(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
15 November 2012 (15.11.2012)

WIPO | PCT

(10) **International Publication Number**
WO 2012/151667 A1

(51) **International Patent Classification**:
B23K 26/28 (2006.01) ***B23K 37/053*** (2006.01)
B23K 26/08 (2006.01)

(21) **International Application Number**:
PCT/CA2012/000416

(22) **International Filing Date**:
3 May 2012 (03.05.2012)

(25) **Filing Language**: English

(26) **Publication Language**: English

(30) **Priority Data**:
61/483,145 6 May 2011 (06.05.2011) US

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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, 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, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, 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,

[Continued on next page]

(54) **Title**: METHOD OF LASER BEAM REMOTE WELDING OF MULTI-PARTS WITHOUT RIGID CLAMPING

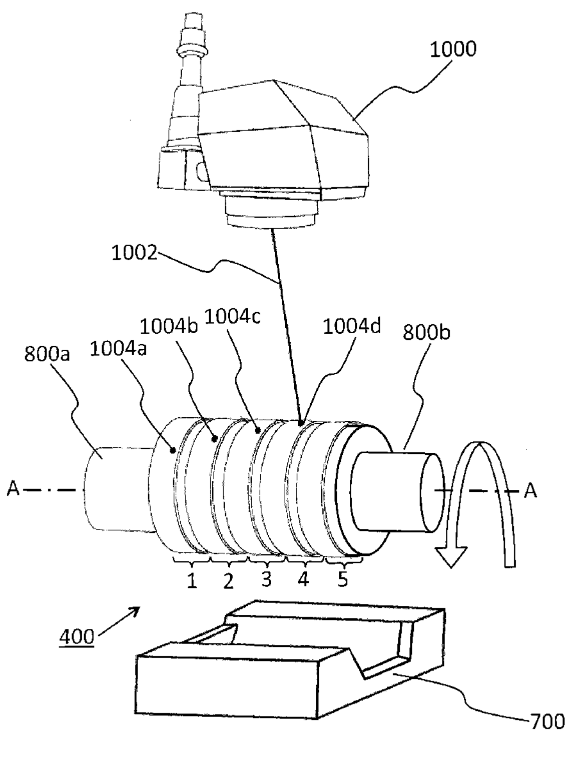

Fig. 10

(57) **Abstract**: A process for welding a plurality of parts in a single production run includes arranging separate components of each part along an axis of rotation, to form a stack having first and second ends. The first and second ends of the stack are gripped using a tool, and sufficient force is applied to maintain the components in stacked arrangement. The stack is rotated about the axis of rotation and laser welding is performed along a plurality of weld lines, each weld line for welding together the separate components of one part. In particular, using a remote laser-welding tool, a plurality of tack welds are applied along each weld line to hold together the components of the separate parts. Subsequently a circular weld is formed along each weld line, thereby consuming the plurality of tack welds and forming each part of the plurality of parts.

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GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, 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, ML, MR, NE, SN, TD, TG).

Published:

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

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

METHOD OF LASER BEAM REMOTE WELDING OF MULTI-PARTS WITHOUT RIGID CLAMPING

[0001] This application claims priority from United States Provisional Patent Application No. 61/483,145, which was filed on May 6, 2011, the entire contents of which are incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The instant invention relates generally to a method and system for laser welding of multiple parts, and more particularly to a method and system for laser welding of multiple parts of small size in one production step and with simplified fixturing for supporting high volume production, such as for instance in the automotive industry.

BACKGROUND OF THE INVENTION

[0003] Automobiles, trucks and other vehicles are made by welding together metal beams and panels to form a chassis, a body and various other parts. The welding process is highly automated in modern factories, with robots typically being utilized to perform the weld and also to handle the parts. Types of welding that are common in the automotive industry include resistance spot welding, friction stir welding, metal inert gas (MIG) welding and laser welding.

[0004] Changing societal priorities, and the concomitant tightening of government regulations requiring reduced vehicle emissions and increased fuel efficiency, have triggered a recent wave of efforts that are aimed at reducing the weights of the parts that are put into new vehicles. Vehicle weight, which is only one of several factors that influences fuel efficiency, may be reduced as a result of using lighter-weight materials, reducing the number of parts that make up the vehicle, and reducing the physical size of the various parts. Unfortunately, some of the traditional welding technologies, such as MIG welding, are not well suited for joining together the components in a small automotive part, due to the excessive amount of heat deposition that occurs. In particular, excessive heating of the part leads to deformation, weakening, or other damage, thereby rendering the part useless.

[0005] Laser welding, on the other hand, is a welding technology that is well suited for joining together the components that make up small parts in vehicles. In particular, laser welding is a non-contact, free form welding technique that is very fast and that generates less heat within a part, i.e., compared to MIG welding. In traditional laser welding the laser output is moved to follow the seam weld, which is usually achieved using a robot. Remote laser welding differs from traditional laser welding in that the laser beam is manipulated from above the work piece by rotating 2 galvo mirrors, which are oriented at 90° to one another. Due to the use of longer focal lengths than are typical in traditional laser welding, small movements in the mirrors result in large movements of the focused beam, resulting in beam speeds over 500 inches per second (13 m/s). Although the heat that is generated during laser welding is reduced to be non-detrimental to the part that is being formed, it is still sufficient to causes distortion to the components that are being welded, especially when the components are made of thin sheet metal. In order to overcome the problems that are associated with distortion, rigid clamping of the part is generally required to ensure that good welds are made. Of course, this rigid clamping mechanism adds complexity to the welding system and limits productivity, and also makes it difficult to process multiple parts in a single step.

[0006] It would therefore be beneficial to provide a method and system that overcome at least some of the above-mentioned limitations and disadvantages of the prior art.

SUMMARY OF THE INVENTION

[0007] According to an aspect of at least one embodiment of the instant invention, there is provided a process for welding a plurality of parts in a single production run, the process comprising: arranging separate components of each part of the plurality of parts in a stacking direction that is aligned along an axis of rotation, so as to form a stack of separate components, said stack having a first end and having a second end that is opposite the first end; engaging gripping portions of a tool one each with the first end and with the second end of the stack, the gripping portions engaging the first and second ends of the stack along the axis of rotation and applying a force to said first and second ends to maintain the stack of separate components in an arranged condition; using the tool, rotating the stack about the axis of rotation; during rotating of the stack, performing laser welding along a plurality of weld lines, each weld line for welding together the separate components of one part of the plurality of parts, the laser welding comprising: using a remote laser welding tool, performing during a first period of time a plurality of tack welds along each weld line of the plurality of weld lines, for welding together the separate components of each part of the plurality of parts; and using the remote laser welding tool, performing during a second period of time a weld along each weld line of the plurality of weld lines thereby consuming the plurality of tack welds and forming each part of the plurality of parts.

[0008] According to an aspect of at least one embodiment of the instant invention, there is provided a process for welding a plurality of parts in a single production run, the process comprising: forming a plurality of groups of separate components in a stacked arrangement along a common axis of rotation, each one of the plurality of groups of separate components for being welded together to form a separate part; fixturing the stacked arrangement of the plurality of groups of separate components using opposing gripper portions of a tool, the opposing gripper portions applying a force at opposite ends of the stacked arrangement, the force that is applied during fixturing being sufficient to maintain the plurality of groups of separate component in the stacked arrangement; rotating the stacked arrangement of the plurality of groups of separate components about an axis of rotation passing through the opposing gripper portions; during rotating, laser welding along a weld line of each group of separate components of the plurality of groups of separate components, each weld line for welding together the separate components of one of the groups of separate components, the laser welding comprising: using a remote laser welding tool, performing during a first period of time a plurality of tack welds along the weld line of each group of separate components, for welding together the separate components of each group of separate components; and using the remote laser welding tool, performing during a second period of time a weld along each weld line thereby consuming the plurality of tack welds and forming each separate part.

[0009] According to an aspect of at least one embodiment of the instant invention, there is provided a system for welding a plurality of parts in a single production run, the system comprising: a support module for supporting a plurality of groups of separate components in a stacked arrangement along a common axis of rotation, each of the plurality of groups of separate components for being welded together to form a separate part; a rotatable gripping assembly having first and second gripping portions, the first gripping portion opposing and spaced apart from the second gripping portion, the first and second gripping portions for applying a force to opposite ends of the stacked arrangement of the plurality of groups of separate components, the applied force being sufficient to maintain the stacked arrangement of the plurality of groups of separate components in the stacked condition subsequent to being removed from the support module; and a laser beam remote welding head for laser welding along a weld line of each group of separate components of the plurality of groups of separate components, wherein during use the rotatable gripping assembly rotates the stacked arrangement of the plurality of groups of separate components, and wherein during use the laser beam remote welding head applies a plurality of tack welds along the weld line of each group of separate components for welding together the separate components of each group of separate components, and subsequently applies a weld along each weld line thereby consuming the plurality of tack welds and forming each part of the plurality of parts.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The instant invention will now be described by way of example only, and with reference to the attached drawings, wherein similar reference numerals denote similar elements throughout the several views, and in which:

[0011] Fig. 1a is a simplified perspective view showing a first component and a second component of a part;

[0012] Fig. 1b is a simplified side view of the first and second components of Fig. 1a;

[0013] Fig. 2a is a simplified perspective view showing a part that is fabricated using the first and second components of Figs. 1a-b;

[0014] Fig. 2b is a simplified side view of the part of Fig. 2a;

[0015] Fig. 3a is an exploded perspective view showing a plurality of first components and a plurality of second components arranged for making a plurality of parts in a single production run according to an embodiment of the instant invention;

[0016] Fig. 3b is a side view showing the arranged components of Fig. 3a;

[0017] Fig. 4a is a simplified perspective view showing a plurality of first components and a plurality of second components arranged and stacked together for making a plurality of parts in a single production run according to an embodiment of the instant invention;

[0018] Fig. 4b is a side view showing the arranged and stacked components of Fig. 4a;

[0019] Fig. 5a is an exploded side view showing a plurality of first components and a plurality of second components arranged for making a plurality of parts according to an embodiment of the instant invention, in which spacer elements are used to achieve desired spacing in the assembly of components;

[0020] Fig. 5b is a side view showing the components of Fig. 5a arranged into a stack, for making a plurality of parts in a single production run according to an embodiment of the instant invention;

[0021] Fig. 6a is a perspective view showing an alternative configuration of a part.

