



(51) International Patent Classification:

B29C 65/04 (2006.01) *H05B 6/62* (2006.01)
H05B 6/50 (2006.01)

(21) International Application Number:

PCT/IB2015/058963

(22) International Filing Date:

19 November 2015 (19.11.2015)

(25) Filing Language:

Italian

(26) Publication Language:

English

(30) Priority Data:

MI2014A002000 19 November 2014 (19.11.2014) IT

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: APPARATUS FOR RADIO FREQUENCY WELDING

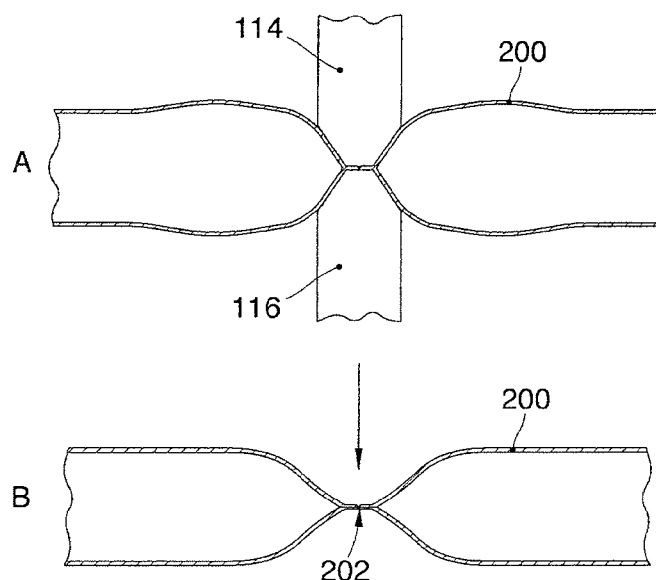


fig. 1

(57) Abstract: Apparatus for radio frequency welding of a tube (200) for use in the field of medical blood transfusions, that comprises an electric power unit (102), a control board (104), a radiofrequency generator module (106), a high-voltage inductor (108) and a welding head (110) provided with a clamp (112) with electrodes (114, 116).



“APPARATUS FOR RADIO FREQUENCY WELDING”

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FIELD OF THE INVENTION

Forms of embodiment described here concern an apparatus for radio frequency
5 welding, in particular of plastic tubes used in the medical field for the passage of
biological liquids, in particular blood, blood components and/or blood
derivatives.

BACKGROUND OF THE INVENTION

It is known that, in the field of medical blood transfusions, the blood, or blood
10 components (haemoderivatives and/or haemocomponents) can be taken from
and/or respectively supplied to the patient using sacs, normally containing an
anti-coagulant, connected to plastic tubes inside which the blood or its
components flow.

In this context, it is known that it is necessary to weld the plastic tubes in
15 which the blood or its components pass in order to stop the flow, to isolate
samples to be subjected to analysis, in particular to close and separate the tube in
a sterile manner or for other needs. In particular, there is a strongly felt need to
guarantee that the welding of the tubes is reliable and quick, that it does not
pollute the sample and is fluid-tight, stable and resistant. Furthermore, other
20 requirements of the welding are that it must not damage the blood molecules and
it must allow to separate the two welded strips easily, retaining the seal on both
sides, i.e. the two terminations of the separated tubes.

There is therefore a need to perfect an apparatus for radio frequency welding
that can overcome at least one of the disadvantages of the state of the art.

25 The Applicant has devised, tested and embodied the present invention to
overcome the shortcomings of the state of the art and to obtain these and other
purposes and advantages.

SUMMARY OF THE INVENTION

The present invention is set forth and characterized in the independent claim,
30 while the dependent claims describe other characteristics of the invention or
variants to the main inventive idea.

According to some forms of embodiment, an apparatus is provided for radio frequency welding of a tube for use in the field of medical blood transfusions. According to one form of embodiment, the apparatus comprises:

- an electric power unit;
- 5 - a control board;
- an RF generator module;
- a high-voltage inductor;
- a welding head provided with a clamp with electrodes.

10 According to some forms of embodiment, the control board comprises at least a central processing unit and an electronic memory in which the software instructions and the data to command the central processing unit are encoded and memorized in order to execute the radio frequency welding.

According to some forms of embodiment, the RF generator module comprises: oscillator, first amplification stage and second amplification stage.

15 According to some forms of embodiment, the high-voltage inductor is configured to transform the power of the radio frequency signal generated at exit from the radio frequency generator module into a high-voltage radio frequency signal and to make a precise adjustment and fine tuning of the impedance matching.

20 According to some forms of embodiment, the high-voltage inductor is a single-coil inductor, or a double-coil inductor.

According to some forms of embodiment, the welding head comprises a clamp provided with a first electrode and a second electrode.

25 According to some forms of embodiment, the welding head comprises a drive member able to reciprocally move the first electrode and the second electrode.

According to some forms of embodiment, the welding head comprises one or more pre-load elastic members able to cooperate with the drive member.

According to some forms of embodiment, the welding head comprises a cover and one or more sensor members able to detect the presence of the cover.

30 According to some forms of embodiment, the welding head comprises one or more sensor members able to detect the presence of the tube in the clamp.

According to some forms of embodiment, the electrodes comprise a first electrode and a second electrode, in which one or the other of either the first

electrode or the second electrode is provided with a protruding tooth able to define a detachment incision in a welding area of the tube.

According to some forms of embodiment, one and/or the other of either the first electrode or the second electrode is provided with a leveled upper surface.

5 According to some forms of embodiment, the tooth protrudes from the leveled upper surface, defining two semi-planes of the leveled upper surface able to determine a desired deformation, for example a flare, of the material of the tube in the welding area of the tube that allows a fluidic seal of the weld.

10 According to some forms of embodiment, one and/or the other of either the first electrode or the second electrode is provided with a beveled or rounded front surface.

According to some forms of embodiment, the welding head is provided with a pair of opposite tube-gripping blades.

15 These and other aspects, characteristics and advantages of the present disclosure will be better understood with reference to the following description, drawings and attached claims. The drawings, which are integrated and form part of the present description, show some forms of embodiment of the present invention, and together with the description, are intended to describe the principles of the disclosure.

20 The various aspects and characteristics described in the present description can be applied individually where possible. These individual aspects, for example aspects and characteristics described in the attached dependent claims, can be the object of divisional applications.

25 It is understood that any aspect or characteristic that is discovered, during the patenting process, to be already known, shall not be claimed and shall be the object of a disclaimer.

BRIEF DESCRIPTION OF THE DRAWINGS

30 These and other characteristics of the present invention will become apparent from the following description of some forms of embodiment, given as a non-restrictive example with reference to the attached drawings wherein:

- fig. 1 is a schematic representation of a radio frequency welding operation;
- fig. 2 is a schematic diagram of a radio frequency welding apparatus according to forms of embodiment described here;

- fig. 3 is a schematic representation of a radio frequency welding apparatus according to forms of embodiment described here;
- fig. 4 is a schematic representation in blocks of a radio frequency welding apparatus according to forms of embodiment described here;
- 5 - fig. 5 is a schematic representation of a radio frequency welding apparatus according to forms of embodiment described here;
- fig. 6 is a schematic representation in blocks of a radio frequency welding apparatus according to forms of embodiment described here;
- fig. 7 is a representation in separate parts of a radio frequency welding
10 apparatus according to forms of embodiment described here;
- figs. 7a and 7b are schematic views of parts of a radio frequency welding apparatus according to forms of embodiment described here;
- fig. 7c is a representation in separate parts of a radio frequency welding apparatus according to forms of embodiment described here;
- 15 - fig. 8 is a lateral view of a part of a radio frequency welding apparatus according to forms of embodiment described here;
- fig. 9 is a schematic representation of a radio frequency welding apparatus according to forms of embodiment described here;
- fig. 10 is a schematic representation in blocks of a radio frequency welding
20 apparatus according to forms of embodiment described here;
- fig. 11 is a schematic representation of a part of a radio frequency welding apparatus according to forms of embodiment described here;
- figs. 12 and 12a are schematic representations of other forms of embodiment of a part of a radio frequency welding apparatus according to forms of embodiment
25 described here;
- fig. 13 is a schematic representation of a radio frequency welding apparatus according to forms of embodiment described here;
- fig. 14 is a schematic representation of a part of a radio frequency welding apparatus according to forms of embodiment described here;
- 30 - fig. 15 is a schematic representation of another form of embodiment of a part of a radio frequency welding apparatus according to forms of embodiment described here;

To facilitate comprehension, the same reference numbers have been used, where possible, to identify identical common elements in the drawings. It is understood that elements and characteristics of one form of embodiment can conveniently be incorporated into other forms of embodiment without further
5 clarifications.

DETAILED DESCRIPTION OF SOME FORMS OF EMBODIMENT

We shall now refer in detail to the various forms of embodiment of the present invention, of which one or more examples are shown in the attached drawing. Each example is supplied by way of illustration of the invention and shall not be
10 understood as a limitation thereof. For example, the characteristics shown or described insofar as they are part of one form of embodiment can be adopted on, or in association with, other forms of embodiment to produce another form of embodiment. It is understood that the present invention shall include all such modifications and variants.

15 Forms of embodiment described here concern an apparatus for radio frequency welding of plastic tubes used for the passage of blood, or blood components, in the field of medical blood transfusions, also including the field of the donation of blood or its components, for example the donation of plasma.

