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(54) Titre : JOINTEUR DE BANDES POUR CONVOYEUR A BASE D'UN COMPOSANT AVANCE
(54) Title: ADVANCED COMPONENT BASED CONVEYOR BELT SPLICER

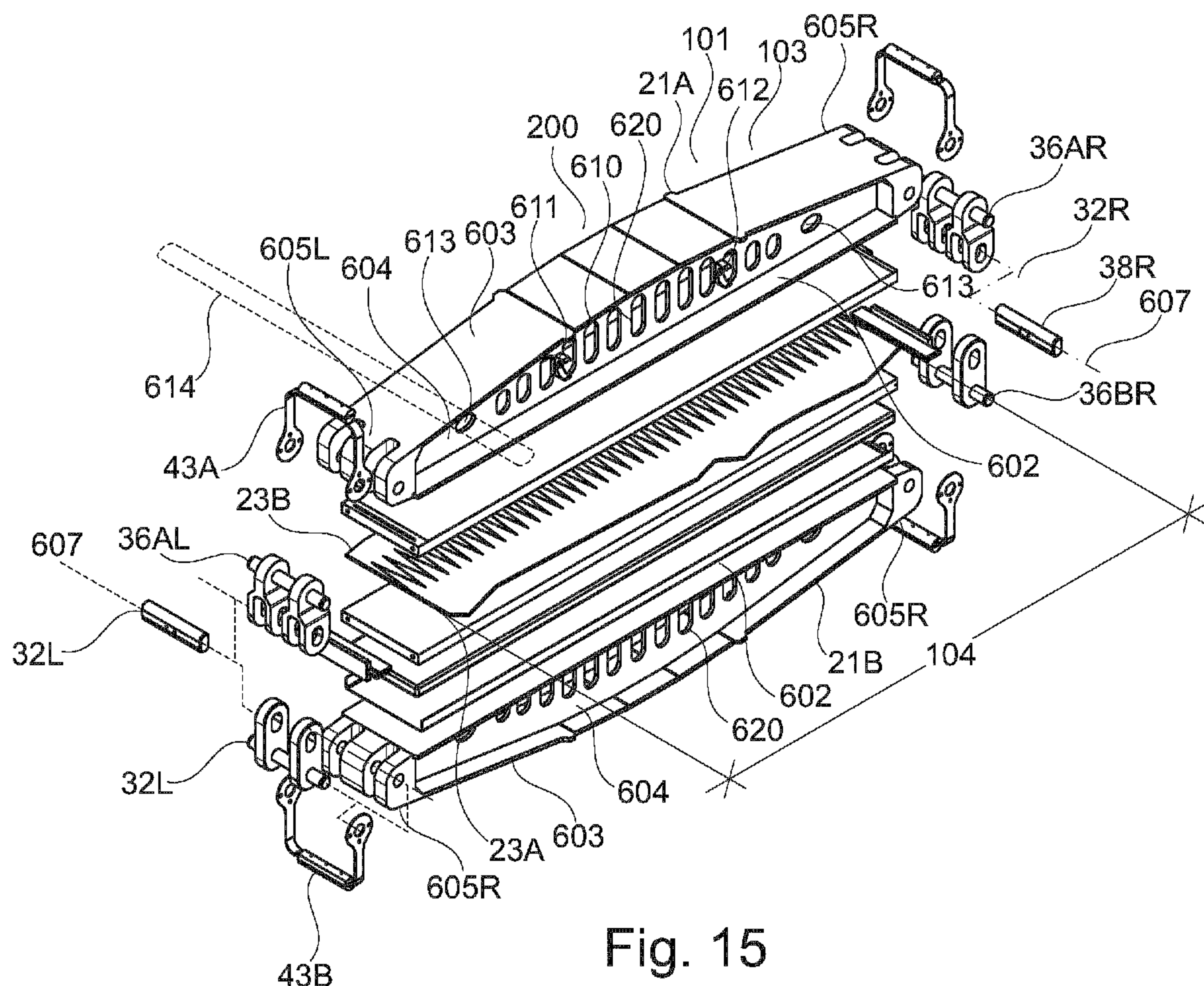


Fig. 15

(57) **Abrégé/Abstract:**

The invention provides a fully modular component based conveyor belt splice with expansible tension links, robust side rails, a component based clamping structure and a modular structurally supported thermal element.

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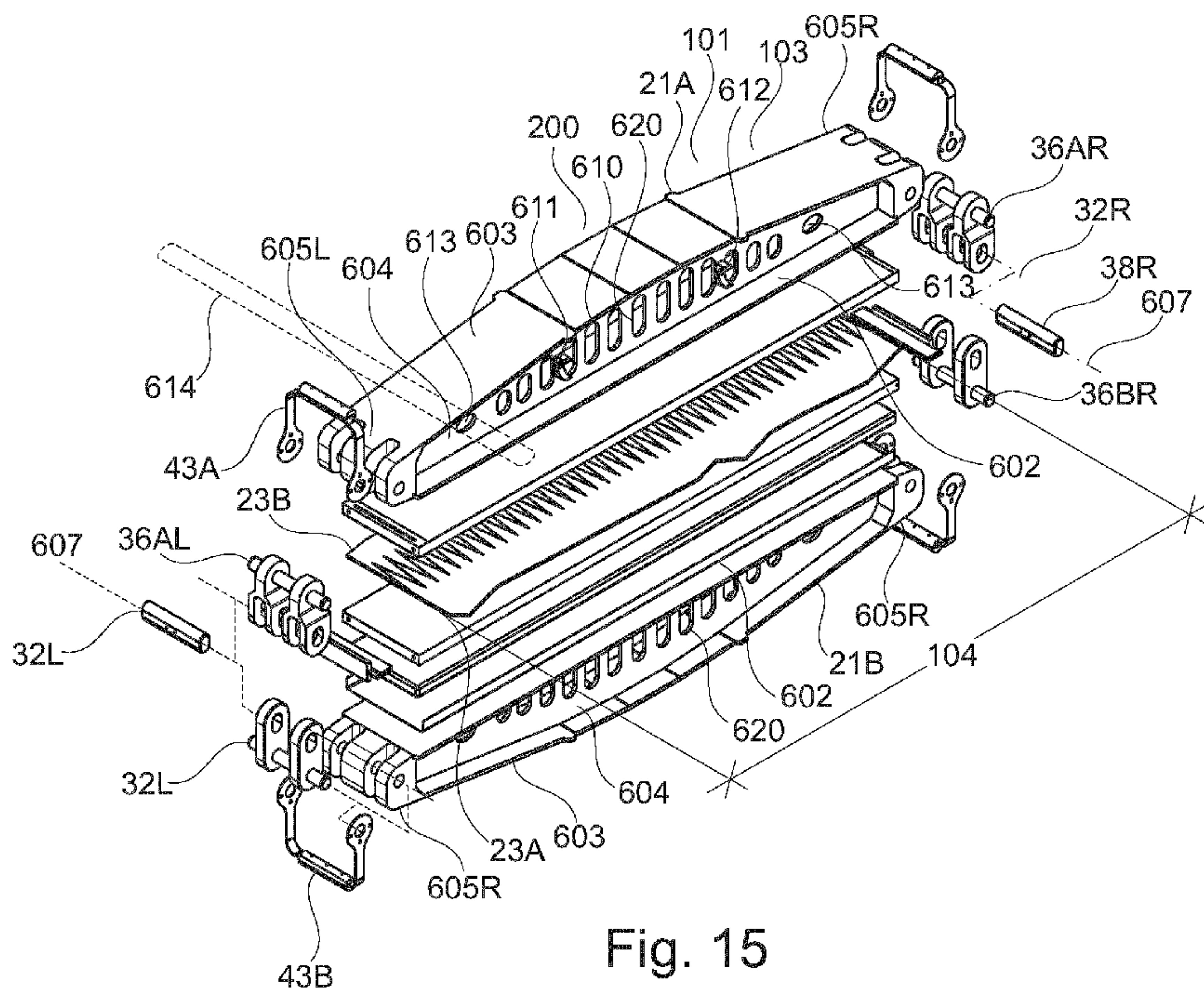


Fig. 15

(57) Abstract: The invention provides a fully modular component based conveyor belt splice with expansible tension links, robust side rails, a component based clamping structure and a modular structurally supported thermal element.

TITLE: ADVANCED COMPONENT BASED CONVEYOR BELT SPLICER**3 FIELD OF THE INVENTION**

[001] The present invention relates to repair of failed conveyor belts by compressive binding of a length of splice material into the failed belt with the application of process heating. Incorporate the abstract by reference.

BACKGROUND

[002] For more than a century there has been a need for a simple and effective way to accurately vulcanize a conveyor belt splice in place without removal of the belt from its operating machinery. This often requires working in the most extreme and awkward conditions, indoors and outdoors, using heavy tools. The placing of such tools is critical their location is determined entirely by the operating conditions of the physical plant where the belt is used. These can be highly elevated conditions on the one hand or completely enclosed conditions on the other.

[003] Difficulties in manoeuvring and placement are rapidly compounded when the belt in question is very wide, as much as 12 feet or more or the actual length of the splice is large, as much as 3-4 feet in the direction of conveyor travel.

DESCRIPTION OF THE PRIOR ART

[004] Various attempts at operative solutions useful in the field are shown in the patent art.

[005] Recent technology involves the use of a pair of heat conductive platens which are placed over and under the belt splicing so as to at least completely cover the splice area being the length of the splice times the width of the belt. Upper and lower heating pads are positioned over the splice area. Such heating pads are known to include electrical resistance wire embedded in a pad of heat conductive silicone so as to provide the necessary heat and transmit the

compressive stresses vertically through the splice. Above and below the heating pads are cooling platens used in sequence with the heating so as to cure the belt splice in the most optimal conditions. Control of the heating, cooling and pressure characteristics of the splice are critical as the belt will be put back into heavy industrial service almost immediately after the splice is concluded.

[006] The temperature of heating must be uniformly ± 3 degrees C across the whole splice, preferably 0 degrees C under uniform and constant pressure. Cooling must be carefully controlled and uniform across the splice as well. Such belt splicers are effective for purpose but require custom engineering, especially for larger sizes, are costly to manufacture and maintain in stock and difficult to deliver intact when just in time tool availability is required. Many industrial locations would of necessity maintain a splicer in tool inventory in the event of a belt failure as a single conveyor belt failure can bring a production facility to an abrupt and catastrophic halt without notice. Given that these belts are critical components of heavy industry belt failure itself can spread damage across a facility and cause personnel injury.

[007] Thus, there is a need for a belt splicer system which can be delivered quickly into remote and difficult locations from stock which is lightweight and simple to use while maintaining safety and process conditions.

[008] Efforts to date have been focused upon a single platen arrangement in order to maintain process conditions with a component clamping arrangement which is assembled into single clamping sections in situ so as to form the necessary platen clamp from the group, a plurality of individual clamping components. Structural requirements for such clamping components are quite high as the clamping surfaces must be flat. This results in the use of large quantities of expensive fabrication materials such as aluminium for lightness and component-to-component uniformity requirements.

[009] The need for heating and cooling uniformity to ± 3 degrees C plus the need for uniform and controllable pressure with a view to overall size, complexity,

57 weight and the sheer cumbersome nature of some prior art belt splicers, given the
extreme environments, has lead to the widespread use of extrusions of expensive
aluminium based metals.

60 [010] Large sections are required not only to bear significant loads but also to act
as uniform heat sources and sinks (forced cooling) while maintaining process
pressures. These same large sections dictate that design improvements be
63 machined or welded components, the former greatly increasing delivery times and
cost, the later adding stress bending issues which continue from manufacture
through distribution and long in to the conditions of actual use.

66 [011] In the past, heating components have been based upon a heating wire strand
uniformly and fully embedded in a heat transmissive silicone pad where the pad
transfers the process pressure load around the heating wire to the process area. In
69 earlier days, this wire heating was applied wherever space permitted often to the
sacrifice of heating uniformity and speed.

72 **ADJUSTABLE TENSION-LINK FOR BELT-SPLICER**

[012] This aspect of the invention lies in the field of splicers for splicing conveyor-
belts. The invention is concerned with the provision for adjustability of the
75 splicer, to accommodate e.g different belt-thicknesses.

LIST OF DRAWINGS:

- Fig. 1 is an elevation of a conveyor belt splicer, looking along the direction
78 of travel of the belt.
- Fig. 2 is the same view as Fig. 1 of a portion of the splicer, showing the
left-side tension-link of the splicer. Fig. 2 also shows some of the components of
81 the splicer that are located between the crossbeams and between the tension-
links.
- Fig. 3 is an exploded pictorial view of the left-side tension-link.

84 • Fig. 4A is the same view as Fig. 2, showing the left-side tension-link assembled with a first clevis-pin. Here, the between-crossbeams components are omitted.

87 • Fig. 4B is the same view as Fig. 4A, showing the left-side tension-link assembled with a second clevis-pin.

90 • Fig. 4C is the same view as Fig. 4A, showing the left-side tension-link assembled with a third clevis-pin.

• Figs. 5A, B and C show the different profiles of clevis-pins that make up a kit of clevis-pins of the left-side tension-link.

93 DESCRIPTION OF THE PREFERRED EMBODIMENTS

[013] The belt-splicer 20 (Fig. 1) includes above- and below-crossbeams 21A, 21B. The crossbeams 21 span across the full width of the conveyor-belt 23 to be spliced. 96 The belt being spliced comprises two belt-ends 23A,23B, which are to be adhered together.

[014] Usually, the belt users prefer that the finished spliced-zone of the belt be of 99 the same thickness as the parent belt. The two belt-ends 23A,23B typically are interfaced conventionally in e.g a tapered or chamfered overlapping configuration, or e.g in a zig-zag pattern, being generally so configured as to 102 create a large area of interface contact between the two belt-ends.

[015] Often, especially when the belts are of rubber, splicing involves applying liquid rubber gum to the contact areas of the belt-ends, and subjecting the splice- 105 zone to heat and pressure. Under controlled conditions, the rubber undergoes vulcanization. The vulcanization having been done properly, the splice is (almost) as strong as the parent belt.

108 [016] In Fig. 1, of the components that lie between the crossbeams, only the belt itself is shown. Fig. 2 shows the rest of the between-beams components, in detail, along with the two overlapping ends 23A,23B of the belt 23. The portion 23A 111 belongs to the end of the belt that extends into the plane of Fig. 2, and the

portion 23B belongs to the end of the belt that extends out of Fig. 2.

[017] The between-beams components in Fig. 2 include an inflation-bag 25. The inflation-bag may be located above or below the belt 23, depending on whether is it easier to accommodate the deflection movements upwards or downwards in the particular case.

[018] Also included between the crossbeams is an above-heater-platen 27A and a below-heater-platen 27B. (In some belt-splicers, only one heater-platen is provided -- usually below the belt.) Also included are above- and below-heat-insulation-layers 29A, 29B.

[019] The present belt-splicer 20 also includes provision for forced cooling of the splice interface, after the period of heating. Rapid forced cooling is preferred, when rapidity might be instrumental in procuring a more favourable molecular structure in the vulcanized rubber, compared with slow ambient cooling.

[020] The crossbeams 21 are long enough to protrude beyond the left and right side edges of the belt 23. The above-beam 21A is provided with a protruding above-left-end-boss 30AL, while the below-beam 21B is provided with a protruding below-left-end-boss 30BL.

[021] The splicer 20 includes two tension-links, being a left tension-link 32L and a right tension-link 32R. The left tension-link 32L comprises an above-link-element 34AL and a below-link-element 34BL. Pivot-pins 36AL,36BL secure the above- and below-left-link-elements 34AL,34BL respectively to the above- and below-end-bosses 30AL,30BL.

[022] The above-link-element 34AL is bifurcated or forked, and forms a clevis. The below-link-element 34BL is plain, and is secured to the above-link-element 34AL by a left-clevis-pin 38L. The clevis-pin 38L passes through an above-clevis-hole 40AL in the above-link-element 34AL, and through a below-clevis-hole 40BL in the below-link-element 34BL.

[023] When the inflation-bag 25 is inflated (with a gas (e.g air) or a liquid (e.g

water) under pressure) the resulting pressure is applied to the splice-zone of the two ends of the belt. The pressure is reacted by the above- and below-crossbeams 21A,21 B, and in turn by the two tension-links 32L,32R. The pressure urges the crossbeams 21 to move apart in the up/down direction, and the tension-links 32 prevent that from happening.

[024] In a typical large belt-splicer, the inflation-bag 25 applies pressure over an area of, say, 0.25 sq.metres (400 sq.ins). The inflation pressure is typically ten atmospheres (150psi), so that the force reacted by the left and right tension-links 32L,34R is typically thirty tonnes, i.e fifteen tonnes in each tension-link. There is considerable potential energy stored in the inflation-bag, during operation, and if either tension-link 32 were to fail, serious injuries might follow.

[025] The designers must see to it that the tension-links 32 are capable of sustaining the imposed forces, with a suitable safety margin. But not only that: the tension-links 32 have to be assembled and disassembled with each splicing event, and the designers have to ensure that the tension-links 32 can only be assembled safely and properly. Also, over a long service period, the components of the tension-links can become less able to perform their functions. Also, inexperienced operators can make dangerous mistakes; and even the experienced operators can start to become careless as the operations become familiar and routine. It is up to the designers to see to it that these possibilities do not put the operators (and others) in danger.

[026] The degree to which the inflation-bag 25 is inflated during operation should be kept to a minimum. Too large an inflation, and portions of the material of the bag can start to bulge, perhaps leading to failure. Thus it is desirable, once the belt-splicer 20 has been assembled onto and around the two ends of the belt 23, and made ready for the splicing operation to commence, that the tension-links 32 should be made as short as possible, thereby minimizing the degree to which the bag 25 is called upon to inflate and expand.

[027] It is preferred that the lengths of the left and right tension-links 32L,R

should be adjustable as to their (vertical) lengths.

[028] The common reason why the length of the tension-links 32 needs to be adjustable is to cater for different thicknesses of the belts being spliced. To that extent, the required length of the tension-links can be predicted ahead of time. However, it is preferred that the manner of adjustment should be such that the tension-links can be finally adjusted by the operators, at the time of final assembly of the belt-splicer onto the belt.

[029] These preferences and functionalities can be attributed to the structure of the present tension-links 32L,32R.

[030] The clevis-holes 40AL,40BL in the link-elements 34 are of (vertically) elongated profile, and the clevis-pin 38L is of a complementary profile. The profile comprises two semi-circles joined by two straights.

[031] Several clevis-pins 38 are provided (i.e. a kit of clevis-pins is provided), which differ from each other as to the lengths of their profile-straights. The operators select which one of the several clevis-pins, in the kit, to use for the particular splicing event, on the basis of which of the several clevis-pins will minimize the degree of inflation of the bag 25 (while enabling the splicer to be assembled). The adjustability of the length of the tension-link derives from the fact that: the larger the clevis-pin (i.e. the longer its profile straights), the smaller the overall length of the tension-links 32.

[032] Figs.4,5 show four sizes of clevis-pin 38. The clevis-pin 38L-A shown in Figs.4A,5A has the same profile as the clevis-holes 40 in the link-elements 34. (Or rather, of course, the clevis-pin is a little smaller than the holes, to enable assembly of the clevis-pin into and through the clevis-holes.) As shown in Fig. 4A, the clevis-pin 38L-A is selected when the event requires the tension-link to be as short as possible. The clevis-pin 38L-A fills both the above-clevis-hole 40AL and the below-clevis-hole 40BL, preventing the link-elements 34L from moving apart.

[033] The clevis-pin 38L-C shown in Figs.4C,5C is actually circular (i.e its profile-

straights are of zero length). As shown in Figs.4C, the clevis-pin 38L-C is selected
198 when it is required to make the tension-link as long as possible. The clevis-pin
38L-C enables or allows the link-elements to move apart the greatest distance.

[034] The clevis-pin 38L-B shown in Figs.4B,5B is of intermediate size, and enables
201 the operators to tailor the size of the tension-link to the particular requirements.
Several intermediate sizes may be included in the kits of clevis-pins.