[0022] Fig. 6b is a simplified side view of the part of Fig. 6a;

[0023] Fig. 7 is simplified perspective view showing the arranged and stacked components of Fig. 4a supported in a cartridge;

[0024] Fig. 8 is simplified perspective view showing the arranged and stacked components of Fig. 4a supported in a cartridge and with gripping portions of a rotary tool positioned adjacent to each end of the stack of components;

[0025] Fig. 9 is simplified perspective view showing the arranged and stacked components of Fig. 4a being rotated using the rotary tool, subsequent to the stacked components being removed from the cartridge;

[0026] Fig. 10 is simplified perspective view showing a sequence of tack welds being applied to the arranged and stacked components of Fig. 4a using a remote laser welding head;

[0027] Fig. 11 is simplified perspective view showing remote laser welding of the arranged and stacked components of Fig. 4a using a remote laser welding head; and

[0028] Fig. 12 shows the individual parts that are fabricated in a single production run according to an embodiment of the instant invention, based on the arranged and stacked components of Fig. 4a.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0029] The following description is presented to enable a person skilled in the art to make and use the invention, and is provided in the context of a particular application and its requirements. Various modifications to the disclosed embodiments will be readily apparent to those skilled in the art, and the general principles defined herein may be applied to other embodiments and applications without departing from the scope of the invention. Thus, the present invention is not intended to be limited to the embodiments disclosed, but is to be accorded the widest scope consistent with the principles and features disclosed herein.

[0030] Fig. 1a is a simplified perspective view showing a first component 102 and a second component 104. Fig. 1b shows a side view of the first component 102 and of the second component 104. In this specific and non-limiting example, the first component 102 and the second component 104 are substantially disc-shaped components. In particular, the first component 102 and the second component 104 are fabricated from sheet metal. The inside diameter of the first component 102 is approximately the same as the outside diameter of the second component 104, with sufficient clearance to allow a portion of the first component 102 to overlap with a portion of the second component 104. Fig. 2a shows a perspective view of a part 200, such as for instance a part for a vehicle, which is fabricated by joining together the first component 102 and the second component 104. As is shown more clearly in the side view of Fig. 2b, the first component 102 and the second component 104 overlap along an overlapping region 202. In order to form the part 200, the first component 102 and the second component 104 are welded together along a weld line 204 within the overlapping region 202, using laser welding.

[0031] Fig. 3a is an exploded perspective view showing a plurality of first components 102a-n and a plurality of second components 104a-n, arranged for making a plurality of parts 200 in a batch process according to an embodiment of the instant invention. Fig. 3b is an exploded side view showing the plurality of first components 102a-n and the plurality of second components 104a-n of Fig. 3a.

[0032] Fig. 4a is a simplified perspective view showing five disc-shaped first components 102a-e that are arranged in an alternating sequence with five disc-shaped second components 104a-e. More particularly, the first components 102a-e and the second components 104a-e are arranged one relative to another to form a stacked assembly 400. Fig. 4b shows the stacked assembly 400 in side view. In this specific and non-limiting example the stacked assembly 400 includes a set of five, generally cylindrical or disc-shaped first components 102a-e. The stacked assembly 400 also includes a set of five, generally cylindrical or disc-shaped second components 104a-e. The first components are stacked in an alternating sequence with the second components along a stacking direction that extends parallel to a longitudinal axis A—A of the assembly 400.

[0033] As is shown in Fig. 4b, each first component overlaps with a portion of a second component that is adjacent thereto. The dashed lines in Fig. 4b indicate those portions of the second component that are overlapped by one of the first components. In the example that is shown in Figs. 4a and 4b, the second components are sized relative to the first components such that, when assembled into the stacked assembly 400, the second components are in an end-to-end abutting relationship with one another. The first components are arranged in an overlapping relationship with the second components, and are arranged at predetermined respective positions along the stacking direction of the stacked assembly 400. In this specific and non-limiting example, five individual parts are fabricated from the components in the stacked assembly 400 in a single production run. In particular, circular welds are formed within the region of overlap 402a for securing together first component 102a and second component 104a. Similarly, circular welds are formed within the remaining regions of overlap 402b-e for securing together the remaining first components and the remaining second components.

[0034] Alternatively, components that are not disc-shaped are arranged relative to one another to form a stacked assembly in a similar fashion. Alternatively, more than two different types of components are arranged to form a stacked assembly for forming multiple parts. For instance, a stacked assembly is formed in which three or more different types of components are arranged relative to one another in a sequence for forming parts. Further alternatively, a number other than five of each type of component is provided. For instance, alternatively ten first components and ten second components are arranged in an alternating sequence for forming ten parts in a single production run according to an embodiment of the instant invention.

[0035] Fig. 5a is an exploded side view showing a plurality of first components 102a-e, a plurality of second components 104a-e, and a plurality of spacer elements 502 arranged for making a plurality of individual parts in a single production run according to an embodiment of the instant invention. Fig. 5b is a side view showing the plurality of first components 102a-e, the plurality of second components 104a-e and the plurality of spacer elements 502 of Fig. 5a, arranged one relative to another to form a stacked assembly 500. In particular, each spacer element 502 is disposed between facing ends of adjacent second components. For instance, a spacer element 502 is disposed between the facing ends of the second components 104a and 104b, and between the facing ends of the second components 104b and 104c, etc. The spacer elements 502 serve to maintain a desired relative spacing between adjacent ones of the second components 104a-e. As discussed with reference to Fig. 4b, each first component overlaps with a portion of the second component that is adjacent thereto. In this specific and non-limiting example, five individual parts are fabricated from the components in the stacked assembly 500 in a single production run. In particular, circular welds are formed within a region of overlap between the first and second components, so as to join together first component 102a and second component 104a, and so as to join together the first component 102b and the second component 104b, etc.

[0036] Fig. 6a is a perspective view showing an alternative configuration of a part 600. In particular, the part 600 that is shown in Fig. 6a comprises a first component 602 and a second component 604. Fig. 6b is a side view of the part 600 of Fig. 6a. In this alternative configuration, the second component 604 is disposed entirely within the first component 602, and the two components are joined together along a weld line 606. A stacked assembly (not shown) of the first components 602 and of the second components 604 requires spacer elements (not shown) in order to maintain a desired spacing between the end faces of the second components 604 in the stack.

[0037] Referring now to Fig. 7, the stacked assembly 400 of Fig. 4a and Fig. 4b is shown supported in a support module, such as for instance a cartridge 700. The cartridge 700 is shaped to support the disc-shaped components of the stacked assembly 400 such that a through-hole or recess 702 at each end of the stacked assembly 400 is accessible. The stacked assembly 400 can be held in the cartridge 700, and then subsequently transported to a welding station for being welded together. Optionally, the cartridge 700 is part of a not illustrated conveyer system, such that successive stacks 400 of disc-shaped components can be fed continuously to the welding station.

[0038] Fig. 8 is simplified perspective view showing the stacked assembly 400 of Fig. 4a and Fig. 4b supported in the cartridge 700 of Fig. 7, and with gripping portions 800a and 800b of a rotary tool positioned adjacent to each end of the stacked assembly 400. In particular, each gripping portion 800a and 800b of the rotary tool includes a protrusion 802a and 802b, respectively, that is sized to fit into the through-hole or recess 702 at each end of the stacked assembly 400.

[0039] Referring now to Fig. 9, the stacked assembly 400 is shown after being extracted from the cartridge 700 by the rotary tool. In particular, the gripping portions 800a and 800b of the rotary tool support the opposite ends of the stacked assembly 400. As is shown in Fig. 9, the stacked assembly 400 is rotatable, at a constant speed, about the longitudinal axis A—A. The disc-shaped components are retained in the stacked relationship due to the force that is exerted at each end of the stacked assembly 400 by the gripping portions 800a and 800b of the rotary tool. In this way, the rotary tool acts as a simple fixture for retaining the overall arrangement of the stacked assembly 400, without the need to clamp each of the various components of the multiple parts individually. As such, in the instant example, fixturing of all the components for five separate parts is achieved simply by gripping the stacked assembly 400 at the opposite ends thereof.

