through the transceiver unit 39 (Pickup), occurs in a similar way to what previously described for the reverse transmission.

[0088] Referring to the Figures 6, 7A and 7B, the signal processing module 275 of the communication module 27 receives (block 701) from the logic module 21 a string of one or more bits B_{tx} to be transmitted and, possibly, a transmission enabling signal (not shown).

[0089] Furthermore, the signal processing module 275 of the communication module 27 is configured to generate (block 703) a digital signal D_m based on the resonance signal s_m that is generated at the ends of the resonant circuit 271 when it passes through the operational region, during the communication time interval Δt .

[0090] Furthermore, the signal processing module 275 is configured to identify (decision block 706) the start of the communication time interval Δt , in particular the initial time instant t_0 of the communication time interval Δt . The start of the communication time interval Δt is preferably identified using the same criterion adopted in the transceiver unit 39 of the Pickup, for example by verifying that the demodulated signal D_m changes logic value due to the electromagnetic coupling between the resonant circuits of the TAG (271) and the Pickup (391).

[0091] Once the start of the communication time interval Δt (output branch Y of the decision block 706) has been determined, the signal processing module 275 selects (block 709) the information to be transmitted.

[0092] The signal processing module 275 is configured to measure an elapsed time of the communication time interval Δt and to detect (decision block 712) that the guard time T_T has been reached starting from the initial instant to of the communication time Δt . Upon detection that the guard time T_T has been reached (output branch Y of the decision block 712) the signal processing module

275 allows determining (decision block 715) whether the resonance signal s_m must be modified to transmit a bit at the desired logic value, in the same way as described above.

[0093] In the case in which it is not necessary to modify the resonance signal s_m (output branch N of the decision block 715), the signal processing module 275 maintains (block 718) the resonance signal s_n unchanged for the duration of the communication time interval Δt . In particular, the signal processing module 275 maintains the switch element 273 open, thereby transmitting a bit at a first logic value, for example 0 as illustrated in the left portion of Figure 6.

[0094] Otherwise (output branch Y of the decision block 715), the signal processing module 275 is configured to modify (block 721) the resonance signal s_m , thereby transmitting a bit at a second logic value, for example 1, as illustrated in the right portion of Figure 6. In detail, the signal processing module 275 is configured to close the switch element 273 for example by switching a control signal s_t which controls the switch element 273. This forms a short circuit branch in parallel with the resonant circuit 271 and the signal processing module 275. Consequently, the amplitude of the resonance signal s_m cancels out quickly. Preferably, the signal processing module 275 is configured to maintain the switch element 273 closed at least until the end of the communication time interval Δt . This causes the resonance signal s_m to remain nil for the remaining part of the communication time interval Δt (that is for a time $\Delta t - T_p$).

[0095] In parallel, the signal processing module 393 of the transceiver unit 39 is configured to select (block 724) at least one resonance signal s_n , provided by a respective resonant circuit 391, to be used, similarly to what has been described above.

[0096] The signal processing module 393 of the transceiver unit 39 is configured to generate (block 727) a digital signal D_n built following the amplitude demodulation of the sum of one or more resonance signals s_n that develop at the ends of the resonant circuits 391 or, as mentioned above, of a resonance signal s_n selected (for example selected since it has a greater amplitude variation).

[0097] Furthermore, the signal processing module 393 is configured to identify (decision block 730) the start of the communication time Δt for a respective rotation period T of the grinding wheel 1.

[0098] The signal processing module 275 is configured to measure an elapsed time to detect (decision block 733) that the guard time T_p has been reached starting from the initial instant to of the communication time Δt .

[0099] As the guard time T_p has elapsed (output branch Y of the decision block 733), the signal processing module 393 is configured to identify (decision block 736) the bit transmitted by the TAG based on the logic value of the digital signal D_m and record in a memory buffer a bit B_{RX} received at the high logic value (block 739) or at the low logic value (block 742) accordingly.

[0100] The operations described above can be repeated at each rotation of the grinding wheel 1, that is with a period T , so as to transmit the entire bit string (bringing the operation back to block 703).

[0101] The invention thus conceived is susceptible to numerous modifications and variations, all falling within this invention as resulting from the appended claims.

[0102] For example, nothing precludes providing a housing for the electronic unit 20 exposed on the first main surface 11 of the grinding wheel 1.

[0103] In an alternative embodiment (not shown), the electronic unit 20 of the grinding wheel 1 can comprise a different power supply circuitry 23; for example, provided with an energy harvesting system from sources external to the electronic unit 20. For example, the power supply circuitry can comprise one or more piezoelectric elements coupled to an accumulator, for example a capacitor or a supercap, able to accumulate electrical energy generated by the piezoelectric element due to the vibrations of the grinding wheel. Alternatively, the energy used by the power supply circuit of the TAG 20 can be, all or in part, harvested by the resonant circuit 271 during the time communication interval Δt .

[0104] Furthermore, nothing precludes providing a grinder 30 in which the spindle 38, which receives the workpiece 40 to be machined, is movable, in particular can be actuated in rotation and/or rigidly translatable in the space. In detail, the movable spindle 38 can be implemented in a grinder comprising the movable actuating arm 31 described above or, alternatively, in a grinder with a fixed support arm. As a further alternative, the workpieces to be machined can be arranged on a conveyor belt, so as to be brought sequentially into an operational position so as to be machined by the grinder 30.