[035] The splicer or splicers that create the splice-zone should include as many
204 kits of clevis-pins as there are tension-links in the splice-zone. And each kit should
include the same range of sizes of pins, so that all the tension-links can be the
same size.

[036] Again, it is important that the left and right tension-links should both be of
207 equal length, after the length adjustment. For this reason, the designers should
provide a simple foolproof indicator, for indicating just what adjustments have
210 been made, which preferably should be visible just before the splicing operation
starts, and after all the assembly and preparations for the splice have been made.
Fig. 3 shows the numeral "4" imprinted on the end of the clevis-pin, as an
213 identifier of the size of the particular clevis-pin profile -- which makes it a simple
matter for the operators to check that both tension-links are using the same size
of clevis-pins from the respective kits of clevis-pins (each kit being identical). It is
216 important that the left and right tension-links of the belt-splicer should be both
the same length, and the operators should see to it that this is so. Fig. 5 shows
(the profiles of) the clevis-pins (or some of the clevis-pins) that make up the kit.
219 Colours can be used to differentiate the different sizes.

[037] There being three sizes of clevis-pin 38 (or whatever number of sizes is
deemed to be convenient and efficient), all but the selected pins are standing idle
222 during the particular splicing event. It is advisable that all the clevis-pins not
currently being used should be retained on the apparatus, and preferably all the
clevis-pins should be held captive by being tethered to the crossbeams. The
225 prudent designer will provide suitable receptacles into which the set of clevis-pins

can be placed, e.g within the form of the crossbeams.

[038] The components of the belt-splicer 20 are transported to the place where the splice is to be carried out. At this time, the two crossbeams 21A,21B are separated from each other. The above-left-link-element 34AL and the above-right-link-element are never detached from the above-crossbeam 21A (except for service, etc) and the below-left-link-element 34BL and the below-right-link-element are never detached from the below-crossbeam 21B during transport. However, during transport, the clevis-pins 38 are not assembled to the respective link-elements. The kit of clevis-pins is transported as a separate sub-assembly (which is why the kit should be housed in a receptacle within the structure of the crossbeam, or the individual clevis-pins of the kit should be tethered to the crossbeams, or both.) Generally, the operators know the nominal belt thickness before arriving at the splicing site, and can make sure that the kits contain at least the size of clevis-pin that goes with that nominal thickness of the belt. However, the operators should check that the other sizes of clevis-pins are available, in case of unpredicted variations.

[039] Provision is made, at the ends of the clevis-pins 38, for ensuring that the clevis-pins, having been fully and properly assembled into the clevis-holes in the link-elements, remain retained within the clevis-holes, and cannot inadvertently become mis-positioned, for any reason, until deliberately moved by the operators. The clevis-pin can be provided with through-holes for attachment of pull-rings, spring-clips, retainers, or the like. There are many proprietary systems for ensuring that clevis-pins cannot improperly become displaced from their clevis-holes, and yet are easy to assemble and disassemble, and designers should select an appropriate system.

[040] The expression “tension-link”, above, has been indicated as including an above-link-element and a below-link element. In fact, the above-link-element 34AL, as may be seen from Fig. 5, comprises two above-link-element-structures 41A, side-by side. The below-link-element 34BL, likewise, comprises two below-

255 link-element-structures 41 B, side-by side. The “tension-link” is the aggregate of
however many such link-element-structures are present (and the number can be
one, two, or more than two, as required.)

258 [041] In Fig. 3, the below-link-element 34BL, comprising the two below-link-
element-structures, is provided with a handle 43B. The handle 43B serves to join
the two below-link-element-structures, and to keep them in their side-by side
261 relationship. The handle 43B also serves to help the operator manipulate the link-
elements when assembling and removing the clevis-pin. The above-link-element
34AL is also provided with a handle, but this is not shown in Fig. 3.

264 [042] The extent of the (vertical) adjustable-range of length of the tension-link 32
is determined by the (vertical) slot-lengths of the clevis-holes 40, and the
(vertical) length of the profile of the clevis-pins 38. Typically, the need for
267 adjustment is based mainly on the differences in nominal thickness of the various
belts being spliced. However other variables might be present, which contribute to
the need for the tension-links to be of adjustable length - and conveyor-belts do
270 vary from their nominal thickness. Typically, the designers should provide a range
of adjustment of two or three cm -- or more, of course, if the requirement (and
the room) exists. The clevis-pin is subjected to shear-stress, under load, and the
273 designers must see to it that even the smallest clevis-pins in the kit are able to
support the maximum stress with a suitable safety margin. (It is not necessary that
the smallest clevis-pins in the kit should have zero-length profile straights.)

276 [043] The (vertical) length of the present tension-links is small, when compared
with tension-links in other designs of belt-splicer. In the other belt-splicers,
typically the crossbeams are, by comparison, significantly taller, vertically, at
279 their ends, than the present crossbeams. The taller the crossbeams, the longer the
tension-links can be; and a longer tension-link can include the kind of length-
adjustment facility that is based on a screw-thread.

282 Screw-thread adjusters can be convenient in those cases (although screw-thread
adjusters can have their own problems).

[044] As shown in patent publication US-2014-0014275 (SHAW), vertically-tall crossbeams can be equipped with the markedly-different tension-links there depicted/described. However, that depicted kind of tension-link, though highly advantageous where it can be accommodated, is not suitable to be made in short lengths. In the present case, where the crossbeams are short, vertically, at the ends, the tension-links are themselves short. The present manner of adjustment is a highly suitable way of providing the required range of adjustment, when the tension-links are short.

[045] As mentioned, in the present case, the splicer includes provision for forced cooling. The forced cooling is done by means of e.g. water pipes embedded in the heater platens 27. The pipes are disposed side-by-side with the (electrical) heating cables required for the heating function, within the heater-platen. Thus, in fact, the present heater-platen should rather be regarded as a combined heating-and-cooling-platen. The combined-platen occupies hardly more than the vertical space that would be required anyway for a platen that contained just the heating elements.

[046] Previously, the cooling function has been provided in a separate cooling platen structure. This may be regarded as disadvantageous because the stack of the two platens inevitably occupies considerably more vertical space than one single combined heating-and-cooling platen. But also, when the heating platens are next to the belt, the cooling platens have to exert their thermal effects through the heating platens -- which is significantly inefficient. (If the cooling platens were the platens that lie next to the belt, the heating platens would then have to exert their thermal effects through the heating platens -- which is just as inefficient.) Thus, the height of the stack of belt-splicer-components that lie between the crossbeams, in the present design, is significantly reduced when the separate heating-platen and cooling-platen are replaced by a combined heating-and-cooling platen. The present as-described manner of arranging tension-link length-adjustability, being particularly suitable for use with crossbeams of low

vertical height, is likewise also particularly suitable for use when the stack of components between the crossbeams is of low vertical height.

315 [047] As mentioned, the pivot-pins 36 enable the tension-links to pivot, under
load, relative to the crossbeams. The lengths of the crossbeams are dictated by
the width of the belt, which can be a considerable span. The crossbeams can
318 undergo considerable deflection when under a load of several tonnes, and in fact
the crossbeams can so deflect as to be several millimetres further apart in the
middle of the span than at the edges of the belt. Such deflection gives rise to a
321 significant rotational movement of the ends of the crossbeams relative to the
tension-links (the tension-links themselves remain vertical during operation), and
such rotation is accommodated by the pivot-pins 36.

324 [048] It is preferred that the left-clevis-pin 38L is long enough to extend right
through both (or all) the link-element-structures, as in the as-depicted design.
However, it is not ruled out that shorter clevis-pins could be used, which each
327 extend through e.g. just one of the link-element-structures. Of course, if more,
shorter, clevis-pins are used, the operators must take care to ensure that all the
clevis-pins in the splicer are the same size.

330 [049] The clevis-pins 38 and the clevis-holes 40 are running-track-shaped, i.e have
the shape of two semi-circles separated by two straights. Other shapes can be
used - e.g. rectangular (preferably with rounded corners). The important aspects
333 are that the components containing the shapes should be strong enough to
accommodate the imposed stresses, should be inexpensive to manufacture, and
should not pose problems of inconvenience during operational assembly and dis-
336 assembly.

[050] Some of the components and features in the drawings and some of the
drawings have been given numerals with letter suffixes, which indicate left, right,
339 etc. versions of the components. The numeral without the suffix has been used
herein to indicate the components or drawings generically or collectively.

[051] Terms of orientation (e.g “up/down”, “left/right”, and the like) when used
 342 herein are intended to be construed as follows. The terms being applied to a
 device, that device is distinguished by the terms of orientation only if there is not
 one single orientation into which the device, or an image (including a mirror
 345 image) of the device, could be placed, in which the terms could be applied
 consistently.

[052] Terms used herein, such as “straight”, “vertical”, and the like, which define
 348 respective theoretical constructs, are intended to be construed according to the
 purposive construction.

[053] The numerals used herein are summarized as follows:

- 351 • 20 - the belt-splicer
- 21A, 21B - the above-, below-crossbeams
- 23A, 23B - the upper and lower to-be-spliced ends of the belt
- 354 • 25 - the inflation bag
- 27A, 27B - the above-, below-heater-platens
- 29A, 29B - the above-, below-heat-insulation layers
- 357 • 30AL - the above-left-end-boss of the above-crossbeam 21A
- 30BL -the below-left-end-boss of the below-crossbeam 21B
- 32L, 32R - the left-, right-tension-links
- 360 • 34AL - the above-left-link-element of the left-tension-link
- 34BL - the below-left-link-element of the left-tension-link
- 36AL, 36BL - the above-, below-left-link-pivot-pin
- 363 • 36AR,36 BR - the above-, below-right-link-pivot-pin
- 38L - the left clevis-pin
- 38L-A - the largest clevis-pin

- 366 • 38L-B - the intermediate clevis-pin
- 38L-C - the smallest clevis-pin
- 40AL - the above-clevis-hole in the above-link-element 34AL
- 369 • 40BL - the below-clevis-hole in the below-link-element 34BL
- 41A, 41B - the above-, below-link-element-structures
- 43B - the below-handle.

372

Title: BELT-SPLICER HAVING ROBUST SUPPORT FOR EDGE-IRONS

[054] This invention lies in the field of splicers for splicing conveyor-belts. The
375 invention is concerned with edge-irons, which are used for constraining the side-
edges of the belt-ends during splicing, and with the manner of supporting the
same, within the splicer.

378

List of the drawings:

[055] Fig.6 is an elevation of a conveyor belt splicer, looking along the direction
381 of travel of the belt.

Fig.7 is the same view as Fig.6 of a portion of the belt-splicer, showing a left-side
edge-iron of the splicer. Fig.7 also shows some of the components of the splicer
384 that are located in the vicinity of the edge-iron.

Fig.8 is a pictorial diagrammatic view of the belt-splicer, shown during a stage of
assembly.

387 Figs.9,10,11A are portions of the same view as Fig.7, showing some variants with
a single stop and a pair of tongue and groove stops.

Fig.11B is the same view as Fig.11A, but shows the components in a separated
390 condition.

DESCRIPTION

393 [056] In Fig.6, the belt-splicer 20 includes above- and below-crossbeams 21A,21B.
The crossbeams 21 span across the full width of the conveyor-belt 23 to be spliced.
The belt being spliced comprises two belt-ends 23A,23B, which are to be adhered
396 together.

[057] Left and right edge-irons 49L,49R are provided. Each edge-iron has a
middle-facing-surface 50L,50R ("middle" means the surface faces towards the
399 middle of the belt) and an outward-facing-surface 51L,51R. The edge-irons
49L,49R are supplemented by left and right filler-strips 52L,52R, each of which has
a middle-facing-surface 53L,R and an outward-facing-surface 54L,R.

402 [058] During splicing, the belt-ends 23A,23B are compressed between an above-
heater-platen 27A and a below-heater-platen 27B. (In fact, the heater-platens, in
the depicted design, are combined heating-and-cooling-platens, but are referred
405 to, here, as heater-platens.) The compression forces on the belt, during splicing,
are transmitted through the heater-platens. An upward-facing-surface 58 of the
below-heater-platen 27B is in close contact with the underside of the belt 23, and
408 a downward-facing-surface 59 of the above-heater-platen 27A is in close contact
with the overside of the belt 23.

[059] In the splicer of Fig.7, a below-groove or slot 61L has been provided, which
411 extends downwards into the material of the below-heater-platen 27B, down from
the upward-facing-surface 58.

[060] The outer wall of the groove 61L is formed as a middle-facing-abutment-
414 surface 63L. In Fig.7, the outward-facing-surface 51L of the left-edge-iron 49L
abuts against the middle-facing-abutment-surface 63L of the left-below-groove
61L. Similarly, the outward-facing-surface 51R of the right-edge-iron 49R abuts
417 against the middle-facing-abutment-surface 63R of the right-below-groove 61R.

[061] The left filler-strip 52L fits between the left side-edge 56L of the belt 23
and the middle-facing-surface 50L of the left edge-iron 49L. The present filler-

420 strips 52 are made of rubber, and are somewhat compressible. The material of
the filler-strips should be selected on the basis of being compressible, in the sense
of being able to conform to (and thereby to make a seal against) the (possibly-
423 uneven) side edges of the two ends 23A,23B of the belt to be spliced. Also,
conveyor belts are not noted for their freedom from variations in the width of the
belt, not only after a period of service, but as-manufactured. The designers' aim,
426 in selecting the material and the dimensions of the filler-strips, should be to
contain the liquid rubber which tends to extrude itself out of the splice-zone,
when the splice-zone is under heavy compression -- and also, preferably, not to
429 adhere to the now-cured rubber, when the time comes to dismantle the splicer.
The left and right filler-strips 52L,R are chosen as to their thicknesses on the basis
of squeezing (compressing) the width of the belt tightly between the filler-strips
432 52. The left and right filler-strips 52L,R abut against the left and right edge-irons
49L,R, and the edge-irons in turn abut against the middle-facing-abutment-
surfaces 63L,R of the left and right grooves 61L,R. Thus, the squeeze-force
435 exerted on the width of the belt is reacted directly within the material of the
below-heater-platen 27B.

[062] Upon assembling the belt-splicer 20 in readiness for a splicing event, the
438 two belt-ends 29A,B are laid upon the upward-facing-surface 58 of the below-
heater-platen 27B (Fig.8). The left and right grooves 61L,61R lie just outside the
side-edges 56 of the belt 23, and the edge-irons 49 and the filler-strips 52 are
441 assembled into their places.

[063] It will be understood that, because the edge-irons 49 reside in the grooves
61 formed in the material of the below-heater-platen, nothing else is required, in
444 order to react the lateral-squeeze-force that is applied to the side-edges 56 of the
belt. This may be contrasted with prior-art configurations of edge-irons, where,
typically, further components are required in order to transmit the lateral-
447 squeeze-force to some other part of the structure of the belt-splicer. The present
design enables the lateral-squeeze-force to be self-contained within the below-

heater-platen 27B.

450 [064] The edge-irons 49 and the filler-strips 52 having been put in place, now the
above-heater-platen 27A and the rest of the components of the splicer 20 can be
assembled. Once the above-crossbeam 21A is assembled, and the tension-links 32
453 are in place and engaged, the operators make the splicer ready for the splicing
event by coupling up the required services (electricity, water, etc).

[065] In Figs.6,7,9, a corresponding above-groove 65L has been formed upwards
456 into the downward-facing-undersurface 59 of the above-heater-platen 27A. The
outward-facing surface 51 of the edge-iron 49 again abuts against the middle-
facing-abutment-surface 67 of the above-groove 65.

459 [066] Fig.10 shows a variant, in which the downward-facing undersurface 59 of
the above-heater-platen 27A is plain, i.e has no groove. Now, the lateral-squeeze-
force on the side-edges 56 of the width of the belt is reacted only within the
462 below-heater-platen 27B.

[067] The absence of the engagement of the above-heater-platen 27A with the
edge-iron can be a disadvantage. In the splicer as described herein, the
465 crossbeams 21 are prevented from separating, when the belt 23 is under
compression, by the tension-links 32. However, the tension-links 32 do not
prevent the above-crossbeam 21A from being able to move laterally, relative to
468 the below-crossbeam 21B, and (small) lateral movements can take place. But
when the edge-irons 49 engage their grooves 61,65 in both the below-heater-
platen 27B and the above-heater-platen 27A, such double-engagement constrains
471 the below-heater-platen 27B and the above-heater-platen 27A against lateral
movement relative to each other, and does so very securely.

[068] On the other hand, there is often little tendency towards lateral relative
474 movement of the crossbeams 21, and the (simple) arrangement of Fig.10 then
would be preferred.

[069] When greater security against relative lateral movement of the crossbeams

477 is required, such can be provided e.g as in Figs.11A,11B. (Fig.11B shows the
above-heater-platen 27A about to be lowered onto the belt 23.)

[070] It has been described that the structure that is in contact with the
480 underside of the belt is the below-heater-platen. However, from the standpoint
of providing the mentioned self-contained reaction to the lateral belt-squeezing-
force, the function of the platen may be other than that of heater, or may include
483 other functions besides that of heater (again, the present heater-platens also
include facility for power cooling). Thus, the below-heater-platen may be
referred to, generally, as the below-belt-contacting-platen, or simply as the
486 below-platen, rather than the below-heater-platen. The important thing, for
present purposes, is that the below-belt-contacting-platen should be provided
with left and right middle-facing abutment-surfaces, and that the left and right
489 edge-irons can engage those surfaces in order to react the lateral belt-squeeze
forces. The following also should be mentioned. It is considerably more
convenient to react the belt-squeeze forces within the below-platen, given that
492 the edge-irons and associated components have to be assembled and configured
on-site, i.e at the belt. It is more convenient to place the edge-irons and
components on the oversurface of the below-platen, than it would be to do the
495 same thing upwards to the undersurface of the above-platen. However, apart
from that difference in convenience, the edge-irons and components can, if the
designers so wish, provide the contained-within-the-platen reaction to the belt-
498 squeeze forces in the above-platen.

[071] Sometimes, the material of the upwards-facing surface of the below-belt-
contacting-platen does not itself make direct touching contact with the belt. For
501 example, sometimes a (thin) sheet of release material is interposed between the
platen and the belt, to act as an aid to separating the block from the belt, after
heat treatment. The belt-contacting-platen may be defined as follows. For
504 present purposes, the belt-contacting-platen is the nearest block of metal to the
belt (above and below) that is at least 3mm thick overall (vertically). Thus, the

thin sheet of release material is not itself the belt-contacting-platen.

507 [072] As mentioned, the middle-facing-abutment-surface 63 of the groove 61 is
integral with the material of the below-platen. In general, the middle-facing-
abutment-surface 63 is defined as being integral with the platen when the middle-
510 facing-abutment-surface is either formed monolithically with the platen, from one
common piece of material (metal), or, if formed separately, are fixed together so
firmly and rigidly as to be functionally and operationally equivalent to having been
513 formed from one common piece of material.

[073] The platen can be manufactured as, for example, an aluminum extrusion for
the main length, and then aluminum end-caps, e.g machined from solid, are
516 affixed to the ends of the extrusion. In that case, the middle-facing-abutment-
surfaces 63 can be provided on the end-caps, without the need to machine (or
otherwise create) the grooves into the extrusion.

519 [074] The belt 23 being horizontal, preferably the left and right middle-facing-
abutment-surfaces 63 that are formed in the below-platen 27B preferably are
vertical -- and likewise the outward-facing surfaces 51 of the edge-irons 49.

522 [075] The edge-irons 49 rest on the upward-facing-surface 58 of the below-platen
27B, and (as with edge-irons generally) the upwards-facing surface of the edge-
irons must be well clear of the downward-facing surface of the above-belt-
525 contacting-platen. The clearance should be sufficient that, when the full
compression is being applied, the edge-iron does not come near to holding the
above- and below-belt-contacting-platens apart. The compression forces should
528 be applied to the belt, not to the edge-irons. A vertical clearance of a millimetre
of two is typical.