We must point out here that the expressions “blood” and “blood components”
20 as used in the forms of embodiment described here can refer respectively to whole blood and to haemoderivatives or haemocomponents, i.e. blood components extracted from whole blood after a centrifugation process. The blood components can be concentrates of red corpuscles, platelets, plasma, buffy coats – the latter being an intermediate component formed by a mixture of plasma, red
25 corpuscle concentrates, white corpuscle concentrates and platelets that is created after the centrifugation process of the whole blood.

We must also point out here that radio frequency (RF) welding as used in the forms of embodiment described here can be a radio frequency welding, in particular high frequency (HF) or very high frequency (VHF), which exploits the
30 dielectric properties of the material subjected to a variable electric field and which can allow to join two parts without glues or adhesives, by a controlled melting of the material. The radio frequency welding that can be used in the forms of embodiment described here can provide to join two materials, supplying

radio frequency energy, in particular high frequency (HF, 3-30 MHz) or even very high frequency (VHF, 30-300 MHz) in the form of an electromagnetic field, and in the form of pressure, i.e. mechanical compression, on the surfaces of the material that are to be joined. In the radio frequency welding used in the forms of
5 embodiment described here, a generator module produces the energy and the tool used to supply the electric energy and mechanical pressure is called welding head with electrode clamp, hereafter called, more simply, welding head, welding clamp or only clamp. See for example fig. 1, part A, used to describe a tube 200 subjected to radio frequency welding by a clamp 112 with pairs of electrodes
10 114, 116. For example, the electrodes can be made of brass.

The electric energy causes the molecules inside the material to start moving, which generates heat that causes the material to soften and melt. In the radio frequency welding used in the forms of embodiment described here, no external heat is applied, but the heat is generated inside the material. The surfaces are kept
15 under pressure and the combination of heat under pressure causes the surfaces to melt and join. After cooling the surfaces of the melted material, a weld is created. See for example fig. 1, part B, used to describe a tube 200 that has a join or weld 202 obtained by radio frequency welding. In general, certain plastic materials can be welded by radio frequency, such as PVC (polyvinyl chloride), polyamides
20 (PA), polyurethane (PU), acetates, nylon, PET (polyethylene terephthalate), PEVA (polyethylene vinyl acetate), EVA (ethylene vinyl acetate) and some plastics ABS (acrylonitrile-butadiene-styrene). The material most commonly used in radio frequency welding in the medical blood transfusion field is PVC. In radio frequency welding, an example of high frequency wave is 27.120 MHz,
25 while an example of very high frequency wave is 40.685 MHz.

Furthermore, we must point out here that a tube 200 as used in the forms of embodiment described here can be a tube for use in the field of medical blood transfusions, a flexible tube, a test tube, a pipe, a standard tube for disposable blood sacs or for plasmapheresis. For example, a tube as used in the forms of
30 embodiment described here can be a plastic tube, in particular PVC. A tube as used in the forms of embodiment described here can be an elongated hollow tubular body with a determinate diameter that can vary from about 2.7 mm to about 6 mm, and has a lateral wall defining internally a passage channel. The

lateral wall can have a determinate thickness which, for example, can vary from about 0.4 mm to about 1.0 mm. For welding PVC tubes in the field of medical blood transfusions as used in the forms of embodiment described here, a frequency of 40.685 MHz can be provided.

5 Fig. 2 is used to describe forms of embodiment of an apparatus 100 for radio frequency welding of a tube 200 for use in the field of medical blood transfusions. According to some forms of embodiment, the apparatus 100 comprises:

- an electric power unit 102;
- 10 - a control board 104;
- an RF generator module 106;
- a high-voltage inductor 108;
- a welding head 110 provided with a clamp with electrodes.

In accordance with some example embodiments, the apparatus 100 can be the
15 portable type, while according to other example embodiments the apparatus 100 can be the benchtop type.

According to possible implementations, the electric power unit 102 is configured to power electrically the control board 104, the RF generator module 106, the high-voltage inductor 108 and the welding head 110.

20 According to possible implementations, the electric power unit 102 can be, for example in the case of a portable apparatus 100, a pack of batteries/accumulators, which can supply at exit a voltage in a range of 22V-30V (DC) or, in other implementations, for example in the case of a benchtop apparatus 100, the power can be at a fixed value, for example 24V, arriving from a voltage transformer/
25 adaptor connected to an electric network.

According to possible implementations, the control board 104 can include a central processing unit (CPU) 104a, an electronic memory 104b, possibly an electronic database and auxiliary circuits (or I/O) (not shown). For example, the CPU 104a can be any type of controller, microcontroller, processor or
30 microprocessor used in the field of control, automation and management of the work or computer cycle. The electronic memory 104b can be connected to the CPU 104a and can be one or more of those commercially available, such as a random access memory (RAM), read only memory (ROM), an erasable

programmable memory (EPROM), an electrically erasable programmable ROM memory (EEPROM), floppy disk, hard disk, optical disks, CD-ROM, optical-magnetic disks, optical or magnetic cards, mass memory, solid-state memory cards or microcards or any other form of digital storage, local or remote. The software instructions and the data can be for example encoded and memorized in the electronic memory 104b to command the CPU 104a. The auxiliary circuits can also be connected to the CPU 104a to help the processor conventionally. The auxiliary circuits can include for example at least one of: cache circuits, feed circuits, clock circuits, input/output circuits, subsystems and suchlike. A program (or computer instructions) readable by the control board 104 can determine which tasks are performable according to a radio frequency welding method. In some forms of embodiment, the program is a software readable by the control board 104. The control board 104 can include a code to generate and memorize information and data introduced or generated during the radio frequency welding method.

According to possible forms of embodiment, the control board 104 can be configured to manage the whole welding cycle according to a radio frequency welding method. The CPU 104a mounted on the control board 104 can verify the state of the apparatus 100 during the welding process, from when the operator starts the welding until the end.

In some forms of embodiment, which can be combined with all the forms of embodiment described here, the CPU 104a of the control board 104 can manage and monitor various signals that come from the apparatus 100, including:

- humidity/liquid signal, which indicates the presence of liquids or humidity on the tube 200, between the electrodes, during welding;
- spark alarm signal, which is generated when the tube 200 is perforated, for example, during welding, and an electric arc is created due to the high difference in potential between the electrodes;
- temperature alarm signal, which indicates the maximum temperature of the RF generation module 106 has been exceeded.

In some forms of embodiment, which can be combined with all the forms of embodiment described here, the CPU 104a of the control board 104 can also manage and monitor other signals that come from the apparatus 100, including:

- signal that informs the user of the absence of a protective cap for the welding head, provided to prevent the user from coming into contact with the electrodes at high-voltage during the welding process;
- low battery signal, in the case of an electric power unit 102 with a battery pack, which informs the user that the battery needs recharging before continuing welding.

In other forms of embodiment, which can be combined with all the forms of embodiment described here, the CPU 104a of the control board 104 can also manage and monitor an end-of-welding signal arriving from the apparatus 100, which informs the operator that welding is complete.

According to possible implementations, the RF generator module 106 is configured to generate a high-voltage radio frequency (RF) signal needed to weld the tube 200. In particular, the RF generator module 106 can generate a very high frequency (VHF) signal, for example 40.685 MHz. Applicant has found that this very high frequency of 40.685 MHz couples well with the PVC material that the tubes 200 to be welded are made of. The RF generator module 106 is also configured to control the stability of the wave signal generated and to supply at exit a low voltage signal proportional to the voltage between the electrodes of the clamp. According to possible example embodiments, the RF generator module 106 can be low power, for example 65W, or high power, for example 90W.

According to some forms of embodiment, the RF generator module 106 can include an oscillator 106a, a first amplification stage 106b and a second amplification stage 106c.

The RF generator module 106 can include a temperature sensor 106d, for example associated with the first amplification stage 106b.

The RF generator module 106 can include a humidity sensor 106e, for example associated with the second amplification stage 106c.

According to possible implementations, the oscillator 106a is configured to generate, at start of welding cycle, a wave signal with a frequency, for example 40.685 MHz, that will be amplified in the subsequent first amplification stage 106b and second amplification stage 106c.

According to possible implementations, the first amplification stage 106b is configured to generate a first amplification of the signal, an impedance matching and a filtering.

5 According to possible implementations, the second amplification stage 106c is configured to generate the final amplification of the signal, even up to 100W, an impedance matching, a filtering and a series of signals for the control board 104.

10 According to possible implementations, the high-voltage inductor 108 can be configured to transform the power of the RF signal generated at exit from the RF generator module 106 into a high-voltage RF signal and to obtain a precise adjustment and tuning of the impedance matching.

According to possible implementations, the welding head 110 is configured to apply the RF signal arriving from the high-voltage inductor 108 to the load, i.e. to the tube 200 to be welded. The welding head 110 can include a clamp 112 provided with a first electrode 114 and a second electrode 116, for example made of brass. A first electrode 114 can be defined the hot electrode, i.e. the electrode that receives the RF signal, while a second electrode 116 can be defined the cold electrode, i.e. the electrode that is earthed. The first 114 and second 116 electrodes can be mobile with respect to each other, to apply the desired compression on the surfaces of the tube 200 during welding.