[0105] Furthermore, it is possible to equip the grinder 30 with a movement means suitable for moving the transceiver unit 39 along an axis parallel to the driving axis (L) of the actuating arm, so as to maintain at least one of the resonance circuits 391 aligned with the resonance circuit 271 of the grinding wheel during a translation of the actuating arm. The two circuits are considered to be maintained "aligned" if, during their movement, a point of the resonant circuit 271 and a point of the at least one resonant circuit 391 lie, at tolerances lower than $\pm 5\%$, on a same plane transverse to the driving axis of the actuating arm. Said in other words, the movement means allows a synchronous movement (or substantially synchronous if the tolerances are considered) of the resonant circuits 271 and 391. Alternatively, in order to avoid mechanical complications, it is possible to use only a resonant circuit 391 whose dimension is sufficient to cover the entire displacement of the TAG 20, along the axis parallel to the axis of rotation, due to the consumption of the grinding wheel.

[0106] The movement means can be equipped with an autonomous movement system (for example it is possible to provide an electric motor controlled by the control unit 35), however to guarantee a better coupling between

the resonant circuits avoiding complications due to an autonomous movement system, the movement means can be integral with the actuating arm. For example, such movement means can comprise a bracket fixed to the actuating arm; the transceiver unit 39 is then mounted on the bracket and is thus translated integrally with the actuating arm.

[0107] It is yet possible to provide for the movement of both the transceiver unit 39 and the control unit 35. However, preferably, the electronic control unit is fixed and connected to the transceiver unit by sufficiently long cables to maintain the connection during the movement of the transceiver unit 39 between two end-of-travel ends.

[0108] Even where a movement means for moving the transceiver unit 39 is provided, instead of providing a plurality of resonant circuits 391 aligned along the driving axis L, it is also possible to provide a resonant circuit 391 only. The communication system and the circuit described above with reference to Figures 4 to 7 does not change except for the number of the resonant circuits 391.

[0109] Finally, all details can be replaced by other technically equivalent elements. For example, nothing precludes providing a grinding wheel 1 with a different conformation, for example with a disc, a cup or a conical shape.

[0110] In an alternative embodiment (not shown), the side wall 15 is used as an abrasive surface. In this case, the electronic unit 20 is arranged in proximity of the connecting element 17 and the probe 50 extends radially from the temperature sensor 251 up to the side wall 15.

[0111] In an alternative embodiment, the transceiver unit 39 and the communication unit 27 are configured to exchange an information comprising more than one bit during a communication time interval Δt . For example, the resonance signals can be modulated to transmit a byte (8 bits).

[0112] In another embodiment, the signal processing module 393 of the transceiver unit 39 is configured to select two or more resonance signals. In this case, the signal processing module 393 can be configured to combine the resonance signals s_n and obtain a single digital reference signal.

[0113] In addition, nothing precludes implementing a procedure which envisages identifying which one/s of the resonant circuits 391 of the transceiver unit 39 couple/s to the resonant circuit 271 of the communication module 27, and determine a position or a direction of movement of the grinding wheel 1, for example to verify the effective positioning of the grinding wheel 1.

[0114] In alternative embodiments, the resonant circuits 391 illustrated in the figures can be replaced by parallel resonant circuits, that is of the resonant circuit type 271 and can be one or more than one. In turn, in other embodiments, the resonant circuit 271 can be of the series type, such as those described above with reference to Figure 3. For the purposes of the present invention, it is therefore sufficient to provide for the TAG

and PickUp to have resonant circuits that can be coupled to generate resonance signals, but the resonant circuits can be of the series type or of the parallel type.

[0115] In conclusion, the materials used, as well as the contingent shapes and dimensions, can be whatever according to the specific implementation requirements without for this reason departing from the scope of protection of the following claims.

Claims

1. Grinding system comprising an abrasive grinding wheel (1) and a grinder (30), wherein the grinder (30) comprises an actuating arm (31) adapted to receive an abrasive grinding wheel (1), an actuator (33) coupled to the actuating arm (31) to rotatably drive or translate it along a driving axis, and a transceiver unit (39) adapted to receive and transmitting electromagnetic signals, wherein the abrasive grinding wheel (1) is fixed to the actuating arm (31) of the grinder (30) and comprises a body (10) which has at least one abrasive surface (13) intended to come into contact with a workpiece to be machined, and an electronic unit (20) coupled to the body (10), wherein the transceiver unit (39) is located in the grinder (30), separated from the abrasive grinding wheel (1), and comprises at least one resonant circuit (391),

characterised in that

the electronic unit (20) of the grinding wheel (1) comprises a further resonant circuit (271) having a resonance frequency equal to or close to, within an interval of $\pm 15\%$, preferably of $\pm 10\%$, with respect to the resonance frequency of the at least one resonant circuit (391) of the transceiver unit (39), so as to allow an exchange of information between the electronic unit (20) of the grinding wheel (1) and the transceiver unit (39) of the grinder (30) and

wherein the grinder further comprises a movement means adapted to move the transceiver unit (39) along an axis parallel to the driving axis of the actuating arm (31), so as to maintain the at least one resonant circuit (391) of the grinder and the further resonance circuit (271) of the grinding wheel (1) aligned during a translation of the actuating arm.