[076] In Fig.8, the axial length (measured in the direction of travel of the belt) of
531 the splice-zone is contained within the axial length of the splicer. But Fig.8 is not
representational: typically, several splicers are arranged side-by-side, to cover the
full axial-length of the splice-zone. When several splicers are present, side by

534 side, it can be advantageous to use one single long left edge-iron (and one single
long right edge-iron), rather than to use separate edge-irons for each splicer. On
the other hand, designers might prefer to arrange for each splicer to be self-
537 contained, each as a separate structure.

[077] As mentioned, the present invention is concerned with the manner in which
the lateral-squeeze-force that is applied to the side-edges 56 of the belt 23 is to
540 be reacted -- and with the preference that the reaction should be done internally, i.e.
the reaction should be self-contained within the splicer, and preferably within the
below-platen. Another example of a way of enabling the reaction to be internal
543 within the splicer will now be described. Here, the outward-facing surface of the
edge-iron is reacted, not against a middle-facing surface actually within the below
platen (for example, herein, the surface numbered 63) but against a middle-facing
546 surface of the tension-link 32. It might be considered that the tension link, as a
structure, is not at all suitable to serve to resist a lateral force, in the plane of the
belt, being a force that urges the tension-link 32 to buckle outwards about its
549 aperture-pins 38. However, in the splicer as illustrated, there is very little
tendency for the tension-links 32 to buckle (outwards) when the belt is subjected
to heavy squeezing, and the liquid rubber in the splice-zone is being urged to
552 extrude out of the zone. The tension-links do not buckle outwards because the
tendency of the liquid rubber to extrude out of the splice-zone does not start to
occur until the belt is under heavy compression -- by which time the tension-links
555 are under correspondingly heavy tension. The heavy tension in the tension-links
keeps the tension-links stable, and resistive to the pressures and forces arising
from the tendency of the liquid rubber to extrude out of the splice-zone. In short,
558 the tendency of the tension-links to buckle outwards under a lateral load is
negated by the fact that the lateral load does not start to develop until a heavy
tension has been established in the tension-links.

561 [078] Some of the components and features in the drawings have been given
numerals with letter suffixes, which indicate left, right, etc versions of the

components. The numeral without the suffix has been used herein to indicate the
 564 components generically or collectively.

[079] Terms of orientation (e.g “left/right” and the like) when used herein are
 intended to be construed as follows. The terms being applied to a device, that
 567 device is distinguished by the terms of orientation only if there is not one single
 orientation into which the device, or an image (including a mirror image) of the
 device, could be placed, in which the terms could be applied consistently.

[080] Terms used herein that define respective theoretical constructs are
 intended to be construed according to the purposive construction.

[081] The expression “can be”, as used herein, should not be construed as “may
 573 be” nor as “might be”, but rather should be construed strictly as “is able to be” or
 “has the capability to be”.

[082] Where, in a particular one of the accompanying claims, the word “left” is
 576 mentioned but not the word “right”, that claim may be construed as if the word
 “left” had been consistently replaced by the word “right”.

[083] The scope of the patent protection sought herein is defined by the
 579 accompanying claims. The apparatuses and procedures shown in the
 accompanying drawings and described herein are examples.

[084] The numerals mentioned herein are summarized as follows.

- 582 • 20 splicer
- 21A,B crossbeams
- 23 belt
- 585 • 23A,B belt-ends
- 27A,B heater-platen
- 32L,R tension-links
- 588 • 38L,R aperture-pins
- 49L,R edge-irons
- 50L,R middle-facing surface of edge iron 49

- 591 • 51L,R outward-facing surface of edge-iron 49
- 52L,R filler-strips
- 53L,R middle-facing surface of filler-strip 52
- 594 • 54L,R outward-facing surface of filler-strip 52
- 56L,R side-edges of the belt, in the splice-zone
- 58 upwards-facing-surface of the below-heater-platen 27B
- 597 • 59 downwards-facing-surface of the above-heater-platen 27A
- 61L,R below-groove in over-surface 58 of below-heater-platen 27B
- 63L,R middle-facing-abutment-surface of the below-groove 61
- 600 • 65L,R above-groove in under-surface 59 of above-heater-platen 27A
- 67L,R middle-facing-abutment-surface of the above-groove 65

603

FURTHER ASPECTS OF THE INVENTION

RE: MODULAR TOOL

606 Drawings

[085] Figures 12, 13 and 14 are a perspective view, a plan view and a side elevation, respectively, of the modular clamping tool of the invention fully assembled as a plurality of individual clamping components into the tool.

[086] Figure 15 is an exploded pictorial view of the clamping component, separately numbered in this drawing.

[087] Figure 16 is a segregated end cross-sectional elevation of the clamping tool taken along stepped line A-A in Figure 13.

615 Description of the Invention

[088] In one aspect of the invention as shown in Figures 12-14, the modular tool 100 comprises abutting modular clamping components 101, 012 and 103 for a 3 module component tool. For wider or narrower splicing the tool may be assembled with one or as few as a pair of abutting modular clamping components 102 and 103 or as many as 4 or more as may be required, each at least abutting

621 the next adjacent unit.

[089] In Figure 15 (showing clamping component 101) the upper clamping crossbeam 21A, for each of clamping components 101, 102 and 103, is shown as a
624 highly elongated component with an aspect ratio of greater than, preferably, 4:1, a length L, a width W and a height H. A corresponding and identical highly elongated cross beam 21B is shown below belt 23 in inverted position.

627 [090] When linked together with linkage components 32L,32R, including components 34A, 34B, 36A, 36B and 38 (either left of right, further designated in the drawings with an “L” or a “R” respectively in the drawings), the clamping
630 component 101 is assembled for uniform compressive belt clamping perpendicular to both the belt surface and the cross-beam across the whole of its elongated projection on to the belt 23, comprising overlapping portions 23A and 23B, an area
633 exceeding the nominal belt width, 104 in Figure 12.

[091] Within each of modular components 101, 102 and 103, herein referred to collectively as cross beam clamping components 100, are upper and lower
636 insulating layer components 29 and upper and lower heating and cooling components 27 (integrated in to a replaceable cartridge, upper 27A and lower 27B), plus at least one airbag 25 adapted to receive externally applied air or water
639 pressure 40. Each modular component 100 has a similar orthogonal projection across the full extent 104 of the belt and within the projected area of the said elongated projection preferably perpendicular to the belt 23 and is adapted to be
642 closely adjacent each other, and preferably abutting, when assembled for use.

Preferably there is only one air bag 25 either situated bottom or top of the belt 23 but there are occasions where 2 airbags, top and bottom are preferred. Also
645 preferably, insulating layer 29 lies between the heating and cooling layers 27 and the air bag position as shown on component 101 in Figure 16. The air bag 25 is preferably an inflatable structure restrained within an open rectangular shell 26.

648 [092] Each of cross beam clamping components 21A and 21B for each of modules 101, 102 and 103 (Figures 12 through 16) is formed by a thin walled casting of light weight material such as aluminium or, alternatively, welded from sheet stock, or a

651 combination of casting and welding. Each modular component 101, 102 and 103,
in section as shown in Figure 16, includes a flat platen surface 602, adapted to act
upon the heating and cooling cartridges 27A and 27B respectively across its full
654 projection onto and preferably perpendicular to the belt, at least, plus an outer
tension surface 603. Platen surface 602 and tension surface 603 are separated by
at least 2 vertical flange elements 604 (also preferably perpendicular to the belt)
657 to comprise a box-beam and I-beam combination across at least the full projection
of the cross-beam 100 on to the belt 23.

[093] Box beam vertical elements 604 are both aligned, as at 604A and 604B in
660 Figure 16, with a corresponding pair of tension links 32L and 32R, each including
upper and lower links 34 joined together by pins 38 for tension perpendicular to
platen surface 602 without twist and with no substantial bending moment other
663 than transverse to the length L and parallel to the width of the belt .

[094] As shown in Figure 14 the upper surface 603 is formed as, preferably, an arch
or double tapered surface, to accommodate the bending forces generated during the
666 long periods of processing required for the splice which occur between assembly of
the modular tool through vulcanization to cooling and dis-assembly and
additionally assist in resisting any residual twisting about length L.

669 [095] In another alternative of the invention a heating and cooling (forced)
cartridge 27 is provided adapted to lie adjacent to and across the full belt splice
alone or as a pair either above or below the belt splice. The cartridge is highly
672 elongated in relation to the belt splice with aspect ratios higher than 4:1 and
corresponds in projected belt area to an individual pair of orthogonally aligned
clamping components.

675 [096] The 2-layer embodiment of the cartridge as depicted in Figures 12 to 17 and
in exploded view in Figure 15 is provided with a planar exterior surface on 2 sides
which are adapted to interact with and perpendicular to the belt being spliced on
678 the one side (the belt surface 702) and the source of pressure on the other (the
pressure surface 703) extending over at least the full nominal width of the splice.
These surfaces are preferably both flat and parallel. The cartridge is designed to

681 be used in and with a plurality of closely abutting identical cartridges to form a
belt splice platen-type array which may be as few as 2 and as many as 6 or more
contiguous cartridges in operation.

684 [097] Most preferably, each of modular components 100 includes a monolithic
structure at each end, as at 605L and 605R in Figures 13 and 15, which extends
across, and most preferably completely across, the full width 606 of each of the
687 modular components 100. The monolithic structures 605 are preferably
engineered to spread loading between the surfaces 602, 603 and flanges 604 and
pins 36A and 36B on each of the left and right ends of each modular component
690 100 as shown in Figures 7 and 16.

[098] As shown in Figures 3, 15 and 16 each of cross-beams 21A (upper) and 21B
(lower) is rotatably pinned to a matched pair of upper links 41A and a matched
693 pair of lower links 41B respectively for rotation solely about axes 606A and 606B
respectively. Axes 606 lie in a plane parallel to the surface of belt 23, are
parallel to each other and perpendicular to the long dimension L of a respective
696 modular component 100. Links 41A and 41B, as shown in Figure 3, are joined
together as by pin 38 having its long axis 607 parallel to each of axes 606. In the
case of a non-circular pin 38, such as shown in Figures 4A and 5A axis 607 of pin
699 38, may be a pair of parallel axes of rotation 607A and 607B as in Figure 15B.
Thus, expansion of air bag 25, preferably, causes separation of cross-beams 21 and
causes the tension in links 41A and 41B to be increased from a low value, or zero,
702 static tension vector 608 resulting (see Figure 14) from assembly to a high value
tension vector 609 for splicing which is most preferably fully perpendicular to both
belt 23 and component surfaces 602 during the full operational cycle. Any
705 misalignment of the this tension force 609 and any bending or twisting moment is
transferred between the upper and lower components 21A and 21B in a manner
fully orthogonal to belt 23 and is restrained to bend components 21A and 21B
708 solely about an axis parallel to and along the operational length of belt 23 without
any twisting moment in the box or I-beam combination of surfaces, or, at least, to
reduce same substantially. Thus, each modular component 100 is restrained with

711 its height H to remain perpendicular to belt 23. Thus components 101, 102 and
103 are parallel to each other and in close proximity to each other at all times as
shown in the drawings. As assembled interconnection between immediately
714 adjacent components 101, 102 and 103 is provided by the belt 23 itself.

[099] Modular component 200 may be fitted with a safety restraint bar or bars 614
which are adapted to be passed through passages 613 in flanges 604 in respective
717 components 101, 102 and 103. For ease of use, flanges 604 may be fitted with
clips 611 to maintain the bar 614 together with a cross-beam 21.

[100] Further, for ease of manufacture and reduced operational weight flanges
720 604 may be relieved as at 610 in Figure 15.

723 RE: MODULAR THERMAL CARTRIDGE

[101] Figure 17 is a pictorial view of the modular thermal cartridge.

[102] Figure 18 is an exploded pictorial view of the cartridge of Figure 17. Figure
726 18b is a lose up of a portion of Figure 18.

[103] Figure 19 is a plan view of intercallated embodiment.

[104] Figure 20a through e are top plan, partial end section, side and selected
729 cross-sectional views of a further embodiment of the densely packed heating and
cooling array of the invention. Figure 20f is a close up of a portion of Figure 20.

[105] Figure 21 is a end cross-section of an another preferred embodiment.

732 [106] The cartridge 701 as shown in Figure 17 with a next-to-belt surface 702 and
an outer surface 703. Cartridge 701 is preferably formed with 3 distinct layers as
shown in Figure 18 whole long dimension L between is shell ends and width W
735 match those of a modular component belt splicer as shown herein.

[107] The belt surface 702 of the cartridge 701 is provided with a base tray 802
including a heat transmissive layer 820 across its full extent which may be bent
738 upwards at its lateral extremities form outside edges 823. The transmissive layer is
preferably no more than a few mm thick.

[108] Formed primarily from an aluminium extrusion the transmissive layer 820 is

741 preferably formed with a plurality of upstanding, preferably integral, internal fins
or supports 821 in a closely packed array 822 which, together, form the heating
layer of the cartridge. Outside edges 823 provide the inside extent of array 822.

744 Fins 821 are minimally thin and may be as little as 1 mm in breadth and may be
tapered to ensure both heat conductivity and structural support across the fin
structure 822 to resist and preferably isolate compressive forces delivered by the
747 cross-beams in a splicing operation.

[109] Inter-fin spacings are occupied, and preferably fully occupied, by a
continuous electrical heating cable 801 in heat transmissive contact with the fin
750 supports 821. Cable 821 lies in a serpentine pattern substantially throughout at
least the projected area of the cartridge onto the belt splice as shown in Figures
18 on. Adjustments to heating capacity and uniformity may be made by changing
753 the fin spacing, engaging the serpentine wire in alternate fin lines as required (see
Figure 18 and 19) or changing the wire or adjusting its heating capacity.

[110] The fin supports 821 extend internally at least as far as the extent of the
756 heating cable 801 so as to bear the load, and preferably substantially all of the
load, associated with process pressure throughout the whole of the heating and
cooling process, plus assembly and dis-assembly operations, including variable
759 bending and stresses associated the thin walled modular componentry.

[111] Most preferably, the serpentine heating cable 801 is a temperature and heat
wattage controlled electrical cable flattened on 2 sides to form a race track
762 configuration as shown in Figure 20b.

[112] The cable 801 is oriented vertically from both the belt splice 23 and the heat
transmissive surfaces 820 and fully contacts that surface and each of the adjacent
765 fin supports along its circular end and along its respective flat sides. Any spacings
between the wire boundary and the fins or heat conductive surfaces may be filled
on manufacture with a suitable heat structurally supporting conductive material as
768 in Figures 19, 20 and 21.

[113] Preferably cable 801 is temperature reactive, with or without embedded
temperature measurement devices, and interacts with minimally thin transmissive

771 layer 820 for uniform delivery of process heat across the splice in conjunction with
cable side or side wall 823 thermal conductivity and fins 821.

[114] In an alternative embodiment, the electrical cable 801 does not fully occupy
774 the fin support array 821. Fin support array 821 may be sized to provide uniform
heating and controlled process temperatures through adjacent fin supports and
the heat transmissive layer 802 but with wire 801 not extending beyond the height
777 of the fin supports 821. Corresponding adjustment of the next layer out is made so
as not to pressure the conductive wire 801 during processing.

[115] A forced cooling layer 805, Figures 18 and 20, preferably lies vertically
780 adjacent the heating layer in thermally transmissive contact with the fin array 821
so as to transmit most or all of the process pressure through to the fin array 821
and not the heating cable 801.

783 [116] Most preferably as shown in Figures 20, the cartridge 701 includes an
elongated outer container 805 adapted to contain both:

- the serpentine heating cable 801 shown in Figure 18, the support fins 821,
786 and heat transmissive filler material 826 adjacent belt surface , and,
- a one or a plurality of serpentine cooling tubes 825 (Figure 20a) embedded
in support material 826 arranged so as to provide vertical structural support across
789 the cartridge 701 and resistance-free flow through of cooling fluid across the full
surface of the belt 23 from manifold end cap 806 to manifold end cap 809.

[117] External sources of process pressure, air or water, may be connected to
792 cooling tubes 825 and 805 through manifold connections 806 and 809 at either
shell end of the thermal cartridge and thence to supply with or without an
intervening manifold in the event that a non-serpentine cooling tube is used.

795 [118] The cartridge 701 includes end spacers (not shown) which close the tray 802
at each shell end so as to provide additional vertical structural support and
spacing for the cartridge 701 against process pressures.

798 [119] The interior of the preferred embodiment of Figures 20 is shown more
closely in the exploded view of Figure 20b.

[120] In Figure 19 the serpentine heating wire 801 is configured to pass down and

801 back between every pair of fins 902 in the heating layer as a single wire or in a
horizontal array of parallel heating wires. Cooling tubes 903 may be intercallated
804 with heating wire 801 and fins 902 in a single layer as in Figure 19. Preferably,
cooling tubes 901 lie within shell 805 and lie vertically outward from the heating
array as shown in Figures 20. Cooling tubes 903 preferably lie above wire 901 so
that vertical alignment of the fins with the supports 904 between tubes 903
807 ensures maximum structural integrity against process pressures and bending.

[121] Most preferably, the cartridge also optionally includes a substantially rigid
load bearing insulating third layer (not shown) either partially integral with or
810 completely supported upon and in contact with at least the cooling layer so as to
transmit process pressures from the cross-beam uniformly through to the cooling
layer and then the fin support array while insulating the heating/cooling elements
813 from non-process heating losses.

[122] Preferably the insulating layer is formed as a single amorphous layer
prefabricated and assembled or poured in place, most preferably including
816 reinforcing fibres and means to lighten the layer.

[123] As can be seen the cartridge 701 may be readily and inexpensively fabricated
on a component basis while remaining light in weight and optimal in heating and
819 cooling delivery. Easily manipulated in the field, the cartridge 701 assists in
approaching a process fail safe condition by providing for ready and rapid
replacement of a single cartridge in the most extreme conditions of storage,
822 installation, process use and decommissioning.

[124] At A in Figure 16 shows co-planar close abutment between adjacent
cartridges in components 101 and 102. Alternatively, this abutment A may include
825 a step or tongue and groove mating.

[125] Most preferably, the cartridge is formed as shown in Figures 20 wherein the
heating and cooling layers are not both inter-callated with the fin supports so as to
828 reduce thermal capacity while maintaining optimal process heat and pressure
without deformation through rapid heating and cooling cycles while processing.

[126] Figures 20a and 20e show a top plan view of this embodiment, a partial end

831 section, a side elevation, and an upper and lower section B-B and C-C.

[127] In Figure 11a the cartridge is shown in an exploded view with a finned base plate 1. Expanded views of Figure 11a are shown in Figures 11b and 11c.

834 Flattened heating cable Z is formed as a serpentine shape and inter-callated with the fins 5 so as to occupy alternate pairs of fin spacings 4, that is 3 fins per wire length, so as to lie in a single plane leaving unoccupied channels 6. Unoccupied
837 channels 6 are preferably also in alternating pairs, 3 fins per channel.

Unoccupied channels 6 may form a cooling structure by closure across the top of the fins 5 for the full width and breadth of the array. Cooling by externally
840 applied air or water occurs by passage of the fluid along the length of the unoccupied channels in contact with vertical surfaces of 3 fins per passage. A manifold would be included at each end of the array of passages to supply and
843 exhaust the cooling fluid. Alternately, the unoccupied channels may include a serpentine cooling tube 7 as shown in Figures 12 and 13 for fluid flow A-A. The flattened sides of cooling tube 2 are in thermally transmissive contact with
846 respective fins, preferably on both sides. A closely packed single plane heating and cooling array is provided and then closed into a single thermal unit by insulating cover plate 3. Most preferably, each length of each of the cable and the
849 cooling tube are in surface to surface contact with fins on both flattened sides.

[128] Figure 13 shows a further expanded plan view of the heating/cooling array of Figure 12 in its cooling tube embodiment. Fins 5 occupy all spacings between back
852 and forth runs of each serpentine of each of the heating cable.