[0040] Referring now to Fig. 10, the stacked assembly 400 is shown in a welding station. The gripping portions 800a and 800b of the rotary tool are used to rotate the stacked assembly 400 about the longitudinal axis A—A, at a welding position within the welding station. A laser beam remote welding head 1000 is used to direct a laser beam 1002 to apply a sequence of tack welds to the stacked assembly 400, using a series of scanning laser pulses. The laser beam remote welding head 1000 is stationary over the welding station throughout the welding process. In particular, the laser beam 1002 is manipulated and directed onto each component, for welding, by adjusting mirrors that are located inside the laser beam remote welding head 1000.

[0041] Referring still to Fig. 10, the first step of the welding process is to make a series of tack welds on each group of components in the stacked assembly 400. In this first step, laser pulses are scanned in sequence over the groups of components that make up each of the parts, in such a way that when the laser beam finishes the tack weld on components of the last part it moves back to components of the first part to start the scanning tack weld again. At the end of a full rotation, the laser beam 1002 has made an equal number of tack welds on the components of each part in the stacked assembly 400, and these tack welds are evenly distributed along each welding line, such as for instance the welding line 202 that is shown in Fig. 2b. In this way, a first tack weld 1004a is applied to fix together the disc-shaped first and second components of a first part "1" in Fig. 10, a second tack weld 1004b is applied to fix together the disc-shaped first and second components of a second part "2" in Fig. 10, a third tack weld 1004c is applied to fix together the disc-shaped first and second components of a third part "3" in Fig. 10, a fourth tack weld 1004d is applied to fix together the disc-shaped first and second components of a fourth part "4" in Fig. 10, and a fifth not illustrated tack weld is applied to fix together the disc-shaped first and second components of a fifth part "5" in Fig. 10. Next, the laser pulse is scanned back to apply another spot weld on the first part "1," and so forth. Advantageously, the process of applying the tack welds results in minimal heat deposition into the disc-shaped components, and accordingly very little deformation occurs during this portion of the process.

[0042] As is shown in Fig. 11, once the tack welds are done the laser beam 1002 begins performing full circular welding in order to form each of the plurality of finished parts. In one approach, which is shown explicitly in Fig. 11, the laser welding operation is performed sequentially on each part by starting within the overlapping region between the first and second disc-shaped components at one end of the stacked assembly 400, and progressing toward the opposite end of the stacked assembly 400. In Fig. 11, a full circular weld 1100a has been applied to form the first part "1," and a second circular weld 1100b has been started to form the second part "2." Alternatively, the welding operation is programmed on the stacked assembly 400 randomly, to avoid potential heat build-up. Since the tack welds 1004a-d etc. are in place before the full welding is started, there is little or no chance for heat distortion to affect the weld integrity. The tack welds 1004a-d etc. are consumed when the full, circular welds (e.g., 1100a, 1100b) are formed.

[0043] After the welding process is completed, the rotary tool releases the finished parts. For instance, the finished parts are returned to the cartridge 700 and are conveyed away from the welding station. A next cartridge (not illustrated) supporting a next stacked assembly (not illustrated) is then advanced into the welding station and the welding process is repeated to form a next batch of finished parts.

[0044] Referring now to Fig. 12, shown is a plurality of individual parts 600a-e fabricated from the stacked assembly 400 according to the process that is described above, and subsequent to being removed from the cartridge 700 and separated. In the instant example, five parts are formed in a single production run and requiring only simple fixturing. That is to say, only the ends of the stack 400 are engaged by the gripping portions 800a and 800b of the rotary tool. The components of each individual part are not clamped individually, thereby reducing processing time and increasing throughput. The method and system that are described with reference to Figs. 1-12 efficiently utilizes the laser resource and maximizes the beam on-time.

[0045] While the above description constitutes a plurality of embodiments of the present invention, it will be appreciated that the present invention is susceptible to further modification and change without departing from the fair meaning of the accompanying claims.

CLAIMS

What is claimed is:

1. A process for welding a plurality of parts in a single production run, the process comprising:

arranging separate components of each part of the plurality of parts in a stacking direction that is aligned along an axis of rotation, so as to form a stack of separate components, said stack having a first end and having a second end that is opposite the first end;

engaging gripping portions of a tool one each with the first end and with the second end of the stack, the gripping portions engaging the first and second ends of the stack along the axis of rotation and applying a force to said first and second ends to maintain the stack of separate components in an arranged condition;

using the tool, rotating the stack about the axis of rotation;

during rotating of the stack, performing laser welding along a plurality of weld lines, each weld line for welding together the separate components of one part of the plurality of parts, the laser welding comprising:

using a remote laser welding tool, performing during a first period of time a plurality of tack welds along each weld line of the plurality of weld lines, for welding together the separate components of each part of the plurality of parts; and

using the remote laser welding tool, performing during a second period of time a weld along each weld line of the plurality of weld lines thereby consuming the plurality of tack welds and forming each part of the plurality of parts.

2. The process of claim 1 wherein arranging comprises putting the separate components of each part into a cartridge, the separate components of one part being disposed adjacent to the separate components of a next part along the stacking direction within the cartridge.

3. The process of claim 1 or 2 wherein the separate components of each part are substantially disc-shaped components each having at least a generally cylindrical sidewall.

4. The process of claim 3 wherein the separate components of each part are arranged such that the generally cylindrical sidewall of one of the separate components overlaps at least partially with the generally cylindrical sidewall of the other one of the separate components, so as to define on each part of the plurality of parts a region of overlap.

5. The process of claim 4 wherein each weld line of the plurality of weld lines is defined within a region of overlap on a different part of the plurality of parts.

6. The process of any one of claims 1 to 5 wherein arranging comprises inserting spacer elements between at least some of the separate components, the spacer elements for imposing a predetermined spacing between adjacent components of the at least some of the separate components.

7. The process of any one of claims 1 to 6 wherein engaging gripping portions of the tool one each with the first end and with the second end of the stack comprises inserting a projecting portion of one of the gripping portions into a through hole or recess at the first end of the stack and inserting a projecting portion of the other one of the gripping portions into a through hole or recess at the second end of the stack.

8. The process according to any one of claims 1 to 7 wherein rotating the stack about the axis of rotation comprises rotating the stack at a constant speed.

9. The process according to any one of claims 1 to 8 wherein arranging is performed absent a step of rigidly clamping the separate components of each part of the plurality of parts.

10. A process for welding a plurality of parts in a single production run, the process comprising:

forming a plurality of groups of separate components in a stacked arrangement along a common axis of rotation, each one of the plurality of groups of separate components for being welded together to form a separate part;

fixturing the stacked arrangement of the plurality of groups of separate components using opposing gripper portions of a tool, the opposing gripper portions applying a force at opposite ends of the stacked arrangement, the force that is applied during fixturing being sufficient to maintain the plurality of groups of separate component in the stacked arrangement;

rotating the stacked arrangement of the plurality of groups of separate components about an axis of rotation passing through the opposing gripper portions;

during rotating, laser welding along a weld line of each group of separate components of the plurality of groups of separate components, each weld line for welding together the separate components of one of the groups of separate components, the laser welding comprising:

using a remote laser welding tool, performing during a first period of time a plurality of tack welds along the weld line of each group of separate components, for welding together the separate components of each group of separate components; and

using the remote laser welding tool, performing during a second period of time a weld along each weld line thereby consuming the plurality of tack welds and forming each separate part.

11. The process of claim 10 wherein forming the plurality of groups of separate components comprises putting the separate components of each group into a cartridge, the separate components of one group being disposed adjacent to the separate components of a next group in a stacking direction along the common axis of rotation within the cartridge.

12. The process of claim 10 or 11 wherein the separate components of each group are substantially disc-shaped components each having at least a generally cylindrical sidewall.

13. The process of claim 12 wherein the separate components of each group are arranged such that the generally cylindrical sidewall of one of the separate components overlaps at

least partially with the generally cylindrical sidewall of the other one of the separate components, so as to define for each group of the plurality of groups a region of overlap.

14. The process of claim 13 wherein for each group of separate components the weld line thereof is defined within a region of overlap between the separate components of said group.

15. The process of any one of claims 10 to 14 wherein forming the plurality of groups comprises inserting spacer elements between at least some of the separate components, the spacer elements for imposing a predetermined spacing between adjacent components of the at least some of the separate components.

16. The process according to any one of claims 10 to 15 wherein rotating the stacked arrangement of the plurality of groups of separate components about the axis of rotation passing through the opposing gripper portions comprises rotating the stacked arrangement at a constant speed.

17. The process according to any one of claims 10 to 16 wherein fixturing is performed absent a step of rigidly clamping the separate components of each group of the plurality of groups.