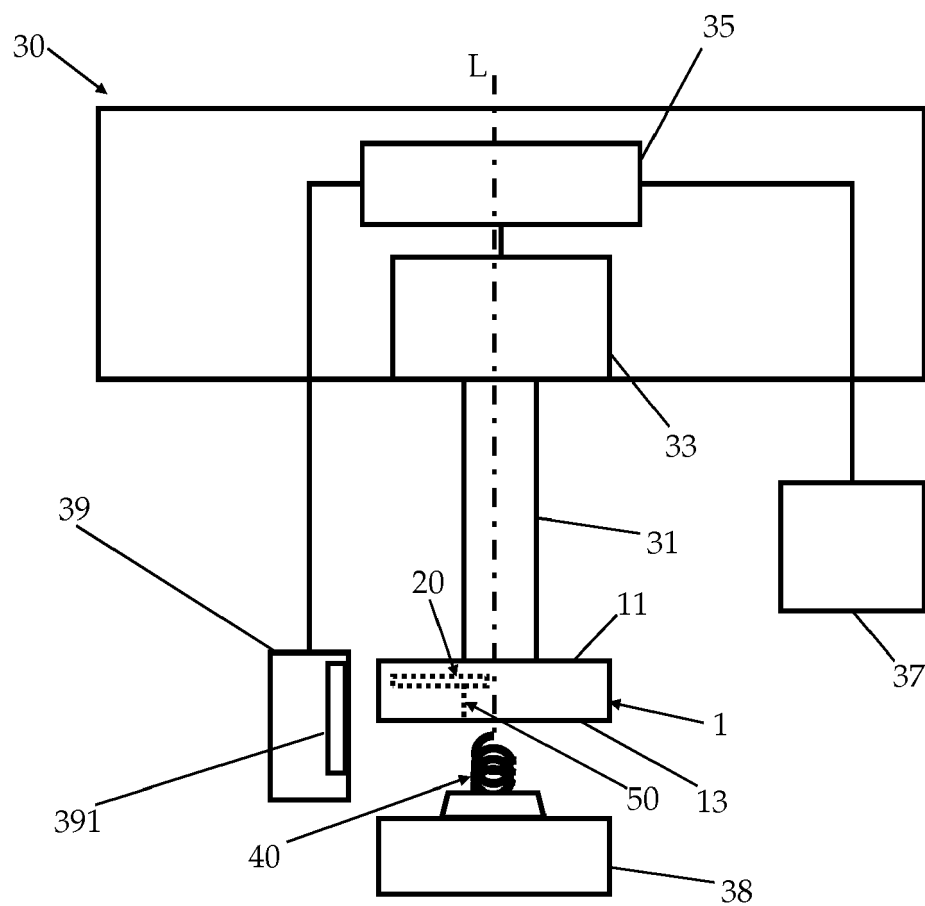
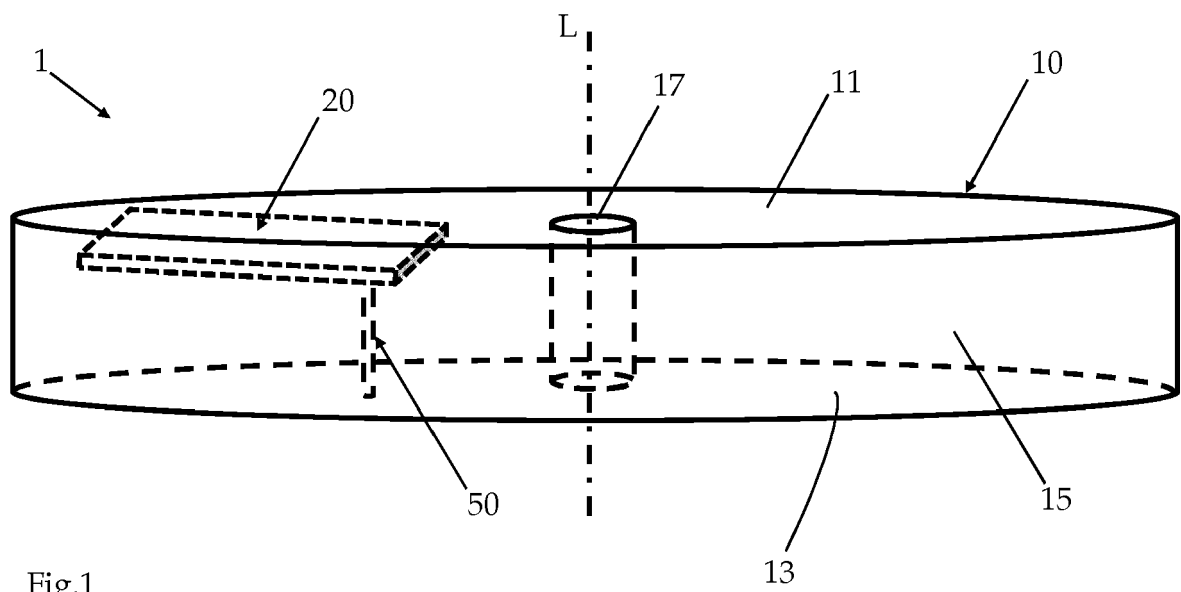
2. System according to claim 1, wherein the movement means is integral with the actuating arm.
3. System according to claim 1 or 2, wherein the grinder further comprises an electronic control unit (35) adapted to supply the transceiver unit (39) with power, the electronic control unit (35) being fixed and

connected to the transceiver unit (39) by sufficiently long cables to maintain the connection during the movement of the receiver unit (39) between two end-of-travel ends.

4. Grinding system according to any one of the preceding claims, wherein the transceiver unit (39) further comprises a signal processing module (393) connected to the at least one resonant circuit (391) and to a switching element (397), wherein the signal processing module (393) is configured to switch, as a function of the value of a bit to be transmitted, the switching element (397) from a first condition in which the at least one resonant circuit (391) is connected to an oscillator module (395), to a second condition in which the at least one resonant circuit (391) is connected to a ground potential.
5. Grinding system according to claim 4, wherein the signal processing module (393) is configured to monitor the amplitude variations of at least one resonance signal (s_n) sensed at said at least one resonance circuit (391) and to switch said switching element after detecting a first amplitude variation of said at least one resonance signal (s_n).
6. Grinding system according to claim 4 or 5, wherein the signal processing module (393) is configured to switch said switch as a function of a value of the bit to be transmitted.
7. Grinding system according to any one of the preceding claims, wherein the electronic unit (20) of the grinding wheel (1) comprises a second signal processing module (275) coupled to said further resonant circuit (271) for monitoring a second resonance signal sensed at said further resonant circuit (271), and a switch element (273), wherein the second signal processing module (275) is configured to switch, as a function of a value of the bit to be transmitted, the switch element (273) between a closed state, in which it short circuits the resonant circuit (271), and an open state in which it does not short circuit the resonant circuit (271), said second signal processing module (275) being configured to switch the switch element based on a value of the bit to be transmitted, and wherein, the second signal processing module (275) is configured to monitor the amplitude variations of said second resonance signal (s_m) sensed at said further resonance circuit (271) and to switch said switch (273) after detecting a first amplitude variation of said second resonance signal (s_m).
8. Grinding system according to claim 7, wherein the control unit (20) further comprises a logic module (21) connected to the second signal processing module (275) for exchanging data re-