[129] Figure 21 shows a partial cross-section of a still further embodiment of the cartridge 701 of the invention. Belt surface 702 is not integrally formed with heat
855 transmissive fins. Alternatively, heat transmissive material 851 is in a liquid or semi-liquid phase and poured into place, optionally between edges 823. While material 851 is still semi-liquid elongated heating cables 801 are embedded wholly
858 or completely in the material 851 in a parallel array or as a serpentine. Continuing while material 851 is still semi-liquid cooling tubes 903 are embedded in the material 851 either directly adjacent cables 801 or vertically above said

861 cables as in Figures 19 and 20 and allowed to harden into a structural support
between the belt surface and surface 701. Once set compressive forces provided
during a belt splic by pass the thermal element structure as they are carried by
864 the support structure without bending or twisting. Cartridge 701 is then
completed with structural heat insulating material 852 which may be poured into
place either before or after material 851 has set or hardened.

867 [130] Cable 801 in Figure 21 is shown as a pair of electrical conductors 852
separated by a thermally adjustable electrical insulator 853 with the whole
surrounded by electrical insulation 854.

870 [131] Structural material 852 may contain lightening and-reinforcing elements
855.

[132] Once hardened, materials 851 and 852 provide the supporting fin structural
873 array of the invention providing full thermal conductivity with the belt surface and
full insulation with the clamping components.

[133] In an alternate embodiment the cable or the cooling tube may be composed
876 of single straight lengths spliced together at each end.

[134] The scope of the patent protection sought herein is defined by the
accompanying claims. The apparatuses and procedures shown in the accompanying
879 drawings and described herein are examples.

What we claim is:

CLAIMS

Claim 1. A belt splicer, which includes an above crossbeam and a below crossbeam, arranged to span across the width of a belt to be spliced, the crossbeams being positioned one above, and the other below, the splice-zone of the belt, wherein:

[2] an above left beam-end of the above crossbeam and a below left beam-end of the below crossbeam extend leftwards beyond the left side edge of the belt;

[3] an above right beam-end of the above crossbeam and a below right beam-end of the below crossbeam extend rightwards beyond the right side edge of the belt;

[4] a left tension-link connects the above left beam-end of the above crossbeam to the below left beam-end of the below crossbeam;

[5] a right tension-link connects the above right beam-end of the above crossbeam to the below right beam-end of the below crossbeam;

[6] the left and right tension-links are engineered to prevent separation of the respective beam-ends of the above and below crossbeams, in the up/down direction, against heavy forces urging the crossbeams apart during operation of the splicer;

[7] the left tension-link includes an above left tension-link-element, which is pinned to the above left beam-end of the above crossbeam;

[8] the left tension-link includes also a below left tension-link-element, which is pinned to the below left beam-end of the below crossbeam;

[9] the above left tension-link-element is formed with an above left aperture, and the below left tension-link-element is formed with a below left aperture;

[10] the left tension-link is arranged for aperture-alignment of the left tension-link-elements, in which:

[11] (a) the above left tension-link-element and the below left tension-link-element so engage and align with each other that the above left aperture overlies the below left aperture;

[12] (b) a left aperture-pin can be inserted through, and can reside in, both left

apertures;

[13] (c) when so inserted through both left apertures, the left aperture-pin is subjected to, and supports, the heavy forces, and thereby prevents the left beam-ends of the cross beams from separating in the up/down direction; and

[14] (d) when the left aperture-pin is withdrawn from the left apertures, the left tension-link-elements are thereby disconnected from each other, whereby the left beam-ends of the crossbeams are no longer connected and the crossbeams can be separated;

[15] the operational distance apart of the left beam-ends of the crossbeams is adjustable, in that:

[16] (a) the splicer includes two aperture-pins, termed pin-A having pin-profile-A, and pin-B having pin-profile-B;

[17] (b) the pin-profile-A is such that, the left apertures being in aperture-alignment, the pin-A can pass through the left apertures;

[18] (c) the pin-profile-B is such that, the left apertures being in aperture-alignment, the pin-B can pass through the left apertures;

[19] (d) the pin-profile-A is different from the pin-profile-B as to their heights in the up/down direction, in that:

[20] (i) when the pin-A is residing in the left apertures and is supporting the heavy forces, the distance apart of the left beam-ends then is distance-A;

[21] (ii) when the pin-B is residing in the left apertures and is supporting the heavy forces, the distance apart of the left beam-ends then is distance-B; and

[22] (iii) the distance-A is not equal to the distance-B.

Claim 2. As in claim 1, wherein the splicer includes a powered thermal-platen, having the capability, as a structure, for sequentially heating and cooling the splice zone of the belt during different phases of a splicing event.

Claim 3. A belt splicer as claimed in claim 1, wherein:

[2] the pin-profile-A is such that, the two apertures being in aperture-alignment, pin-A can pass through and reside in both apertures;

[3] the pin-profile-B is such that, the two apertures being in aperture-alignment,

pin-B can pass through and reside in both apertures;

[4] but the pin-A cannot reside in the apertures at the same time as the pin-B.

Claim 4. A belt splicer as claimed in claim 3, wherein:

[2] the pin-profile-A is a clearance fit within the above aperture;

[3] the pin-profile-A is a clearance fit within the below aperture;

[4] whereby -- the two apertures being in aperture-alignment -- the pin-A can be inserted into and right through both apertures, and can be withdrawn from both apertures;

[5] the pin-profile-B is a clearance fit within the above aperture;

[6] the pin-profile-B is a clearance fit within the below aperture; [7] whereby, the two apertures being in aperture-alignment, the pin-B can be inserted into and right through both apertures, and can be withdrawn from both apertures.

Claim 5. A belt splicer as claimed in claim 3, wherein:

[2] the pin-profile-A substantially fills at least one of the aperture profiles;

[3] the pin-profile-B is substantially clear of at least one of the aperture profiles, in the up/down direction.

Claim 6. A belt splicer as claimed in claim 5, wherein:

[2] the above aperture profile is identical to the below aperture profile;

[3] the pin-profile-A is identical to the aperture profiles, except that the pin-profile is a clearance fit within the aperture profiles.

Claim 7. A belt splicer as claimed in claim 1, wherein the above and below apertures are formed as slotted holes.

Claim 8. A belt splicer as claimed in claim 1, wherein:

[2] the splicer includes a left-kit of aperture-pins;

[3] the left-kit includes pin-A and pin-B, and at least one further aperture-pin, where the aperture-pins in the left-kit differ from each other, as to their profile dimensions in the up/down direction;

[4] the profile dimensions in the up/down direction of the pins differ in a series of steps, at such convenient intervals as to enable the distance between the above left beam-end and the below left beam-end to be adjusted by exchanging one pin

of the kit for another.

Claim 9. A belt splicer as claimed in claim 8, wherein:

- [2] the above left aperture in the above left tension-link-element; and
- [3] the below left aperture in the below left tension-link-element; and
- [4] the left aperture-pin;
- [5] are all running-track shaped, comprising two semi-circles joined by two straights;
- [6] the different profile dimensions in the up/down direction of the pins in the left-kit differ from each other in that the pins have different lengths of their respective straights, while the rest of the profile is the same.

Claim 10. A belt splicer as claimed in claim 1, wherein the above left tension-link-element is pinned to the above left beam-end in that:

- [2] an above left beam pin-hole in the tension-link-element is aligned with an above left link pin-hole in the beam-end, and an above left beam-link-pin passes through the beam pin-hole and the link pin-hole;
- [3] the beam-link-pin and the pin-holes are so configured:
- [4] (a) that the beam-link-pin is subjected to and supports the heavy forces;
- [5] (b) as to enable pivoting movement of the above left tension-link-element relative to the above left beam-end; and
- [6] (c) that the pivoting movement takes place in the pitch-mode relative to the crossbeams.

Claim 11. A belt splicer as claimed in claim 10, wherein:

- [2] all the tension-links in the splice-zone are adjusted each to substantially the same length.L, being the length measured between the respective above and below beam-link-pins of the tension-links;
- [3] and the length.L is no more than twenty cm.

Claim 12. A belt splicer as claimed in claim 1, wherein:

- [2] the above left tension-link-element comprises two clevises, having respective pairs of spaced arms, and the above left apertures are formed as through-holes in the arms;

[3] the below left tension-link-element comprises two drawbars, which engage between the arms of the clevises, and the below left apertures are formed as respective through-holes in the drawbars;

[4] the two clevises are structurally integrated, so that both are constrained to move together when the above left tension-link-element undergoes pivoting movement;

[5] the two drawbars are structurally integrated, so that both are constrained to move together when the below left tension-link-element undergoes pivoting movement;

[6] an above left handle is provided on the above left tension-link-element to enable manual control of the pivoting movement thereof;

[7] a below left handle is provided on the below left tension-link-element to enable manual control of the pivoting movement thereof;

[8] the aperture-pins are now termed clevis-pins.

Claim 13. A belt splicer as claimed in claim 8, wherein the kit of aperture-pins is contained in a receptacle on the splicer, and all the aperture-pins are permanently tethered to components of the splicer.

Claim 14. Belt splicer, which includes an above crossbeam and a below crossbeam, arranged to span across the width of a belt to be spliced, wherein:

[2] the crossbeams are positioned above and below a splice-zone of the belt;

[3] a left tension-link connects a left end of the above crossbeam to a left end of the below crossbeam;

[4] a right tension-link connects a right end of the above crossbeam to a right end of the below crossbeam;

[5] the splicer includes an operable inflator, which is so configured as to be effective, when operated, to subject the splice-zone of the belt to heavy compression pressure;

[6] the splicer includes a below-platen having an over-surface which, during a splicing event, resides underneath the belt;

[7] the splicer includes an above-platen having an under-surface which, during

a splicing event, resides on top of the belt;

[8] the splicer includes left and right edge-irons;

[9] the left edge-iron is formed with a left middle-facing sealing surface;

[10] the right edge-iron is formed with a right middle-facing sealing surface;

[11] the splicer is so configured that, during splicing, the left and right sealing surfaces press inwards against the left and right side-edges of the belt, in the splice zone, thereby exerting a laterally-inwards-directed sealing-pressure against the side-edges of the belt;

[12] the lateral sealing pressure is enough to prevent, or substantially inhibit, lateral extrusion and leakage of liquids out of the splice-zone, during splicing, being such liquids as arise within the splice-zone during a splicing event;

[13] the left edge-iron is formed with a left outwards-facing abutment-surface;

[14] the right edge-iron is formed with a right outwards-facing abutment-surface;

[15] the below platen is formed with left and right middle-facing abutment-surfaces;

[16] the outwards reaction of the left edge-iron due to the inwards-directed sealing-pressure is reacted by abutment engagement of the left outwards-facing abutment-surface of the left edge-iron against the left middle-facing abutment-surface of the below-platen;

[17] the outwards reaction of the right edge-iron due to the inwards-directed sealing-pressure is reacted by abutment engagement of the right outwards-facing abutment-surface of the right edge-iron against the right middle-facing abutment-surface of the below-platen.

[18] whereby the forces causing the inwards sealing pressure, and the reactions to those forces, are all contained within the below-platen.

Claim 15. As in claim 14, wherein:

[2] the below-platen is a powered thermal-platen, having the capability to be operated to sequentially heat and cool the splice-zone, from below, during

different phases of a splicing event;

[3] the below-platen is another powered thermal-platen, having the capability to be operated to sequentially heat and cool the splice-zone, from above, during different phases of a splicing event.

Claim 16. As in claim 14, wherein:

[2] the left middle-facing abutment-surface is an integral component of the below-platen, in that:

[3] (a) the left middle-facing abutment-surface is formed monolithically with the body of the below-platen; or

[4] (b) the left middle-facing abutment-surface having been formed separately from the body, the abutment-surface and the body are fixed together so firmly as to be functionally and operationally equivalent to having been formed monolithically.

Claim 17. As in claim 14, wherein:

[2] a left extension of the below-platen extends outwards beyond the left side-edge of the belt;

[3] a right extension of the below-platen extends outwards beyond the right side-edge of the belt;

[4] the left middle-facing abutment-surface is located in the left-extension of the below-platen;

[5] the right middle-facing abutment-surface is located in the right-extension of the below-platen.

Claim 5. As in claim 17, wherein:

[2] the left extension is an integral component of the below-platen, in that:

[3] (a) the left extension is formed monolithically with the body of the below-platen; or

[4] (b) the left extension having been formed separately from the body, the left extension and the body are fixed together so firmly as to be functionally and operationally equivalent to having been formed monolithically.

Claim 19. As in claim 14, wherein:

[2] the left edge-iron includes two components, being a left hard-metal strip and a left filler-strip;

[3] the material of the left filler-strip is softer, and more compliant, than the hard-metal;

[4] the left middle-facing sealing-surface is a surface of the left filler-strip;

[5] the left outwards-facing abutment-surface is a surface of the left hard-metal strip;

[6] the components are so dimensioned and configured, with respect to the belt, that the left filler-strip is squeezed between the left side-edge of the belt and left hard-metal strip, during operation of the splicer.

Claim 20. As in claim 19, wherein:

[2] the physical structure of the edge-irons in relation to the other components of the splicer, is such as to ensure that:

[3] under heavy compression on the splice-zone of the belt during operation of the splicer, no portion of the compressive pressure is supported by and transmitted through:

[4] (a) the left hard-metal strip of the left edge-iron; nor

[5] (b) the right hard-metal strip of the right edge-iron.

Claim 21. As in claim 19, wherein:

[2] the above-platen is formed with above-lateral-abutment-surfaces;

[3] the above-lateral-abutment-surfaces interact with lateral abutment surfaces on the hard-metal components;

40

[4] thereby eliminating or limiting lateral movement of the above-platen with respect to the below-platen, during splicing.

Claim 22. As in claim 14, wherein:

[2] the left middle-facing abutment-surface is a middle-facing sidewall of a left groove;

[3] the left groove has been formed directly down from the over-surface of the below-platen into the material of the below-platen.

Claim 23. As in claim 22, wherein the left groove has been formed directly down from the over-surface of a left-extension of the below-platen, into the material of the left-extension of the below-platen.

Claim 24. A modular belt splicer comprising one or more unconnected modular clamping components wherein each modular clamping component includes:

- an upper and a lower elongated cross-beam with a length L, a width W and a height H, each cross-beam adapted:

- for length L to extend between a left beam end and a right beam end fully across the long dimension of a belt to be spliced, and,

- said beam ends protruding beyond corresponding left and right belt edges on each side of the belt, and,

- to provide clamping forces perpendicular to the belt to be spliced, and,

- to restrain the clamping forces in bending along its respective length L,

- a left and a right tension link each pivotally secured to and between respective left and right beam ends for rotation about at least a pair of parallel axes each transverse to length L and parallel to the surface of the belt, and,

- wherein said tension links are operable under tension solely by rotation about said parallel axes.

Claim 25. A modular belt splicer as claimed in claim 24 wherein:

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- each cross-beam comprises either an elongated box beam or I-beam structure oriented along length L, and,
- each beam end includes a monolithic cross-beam-end structure.

20 **Claim 26.** A modular belt splicer as claimed in claims 24 or 25 wherein each beam structure includes:

- an upper tension surface, and,
- a belt-facing surface adapted to lie parallel to and in intimate contact with the belt, and,
- 25 • at least one beam flange aligned with length L and perpendicular to the belt extending between the upper tension surface and the belt-facing surface.

Claim 27. A modular belt splicer as claimed in claim 26 wherein each monolithic end extends between the respective tension surface and belt-facing surface and to said flange.

30 **Claim 28.** A modular belt splicer as claimed in claim 27 wherein each monolithic end extends the full width W of the cross-beam.

Claim 29. A modular belt splicer as claimed in claims 26 or 27 wherein each tension link is pivotally secured to its respective monolithic end by a pin extending substantially the full width W of the cross-beam and adapted to constrain relative
35 motion between said tension link and said monolithic end to pivotal rotation about the pin pivot axis.

Claim 30. A modular belt splicer as claimed in claim 29 wherein each tension link is separable into two tension link components, each pivotally connected to a respective beam end.

40 **Claim 31.** A modular belt splicer as claimed in claim 30 wherein said two tension link components are adapted to be constrained when connected together under tension for relative rotational motion solely about a link axis parallel to said pin pivot axis.

42

Claim 32. A modular belt splicer as claimed in claim 31 wherein said tension links
45 are adapted for relative movement when not under operational tension.

Claim 33. A modular thermal cartridge for delivery of the thermal energy
required for a belt splicer including an elongated clamping cross-beam comprising:

- an elongated outer shell adapted to conform to both the width B of a belt
to be spliced and a pair of compressive elongated clamping cross-beams
50 each having a length L between ends and a width W,
- said shell including:
- an elongated heat-transmissive exterior belt surface adapted to conform to
the belt across its width B, and,
- a exterior elongated beam surface adapted to conform to the beam across
55 its length L, and,
- a plurality of heat transmissive supports extending from said belt surface
toward said beam surface aligned along the cross-beam length L,
- a thermal element structure extending from a shell end to a distal shell end
along the cross-beam length L and lying between said supports, and,
- 60 • means to deliver heat energy and cooling to said thermal element structure
adjacent at least one said end.

Claim 34. A thermal cartridge as claimed in claim 33 wherein said supports are
flanges.

Claim 35. A thermal cartridge as claimed in claims 33 or 34 wherein said supports
65 provide a linear support array aligned along length L and adapted to transmit
compressive forces between said cross-beams and the belt perpendicular to the
belt .

Claim 36. A thermal cartridge as claimed in claim 35 wherein said support array
relieves substantially all of the compressive forces between the said cross-beams
70 and the belt from the thermal element structure.

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Claim 37. A thermal cartridge as claimed in claim 36 wherein said thermal element structure lies entirely between said supports and within the support array.

Claim 38. A thermal cartridge as claimed in claim 37 wherein said thermal element structure includes a thermal delivery element and heat transmissive material between the delivery element, said supports and said exterior belt surface.

Claim 39. A thermal cartridge as claimed in claim 38 wherein said thermal delivery element is arranged in a serpentine pattern parallel to the belt and extending continuously between said supports from the shell end to a distal shell end and back across the belt.

Claim 40. A thermal cartridge as claimed in claim 39 wherein said thermal element is a electrical heating element.

Claim 41. A thermal cartridge as claimed in claim 40 wherein said heating element is non-circular, having a long dimension and a short dimension in cross-section.

Claim 42. A thermal cartridge as claimed in claim 41 wherein said heating element is oval in cross-section.

Claim 43. A thermal cartridge as claimed in claim 42 wherein said long dimension lies parallel with said supports.

Claim 44. A thermal cartridge as claimed in claim 43 wherein said thermal cartridge includes electrical supply connections adjacent a shell end.

Claim 45. A thermal cartridge as claimed in any of claims 33 through 44 wherein said thermal element structure includes a cooling element structure between said plurality of supports and said beam surface.

Claim 46. A thermal cartridge as claimed in claim 45 wherein the cooling element structure includes a thermal cooling delivery element and heat

transmissive material between the thermal cooling delivery element, said supports and said exterior beam surface.

100 **Claim 47.** A thermal cartridge as claimed in claim 46 wherein said cooling element structure is arranged in a serpentine pattern extending generally parallel to said supports from the shell end to a distal shell end and back across the belt.

Claim 48. A thermal cartridge as claimed in claim 47 wherein said cooling element structure and said thermal element structure are intercallated between
105 said supports.

Claim 49. A thermal cartridge as claimed in claim 48 wherein said cooling element structure includes cooling supply connections adjacent at least one shell end.

Claim 50. A thermal cartridge as claimed in claim 46 wherein the cooling
110 element structure includes:

3. a thermal cooling delivery element,
4. heat transmitting material between the thermal cooling delivery element and said supports,
5. heat insulating material between said cooling delivery element and said
115 exterior beam surface.