20 Figs. 3, 4, 5, 6 and 7 are used to describe forms of embodiment, which can be combined with all the forms of embodiment described here, in which the apparatus 100 is the portable type and can be powered by a battery pack power unit 102 and can be provided with a welding head 110 as described above.

In particular, figs. 3 and 4 are used to describe a portable apparatus 100 with a handpiece 118 provided with an activation lever 120 by means of which to start the welding cycle. The apparatus 100 described using figs. 3 and 4 includes the battery pack power unit 102, a load input connector 107, the control board 104, the RF generator module 106, the high-voltage inductor 108 and the welding head 110. The RF generator module 106 is connected to the control board 104 from which it receives command and control impulses and signals and with which it can also exchange data and information concerning the welding. The control board 104, in turn, receives power from the battery pack power unit 102 and directs it to the RF generator module 106. The RF generator module 106 is

also connected to the handpiece 118 to transmit the radio frequency signal generated to the high-voltage inductor 108 which transmits it to the welding head 110, which in this case has a hot first electrode 114 and a cold second electrode 116. The high-voltage inductor 108 can include at least a high-voltage coil 108a (see also fig. 15), an impedance calibration ring 108b and a coil support 108c, for example made of acetal resin, such as Delrin, or polytetrafluoroethylene (PTFE, Teflon).

Figs. 5, 6, 7, 7a, 7b, 7c and 8 are used to describe a pistol-type portable apparatus 100, or parts thereof, provided with a handle or stock 124, a containing casing or shell 125, and an activation button 126 by means of which to start the welding cycle. The apparatus 100 described using figs. 5 and 6 includes, inside the containing casing 125, the battery pack power unit 102, the control board 104, a CPU-RF interface card 105, the RF generator module 106, the high-voltage inductor 108, in this case contained in and belonging to the RF generator module 106, a conversion module for data connection 109 and the welding head 110. The RF generator module 106 is connected to the CPU-RF interface card 105 and this is connected to the control board 104. The control board 104 in turn receives power from the battery pack power unit 102 and directs it to the RF generator module 106, passing through the CPU-RF interface card 105. Finally, the control board 104 is connected to the conversion module for data connection 109, usable to exchange data with a computer. The RF generator module 106 transmits the radio frequency signal generated to the high-voltage inductor 108. The high-voltage inductor 108 can include at least a high-voltage coil 108a and a coil support 108c, for example made of acetal resin, such as Delrin, or Teflon. In this specific case, the high-voltage inductor 108 can have a double high-voltage coil, which can supply a higher voltage thrust (see also fig. 14). The high-voltage inductor 108 therefore supplies the signal to the welding head 110, in this case too provided with a hot first electrode 114 and a cold second electrode 116, mobile linearly with respect to each other, for example using a drive member 103 provided with a drive shaft 101. According to some forms of embodiment, which can be combined with all the forms of embodiment described here, the drive member 103 can be a motor provided with an intrinsically linear movement actuator or can be configured to convert a circular movement into a linear

movement. The conversion can commonly be made using types of conversion mechanisms, for example screw actuators, ball screw actuators and roll screw actuators. A drive member 103 as used in association with the forms of embodiment described here can be a drive member chosen from a group comprising: an electric motor, a step electric motor, a magnetic motor, a linear axle with a motor, a linear motor, such as a mechanical linear motor, a piezoelectric linear motor, an electromagnetic linear motor, an electromechanical motor, an electromagnet. For example, motors can be provided that use electromagnetism and magnetic fields for interaction between a first part formed by electric coils and a second part formed by other electric coils, or by permanent or energized magnets or a conductor. In specific possible examples, the drive member can be configured as a linear motor, for example an induction linear motor, synchronous linear motor, brushless synchronous linear motor, homopolar linear motor, voice coil linear motor, tubular linear motor or also, as we said, a piezoelectric linear motor or an electromagnet.

Fig. 7 is used to describe forms of embodiment of a welding head 110, usable for example in combination with the forms of embodiment described using figs. 5 and 6. The welding head 110 can include a protective cap 130 to which the second electrode 116 can be attached, for example by screws 132. The screws 132, for example the flared steel type, are used to clamp the second electrode 116 and also to adjust its planarity and alignment with respect to the first electrode 114. The welding head 110 can also include a clamping nut 134, for example made of nickel-plated aluminum, to clamp the cap 130. Moreover, the welding head 110 can be provided with a magnet 136, for example made of neodymium, to supply a signal of the presence or absence of the cap 130. A sensor member is provided, for example a magnetic sensor 137, able to cooperate with the magnet 136 to signal the presence of the cap 130. The welding head 110 can also be provided with an upper thrust bushing 138, on which the first electrode 114 can be disposed, and a lower thrust bushing 140, both of which can be made, for example, of acetal resin (for example Delrin). The upper thrust bushing 138 can be provided with an integrated protective wall, to protect it from possible splashes if the welding is not successful and to protect the operator from accidental leakage of hematic material. Guide pins 144 can be provided, for

example made of steel, to join the upper thrust bushing 138 and the lower thrust bushing 140, and also screws 142, for example flared steel ones, to clamp the upper thrust bushing 138 and the lower thrust bushing 140 to each other. Furthermore, the welding head 110 can be provided with one or more gaskets 5 148, for example O-rings, for the hydraulic seal and to keep the upper thrust bushing 138 and the lower thrust bushing 140 axial with respect to each other. An RF cable 146 is provided to transmit the radio frequency signal generated by the RF generator module 106 to the first electrode 114. The welding head 110 can also be provided with a pair of opposite tube-gripping blades 150, for example 10 made of ABS, which are suitable to prevent lateral/transverse movements of the tube 200 during welding. The tube-gripping blades 150 work independently of each other and each is associated with its own spring 152, for example made of stainless steel, or similar elastic element, which facilitates and compensates the movement thereof.

15 The welding head 110 is also provided with the drive member 103, which can be, as we said, a step electric motor member, for example associated with a drive member support 154, for example made of nickel-plated aluminum. The drive member 103 has a drive shaft 101 which can be extended and retracted along a linear travel. The drive member 103 can be clamped to the drive member support 20 154 by pins or screws 164, for example steel, and nuts 168, also for example made of steel. In some forms of embodiment, which can be combined with all the forms of embodiment described here, the drive member 103 is associated with one or more elastic pre-load members, for example hereafter pre-load springs 166, in this specific case two springs disposed opposite at the sides of the drive 25 member 103. The pins 164 and nuts 168 can also be provided to clamp the pre-load springs 166. The pre-load springs 166 are compressed when the drive member 103, after it has caused the electrodes 114, 116 to draw near to the tube 200, retreats due to the resistance of the tube 200. However, when the latter collapses following the start of the radio frequency, the pre-load springs 166, no 30 longer meeting the resistance of the tube 200, extend again and thus make the drive member 103 move forward, supplying the necessary compression thrust during welding.

An anti-rotation pin 156 can be provided, for example made of steel, to prevent the rotation of the lower thrust bushing 140. A magnet 158, for example neodymium, can be located on the anti-rotation pin 156 and configured to signal an end-of-travel of the lower thrust bushing 140, if the drive member 103 were to lose its number of revs. A magnetic sensor 160 is provided, able to cooperate with the magnet 158, to signal the end-of-travel at end of welding. A welding head support 162, for example in aluminum, is provided to attach the welding head to the RF generator module 106 and to a dissipater 127 (fig. 7c). The welding head support 162 can be connected to the drive member support 154 by the pins 164. The magnetic sensor 137 to signal the presence of the cap 130 can be disposed on the welding head support 162.

Figs. 7a and 7b are used to describe forms of embodiment respectively of a first electrode 114 (fig. 7a) and a second electrode 116 (fig. 7b) which can be used for example in the forms of embodiment described with reference to figs. 5, 6 and 7.

In particular, the first electrode 114 can have for example a truncated pyramid shape with beveled lateral faces: for example it can have a shape like a cupola, or wedge, with a quadrangular base, for example essentially square, with a rounded lateral surface, for example formed by four faces rounded at the sides, 114a, having a radiated surface, for example with a radius of curvature from 3 mm to 5 mm, for example about 4 mm, and a leveled upper face 114b, with an essentially planar shape, which can face toward the second electrode 116. The first electrode 114 can be attached to the upper thrust bushing 138 and receive the radio frequency signal and can therefore be defined the hot electrode. Thanks to its geometry as described above, the first electrode 114 allows a good radio frequency welding, in particular the leveled upper face 114b defines a support plane that guarantees a correct welding.

The second electrode 116 instead can have for example a prismatic shape with beveled lateral faces; for example it can have a shape like a parallelepiped with rounded lateral faces, with a quadrangular base, for example essentially rectangular, with two rounded faces 116a and two leveled lateral faces 116c, and a leveled upper face 116b, essentially planar which can face toward the first electrode 114. A tooth or ridge 116d can be provided on the leveled upper face

116b, protruding from it toward the first electrode 114, with a height of between about 0.25 mm and 0.35 mm, for example about 0.3 mm.

The tooth 116d can divide the leveled upper face 116b into two identical semi-planes, for example each with a width of about 1.5 mm, to define a desired
5 deformation, for example a flare, of material of the tube 200 in the welding region of the tube 200, which allows a fluid seal of the weld.