ceived and to be transmitted, and a measuring circuitry (25) adapted to measure a temperature of the abrasive surface (13) of the grinding wheel (1) and connected to the logic module (21) to provide a temperature measurement, wherein said measuring circuitry comprises a temperature sensor (251) arranged in a seat formed in the body of the grinding wheel (1) and a probe (50) made of a good heat conducting material, the probe (50) being thermally connected to the temperature sensor (251) and passing through the body (10) of the grinding wheel (1) from the abrasive surface (13) to the temperature sensor (251), and wherein the second signal processing module (275) is configured to switch said switch (273) to transmit a plurality of bits corresponding to said temperature measurement performed by said measuring circuitry (25).

9. Grinding system according to any one of the preceding claims, wherein the electronic unit (20) comprises a battery (231) for supplying electrical operating energy and a switch element (233) coupled to the battery (231) and adapted to selectively enable the supply of electrical energy from the battery (231), and wherein an enabling assembly (231) is coupled to the switch element (233) to close it at an intensity of the vibrations, or alternatively by the centrifugal force, indicative of an actuation of the grinding wheel (1).
10. Grinding system according to any one of the preceding claims, wherein the electronic unit (20) comprises an energy harvesting system, the energy harvesting system being adapted to generate electrical energy from sources external to the electronic unit (20).
11. Grinding system according to claim 10, wherein the energy harvesting system is suitable for generating electrical energy from mechanical vibrations of the grinding wheel.
12. Grinding system according to claim 10 or 11, wherein the energy harvesting system is suitable for generating electrical energy by harvesting it from that exchanged by the resonant circuits during the communication interval.