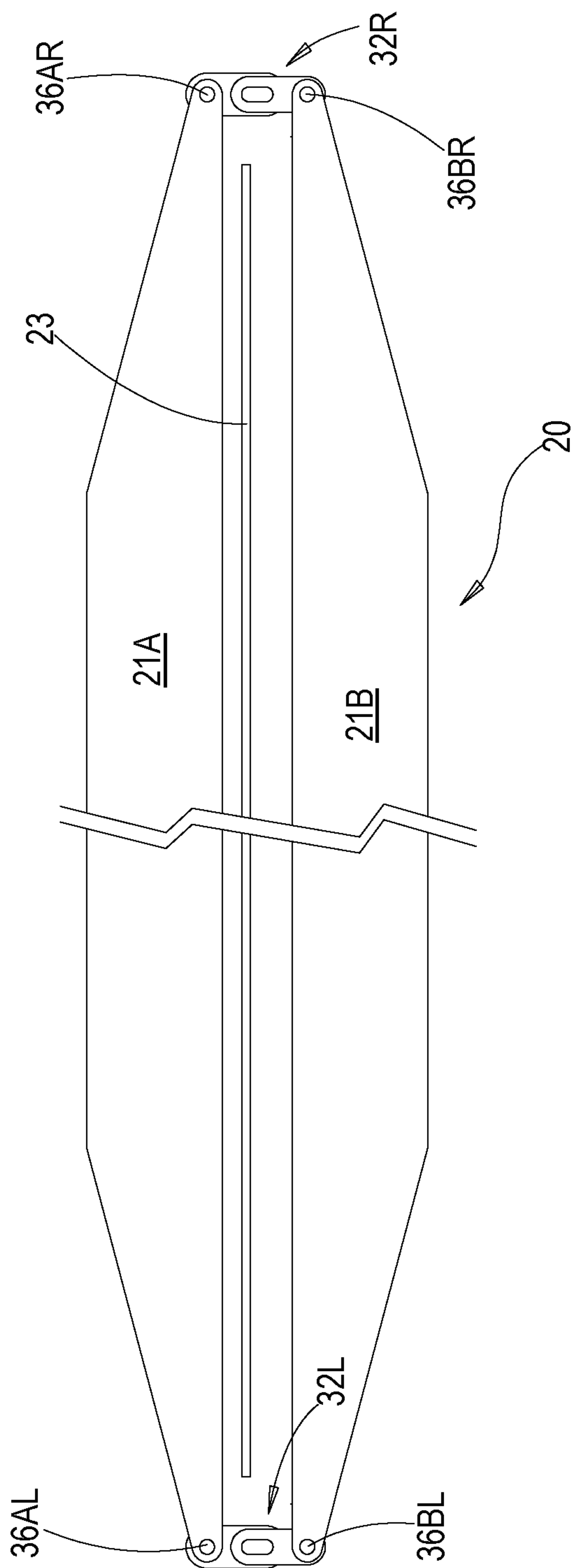
Claim 51. A thermal cartridge as claimed in claim 50 wherein said supports are molded around said thermal element structure.

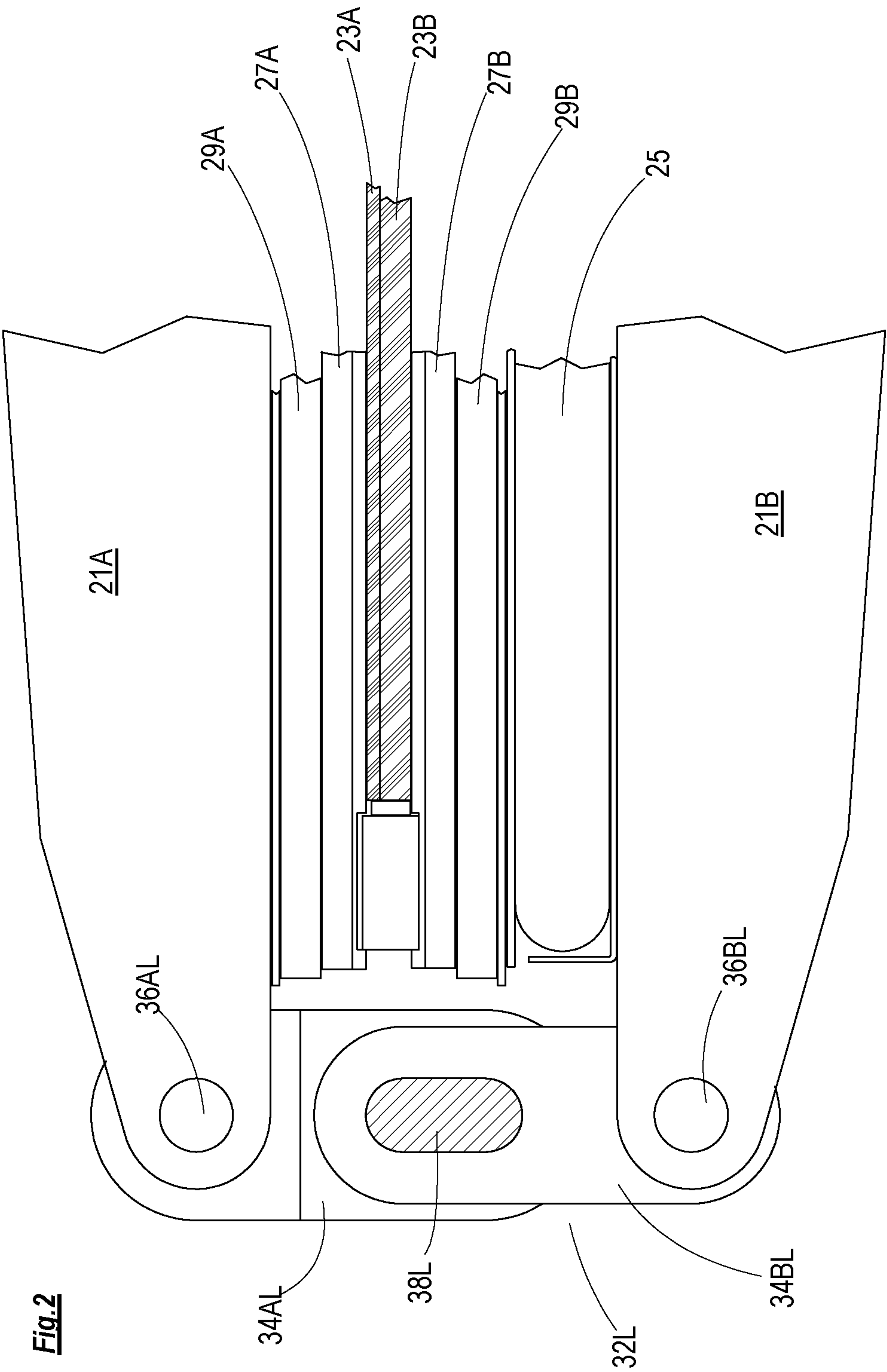
Claim 52. A thermal cartridge as claimed in claim 51 wherein said heat transmitting material and said heat insulating material are adapted to transmit
120 compressive forces between said cross-beams and the belt perpendicular to the belt.

Claim 53. A thermal cartridge as claimed in claim 52 wherein said heat transmitting material and said heat insulating material are adapted to provide said support array any relieve substantially all compressive forces between the said

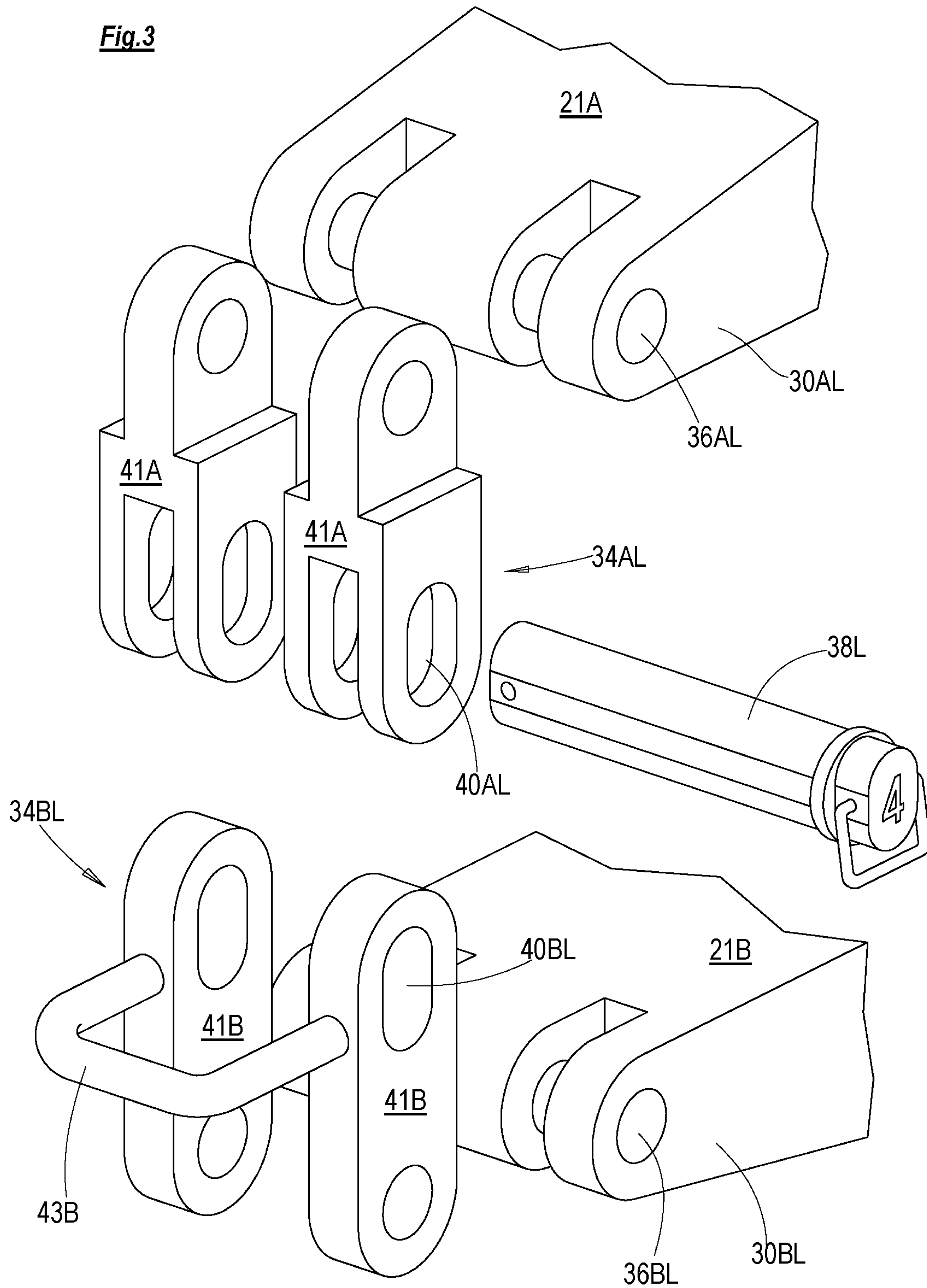
125 cross-beams and the belt from the thermal element structure.

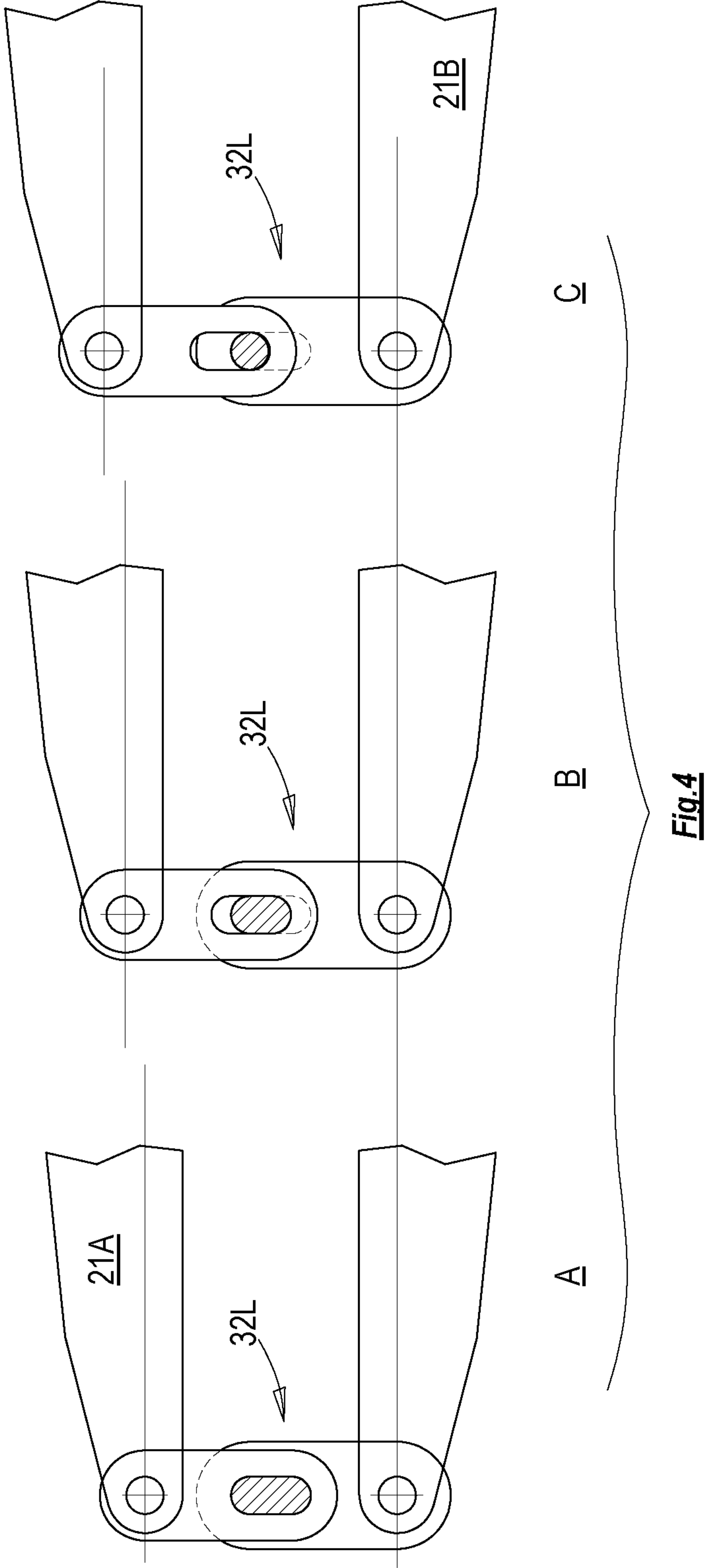
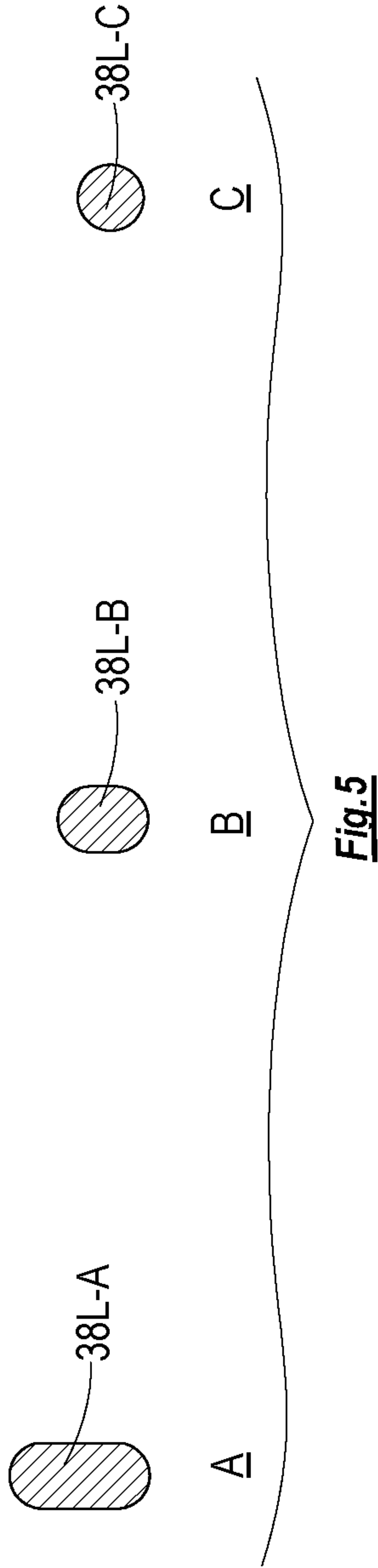
Fig. 1





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Fig.3



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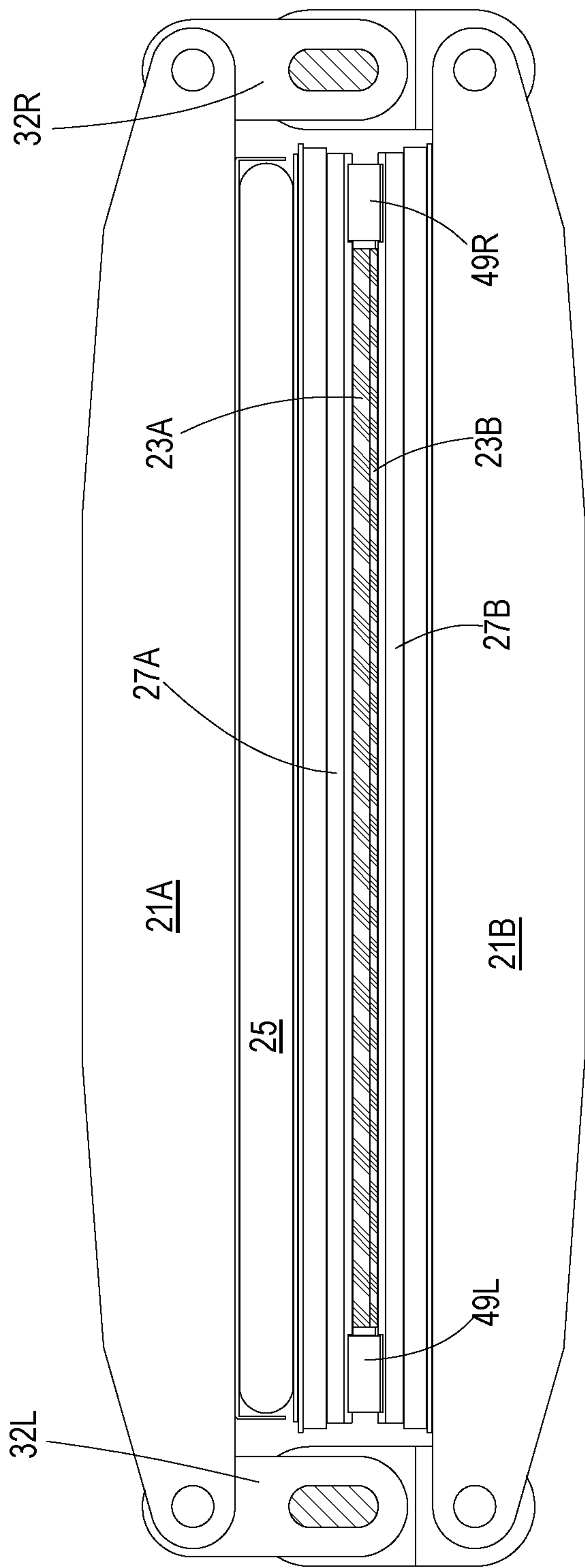
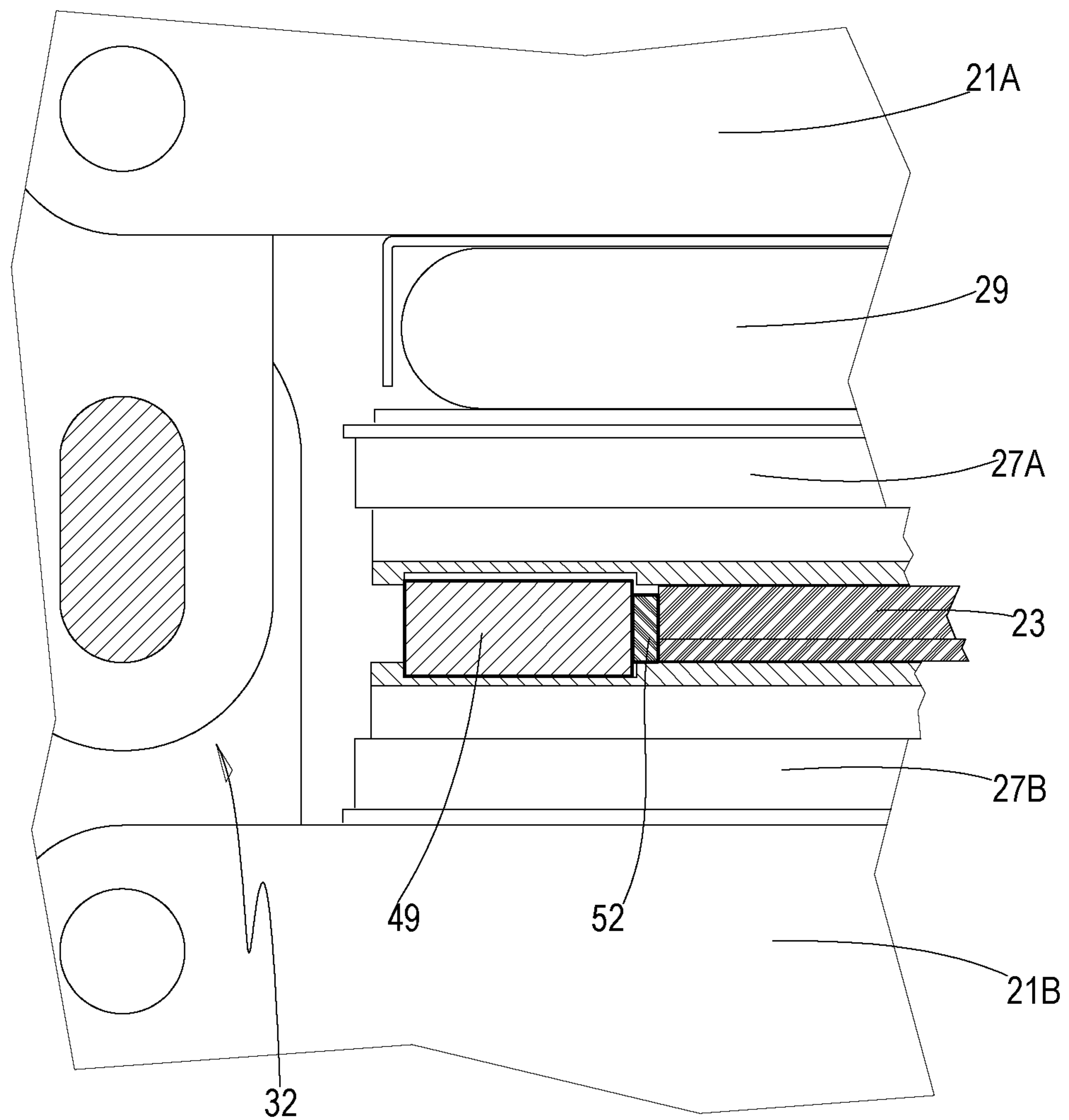


