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(54) Title: HANDHELD TOOL

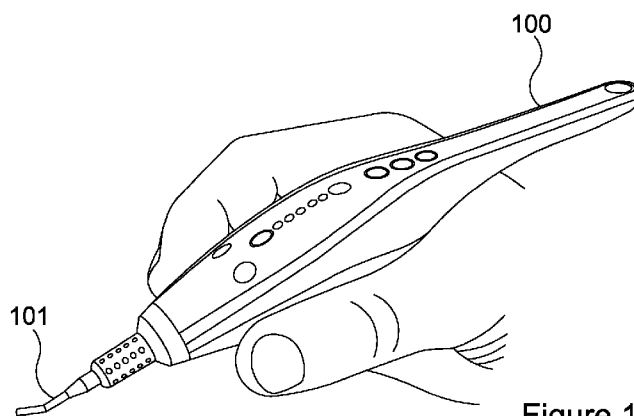


Figure 1

(57) Abstract: A heated handheld tool is described. The system includes a handheld device with interchangeable heads which may provide heat application, rotated abrasion, rotated polishing, or ultrasonic techniques, optionally in conjunction with a haptic control system. The tool may be used to remove unwanted material from 3D printed models, or as a soldering iron or heated wax tool.



Handheld tool

Technical Field

5 The present invention relates to a handheld tool. Some embodiments of the invention relate to a heated tool for removing or refining unwanted material from objects produced by 3D printers.

Background

10 The rapid growth in 3D printing has seen a large number of low cost desktop 3D printers being developed and sold in both prosumer and consumer market places, and this growth looks set to continue or even accelerate.

15 One of the undesirable features of many 3D printers is that the printers leave large amounts of unwanted spurs, anomalies and printer supports attached on the final raw prints. 3D printer users struggle with cleaning-up their raw printed models, and are often unable to refine detail and remove large amounts of spurs and supports. The mainstream materials used for 3D printing are thermoplastics, although there is an ever-increasing choice of materials and their corresponding properties.

20 Similar issues may arise in tools used as soldering irons or heated wax tools used by dental technicians and jewellers.

Summary

25 In order to address the problems outlined above, there is disclosed herein a 3D finishing system comprising a handheld device with interchangeable heads based on heat application, rotated abrasion, rotated polishing, or ultrasonic techniques in conjunction with haptic feedback and pre-set settings to remove unwanted material from a 3D printed model. In addition, a 3D printer attachment, which is fixed to the existing 3D printer's printer head mounting mechanism, may trace the external shape
30 of the 3D print to cut and polish unwanted spurs and printer errors.

In accordance with one aspect of the present invention there is provided a haptic feedback system utilising the sense of touch and pressure in a user interface design to provide information to the control system to increase temperature or rotation speed
35 beyond a pre-set setting or return the temperature or rotation speed to a pre-set

setting. The invention also provides a closed loop derivative whereby an automatic control system is regulated by feedback to continually adjust back to the measure: increasing pressure increases temperature or rotation speed; decreasing pressure decreases temperature or rotation speed. If pressure is too low temperature or rotation speed falls; if pressure is too high it increases so as to meet the preset pressure level.

In accordance with one aspect of the present invention there is provided a handheld tool comprising a body configured to be grasped by a user, a retaining mechanism in the body for retaining a tool tip extending from the body, an activation mechanism for causing a tool head retained by the retaining mechanism to heat, rotate and/or vibrate.

The retaining mechanism may be configured to release the tool head and receive an alternative tool head. This means that heads can be interchangeable. This allows different heads to be used for different purposes. For example, if the tool is used to touch up 3D printed models, different heads may be used for different materials or for specific tasks.

The activation mechanism comprises a heat source for applying heat to the head. The tool may comprise a closed feedback loop to maintain a temperature of the head at a chosen temperature.

The body may comprise a heat dissipation mechanism for ensuring that heat generated by the heat source is not conducted into a portion of the body grasped by the user. This avoids heat which may be uncomfortable for users being conducted into the handle, and enables the tool to be kept relatively short. The heat dissipation mechanism may comprise a heat reflective bulkhead within the body, and/or vents to allow heat to escape from the body, and/or a fan to direct airflow away from a portion of the body grasped by the user.

The activation mechanism may comprise a motor for causing the head to rotate and/or a vibration mechanism for imparting vibration, optionally ultrasonic vibration, to the head.