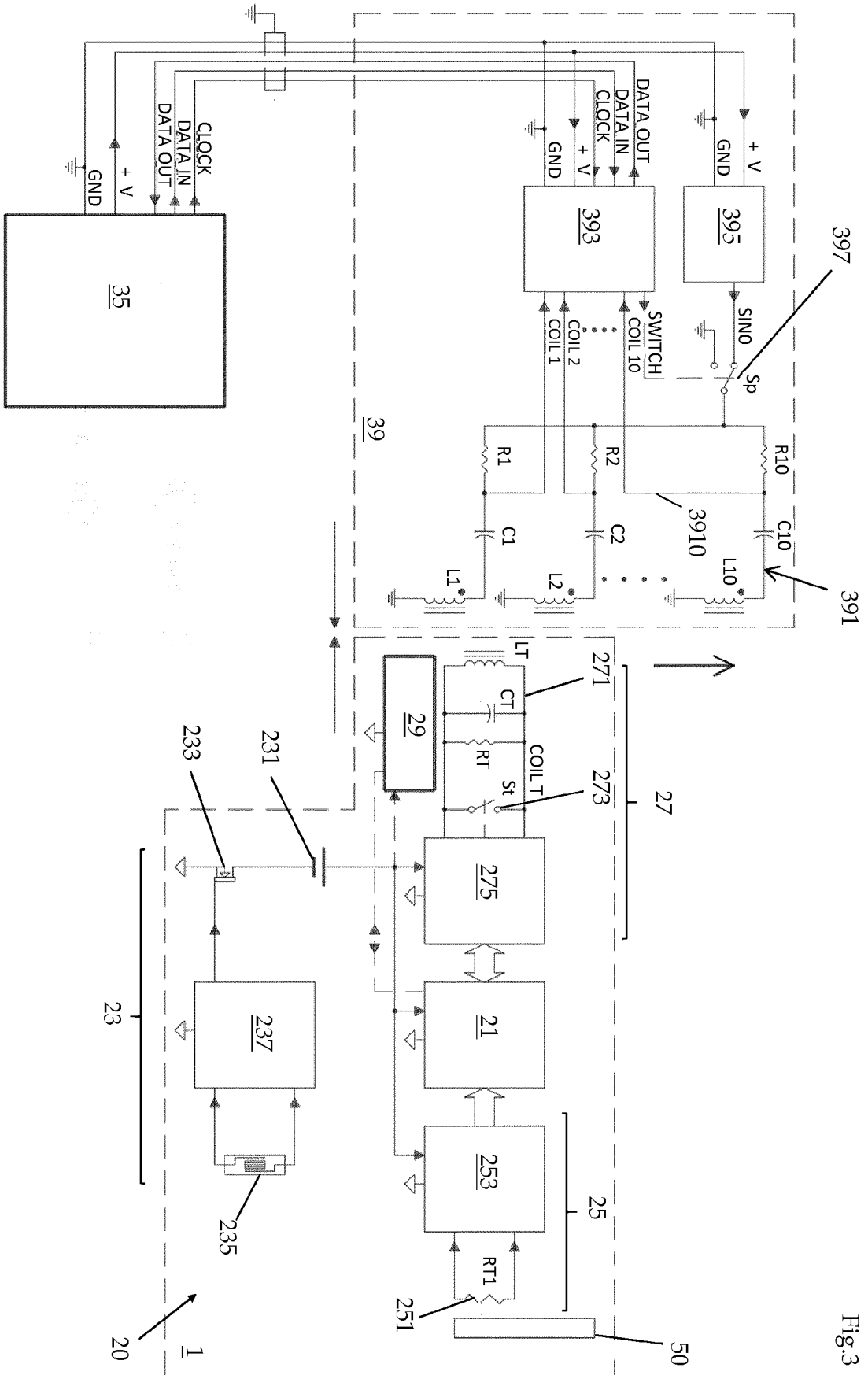


Fig.3

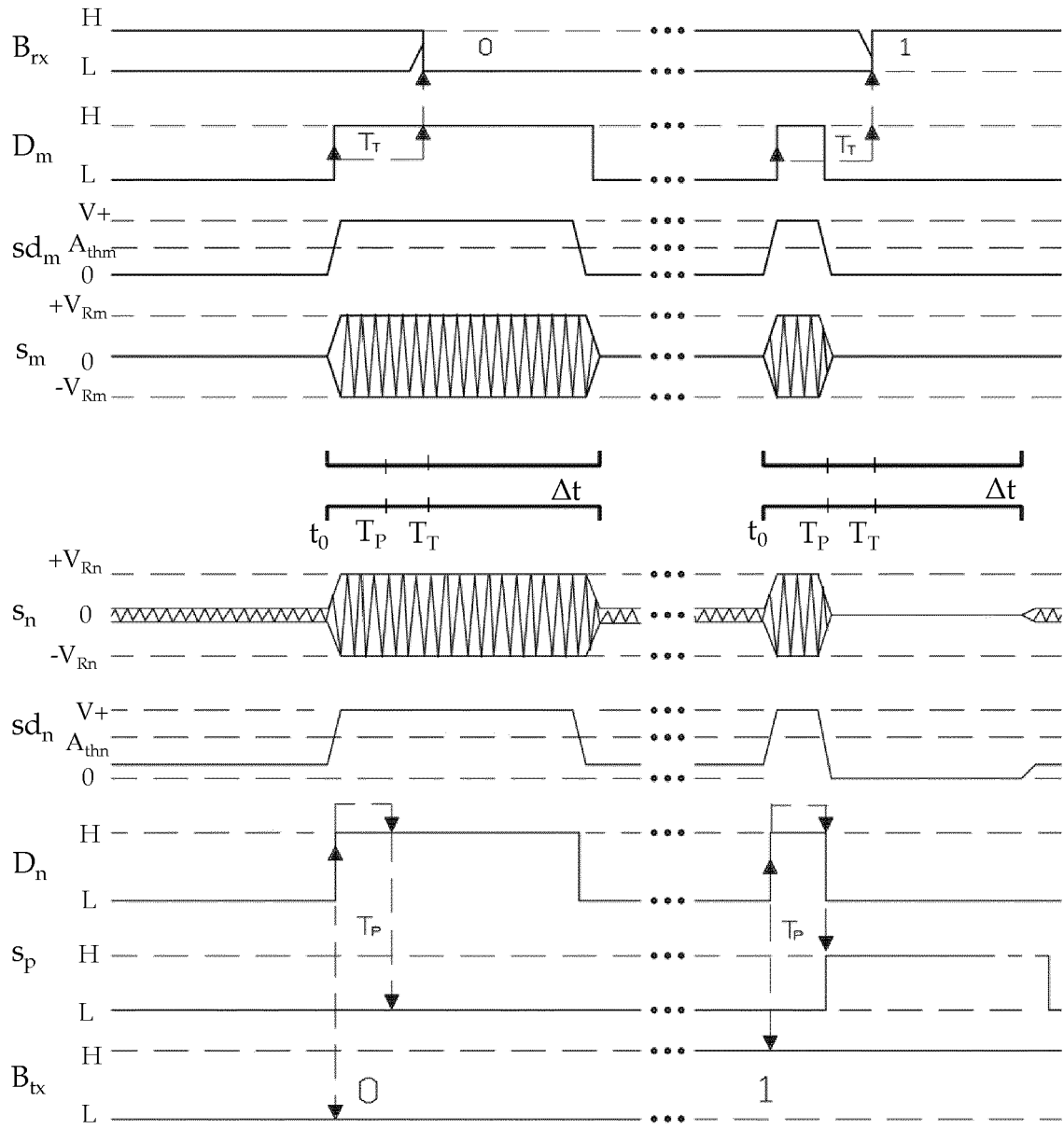


Fig.4