Fig.6

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Fig.7



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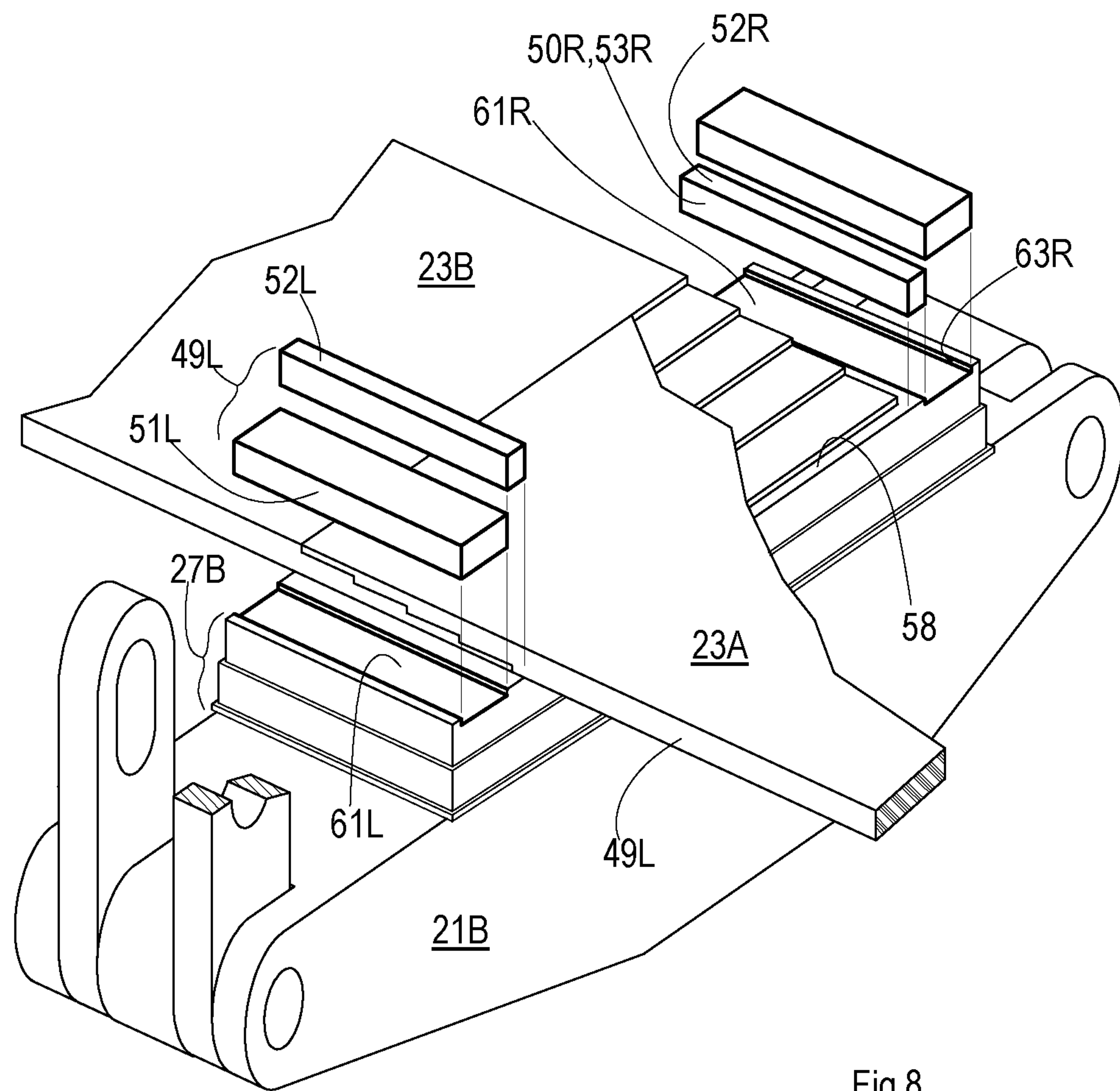


Fig.8

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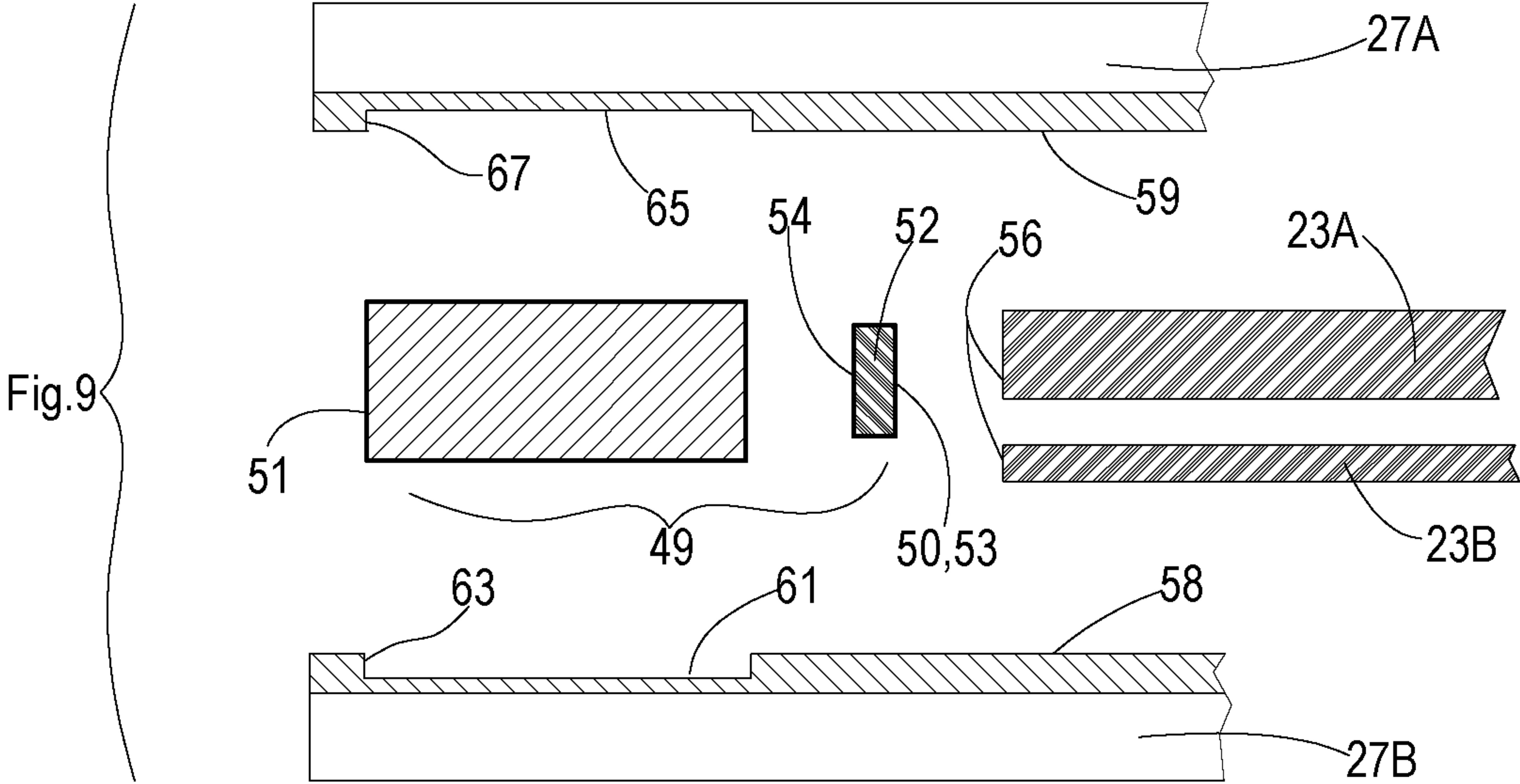


Fig.10

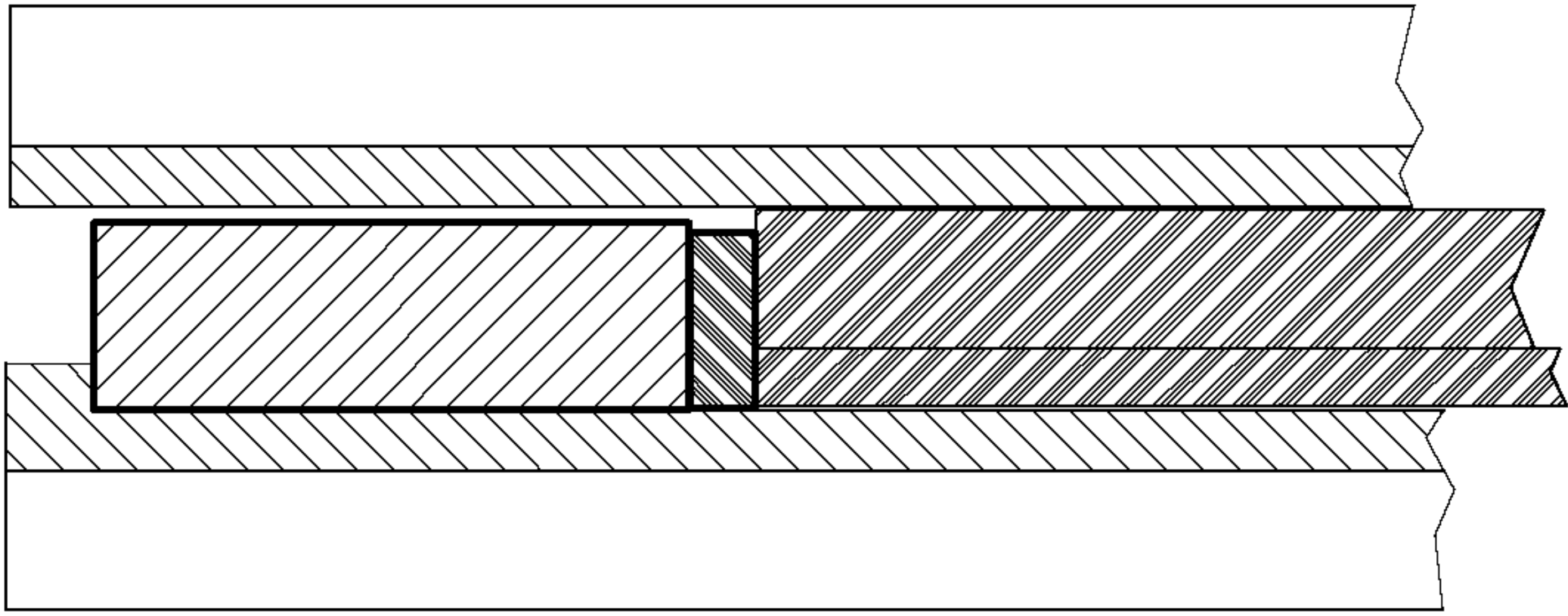


Fig.11A

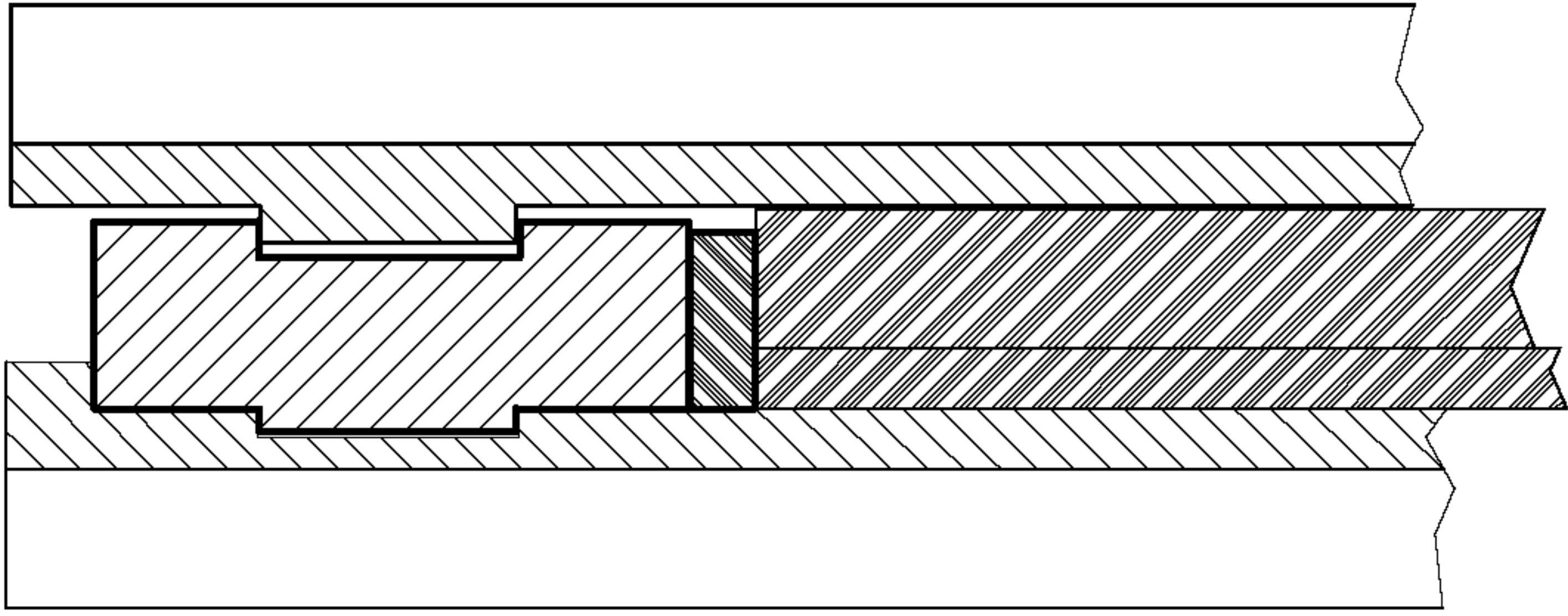
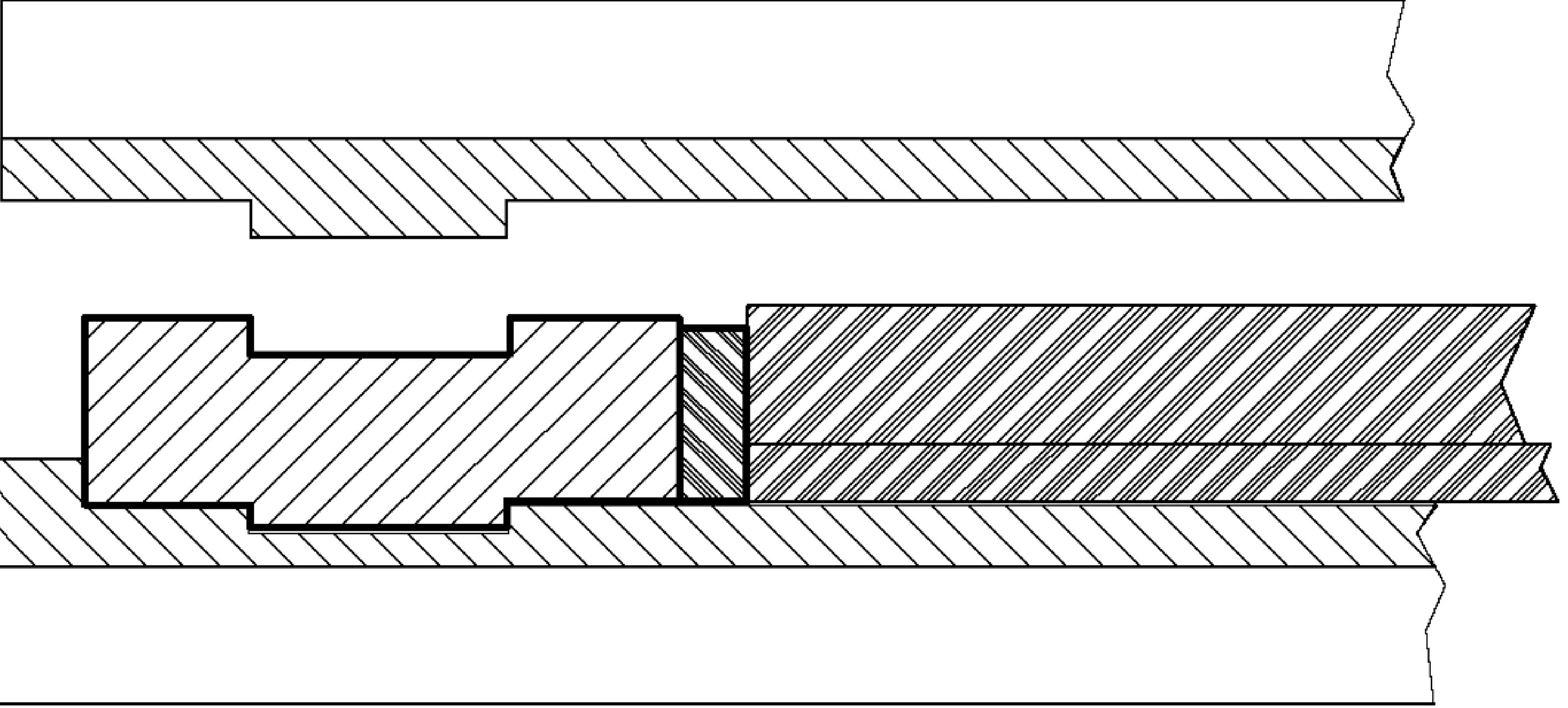