18. A system for welding a plurality of parts in a single production run, the system comprising:

a support module for supporting a plurality of groups of separate components in a stacked arrangement along a common axis of rotation, each of the plurality of groups of separate components for being welded together to form a separate part;

a rotatable gripping assembly having first and second gripping portions, the first gripping portion opposing and spaced apart from the second gripping portion, the first and second gripping portions for applying a force to opposite ends of the stacked arrangement of the plurality of groups of separate components, the applied force being sufficient to maintain the stacked arrangement of the plurality of groups of separate components in the stacked condition subsequent to being removed from the support module; and a laser beam remote welding head for laser welding along a weld line of each group of separate components of the plurality of groups of separate components, wherein during use the rotatable gripping assembly rotates the stacked arrangement of the plurality of groups of separate components, and wherein during use the laser beam remote welding head applies a plurality of tack welds along the weld line of each group of separate components for welding together the separate components of each group of separate components, and subsequently applies a weld along each weld line thereby consuming the plurality of tack welds and forming each part of the plurality of parts.

19. The system of claim 18 wherein the support module comprises a conveyor element of a conveyor system for conveying the plurality of groups of separate components to a welding station adjacent to the laser beam remote welding head and for conveying the plurality of parts away from the welding station.

20. The system of claim 18 wherein the support module other than comprises clamps for rigidly clamping the separate components of each group of the plurality of groups.