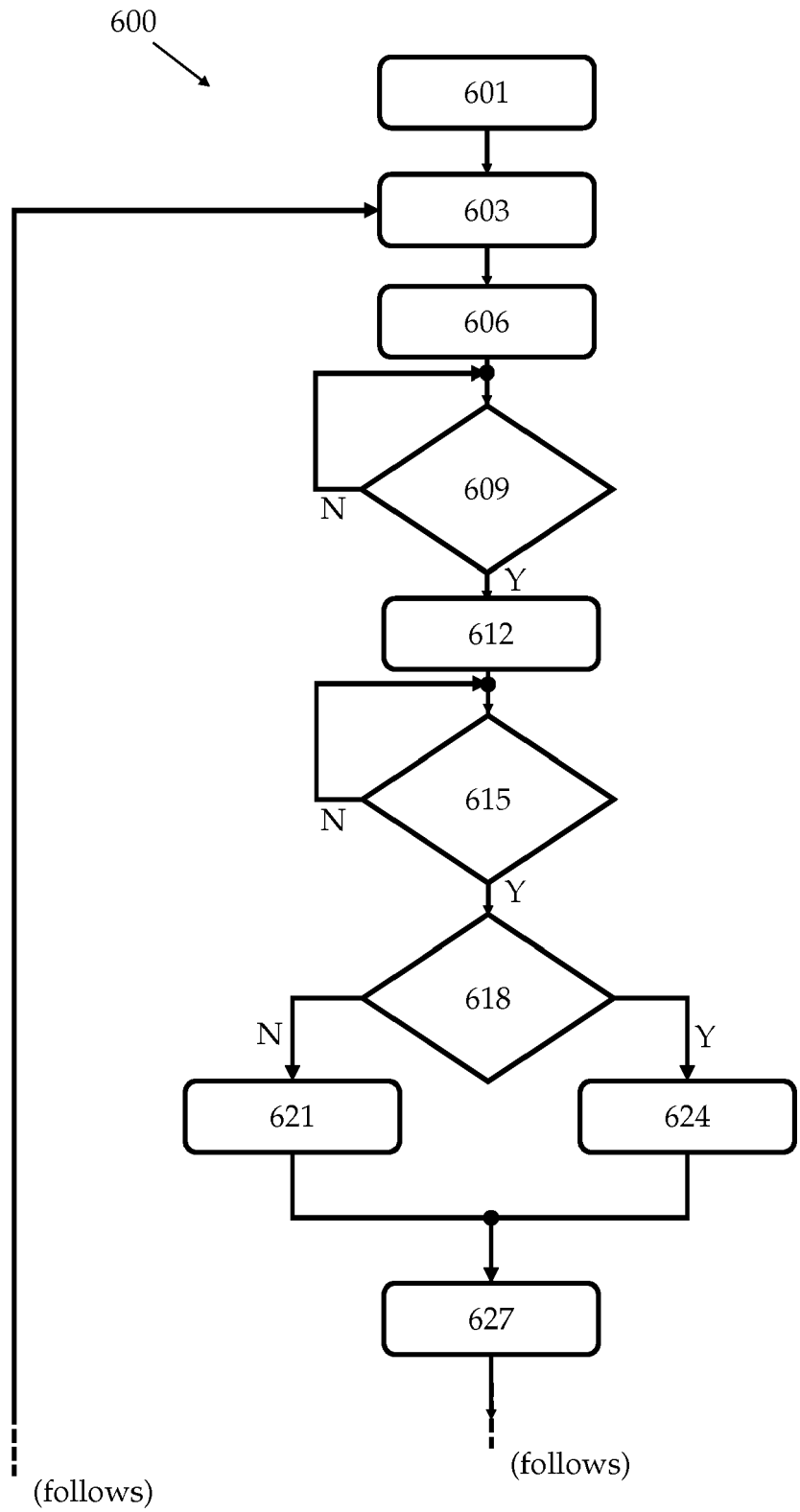


Fig.5A

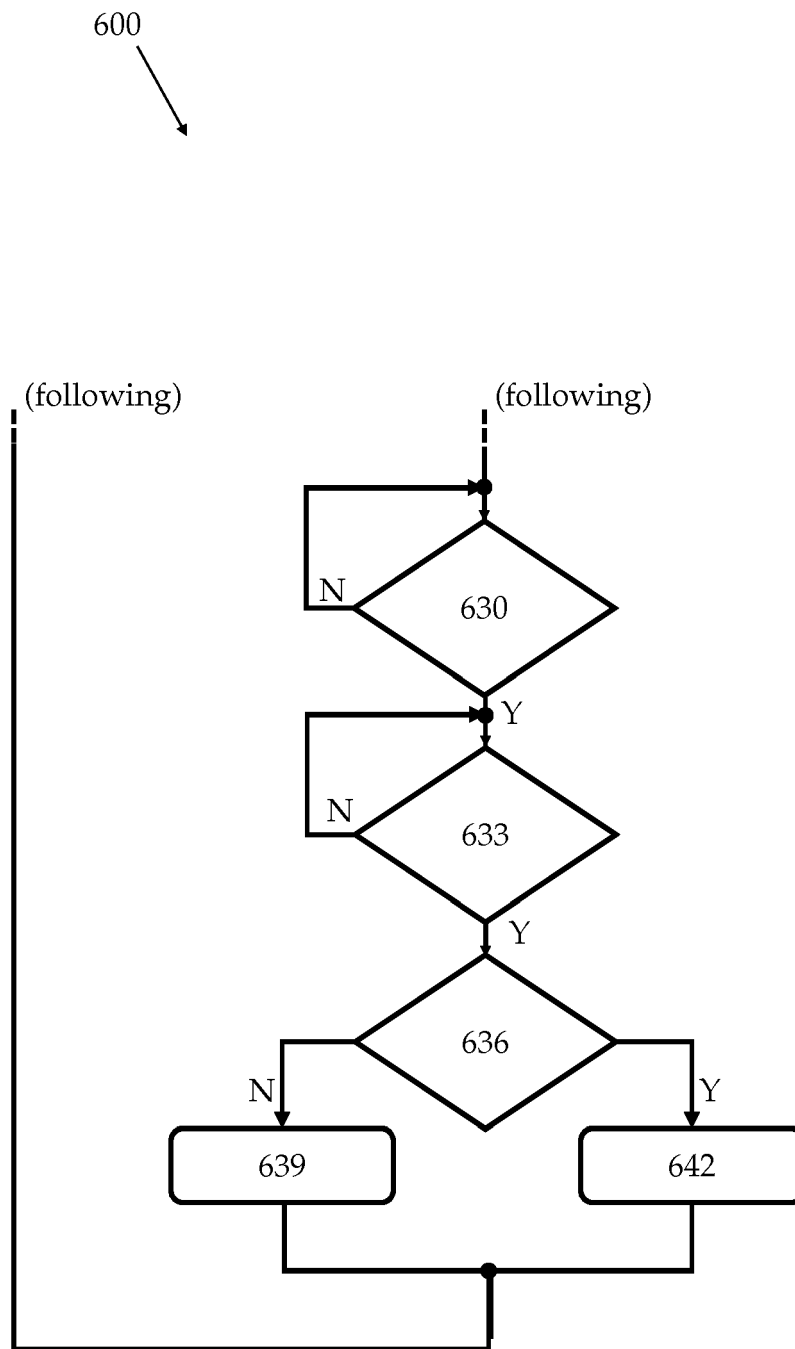


Fig.5B