Fig.11B



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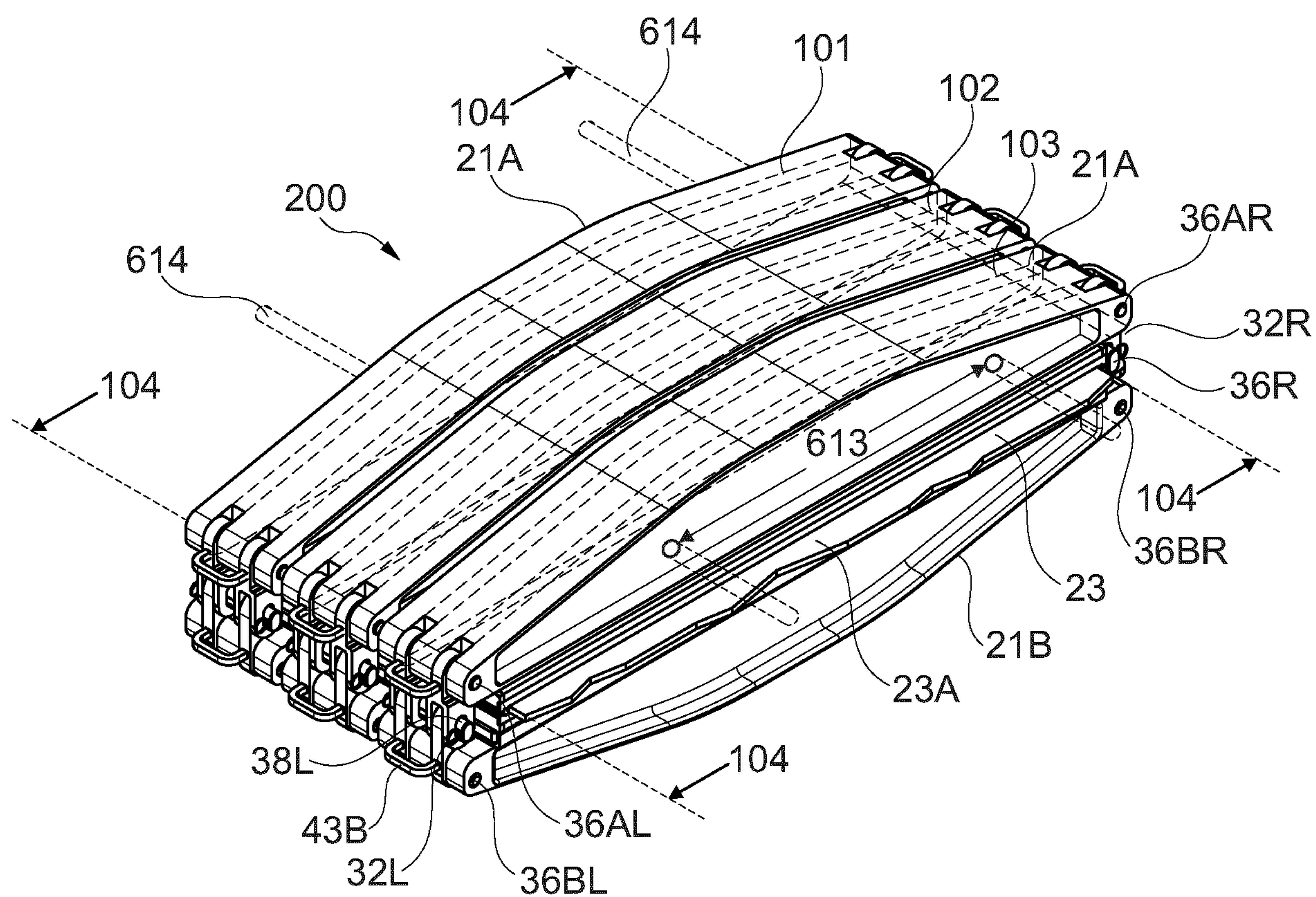


Fig. 12

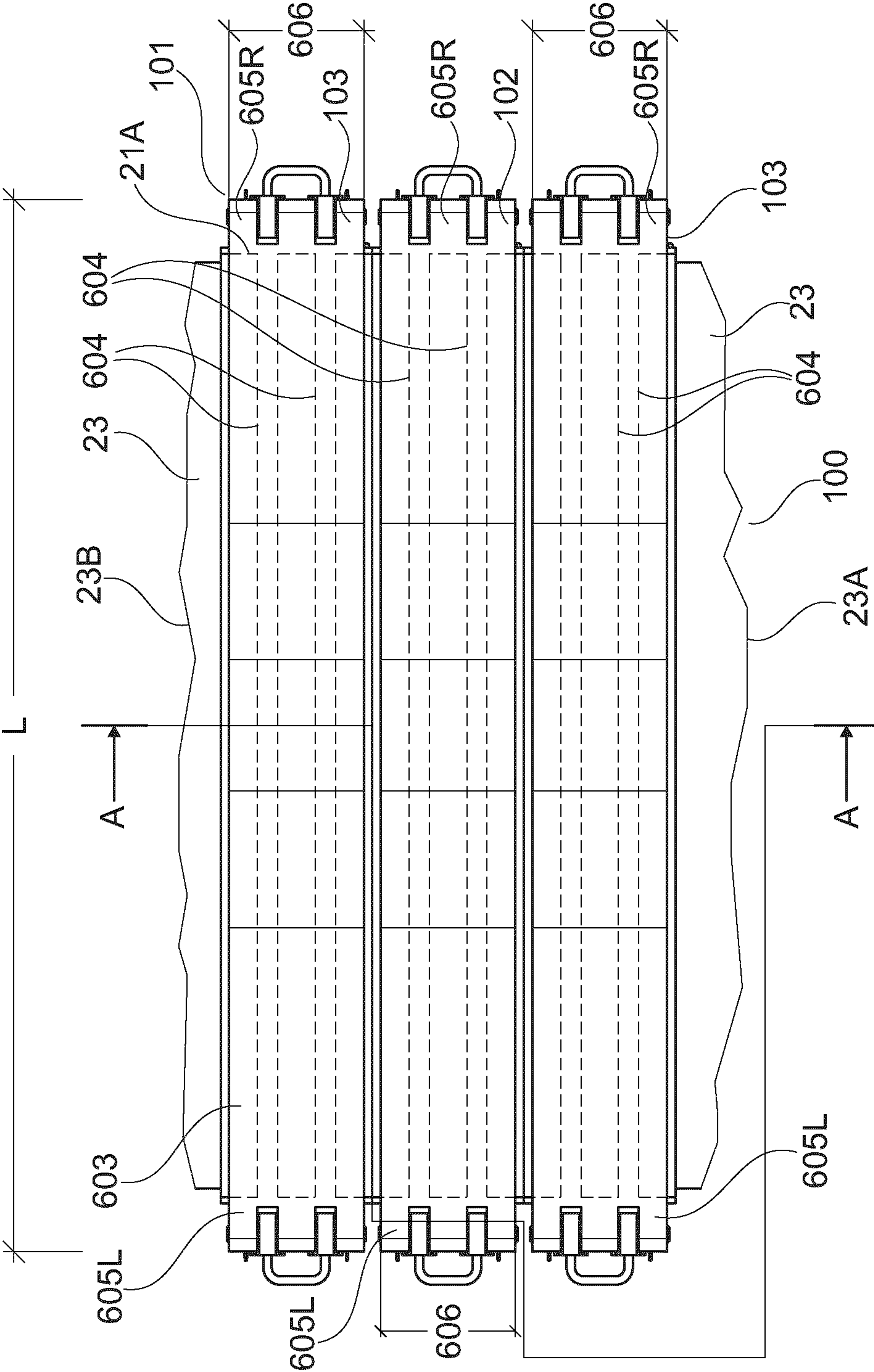


Fig. 13

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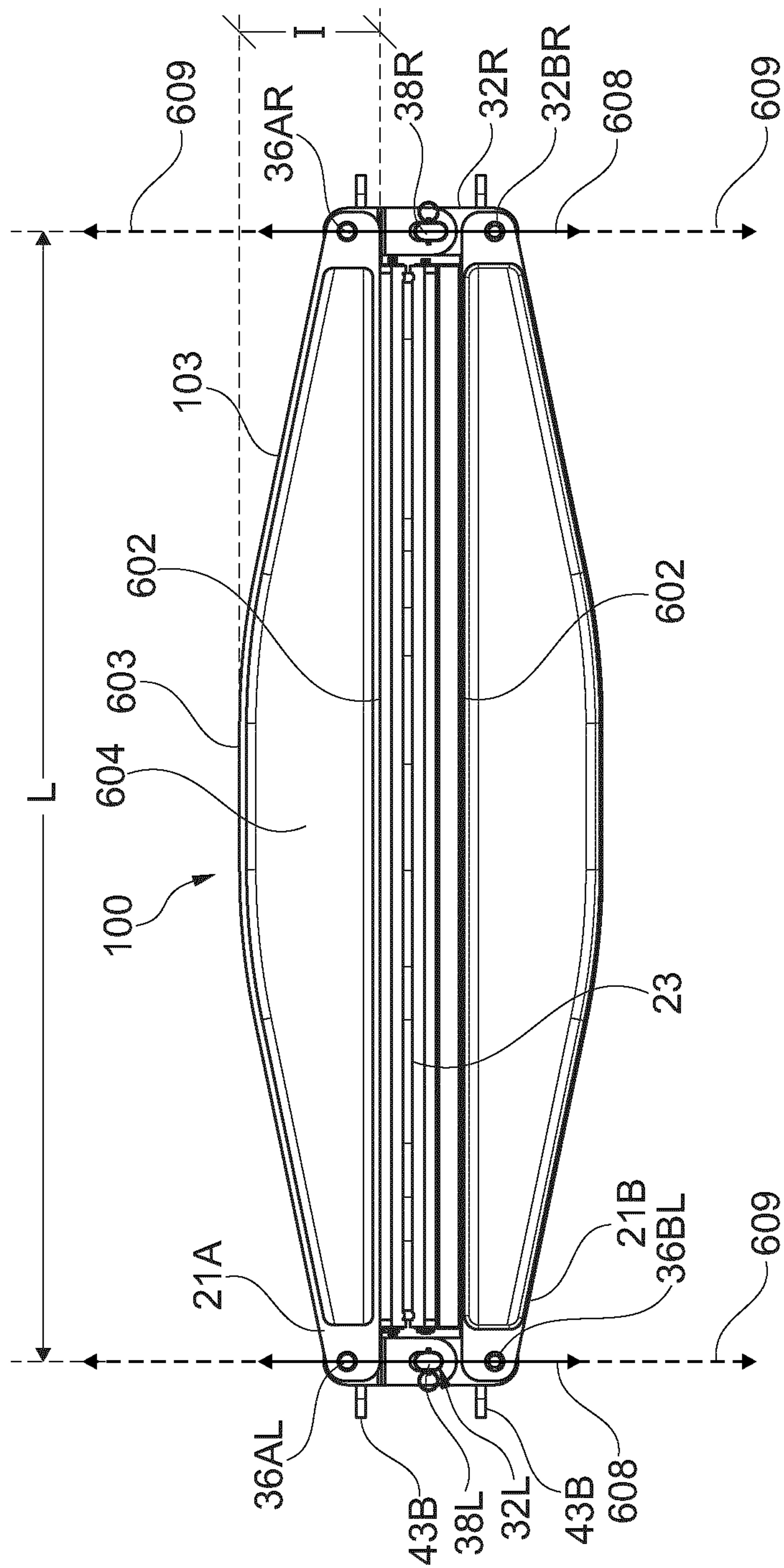
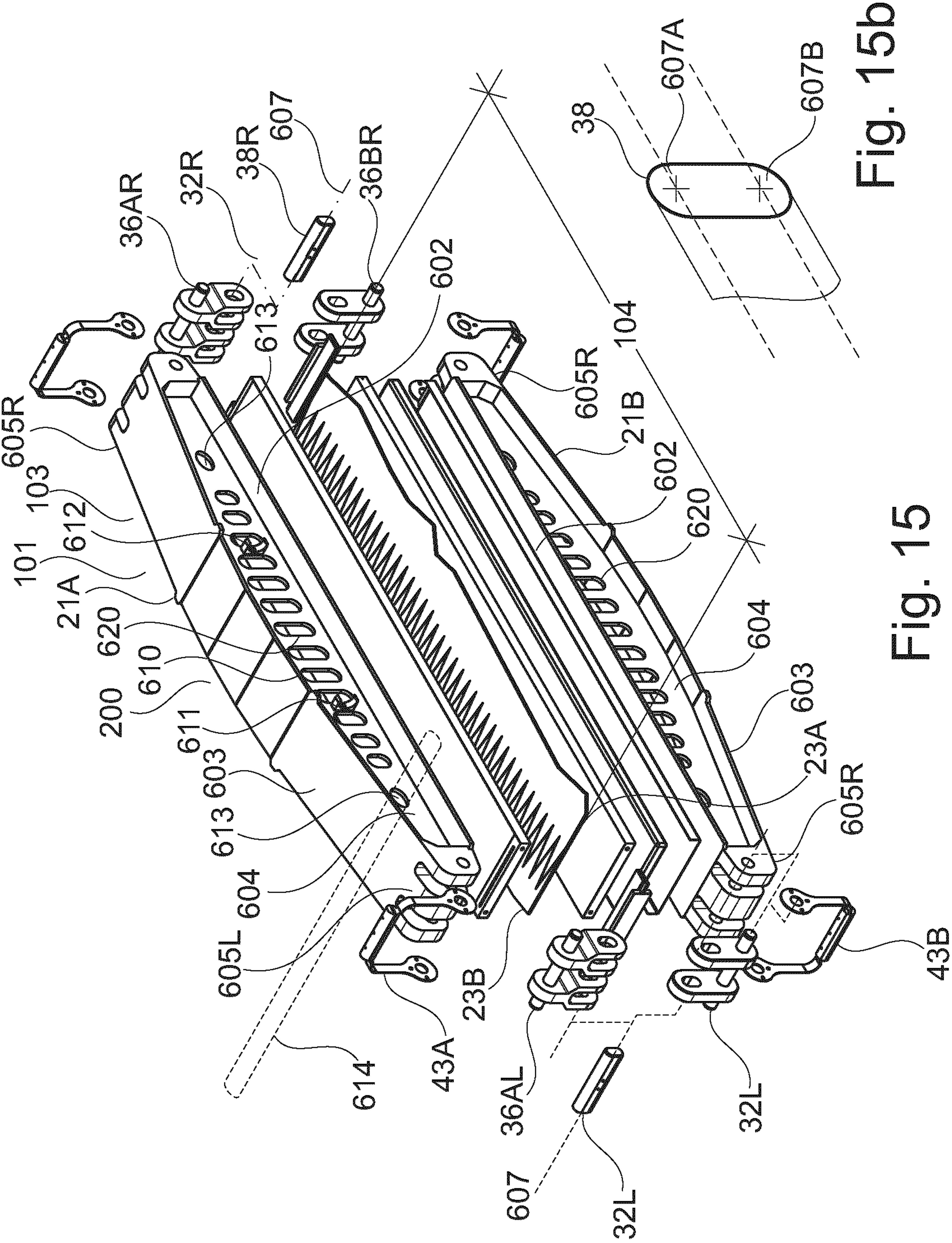