The second electrode 116 can be attached to the cap 130 and is earthed, and can therefore be defined as the cold electrode. Thanks to its geometry as described above, the second electrode 116 allows a correct radio frequency
10 welding, defining an incision thanks to the tooth 116d, which promotes the detachment of the two parts of the tube 200 (see fig. 1 for example). The incision is between two welding planes defined by said semi-planes of the leveled upper face 116b.

Fig. 7c is used to describe forms of embodiment of the apparatus 100, in
15 which the control board 104 is included in the handle 124 on which the activation button 126 is mounted, and from the end of which a power cable 122 extends, for connection to the power unit 102. At the end of the handle 124 there is also a connector 129 for connection to a computer, for example by the data connection conversion module 109. The welding head 110 is mounted protruding from the
20 front of the casing 125 and is attached to the RF generator module 106 and to the dissipater 127 (fig. 7c). The RF generator module 106 also includes inside it the CPU-RF interface card 105 and the high-voltage inductor 108. The casing 125 and the handle 124 are formed by two half-shells, connected to each other by screws and nuts 121, which once connected have the appearance of a pistol.

25 With reference to figs. 6, 7, 7c and 8, we shall now describe a possible functioning of the apparatus 100. After positioning the tube 200 to be welded between the first electrode 114 and the second electrode 116 and having pressed the start button 126, the upper thrust bushing 138 is driven to advance and the first electrode 114 thus begins to move toward the second electrode 116. The
30 movement occurs by means of the drive member 103 which, thanks to the extension of the drive shaft 101, starts the travel of the upper thrust bushing 138. As soon as the first electrode 114 enters into contact with the tube 200, the latter in turn enters into contact with the second electrode 116 and starts to ovalize. The

drive member 103, thrusting on the incompressible material of the tube 200, retracts thanks to the presence of the pre-load springs 166 located at its sides. At this moment the radio frequency starts, the tube 200 collapses and the material of which it is made no longer offers any resistance to the thrust of the drive member 103; thanks to the thrust given to the drive member 103 by both the pre-load springs 166, the necessary thrust is consequently obtained by the first electrode 114, and an optimum welding profile is obtained. In particular, the backward movement of the drive member 103 by a few millimeters is given by the thickness of the tube 200, added to a pre-load of the pre-load springs 166 of a few millimeters, for example 1.5 mm, provided as a safety margin to ensure the welding has taken place. When the welding operation is finished, the upper thrust bushing 138 returns to the starting position, ready to make a second weld. Fig. 8 is also used to describe forms of embodiment of a welding head 110 in which a maximum length C of the pre-load springs 166 is shown. It may be important that, in the calibration step, the springs are compressed and the maximum length C is defined, for example between about 10 mm and about 15 mm, for example about 13 mm, which can be decisive to overcome the inertia or friction between the gaskets 148 and the cap 130.

Figs. 9, 10 and 13 are used to describe forms of embodiment, which can be combined with all the forms of embodiment described here, of a benchtop apparatus 100 powered from the electric mains by a power cable 122.

In particular, figs. 9 and 10 are used to describe a benchtop apparatus 100, provided with a single welding head 110, whereas fig. 13 is used to describe a multiple type benchtop apparatus 100, i.e. provided with a multiple welding head 110, by means of which it is possible to perform a plurality of welding operations on a tube 200.

Fig. 10 is used to describe forms of embodiment of a benchtop apparatus 100 with a single welding head 110, which can be combined with all the forms of embodiment described here, using fig. 9. In possible implementations, the apparatus 100 comprises the control board 104, the CPU-RF interface card 105, the RF generator module 106, the high-voltage inductor 108 and the welding head 110. The high-voltage inductor 108 can be provided with a high-voltage coil 108a, for example a double coil, an impedance calibration ring 108b and a coil

support 108c. A welding module 111 is provided, formed by a casing 111a inside which the high-voltage inductor 108 is disposed, between the drive member 103, which in this case can be an electromagnet, and the welding head 110. In some forms of embodiment, the welding module 111 can be associated with, or include
5 or cooperate with, the drive member 103. A pre-load spring 166 is provided, disposed in cooperation between the drive member 103 and the first electrode 114. The pre-load spring 166 can be fitted on the coil support 108c and constrained between two stop elements, front 166a and rear 166b, to define the desired maximum length C. The coil support 108c has a slit 166c in which the
10 rear stop element 166b can slide. The function of the pre-load spring 166 and its cooperation with the drive member 103 and the first electrode 114 are essentially as described for the forms of embodiment in figs. 5, 6, 7, 7c and 8. The welding head 110 has the cap 130, provided with an opening 131, for example a shaped slit, a groove, a window or suchlike, for the passage of the tube 200 so that it can
15 be inserted into the clamp 112.

Fig. 11 is used to describe forms of embodiment of a welding head 110 that can be used for example in forms of embodiment described using figs. 9 and 10. The welding head 110 includes a clamp 112 provided with a first electrode 114 and a second electrode 116. The welding head 110 can be provided with a
20 clamping ring 172 with bayonet-type clamping seatings 173, to connect to the remaining part of the apparatus 100. The welding head 110 can also include an electrode support structure 174, which supports the second electrode 116 and is provided with positioning seatings 176 to house the tube 200 during welding. The second electrode 116 can be clamped to the electrode support structure 174, by a
25 screw 132 also usable to adjust its planarity and alignment with respect to the first electrode 114. Pins 170 to hold the tube can also be provided, able to hold the tube in the positioning seating 176 during welding, and prevent it from coming loose.

Furthermore, in some forms of embodiment, which can be combined with all
30 the forms of embodiment described here, one or more sensor members can be provided, able to detect the presence of the tube 200 in the clamp 112.

For example, in possible implementations, the one or more sensor members able to detect the presence of the tube 200 in the clamp 112 can include a pair of

micro switches 178 of the mechanical type, able to signal the presence of the tube 200, mounted on a support frame 180. According to possible implementations, the first electrode 114, which functions as the hot electrode, can be shaped with a leveled upper face 114b, facing toward the second electrode 116, from which a
5 tooth 114d projects, similar to the tooth 116d described with reference to fig. 7b, and leveled lateral faces 114c.

The tooth 114d is provided to generate the detachment incision in the welding region, and divides the leveled upper face 114b into two semi-planes, to define the desired deformation, for example a flare, of material of the tube 200 in the
10 welding region of the tube 200, which allows the fluidic seal of the weld.

The second electrode 116, which functions as a cold electrode, can have a rounded lateral surface 116f and a leveled upper face 116g facing toward the first electrode 114. In particular, the first electrode 114 used in the forms of embodiment described using fig. 11 can be made like the second electrode 116
15 described using fig. 7b, while the second electrode 116 used in the forms of embodiment described using fig. 11 can be made like the first electrode 114 described using fig. 7a.

Figs. 12 and 12a are used to describe other forms of embodiment of a welding head 110 which can be used for example in forms of embodiment described using
20 figs. 9 and 10, and in which the first electrode 114, or hot electrode, has a completely rounded and beveled front surface 114f, while the second electrode 116, or cold electrode, has the tooth 116d already described for example with reference to fig. 7b. In possible implementations, the second electrode 116 can have a convex shape, for example wedge-shaped, and can have a leveled upper
25 surface 116e, or flat front surface, from which the tooth 116d projects. In possible implementations, instead of the clamping ring 172 with bayonet-type seatings 173, the welding head 110 has a threaded attachment nut 182. Moreover, attachment pins 183 can also be provided, for connection to the remaining part of the apparatus 100. The welding head 110 described using figs. 12 and 12a can
30 also include an electrode support structure 184, which supports the second electrode 116 and is provided with positioning seatings 186 to house the tube 200 during welding, and with a front cap 192. The second electrode 116 can be clamped to the electrode support structure 184 by a screw 132 also usable to

adjust its planarity with respect to the first electrode 114. Inserts 177 to hold the tube can also be provided, for example made of acetal resin such as Delrin, disposed in the positioning seatings 186 and able to hold the tube in the positioning seating 186 during welding, and prevent it from coming loose. As can
5 be seen for example in fig. 12a, the inserts 177 to hold the tube can be shaped in a shape mating with that of the tube, having an insertion opening 180a, slightly smaller than the nominal size or diameter of the tube 200, so that insertion occurs by means of a slight deformation of the material of the tube 200, and any accidental detachment is prevented. Furthermore, in possible implementations,
10 the one or more sensor members able to detect the presence of the tube 200 in the clamp 112 can be a pair of optical sensors 188 able to signal the presence of the tube 200 and mounted on a support plate 190.

With reference to fig. 13, used to describe a benchtop apparatus 100 with a multiple welding head, it is provided that in said forms of embodiment a
15 plurality, for example two, three, four, five or more than five welding modules 111 are used, as described using fig. 10 and which can provide welding heads 110 for example as described with reference to figs. 11 or 12. The apparatus 100 can include a single control board 104, a possible single CPU-RF interface card 105, and a single RF generator module 106, all cooperating with the welding
20 modules 111. In the forms of embodiment described using fig. 13, the welding modules 111 can be disposed enclosed inside a casing 123, and an external housing seating 133 can be provided, outside the casing 123, with which the welding heads 110 of the various welding modules 111 cooperate. The welding heads 110 can protrude with their clamps 112 from the casing 123 and therefore
25 have the first electrode 114 and second electrode 116 inside the housing seating 133.