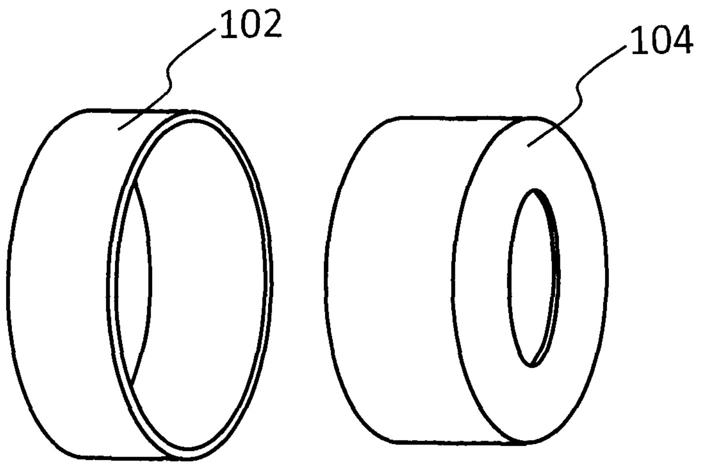

Fig. 1a

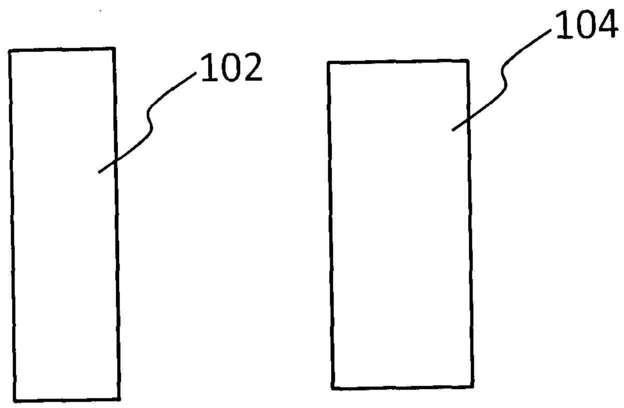

Fig. 1b

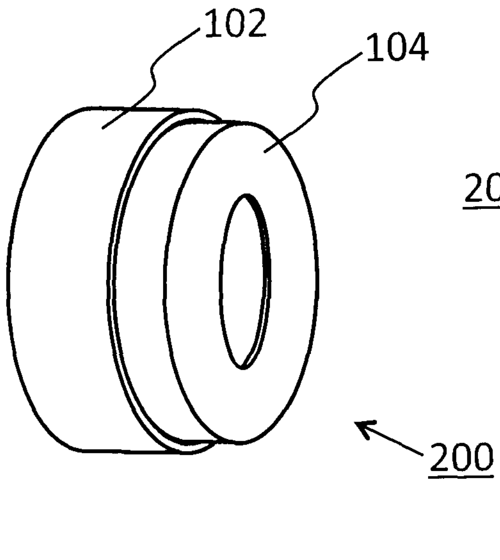

Fig. 2a

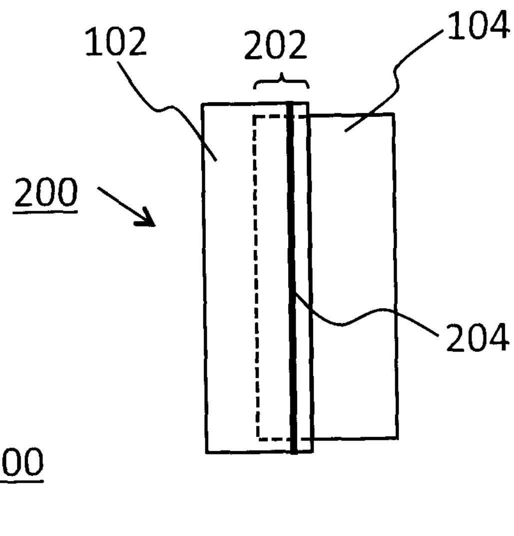

Fig. 2b

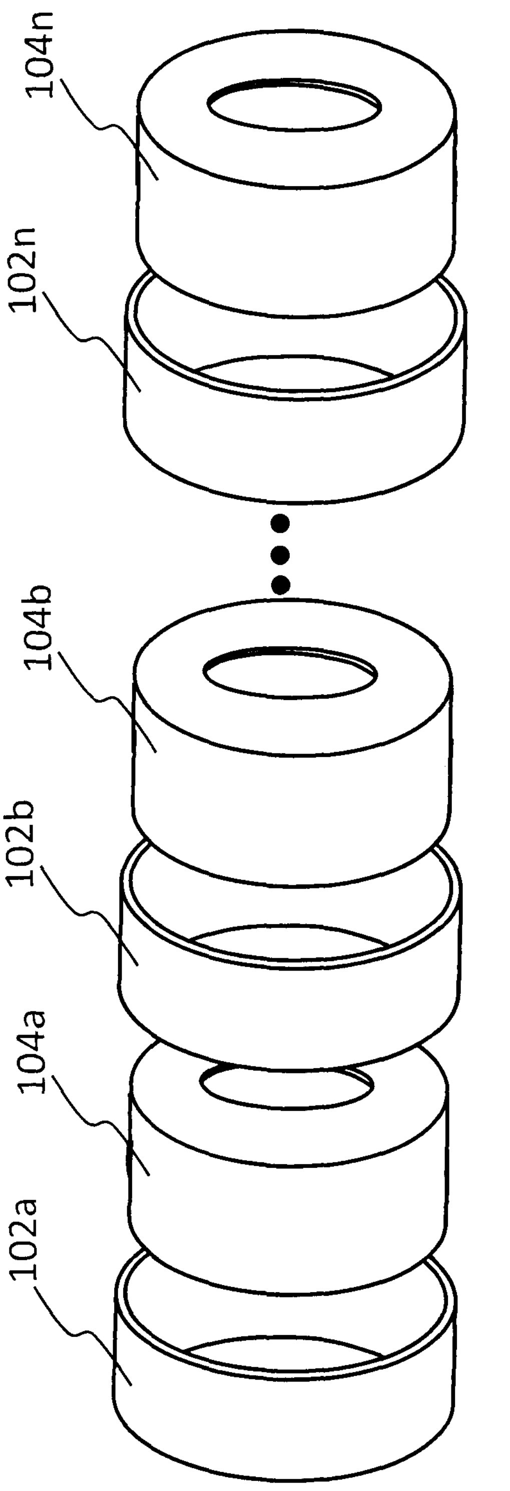

Fig. 3a

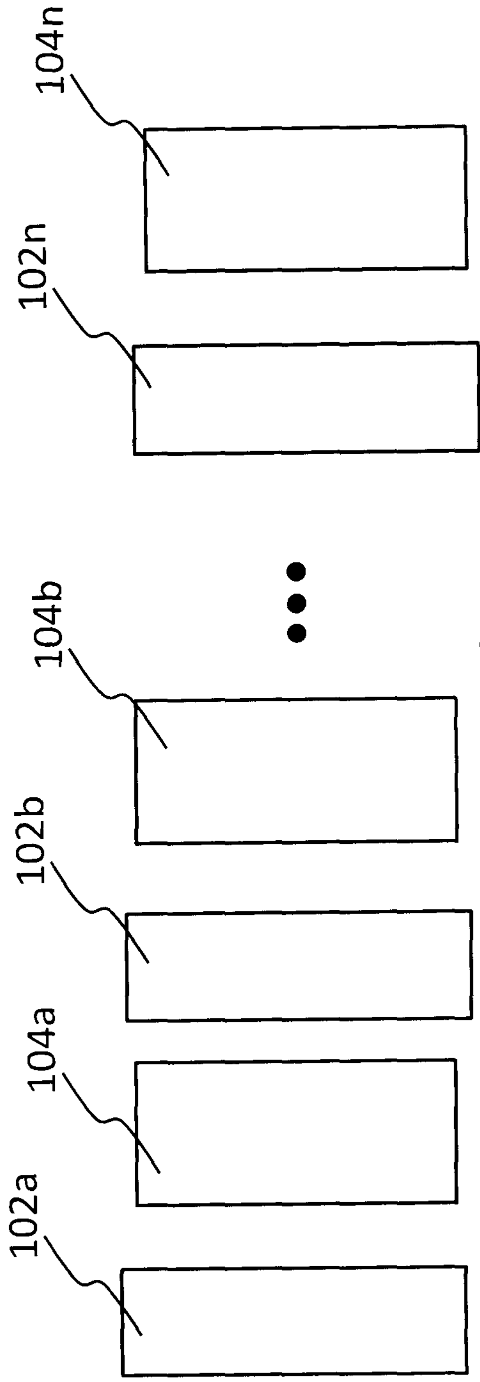

Fig. 3b

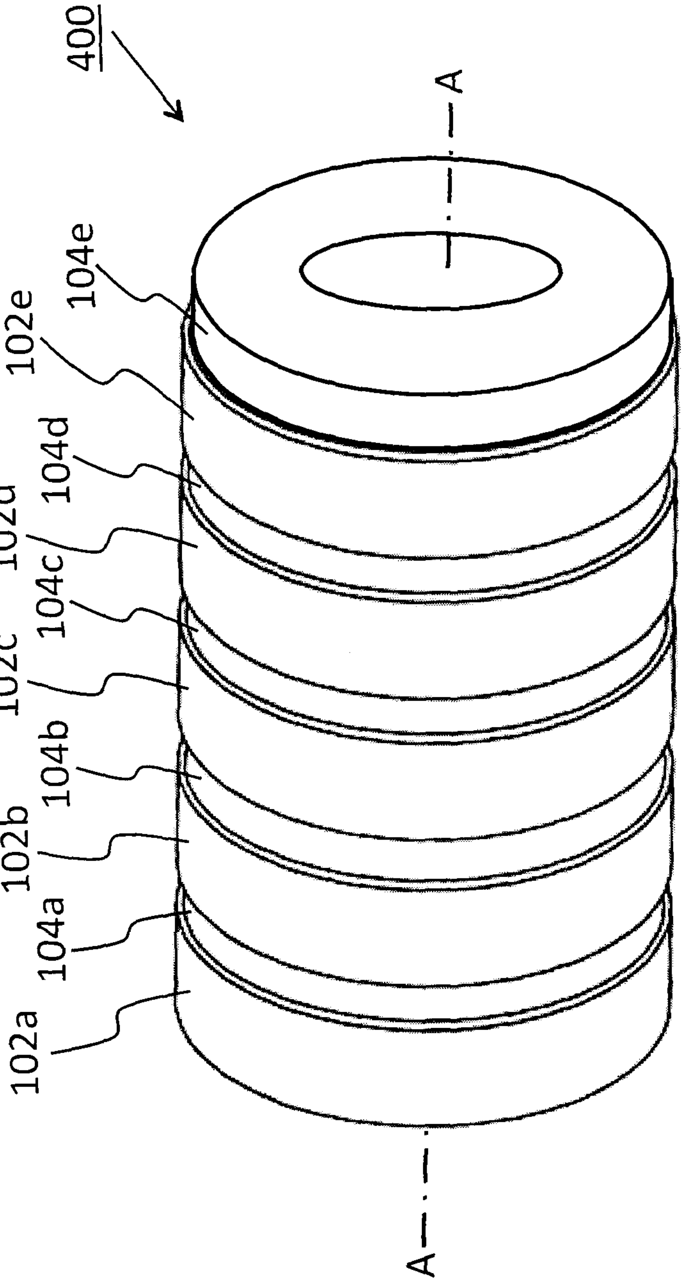

Fig. 4a

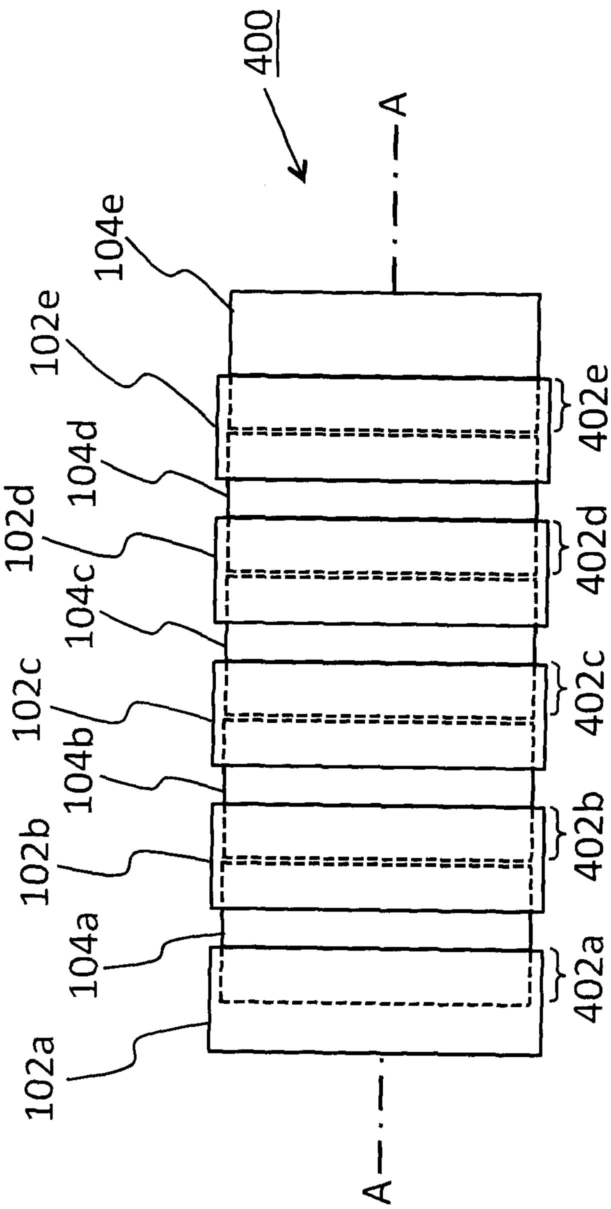
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Fig. 4b

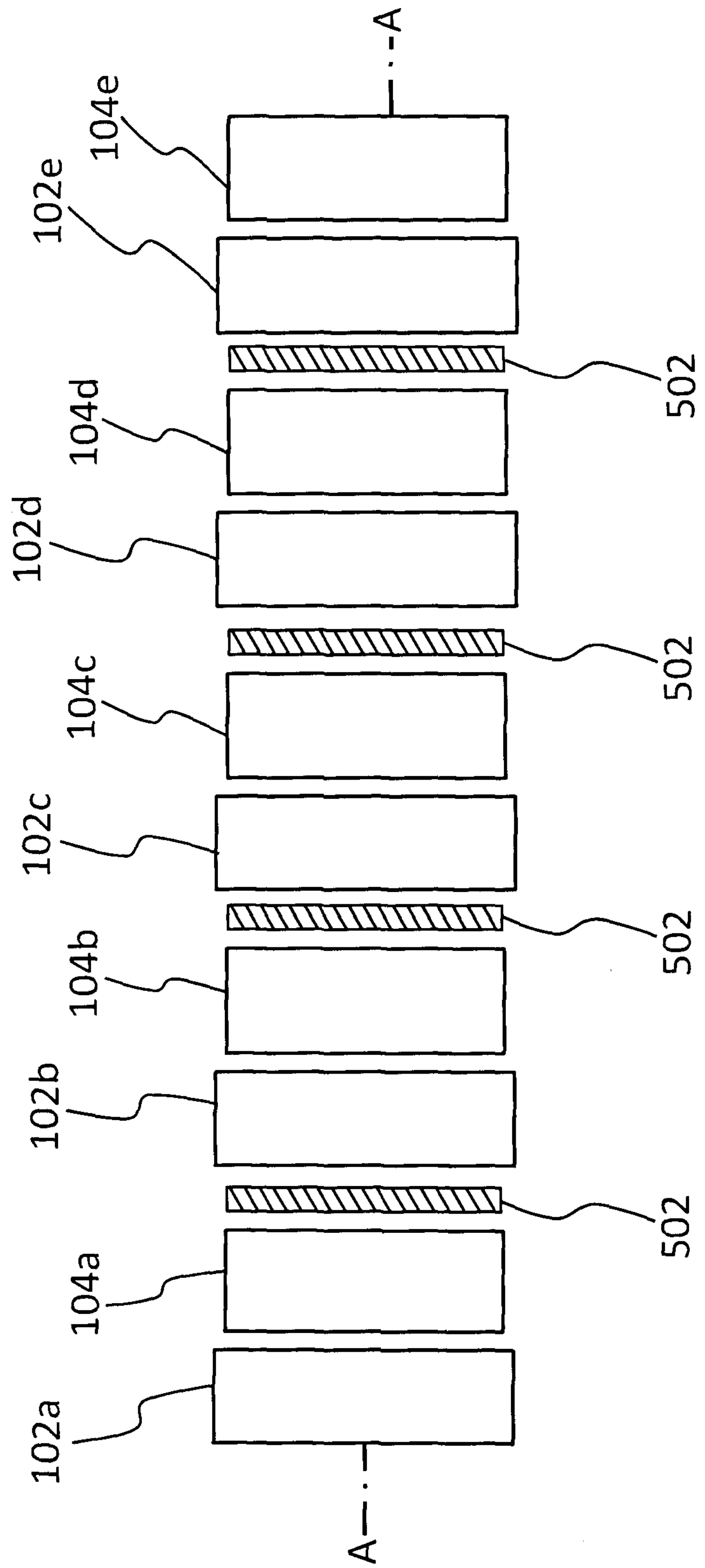
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Fig. 5a