The tool may comprise a control system for controlling the temperature, rotation speed and/or vibration frequency of the head. The control system may be configured to

enable a user to choose appropriate temperature, rotation speed and/or vibration frequency settings for the head in dependence on a specific task. The control system may include pre-programmed settings for specific tasks, and /or may be programmable to enable settings to be entered. The control system may include a communication
5 device to allow instructions to be received by the tool wirelessly from a remote device, for example *via* Bluetooth® from an app executed by a mobile device.

The tool may include a pressure sensor for detecting pressure applied to a user interface on the body or to the head. The control system may be configured to respond
10 to haptic feedback from the pressure sensor to control the temperature, rotation speed and/or vibration frequency of the head. A change in pressure applied by the user may cause the control system to increase the temperature, rotation speed and/or vibration frequency of the head beyond a pre-set setting, or to return to a pre-set setting. The temperature and/or rotation speed of the head may be continually adjusted in response
15 to the pressure.

In accordance with another aspect of the invention there is provided a kit of parts comprising the tool described above and a plurality of heads configured to be received by the retaining mechanism. The heads and control system may be configured so that
20 the tool can be used for touching up a 3D printed model, wherein the heads are configured to remove, refine, polish and/or blend material on the model. Alternatively, the heads and control system may be configured so that the tool can be used as a soldering iron, or as a heated wax tool.

In accordance with another aspect of the present invention there is provided an interchange system for enabling tool heads to be inserted into and removed from the tool described above. The system comprises a tool head having a tip for carrying out a task and a body for insertion into the tool described above, the body having a recess or rebate therearound. The system also comprises a tool head holder comprising jaws
30 pivotable between an open position and a closed position and configured to allow the tool tip to be inserted therebetween in the open configuration. The jaws comprise a profile configured to close around the recess or rebate in the closed configuration so as to retain the tool head and pull it from the tool. This enables the tool head to be pulled from the tool and stored even when hot.

In accordance with another aspect of the present invention there is provided a tool for touching up a 3D printed model, comprising a head configured to remove, refine, polish and/or blend material on the model.

5 Brief Description of the Drawings

Some preferred embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings, in which:

Figure 1 shows a handheld device with interchangeable heated heads;

Figure 2 shows a handheld device with interchangeable rotating heads;

10 Figure 3 shows a handheld device with interchangeable ultrasonic vibrating heads;

Figures 4A and 4B show an interchangeable head attachment fixed to a 3D printer's printer head mechanism;

Figures 5A and 5B illustrate heat dissipation mechanisms; and

Figures 6A and 6B illustrate a system for exchanging tool heads.

15

Detailed Description

Figure 1 is an illustration of an exemplary handheld tool comprising a body 100 for grasping by a user and removable head 101, and a control system offering a closed loop feedback system to monitor and control temperature of the tool's head 101. The heads are interchangeable. The tool may be used as a heated 3D print finishing tool, and the following discussion is mainly concerned with this example, but it will be appreciated that other uses for the tool may also be envisaged, for example as a soldering iron or a heated wax tool, such as those used by jewellers and dental technicians. When used as a 3D print finishing tool, The device uses the temperature properties of 3D printing materials to calculate the optimal melting and blending temperatures for the heated head. Further, through additional haptic feedback the tool 100 can respond to the pressure applied by the user to either heat-up or cool-down the temperature of the interchangeable head and therefore the level of heat at the operating end. The tool may have temperature pre-sets programmed preferably to current favourable 3D printing materials with assistance of a look-up chart that is referenced by either a visual system or computer programme.

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Figure 2 is an illustration of an exemplary handheld rotating 3D print finishing tool having a body 200 and interchangeable abrasion and polishing heads 201, and a control system offering a closed loop feedback system to monitor and control speed of

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the tool's head 201. Further, through additional haptic feedback the tool 200 can respond to the pressure applied by the user to either speed-up or slow-down the rotation of the interchangeable head and therefore the level of positive or negative friction at the operating end. The tool may have speed pre-sets programmed preferably to current favourable 3D printing materials with assistance of a look-up chart that is referenced by either a visual system or computer programme.

Figure 3 is an illustration of an exemplary handheld vibrating 3D print finishing tool having a body 300 with interchangeable abrasion and polishing heads 301, and a control system offering a closed loop feedback system to monitor and control mechanical or ultrasonic vibration of the tool's head 301. Further, through additional haptic feedback the tool can respond to the pressure applied by the user to either speed-up or slow-down the ultrasonic vibration of the interchangeable head and therefore the level of positive or negative vibration at the operating end. The tool may have ultrasonic pre-sets programmed preferably to current favourable 3D printing materials with assistance of a look-up chart that is referenced by either a visual system or computer programme.