Fig. 14 is used to describe forms of embodiment, which can be combined with all the forms of embodiment described here, of a high-voltage inductor 108 of the type with a double coil, which includes an internal primary coil 108d, an external
30 secondary coil 108e, an external support 108f, for example made of fiberglass, and an internal coil support 108c.

The internal secondary coil 108e is fitted on the internal coil support 108c and the external support 108f is disposed above it. The primary coil 108d is fitted in

turn on the external support 108f, which therefore keeps the primary coil 108d separate and distanced from the secondary coil 108e. This solution, as we said, can be advantageous to supply a greater voltage thrust. For example, the primary coil 108d and the secondary coil 108e in the forms of embodiment described here
5 can be, respectively, coils made of silver-plated copper wire and enameled copper wire.

Fig. 15 is used to describe forms of embodiment, which can be combined with all the forms of embodiment described here, of a high-voltage inductor 108 of the single coil type, which includes the high-voltage coil 108a, the possible
10 impedance calibration ring 108b and the coil support 108c. The high-voltage coil 108a is fitted on the coil support 108c and in turn the impedance calibration ring 108b is disposed on the high-voltage coil 108a.

It is clear that modifications and/or additions of parts may be made to the radio frequency welding apparatus 100 as described heretofore, without departing from
15 the field and scope of the present invention.

It is also clear that, although the present invention has been described with reference to some specific examples, a person of skill in the art shall certainly be able to achieve many other equivalent forms of radio frequency welding apparatus, having the characteristics as set forth in the claims and hence all
20 coming within the field of protection defined thereby.

Although the above refers to forms of embodiment of the invention, other forms of embodiment can be provided without departing from the main field of protection, which is defined by the following claims.

CLAIMS

1. Apparatus for radio frequency welding of a tube (200) for use in the field of medical blood transfusions, **characterized in that** said apparatus comprises:
 - an electric power unit (102);
 - 5 - a control board (104);
 - a radiofrequency generator module (106);
 - a high-voltage inductor (108);
 - a welding head (110) provided with a clamp (112) with electrodes (114, 116).
2. Apparatus as in claim 1, **characterized in that** said control board (104)
10 comprises at least a central processing unit (104a) and an electronic memory (104b) in which the software instructions and the data to command the central processing unit (104a) are encoded and memorized in order to execute the radio frequency welding.
3. Apparatus as in claim 1 or 2, **characterized in that** said RF generator module
15 (106) comprises: oscillator (106a), first amplification stage (106b) and second amplification stage (106c).
4. Apparatus as in claim 1, 2 or 3, **characterized in that** said high-voltage inductor (108) is configured to transform the power of the radio frequency signal generated at exit from the RF generator module (106) into a high-voltage radio
20 frequency signal and to make a precise adjustment and fine tuning of the impedance matching.
5. Apparatus as in any of the claims from 1 to 4, **characterized in that** said high-voltage inductor (108) is a single-coil inductor (108a), or a double-coil inductor (108d, 108e).
- 25 6. Apparatus as in any of the claims from 1 to 5, **characterized in that** the welding head (110) comprises a clamp (112) provided with a first electrode (114) and a second electrode (116).
7. Apparatus as in claim 6, **characterized in that** the welding head (110) comprises a drive member (103) able to reciprocally move the first electrode (114) and the second electrode (116).
30
8. Apparatus as in claim 7, **characterized in that** the welding head (110) comprises one or more pre-load elastic members (166) able to cooperate with the drive member (103).

9. Apparatus as in any of the claims from 1 to 8, **characterized in that** the welding head (110) comprises a cap (130) and one or more sensor members (136, 137) able to detect the presence of the cap (130).

10. Apparatus as in any of the claims from 1 to 9, **characterized in that** the welding head (110) comprises one or more sensor members (178, 188) able to detect the presence of the tube (200) in the clamp (112).

11. Apparatus as in any of the claims from 1 to 10, **characterized in that** said electrodes comprise a first electrode (114) and a second electrode (116), in which one or the other of either the first electrode (114) or the second electrode (116) is provided with a protruding tooth (114d, 116d) able to define a detachment incision in a welding area of the tube (200).

12. Apparatus as in claim 11, **characterized in that** one and/or the other of either the first electrode (114) or the second electrode (116) is provided with a leveled upper surface (114b, 116b, 116e, 116g).

13. Apparatus as in claims 11 and 12, **characterized in that** said tooth (114d, 116d) protrudes from said leveled upper surface (114b, 116b, 116e), defining two semi-planes of said leveled upper surface (114b, 116b, 116e) able to determine a desired deformation of the material of the tube (200) in the welding area of the tube (200) that allows a fluidic seal of said welding.

14. Apparatus as in any of the claims 11, 12 or 13, **characterized in that** one and/or the other of either the first electrode (114) or the second electrode (116) is provided with a beveled or rounded front surface (114f).

15. Apparatus as in any of the claims from 1 to 14, **characterized in that** said welding head (110) is provided with a pair of opposite tube-gripping blades (150).

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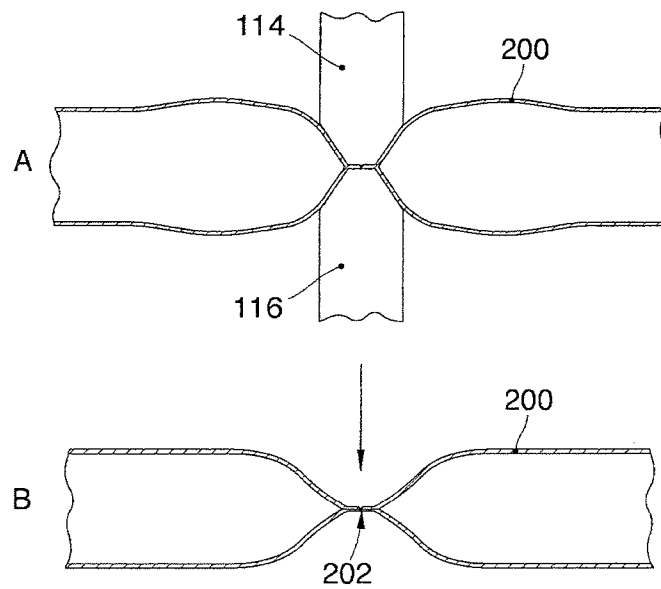