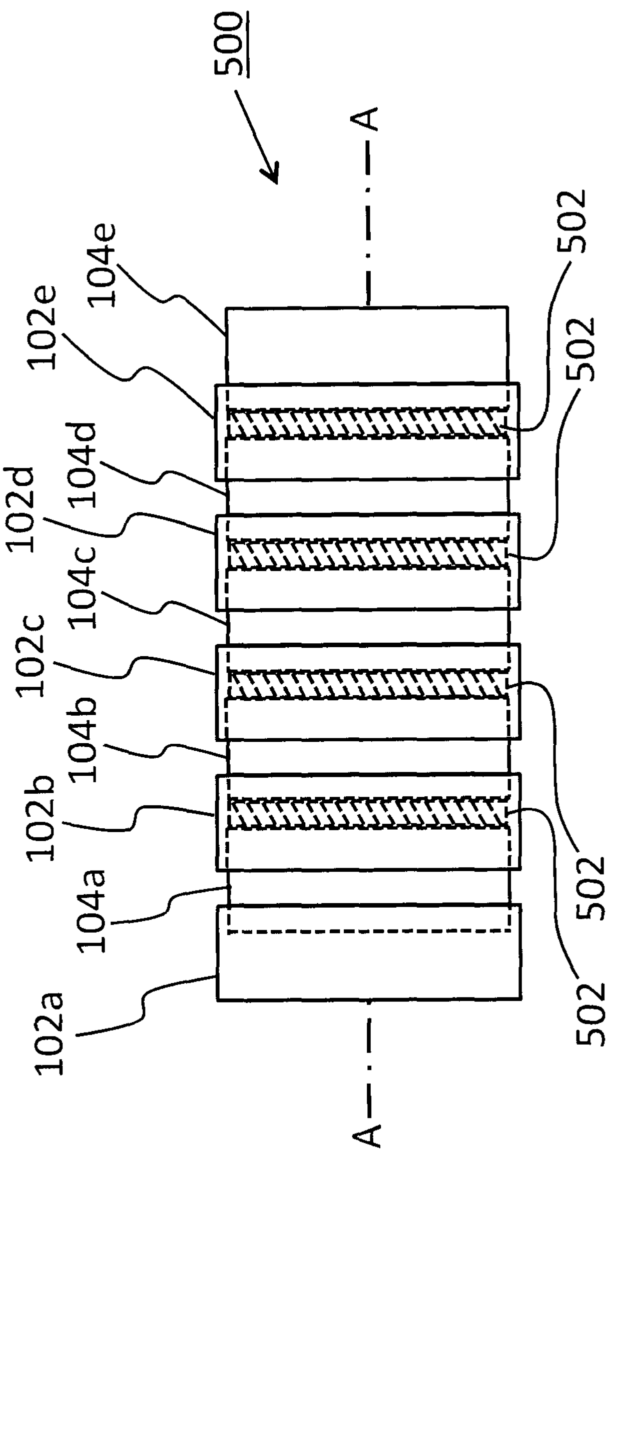
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Fig. 5b