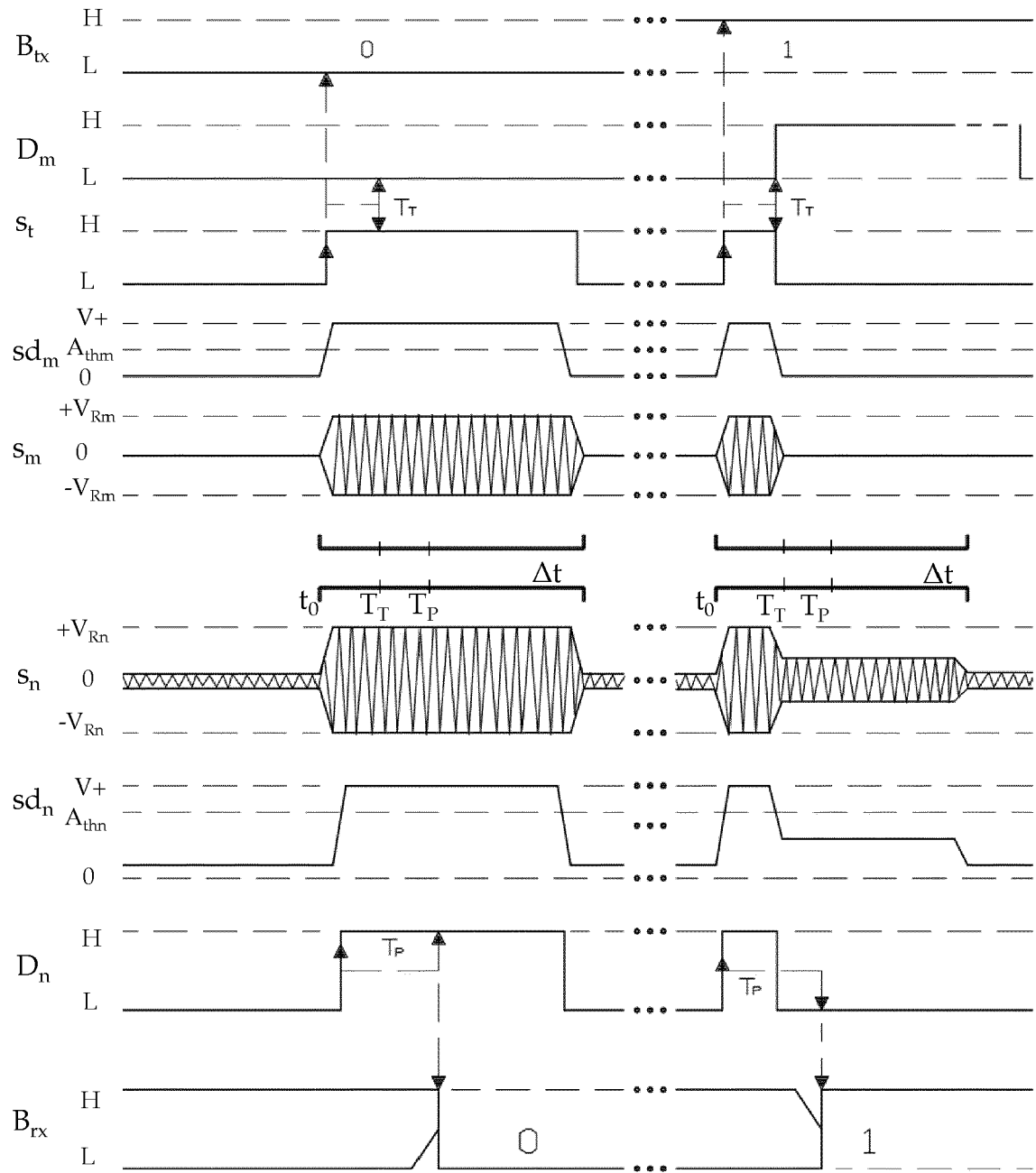


Fig.6

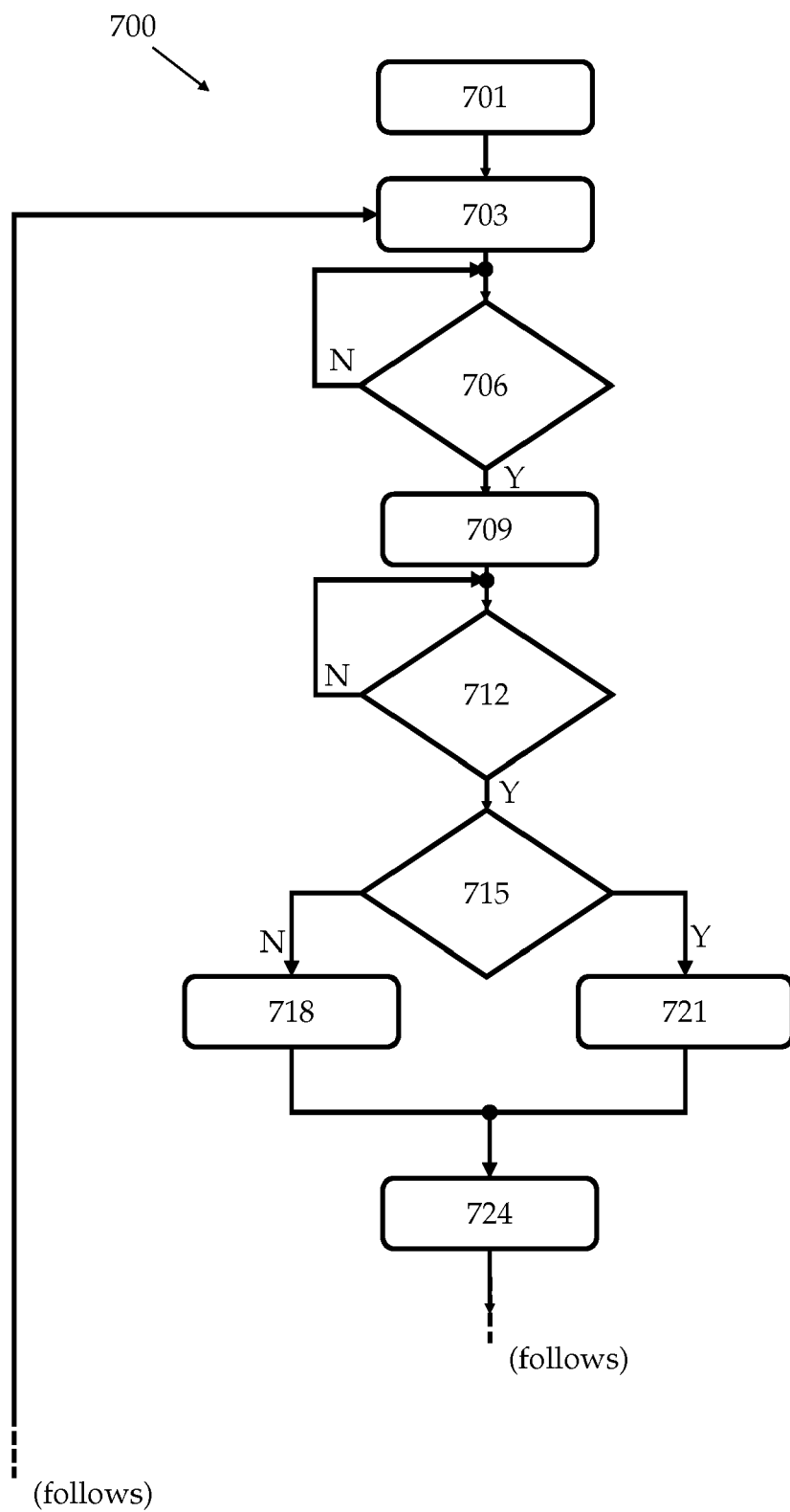


Fig.7A