fig. 1

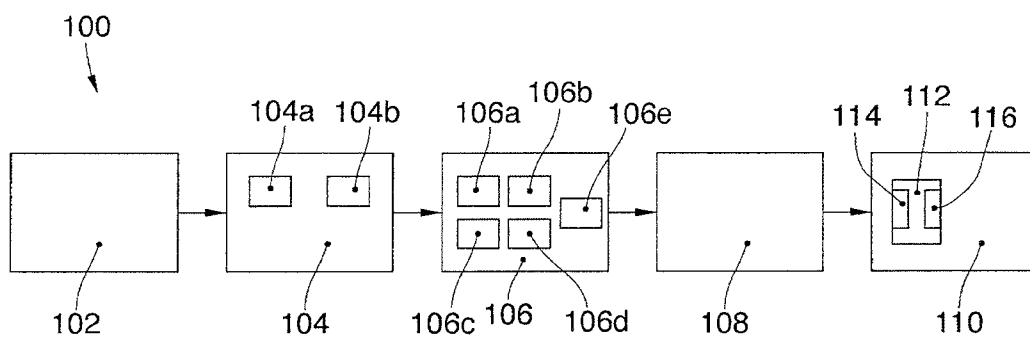


fig. 2

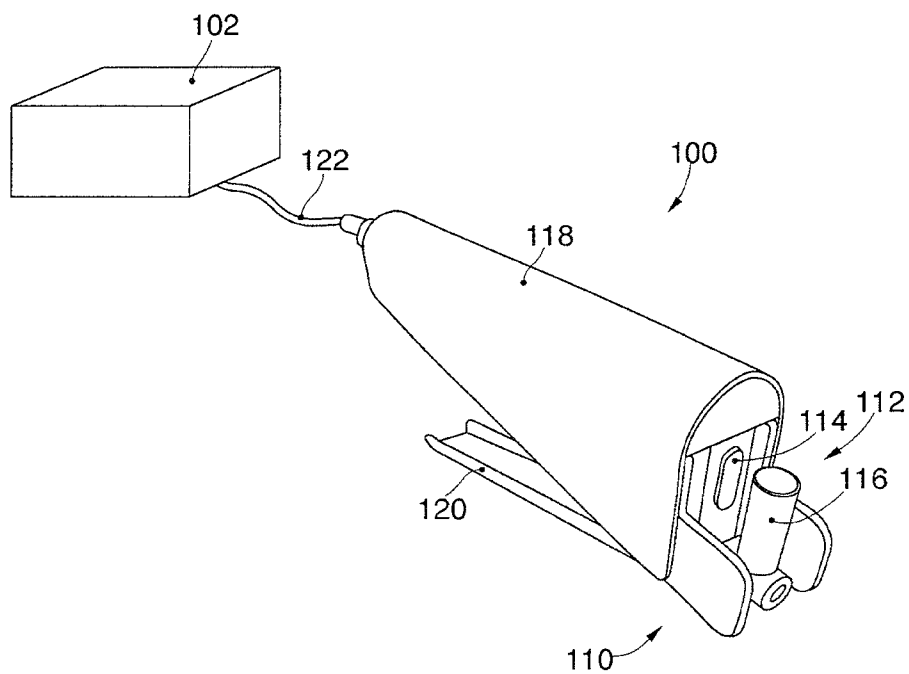


fig. 3

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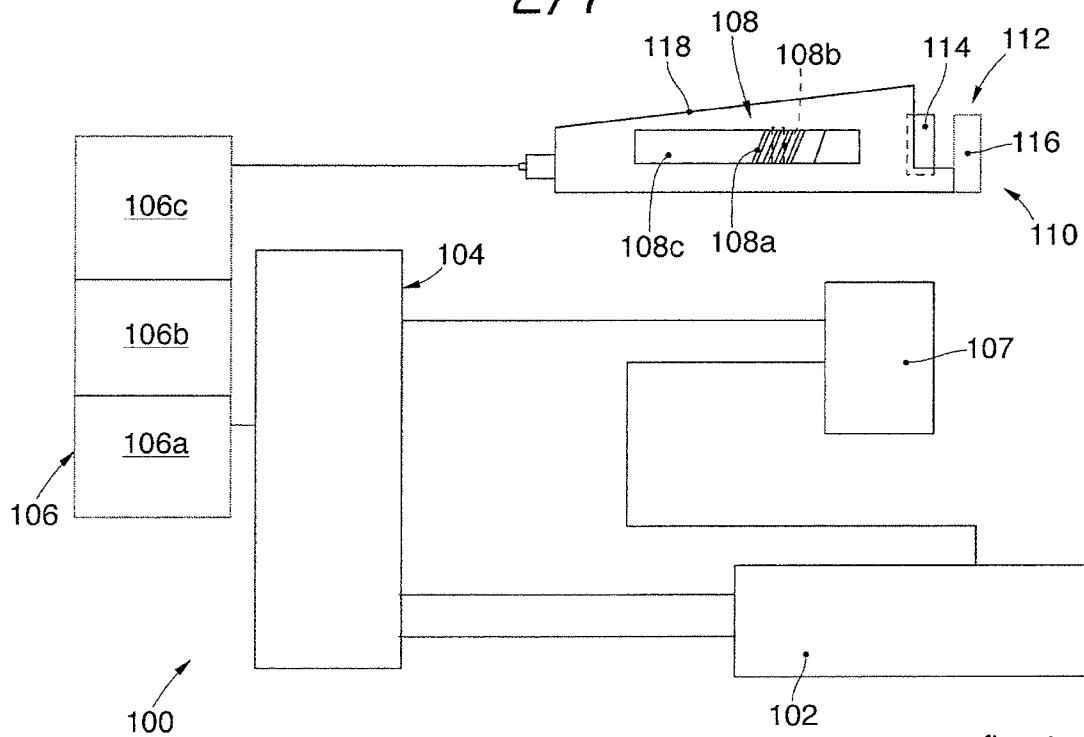


fig. 4

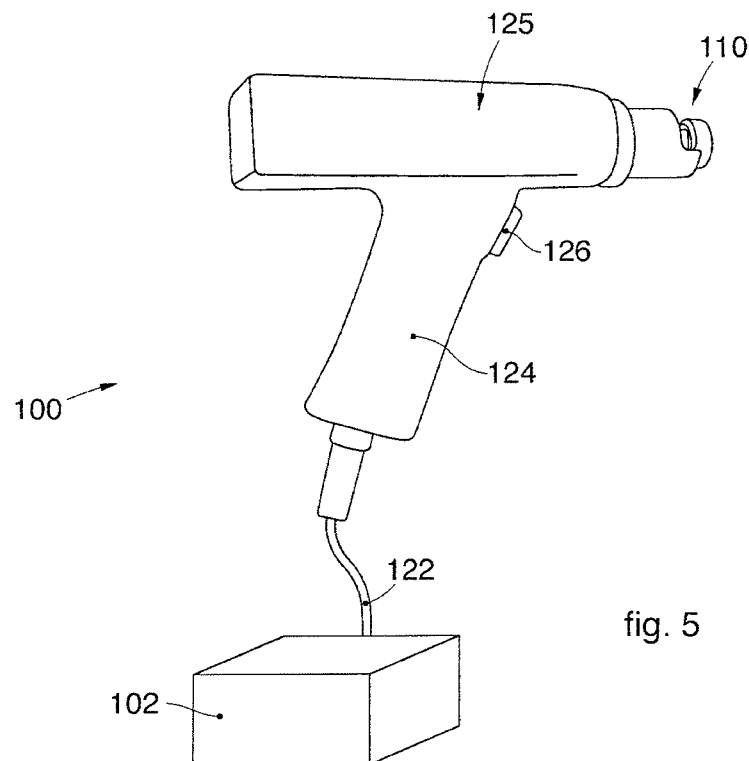
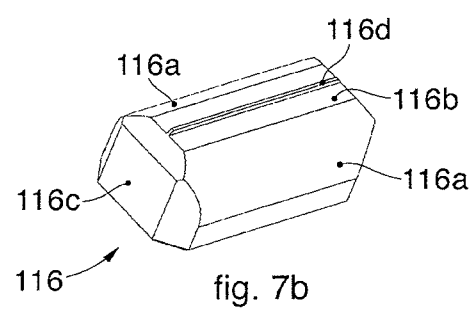
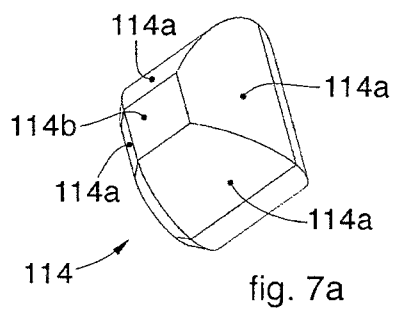
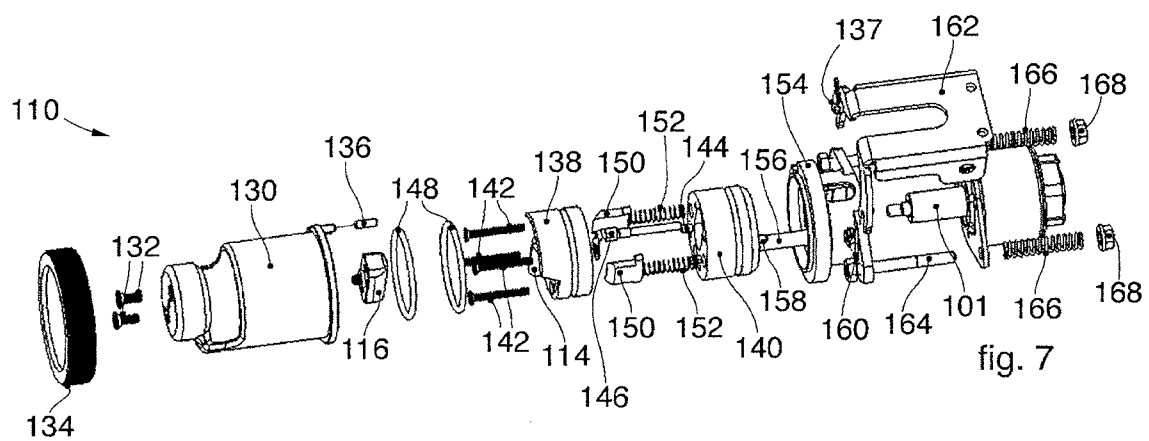
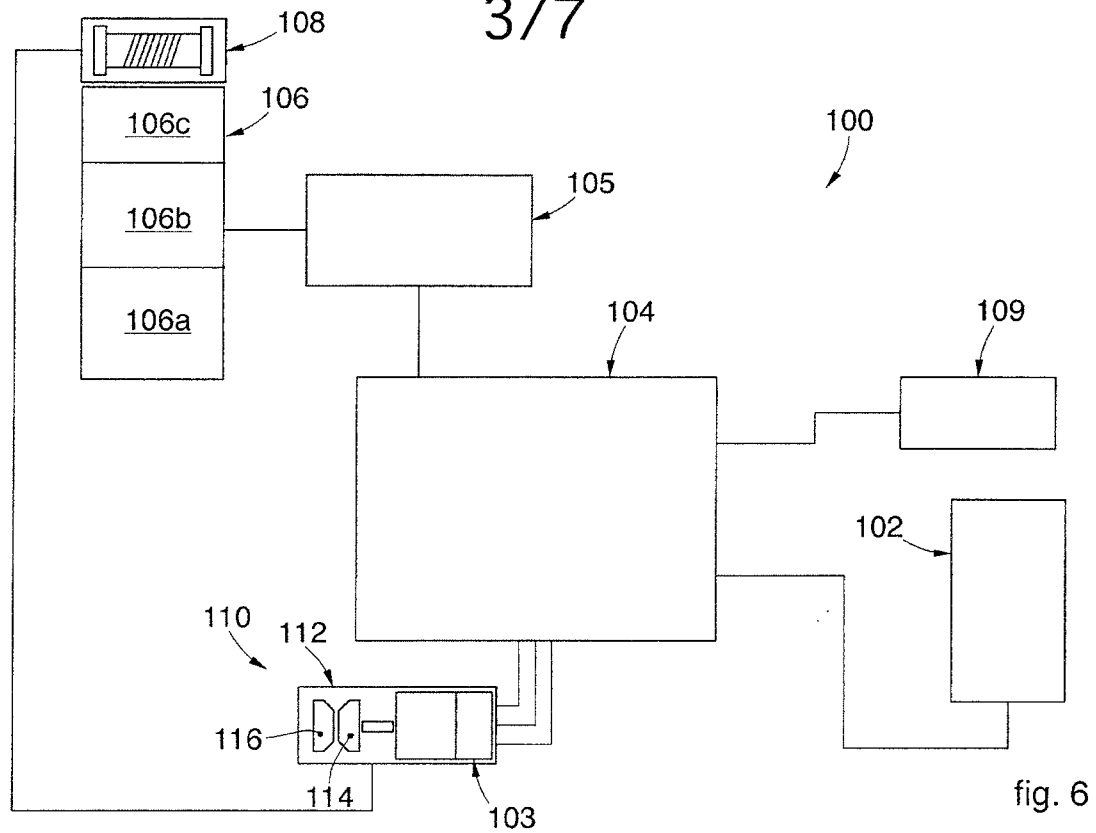
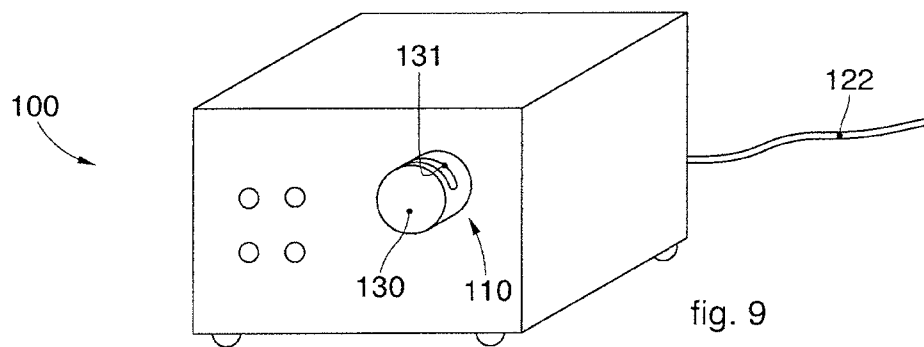
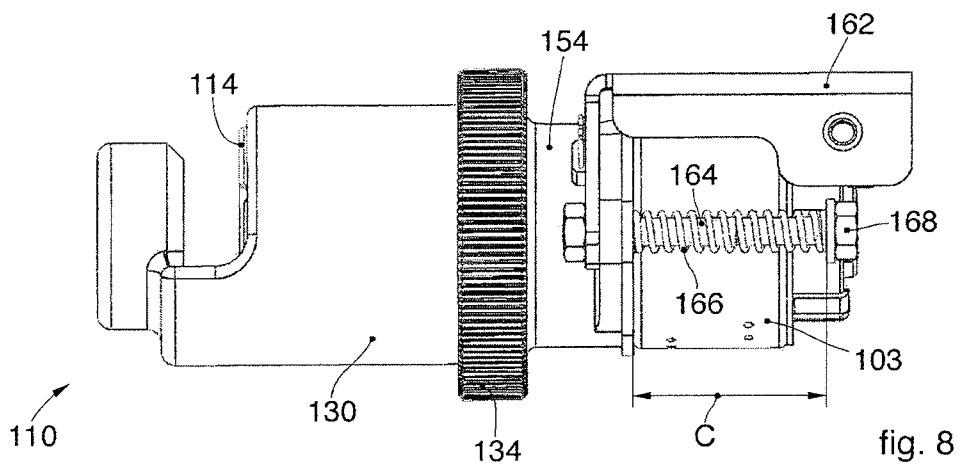
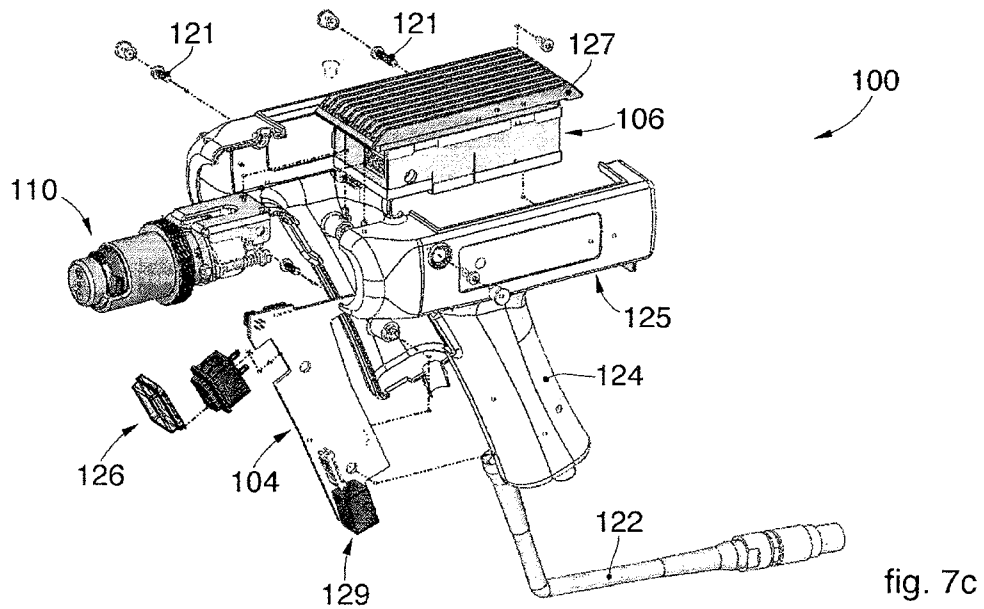