The interchangeable heads and pre-sets from the look-up chart or computer programme may be adjustable as new 3D printing materials become available to the market.

It will be appreciated that, although the tools of Figures 1, 2 and 3 are shown as separate devices, it may be possible for a single tool to support heads which can be heated, rotated and/or vibrated. Individual heads may be capable of providing one or more of these functions and can be interchangeable.

In addition, the haptic feedback may take a number of forms. For example, the touch and pressure applied by the user either may be detected either through the pressure applied to the head, or to the pressure applied to a user interface on the body of the tool. The change in pressure may provide information to the control system to cause a parameter such as temperature or rotational speed or vibration frequency to increase beyond a pre-set setting, or to return to a pre-set setting. An alternative possibility may be for an automatic control system to be regulated by feedback to continually adjust the parameter: increasing pressure increases the parameter. If pressure is too low the

parameter is reduced: if pressure is too high it increases so as to meet the pre-set pressure level.

5 Such tools may be entirely handheld devices (for example devices rechargeable by insertion into a cradle or by plugging in to an electrical source) but another alternative is to locate most of the electronics in a control unit, and include a tool in the form of a terminal connected to the control unit by a cable. It will also be appreciated that a rechargeable terminal could be both recharged and reprogrammed from a remote control unit, whether *via* a cable or wirelessly. The user interface show in the Figures
10 could then be located on the control unit rather than on the tool held in the hand.

Figure 4A illustrates an interchangeable head attachment 400 which can be fixed to an existing 3D printer's printer head mounting mechanism. Figure 4B shows the head attachment 400 fixed to an exemplary printer head mounting mechanism 402. The
15 head attachment 400 has an interchangeable head 401 which may use heat, rotation or vibration in the same way as the heads 101, 201, 301 described with reference to the tools of Figures 1 to 3. The head attachment may utilize software running on top of the operating system of the 3D printer to plot the 3 dimensional XYZ coordinates of the 3D computer file which has previously been 3D printed by the printer.

20 The attachment 400 traces the external shape of the 3D printed model provided by the 3D CAD file used for printing. A small motor 403 allows the head to turn to make cuts and polish. Interchangeable heads offer different heads for different tasks; for example but not limited to, polishing, cutting, and sanding. The cutting head removes all excess
25 material created by the 3D printer. Variations of this device may be attached to existing printer head mounting mechanisms of popular 3D printers. Figure 4B illustrates dual motors to create a 5 axis system; therefore, allowing the attachment to perform undercutting.

30 The finishing system utilised by the interchangeable heads may be based on heat application, rotated abrasion, rotated polishing, or ultrasonic techniques.

One problem with existing heated tools such as soldering irons is that they generate heat which makes it uncomfortable for users to hold unless the heat is extended away

from the device. This creates devices which are longer and harder to control with a high degree of accuracy. This decreases usability.

5 In order to keep the tool short without increasing user discomfort, a heat dissipation device as shown in Figure 5A may be provided. This may include a heat reflective bulkhead 501 and/or vents 502 in the body to allow heat to escape. A fan 503 may also be added to direct airflow more actively, as shown in Figure 5B.

10 In addition, as discussed above, it is desirable for users to be able to change heads to carry out different tasks. This is particularly problematic when the head is hot. Such heads may be removed from the tool using pliers, but this can result in damage and may be unsafe.

15 Figure 6A illustrates a set of heads 600 configured for use with a head removal and storage tool 601 (shown in Figure 6B). Each head has a tip 602 for carrying out a task, and a body 603 for insertion into a body 100,200,300 of a tool such as that shown in Figures 1-3. A recess or groove 604 is provided around the body at a point which will extend externally of the body of the tool.

20 The head removal and storage tool 601 is formed by two jaws 605, 606 which are pivotable about an axis 607 so as to move between open and closed configurations. A spring 608 biases the jaws towards the closed configuration. The jaws may be opened by squeezing handles 609, 610 at a proximal end of the jaws.

25 A distal end of each jaw terminates in a profile 611 which matches the recess 604 in the body of the head 600. The jaws can be opened, by hand, passed over the tip 602 of the head 600, and closed so that the profile 611 mates with the recess 604. The head is then held securely in the jaws and can be pulled free of the body of the tool even when hot, and also stored safely.