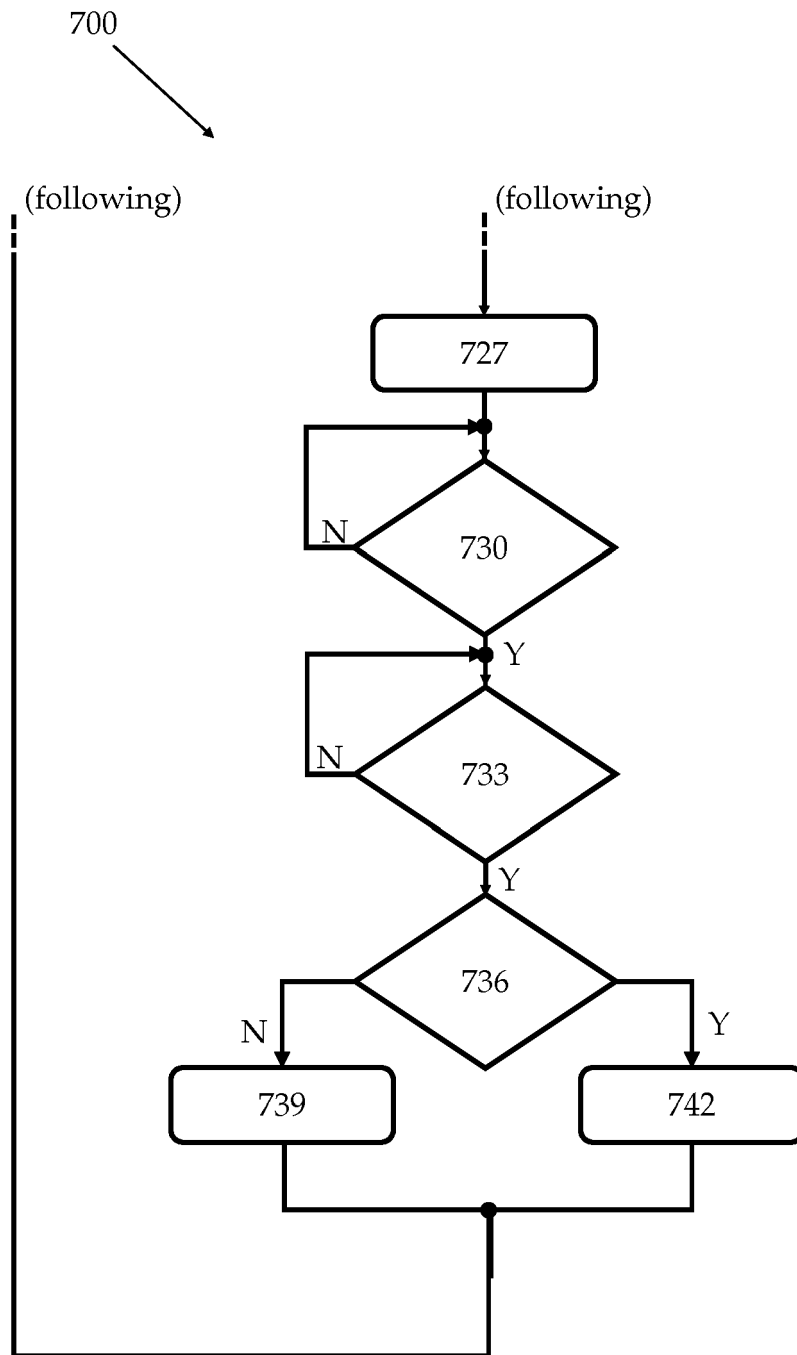


Fig.7B



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