fig. 5



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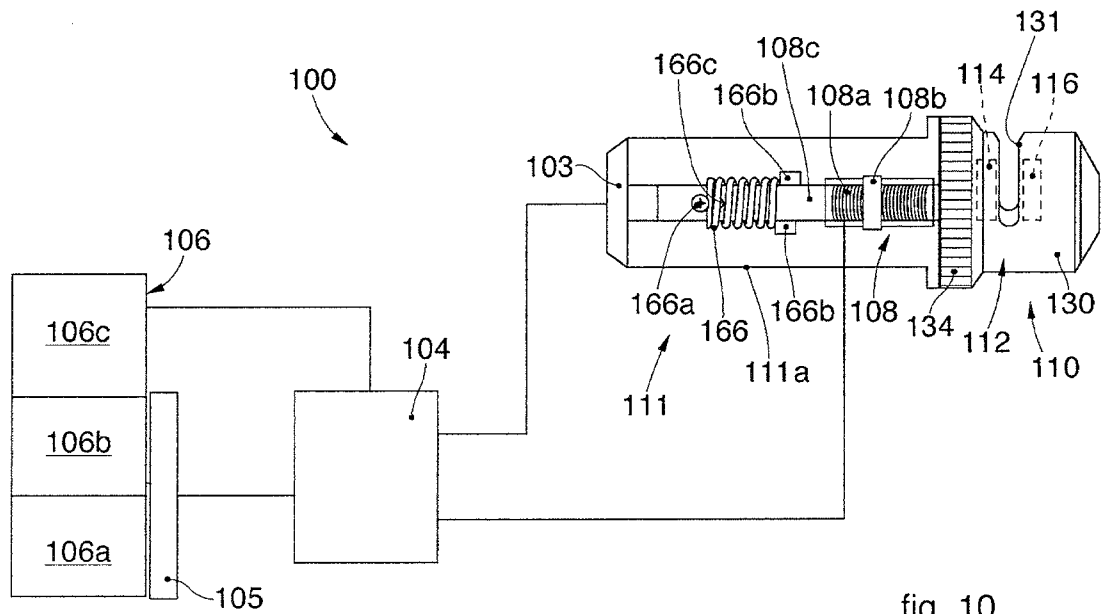