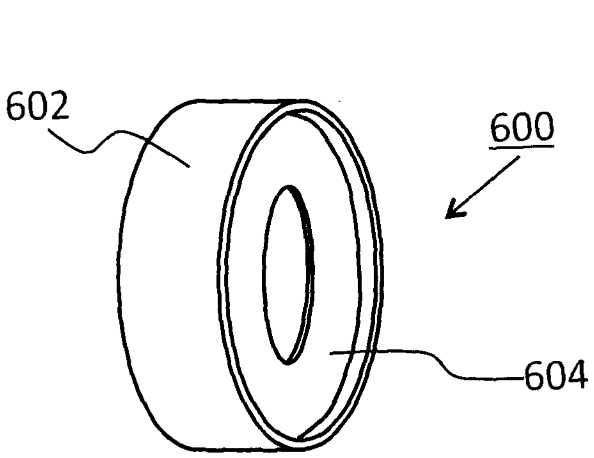

Fig. 6a

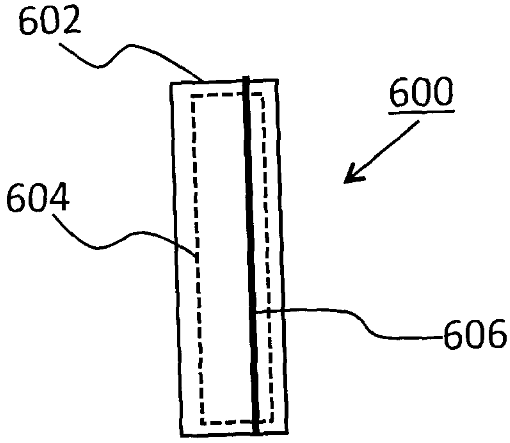

Fig. 6b

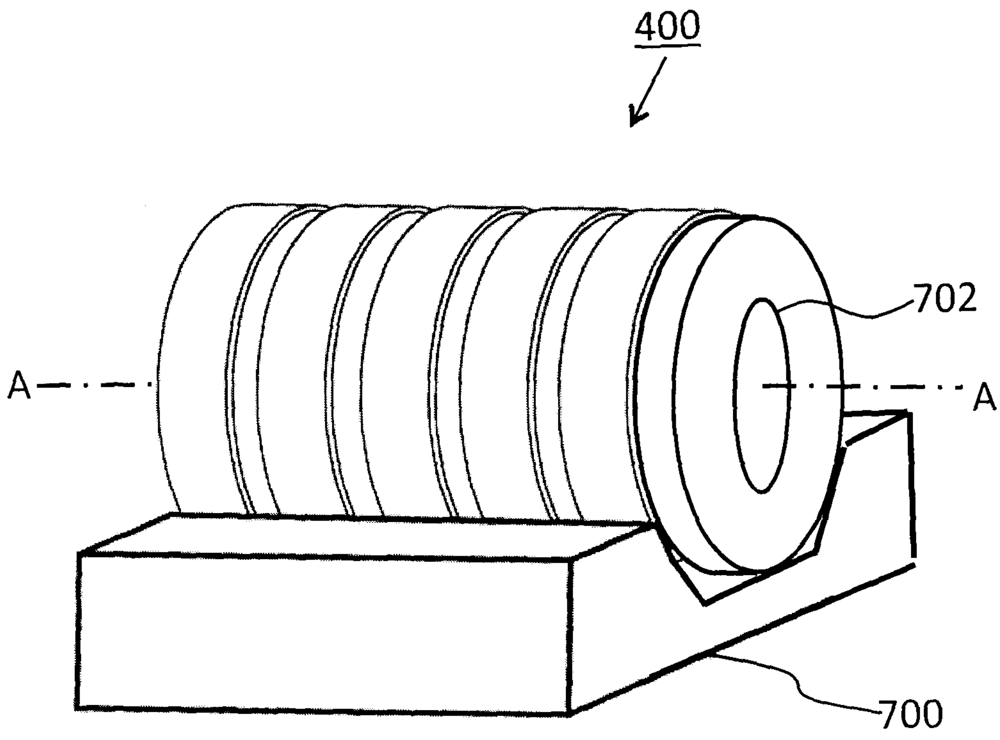

Fig. 7

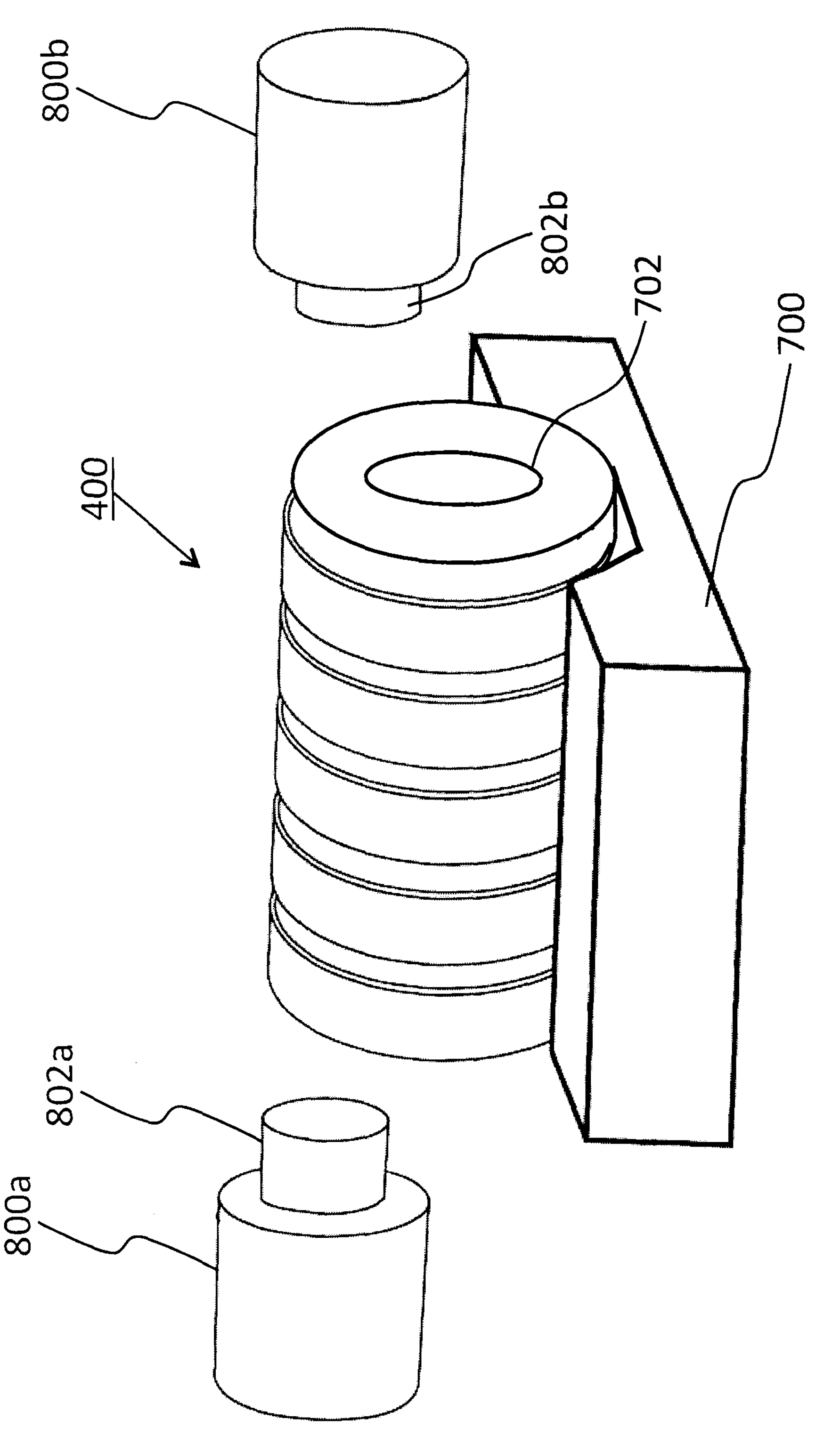

Fig. 8

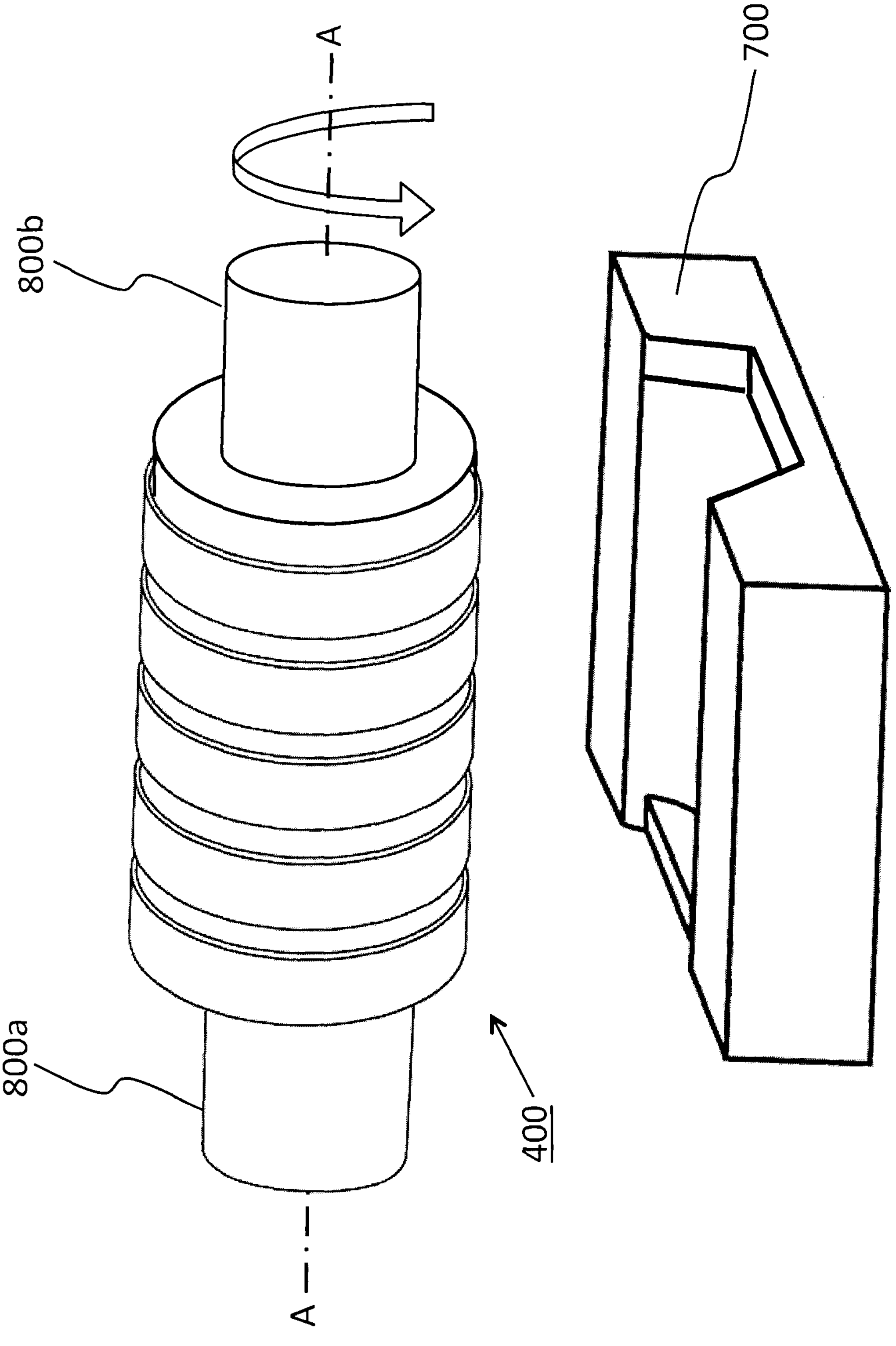

Fig. 9

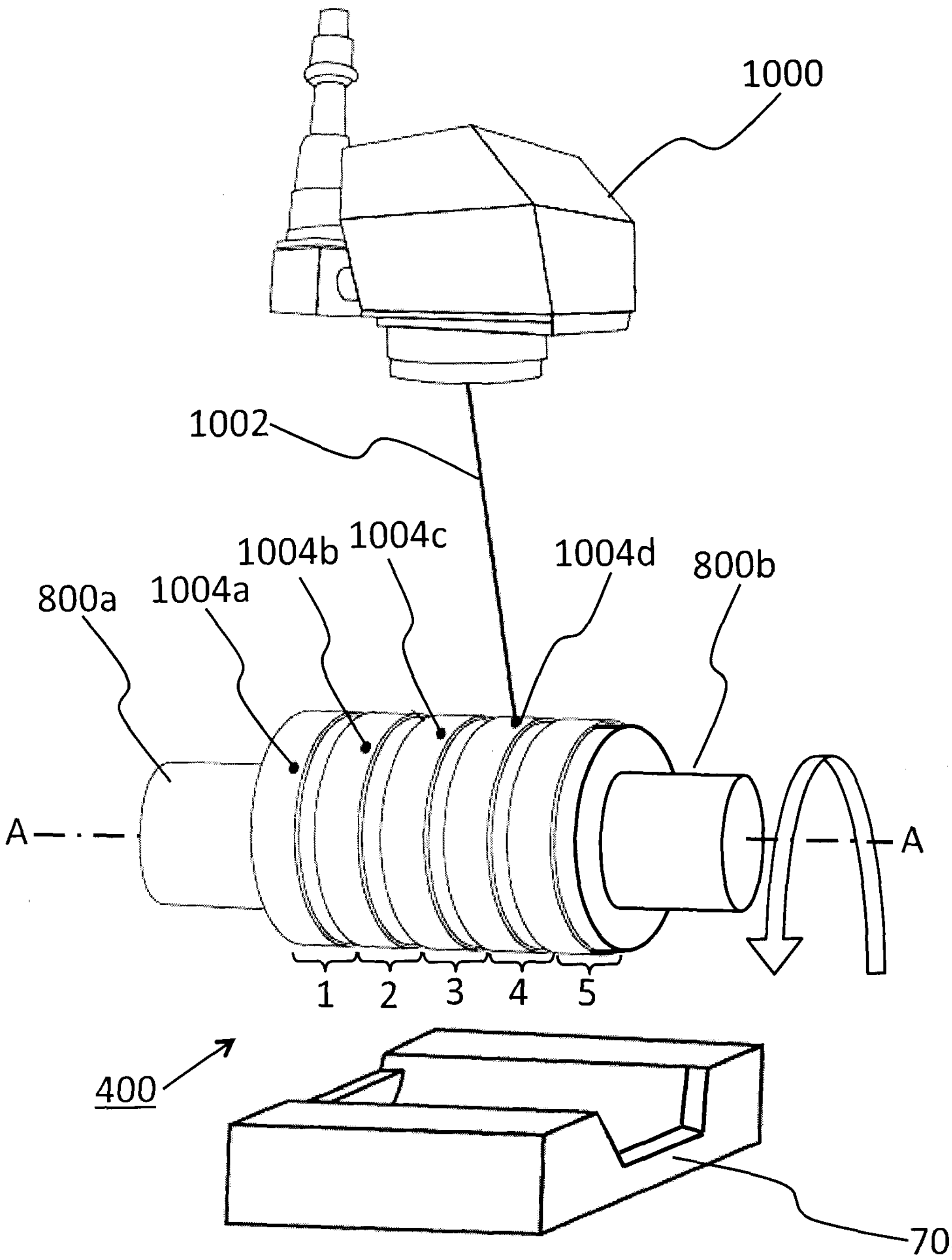

Fig. 10

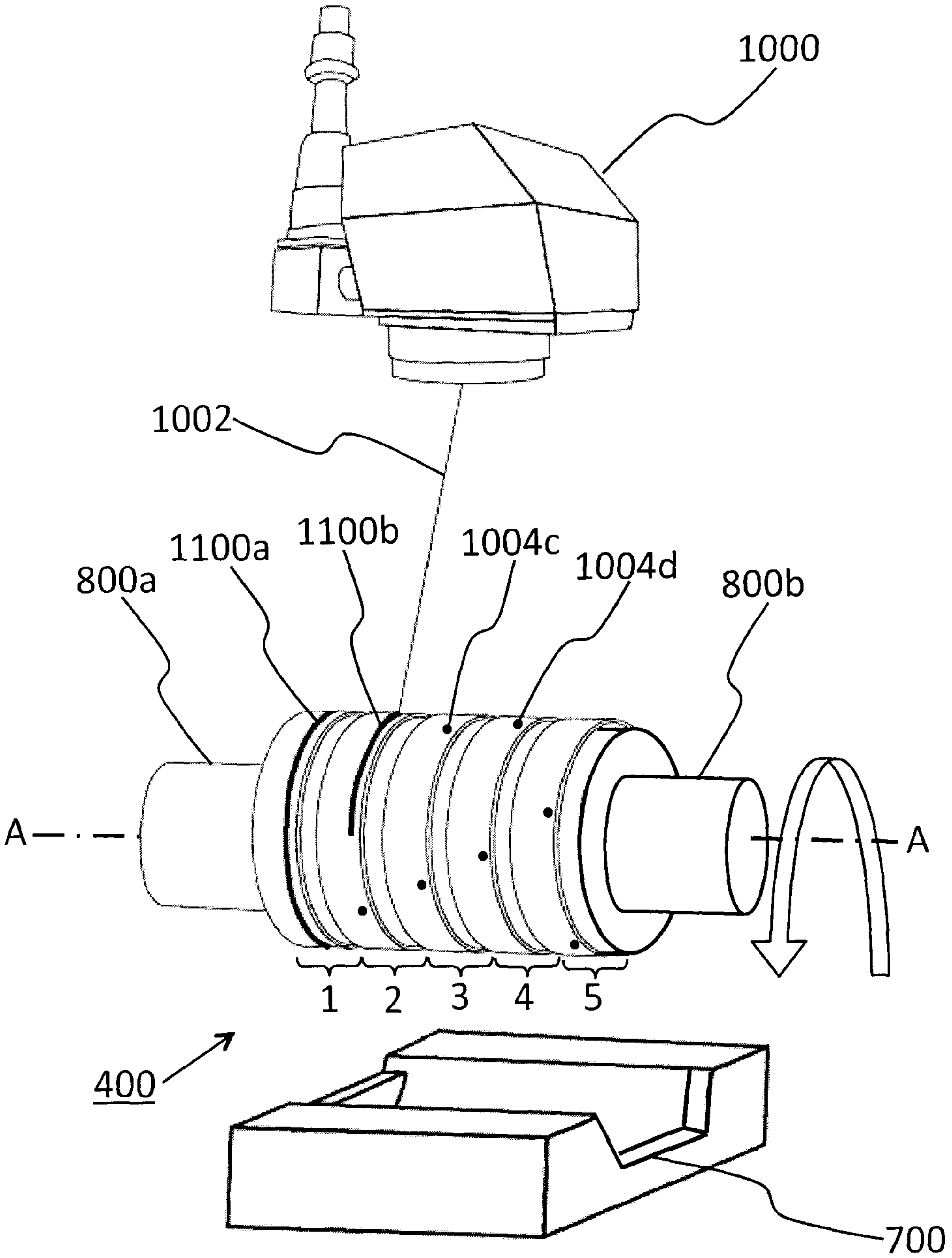

Fig. 11

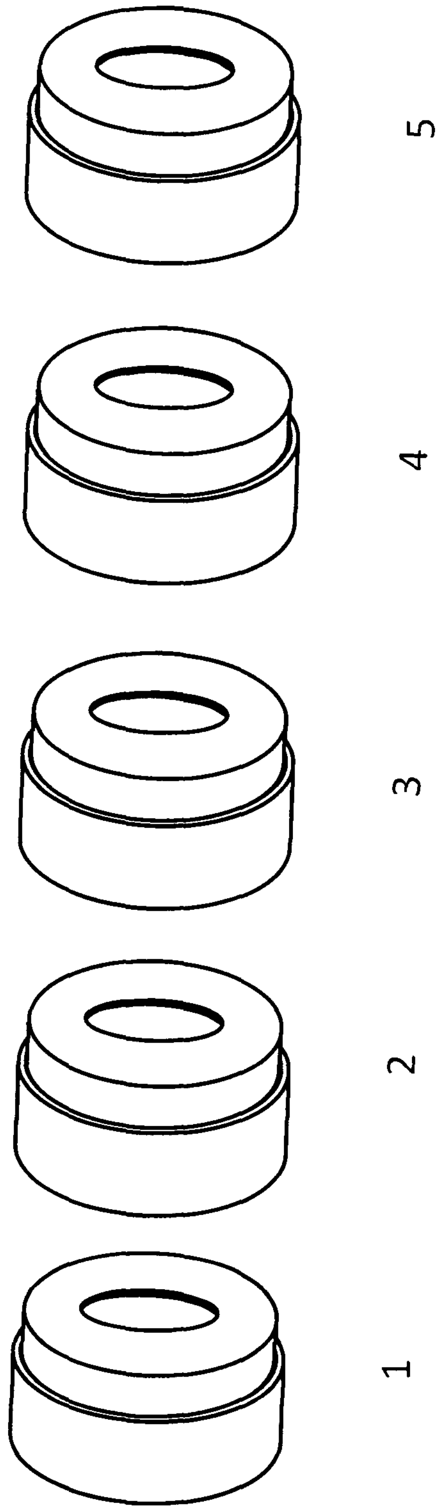

Fig. 12

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***B23K 26/28*** (2006.01) , ***B23K 26/08*** (2006.01) , ***B23K 37/053*** (2006.01)
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)
IPC: B23K 26/28 (2006.01), B23K 26/08 (2006.01), B23K 37/053 (2006.01)
US Cl.: 219/121

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
None

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
EPOQUE (X-Full and Internal (EPODOC)) Canadian Patent Database Google Scholar
IEEE Online Database ESPACENET
key words used: laser, weld+, part+, component+, production, run, force, grip+, hold, clamp+, secure, stack, axis, rotat+, round, cylindrical, nest+, overlap, inset, engag+, sequence, arbor, fixture, 'seam weld', 'spot weld', 'tack weld', conveyor, method, technique and process.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US20020088778 A1 **CHANG** (11-07-2002) (11 July 2002) (see paragraphs [0010], [0011], [0015], [0025], [0027], [0046] and [0049] to [0051], along with figs. 1 to 4)	1 to 20
Y	US20050109740 A1 **BECKER ET AL**. (26-05-2005) (26 may 2005) (see paragraphs [0012], [0013], [0020] and [0024])	1, 3, 6, 8 to 10, 12 and 15 to 20
Y	US6060682 **WESTBROEK ET AL**. (09-05-2000) (09 May 2000) (see col. 5, line 5 to col. 6, line 40, along with figs. 10 to 16)	2, 4, 5, 11, 13 and 14
Y	US3918622 **LARSEN** (11-11-1975) (11 November	7

[ ] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents :
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"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 September 2012 (18-09-2012)	05 October 2012 (05-10-2012)

Name and mailing address of the ISA/CA	Authorized officer
Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001-819-953-2476	Daniel Weslake (819) 997-2999

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		FR2859934A1	25 March 2005 (25-03-2005)
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		JP2005131707A	26 May 2005 (26-05-2005)
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		FR2265494A1	24 October 1975 (24-10-1975)
		FR2265494B3	25 November 1977 (25-11-1977)
		JP50128648A	09 October 1975 (09-10-1975)