30 It will be appreciated that other configurations are also possible in addition to a recess in the head: a detent or other rebate or shoulder may alternatively be provided.

35 The control system for the handheld tools of Figures 1, 2 or 3 provides for accurate temperature heating, rotating speed, and ultrasonic vibrating speed. The control

system can generate fixed outputs or haptic feedback variations through pressure sensitivity technology, incorporating haptic feedback. Through haptic feedback the device can respond to the pressure applied by the user to control the temperature, rotating speed, or ultrasonic vibrating speed. The tool may have programmed pre-sets to current favourable 3D printing materials with assistance of a look-up chart that is referenced by either a visual system or computer program. This process allows for the head to be maintained at a constant temperature or speed irrespective of the material or tip design used while cleaning-up a 3D print. This combination allows the user to optimize the tool for a variety of tasks and personal preferences when it comes to cleaning-up 3D prints. The pre-sets from the look-up chart or computer programme may be adjustable as new 3D printing materials become available to the market.

The control system may also be configured for remote operation, for example *via* an app in a smartphone. Instructions may be sent wirelessly to the tool, for example *via* Bluetooth®.

The use of interchangeable heads provides significant flexibility, enabling accurate operations including but not limited to removal, refinement, polishing, fixing and blending unwanted material from 3D prints. Further, each head may be illuminated by an LED working light (not shown in the figures). The interchangeable heads may be adjustable as new 3D printing materials become available to the market. Different heads may be used for different tasks (*e.g.* removal of large or small blemishes, polishing *etc.*) or for use with different materials.

The ergonomic handheld design of the tool combines comfort and precision, allowing users to hold the tool in different hand positions for finishing 3D printed models.

CLAIMS:

1. A handheld tool comprising:
a body configured to be grasped by a user;
5 a retaining mechanism in the body for retaining a tool tip extending from the body; and
an activation mechanism for causing a tool head retained by the retaining mechanism to heat, rotate and/or vibrate.
- 10 2. The tool of claim 1, wherein the retaining mechanism is configured to release the tool head and receive an alternative tool head so that heads are interchangeable.
3. The tool of claim 1, wherein interchangeable heads are usable for specific tasks.
- 15 4. The tool of any preceding claim, wherein the activation mechanism comprises a heat source for applying heat to the head.
5. The tool of claim 4, further comprising a closed feedback loop to maintain a
20 temperature of the head at a chosen temperature.
6. The tool of claim 5, wherein the body comprises a heat dissipation mechanism for ensuring that heat generated by the heat source is not conducted into a portion of the body grasped by the user.
- 25 7. The tool of claim 6, wherein the heat dissipation mechanism comprises a heat reflective bulkhead within the body.
8. The tool of claim 6 or 7, wherein the heat dissipation mechanism comprises
30 vents to allow heat to escape from the body.
9. The tool of claim 6, 7 or 8, comprising a fan to direct airflow away from a portion of the body grasped by the user.

10. The tool of any preceding claim, wherein the activation mechanism comprises a motor for causing the head to rotate.

5 11. The tool of any preceding claim, wherein the activation mechanism comprises a vibration mechanism for imparting vibration, optionally ultrasonic vibration, to the head.

12. The tool of any preceding claim, further comprising a control system for controlling the temperature, rotation speed and/or vibration frequency of the head.

10 13. The tool of claim 12, wherein the control system is configured to enable a user to choose appropriate temperature, rotation speed and/or vibration frequency settings for the head in dependence on a specific task.

15 14. The tool of claim 13, wherein the control system includes pre-programmed settings for specific tasks.

15. The tool of claim 13 or 14, wherein the control system is programmable to enable settings to be entered.

20 16. The tool of any of claims 12 to 15, wherein the control system includes a communication device to allow instructions to be received by the tool wirelessly from a remote device.

25 17. The tool of any of claims 12 to 16, further including a pressure sensor for detecting pressure applied to a user interface on the body or to the head, wherein the control system is configured to respond to haptic feedback from the pressure sensor to control the temperature, rotation speed and/or vibration frequency of the head.

30 18. The tool of claim 17, wherein a change in pressure applied by the user causes the control system to increase the temperature, rotation speed and/or vibration frequency of the head beyond a pre-set setting, or to return to a pre-set setting.