fig. 10

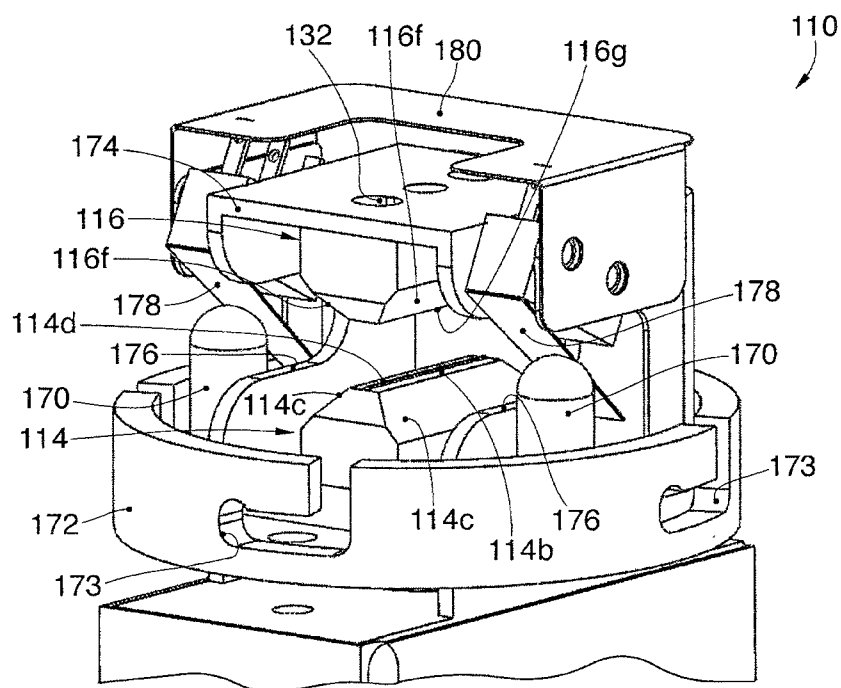
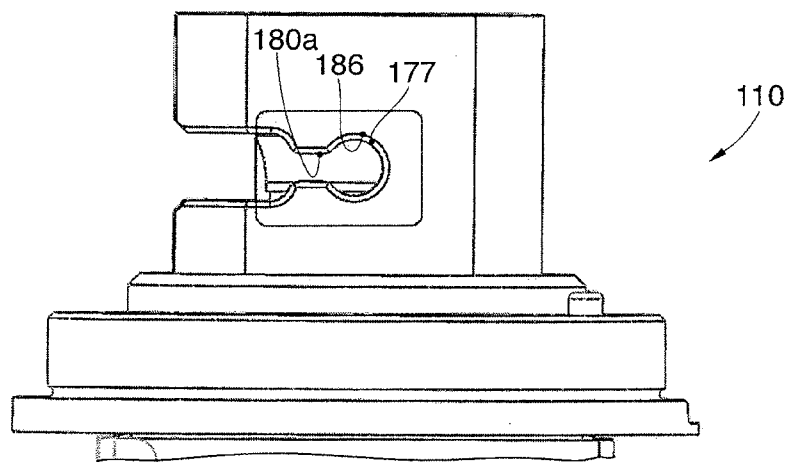
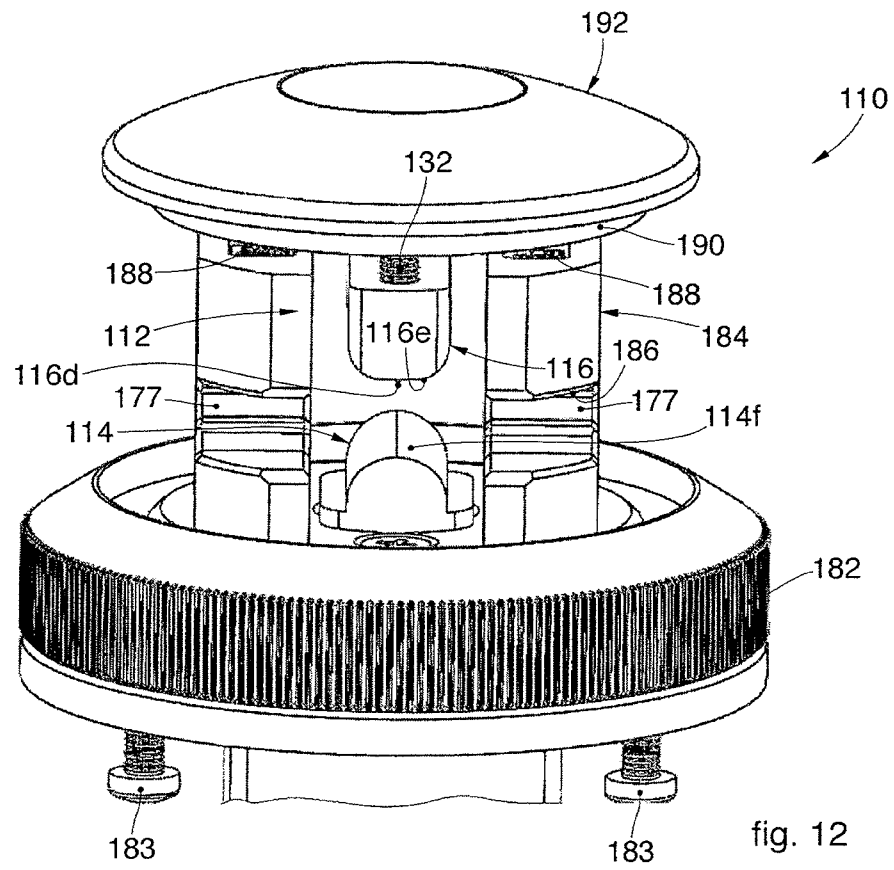
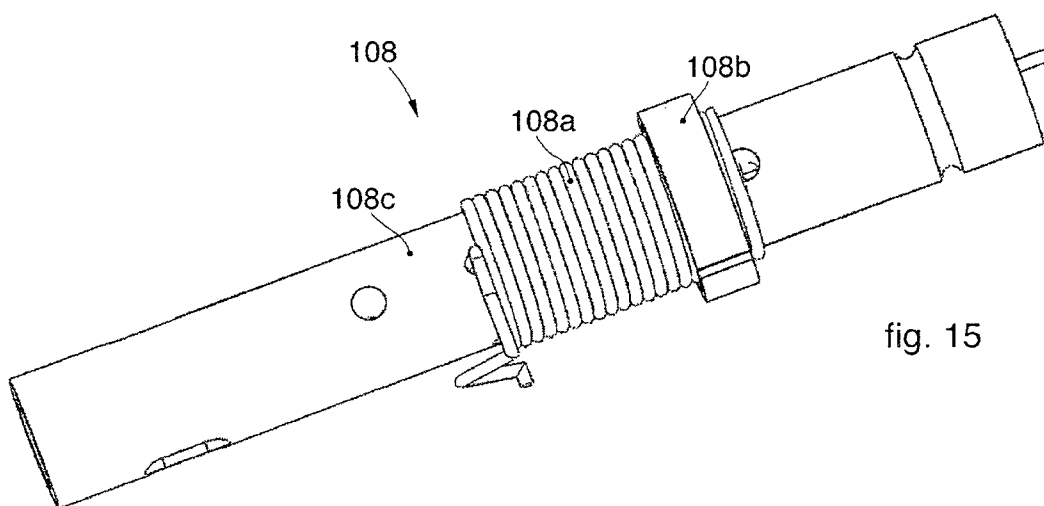
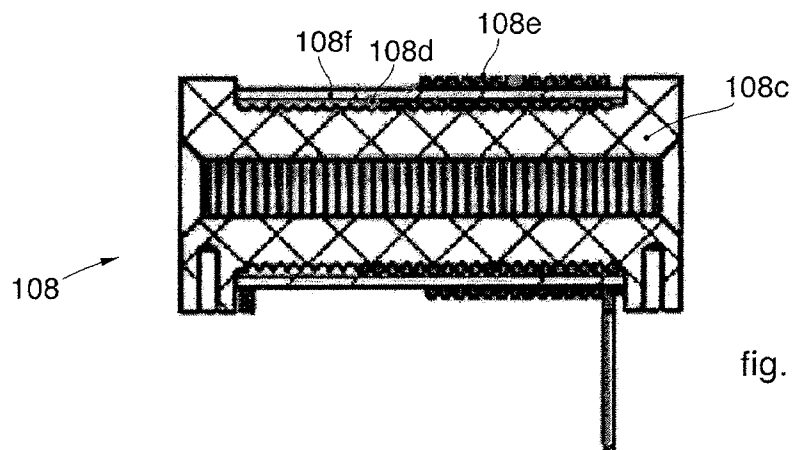
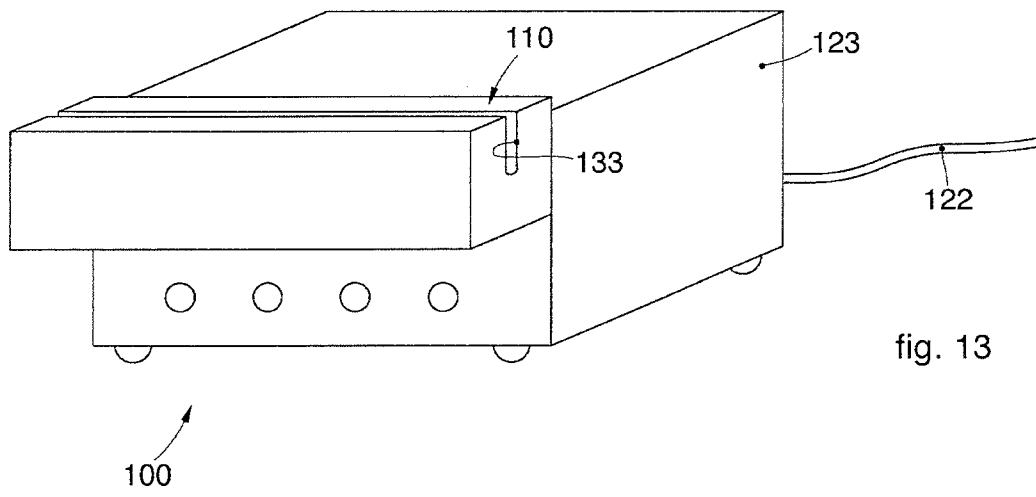


fig. 11

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INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2015/058963

A. CLASSIFICATION OF SUBJECT MATTER

INV. B29C65/04

ADD. H05B6/50 H05B6/62

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)

B29C H05B

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

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X	US 4 488 028 A (ACKER LOREN C [US] ET AL) 11 December 1984 (1984-12-11) abstract figures 3,4,10 column 4, line 35 - column 16, line 15 ----- -/--	1



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

22 February 2016

Date of mailing of the international search report

03/03/2016

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Authorized officer

Taillandier, Sylvain

INTERNATIONAL SEARCH REPORT

International application No
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