35 19. The tool of claim 18, wherein the control system is configured so that the temperature and/or rotation speed of the head is continually adjusted in response to the pressure.

20. A kit of parts comprising the tool of any preceding claim and a plurality of heads configured to be received by the retaining mechanism.

5 21. The kit of parts of claim 20, of any preceding claim, wherein the heads and control system are configured so that the tool can be used for touching up a 3D printed model, wherein the heads are configured to remove, refine, polish and/or blend material on the model.

10 22. The kit of parts of claim 20, wherein the heads and control system are configured so that the tool can be used as a soldering iron.

23. The tool of any of claim 20, wherein the heads and control system are configured so that the tool can be used as a heated wax tool.

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24. An interchange system for enabling tool heads to be inserted into and removed from the tool of any of claims 1 to 19, comprising:

a tool head having a tip for carrying out a task and a body for insertion into the tool, the body having a recess or rebate therearound; and

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a tool head holder comprising jaws pivotable between an open position and a closed position and configured to allow the tool tip to be inserted therebetween in the open configuration;

wherein the jaws comprise a profile configured to close around the recess or rebate in the closed configuration so as to retain the tool head.

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25. A tool for touching up a 3D printed model, comprising a head configured to remove, refine, polish and/or blend material on the model.

26. The tool of claim 25, wherein the head is interchangeable and wherein interchangeable heads are usable with specific printing materials or for specific tasks in relation to touching up the model.

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27. The tool of claim 25 or 26, comprising a heat source for applying heat to the head and/or a motor for causing the head to rotate and/or a vibration mechanism for imparting vibration, optionally ultrasonic vibration, to the head.

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28. The tool of claim 25, 26 or 27, further comprising a control system for controlling the temperature, rotation speed and/or vibration frequency of the head, the control system being configured to enable a user to choose appropriate temperature, rotation speed and/or vibration frequency settings for the head in dependence of the material of the 3D printed model and/or a specific task.

29. The tool of claim 28, wherein the control system includes pre-programmed settings for specific materials for 3D printing and/or specific tasks and/or is programmable to enable settings to be entered.

30. The tool of any of claims 25 to 29, which tool is a hand-held device or comprises a hand held terminal connected to a control unit.

31. The tool of any of claims 25 to 29, further comprising an attachment mechanism for attachment to a print head mounting unit of a 3D printer.

32. A 3D printer comprising the tool of claim 31 attached to the print head mounting unit of the printer, configured so that the tool is movable by the printer to trace the external perimeter of the 3D model.

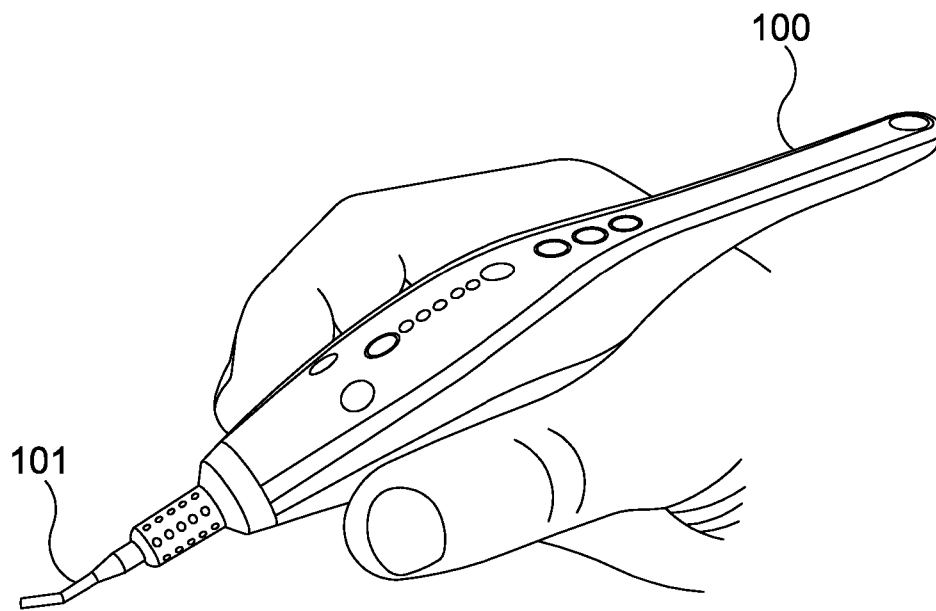


Figure 1

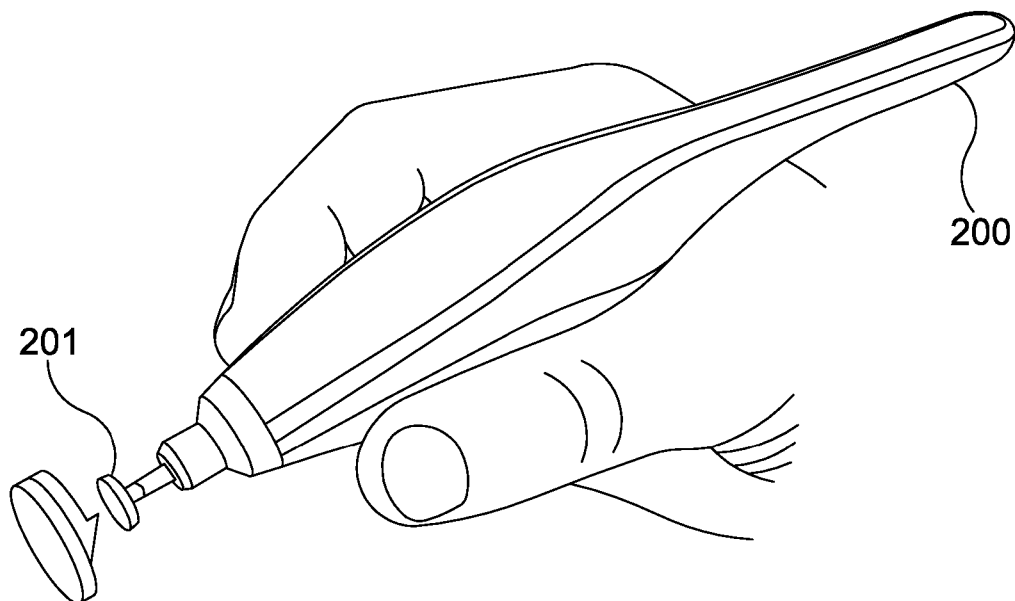


Figure 2

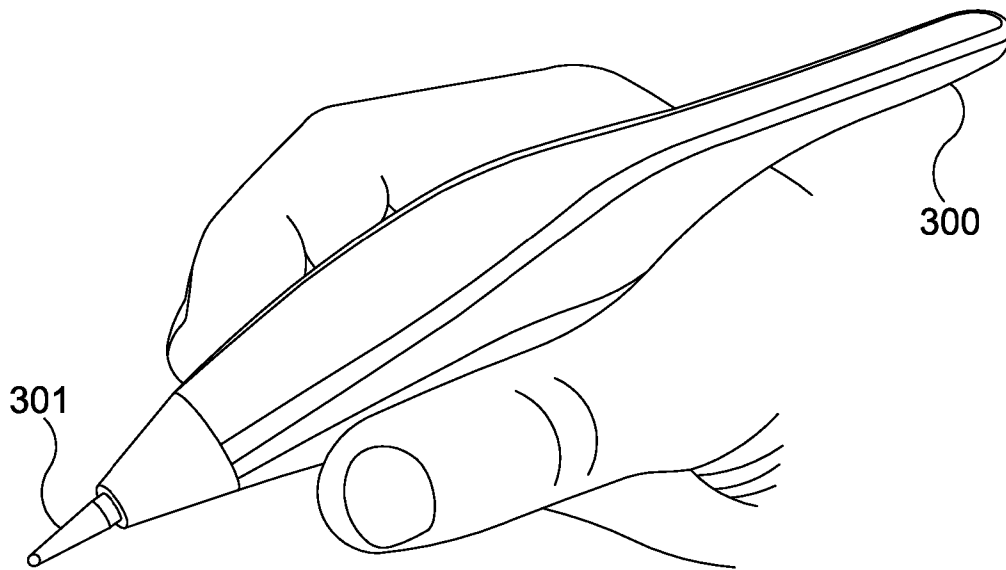


Figure 3

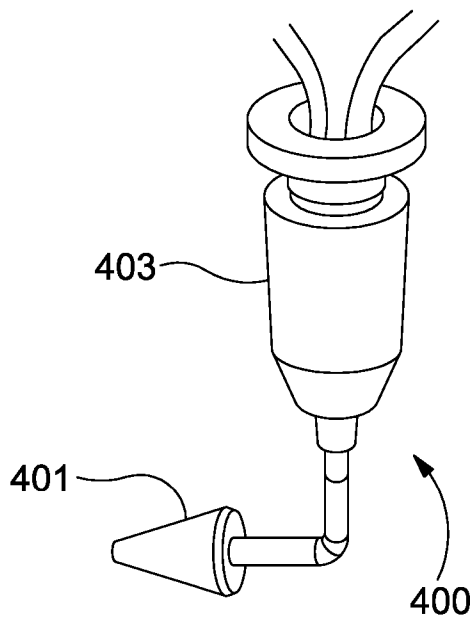


Figure 4a

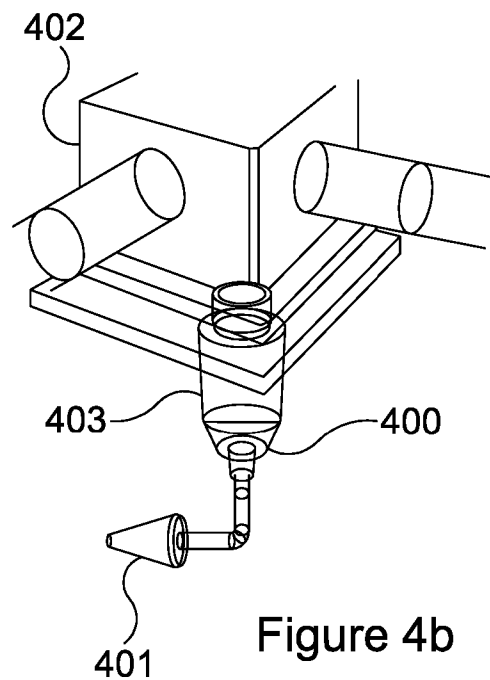


Figure 4b

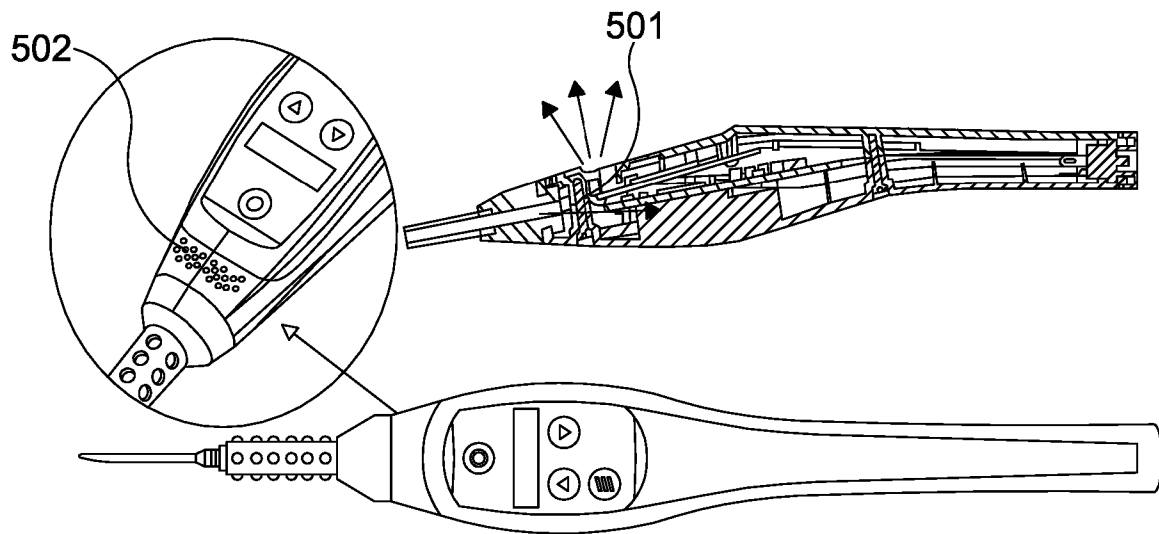


Figure 5a

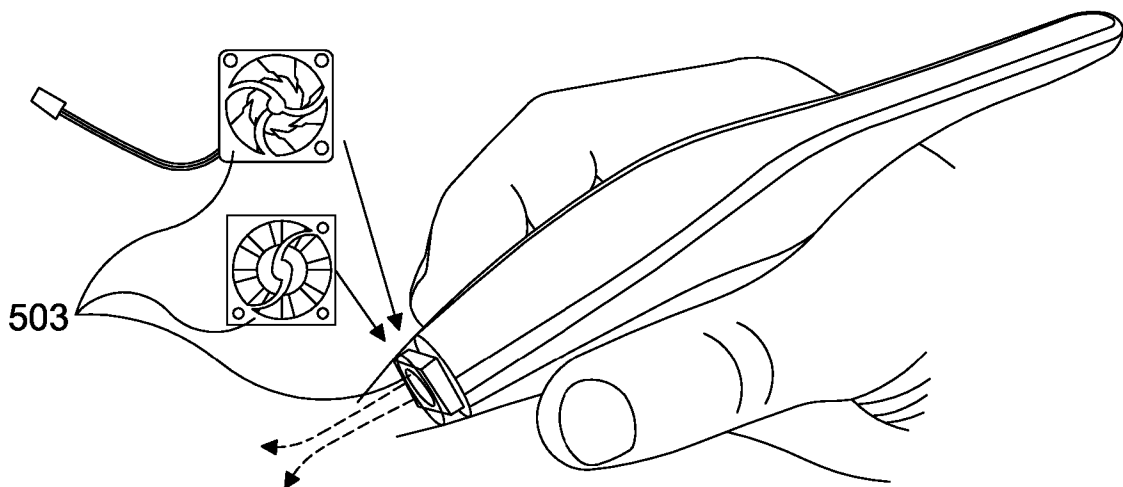


Figure 5b

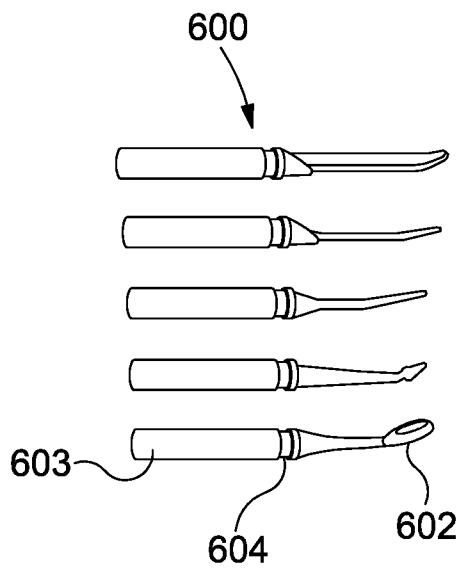


Figure 6a

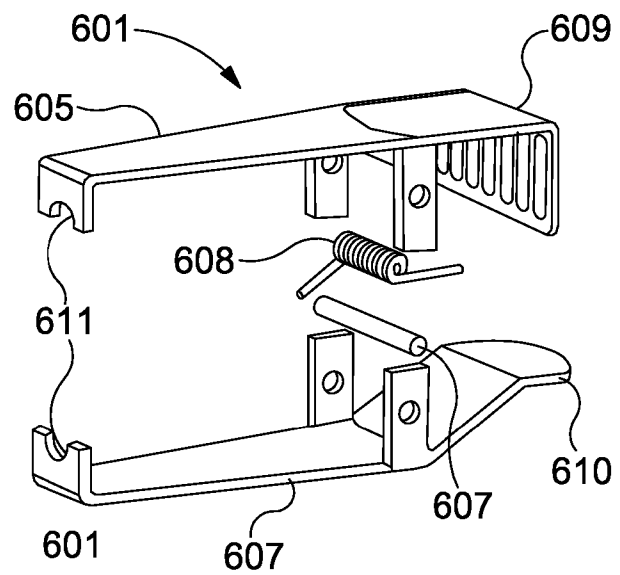


Figure 6b

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2016/050351

A. CLASSIFICATION OF SUBJECT MATTER

INV. B25F3/00 B29C37/02 B29C67/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B25F A61C B29C B33Y B23K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 962 681 A (YANG TAI-HER [TW]) 16 October 1990 (1990-10-16) column 1, line 13 - line 14 column 2, line 26 - column 4, line 50 figures	1-10, 12, 13, 20-27, 30
X	US 2005/200087 A1 (VASUDEVA KAILASH C [CA] ET AL) 15 September 2005 (2005-09-15) paragraph [0002] - paragraph [0004] paragraph [0015] - paragraph [0024] paragraph [0057] - paragraph [0075] paragraph [0094] - paragraph [0121] figures ----- -/-	1-3, 10, 12-15, 20, 21, 24-30



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

15 July 2016

Date of mailing of the international search report

22/07/2016

Name and mailing address of the ISA/

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van Woerden, N

INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2016/050351

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

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