Fig. 14



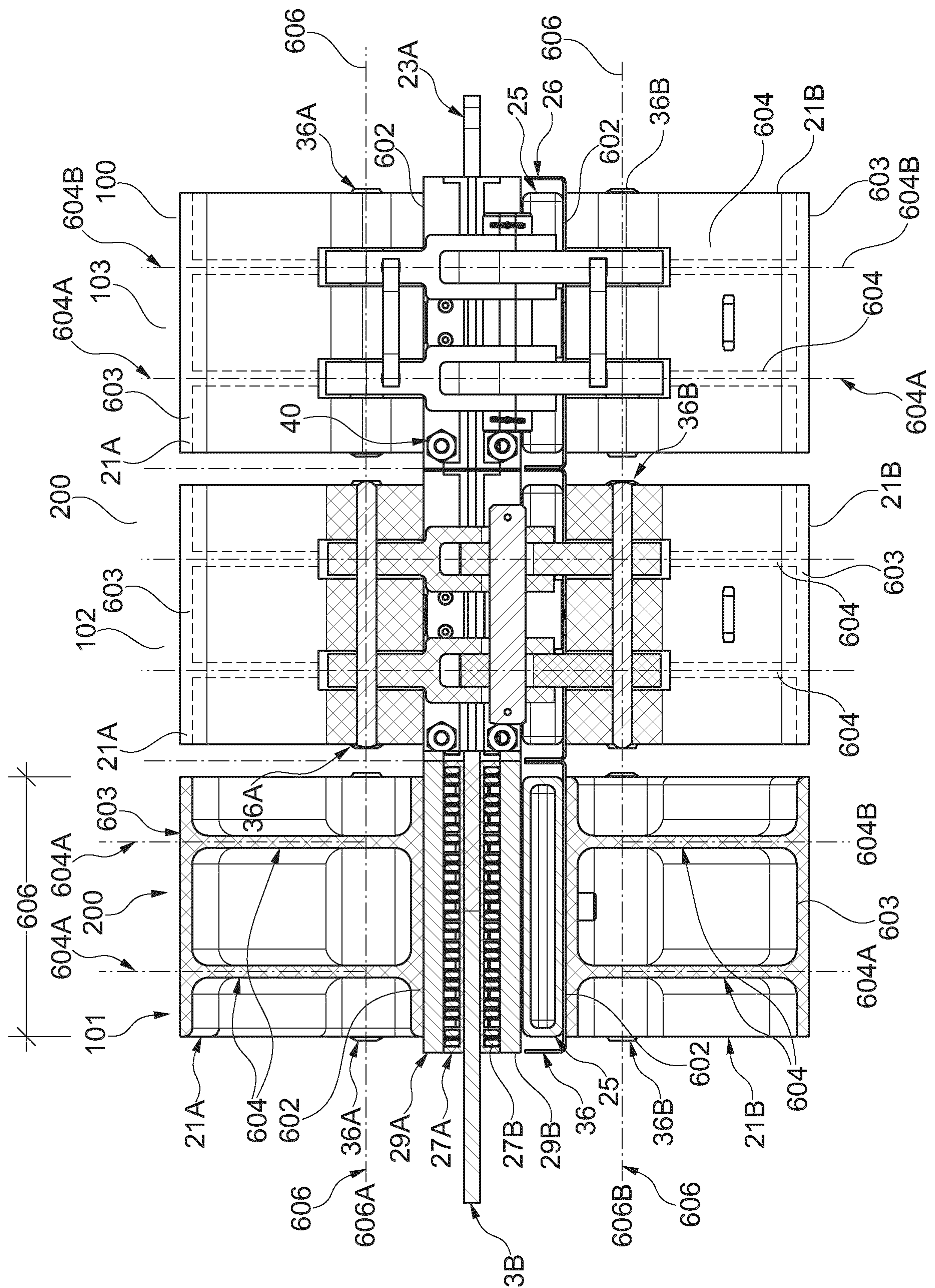


Fig. 16

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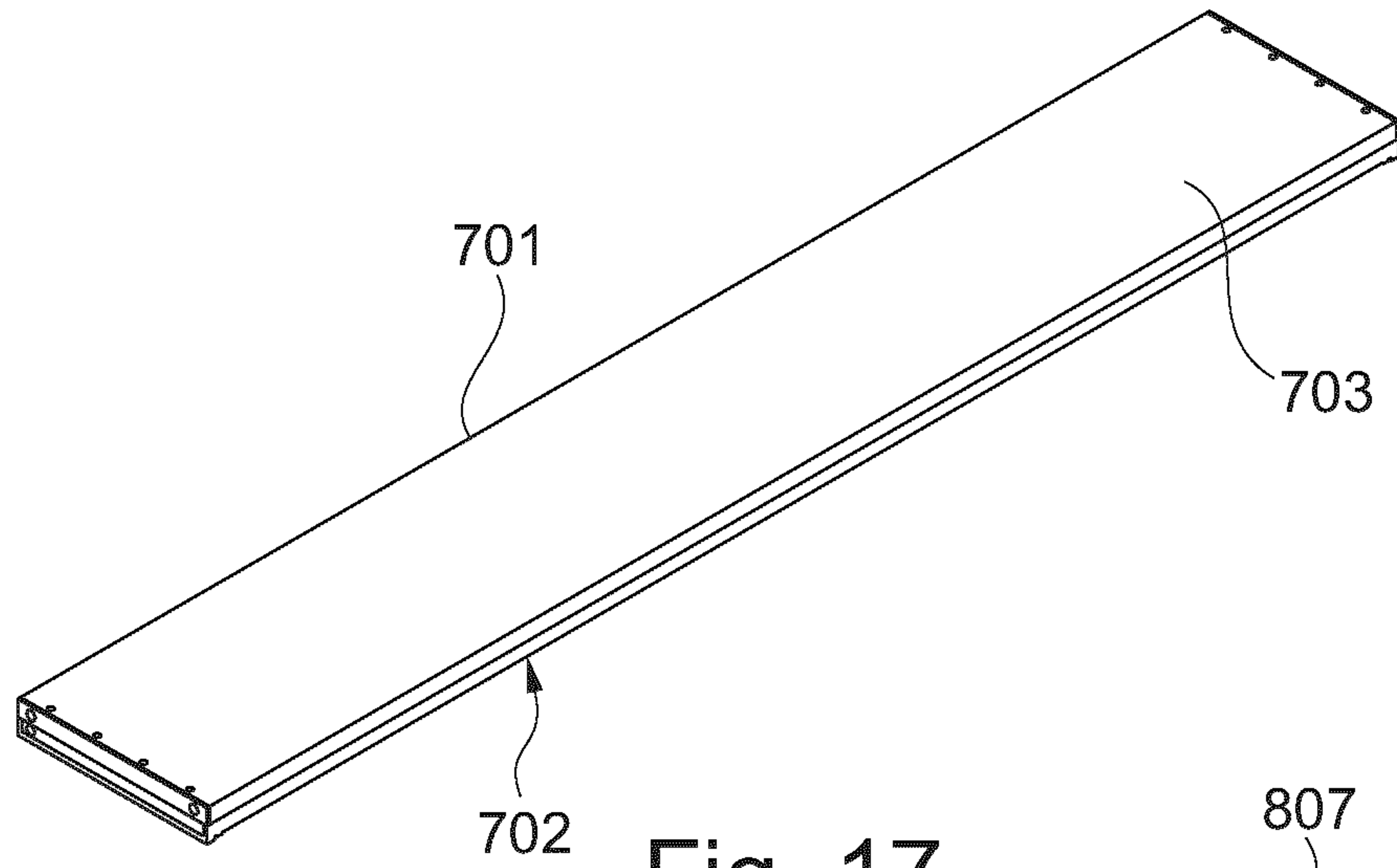


Fig. 17

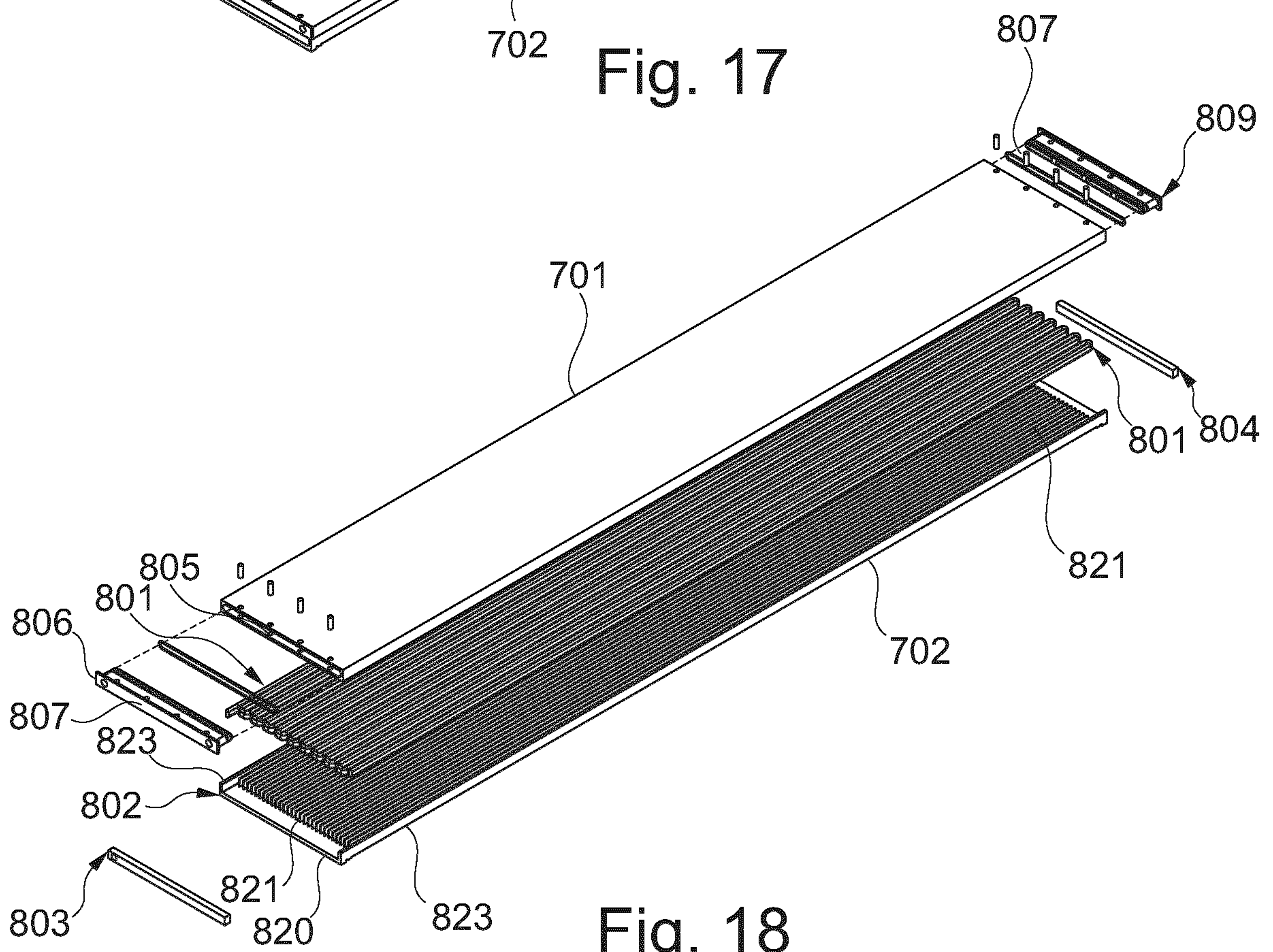
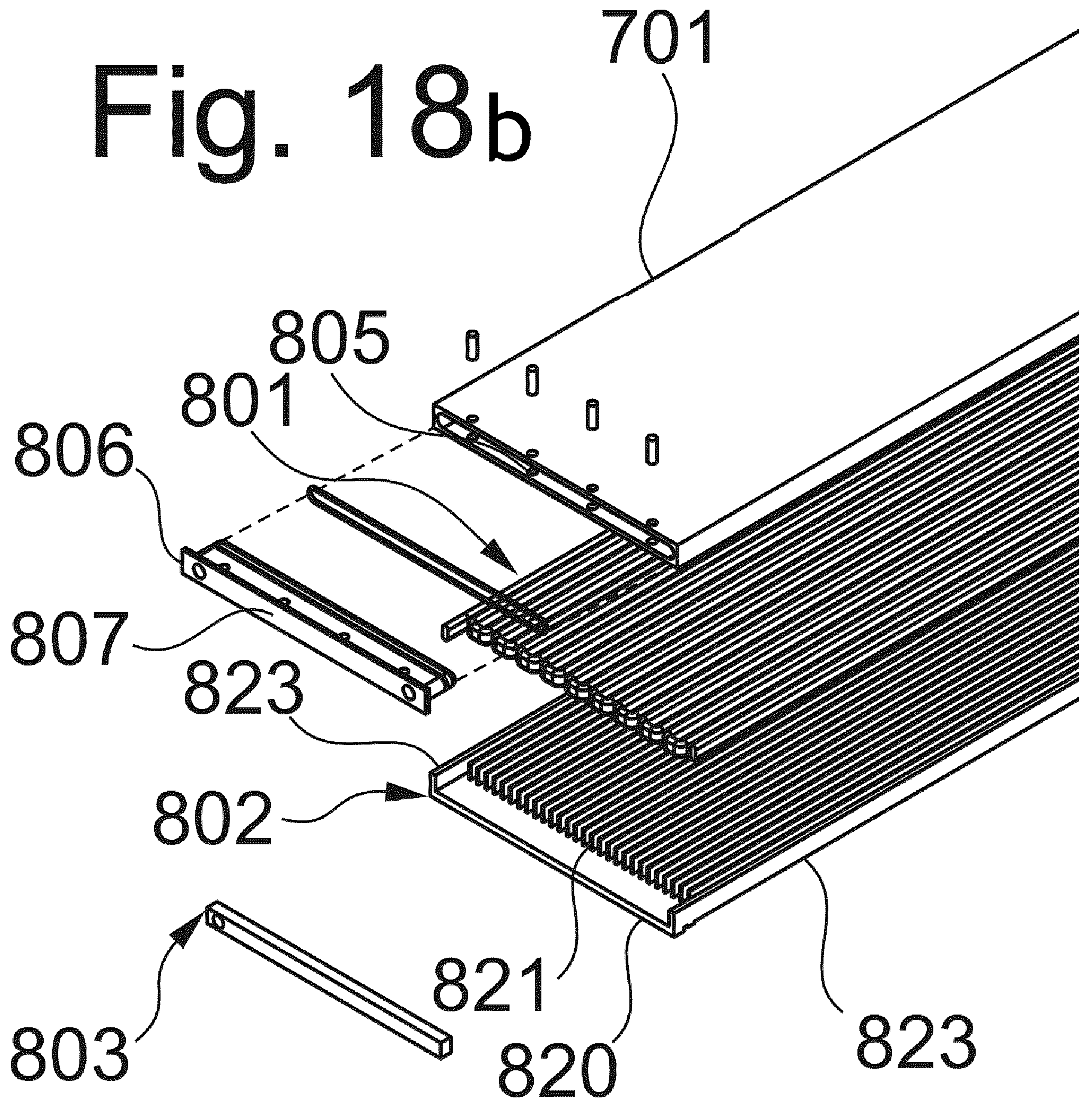


Fig. 18

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Fig. 18b



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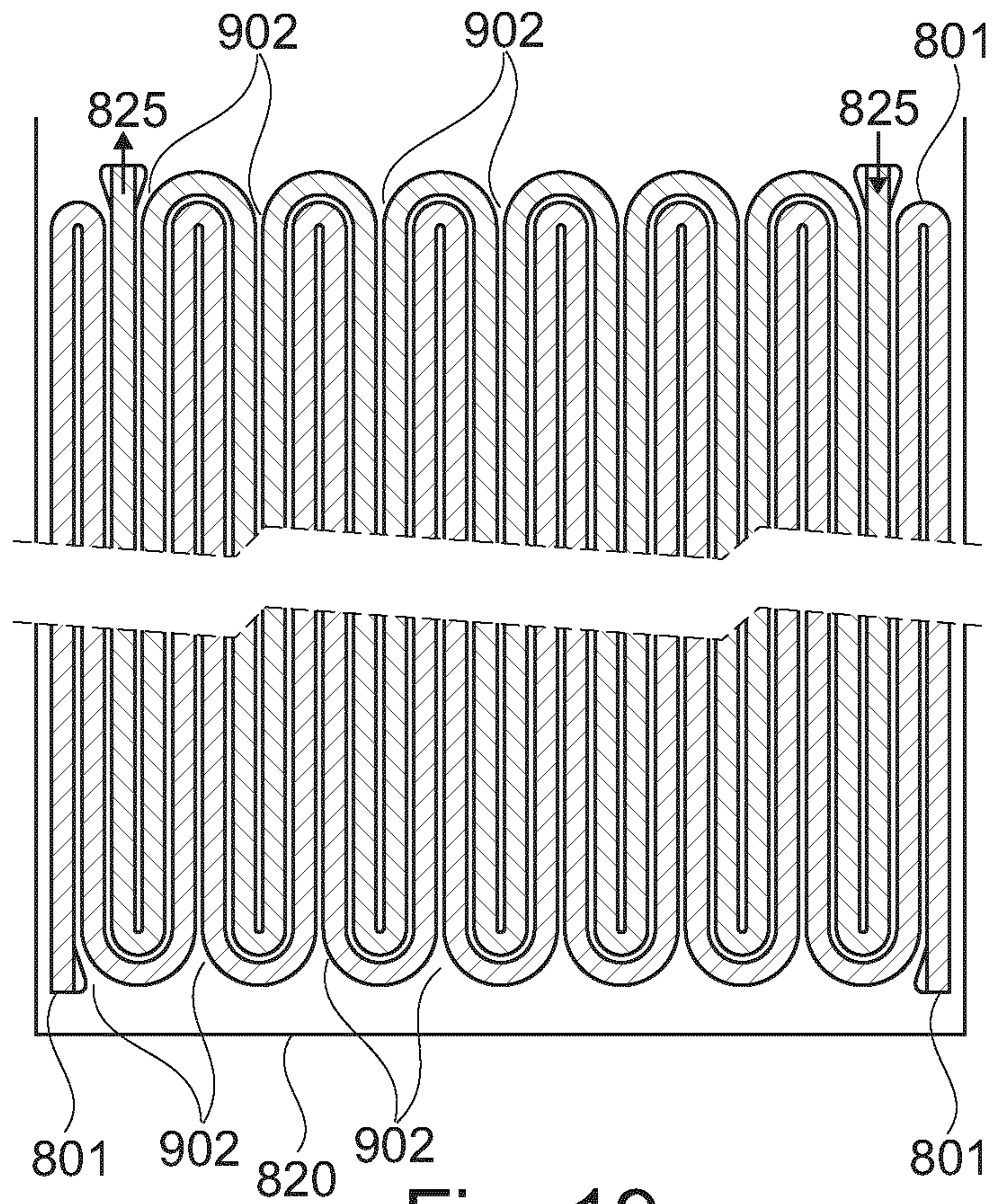


Fig. 19

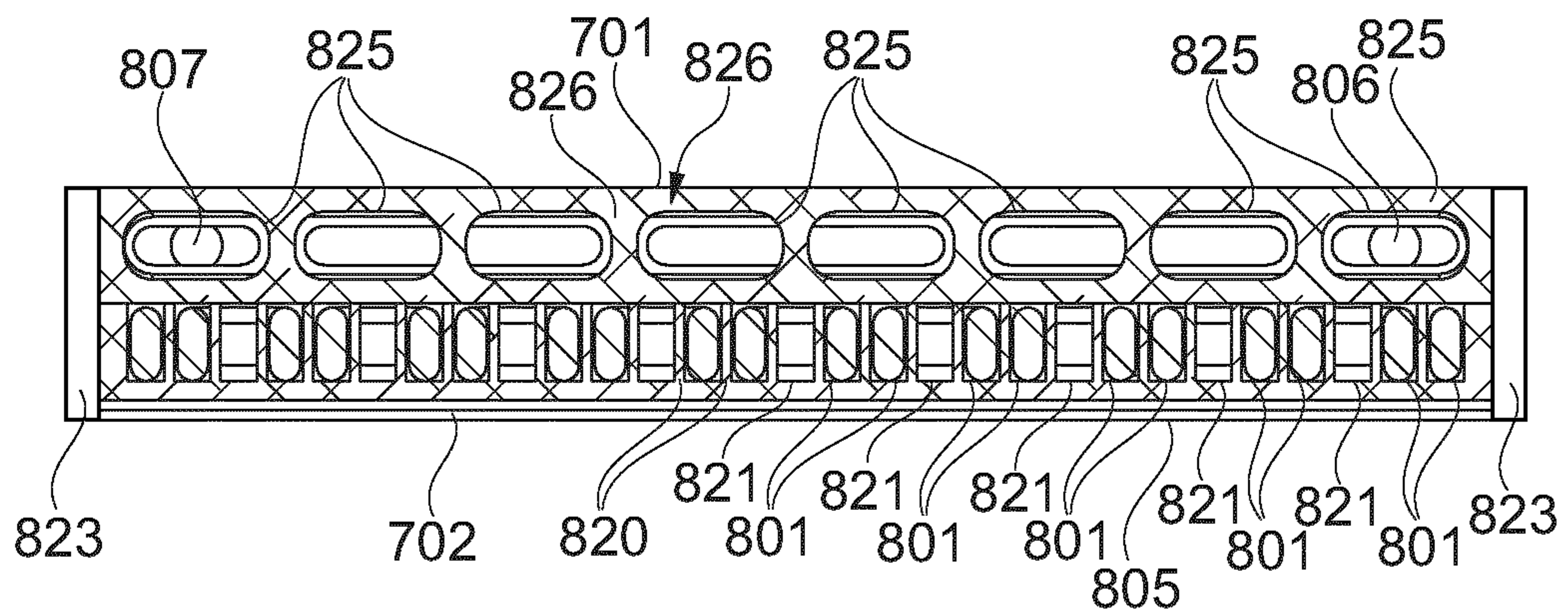


Fig. 20b

Fig. 20a

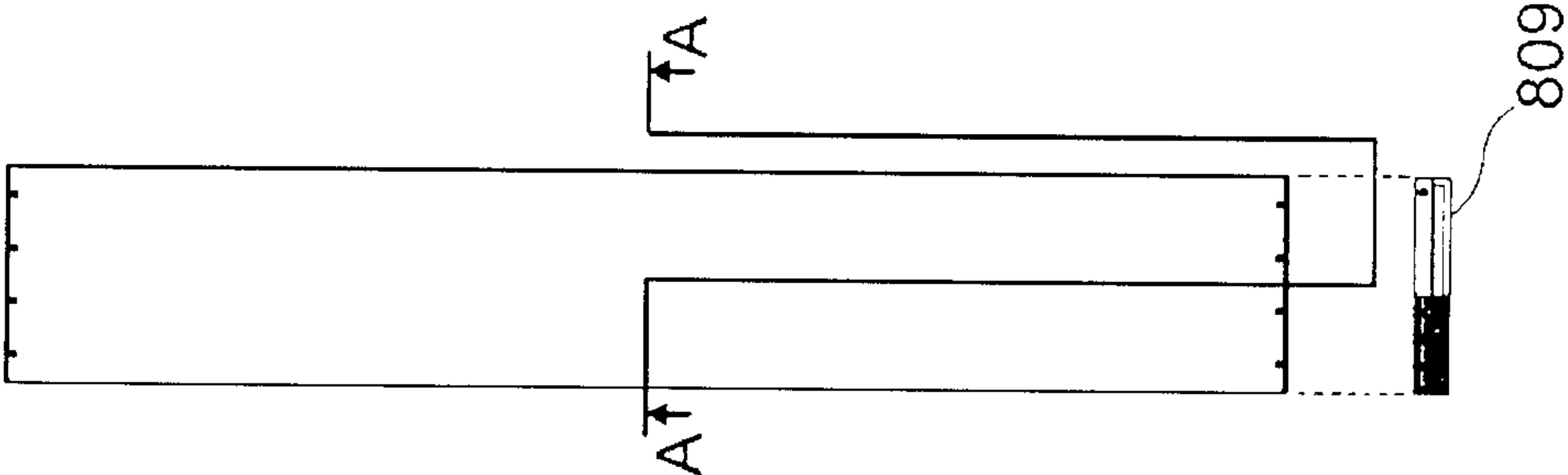


Fig. 20c

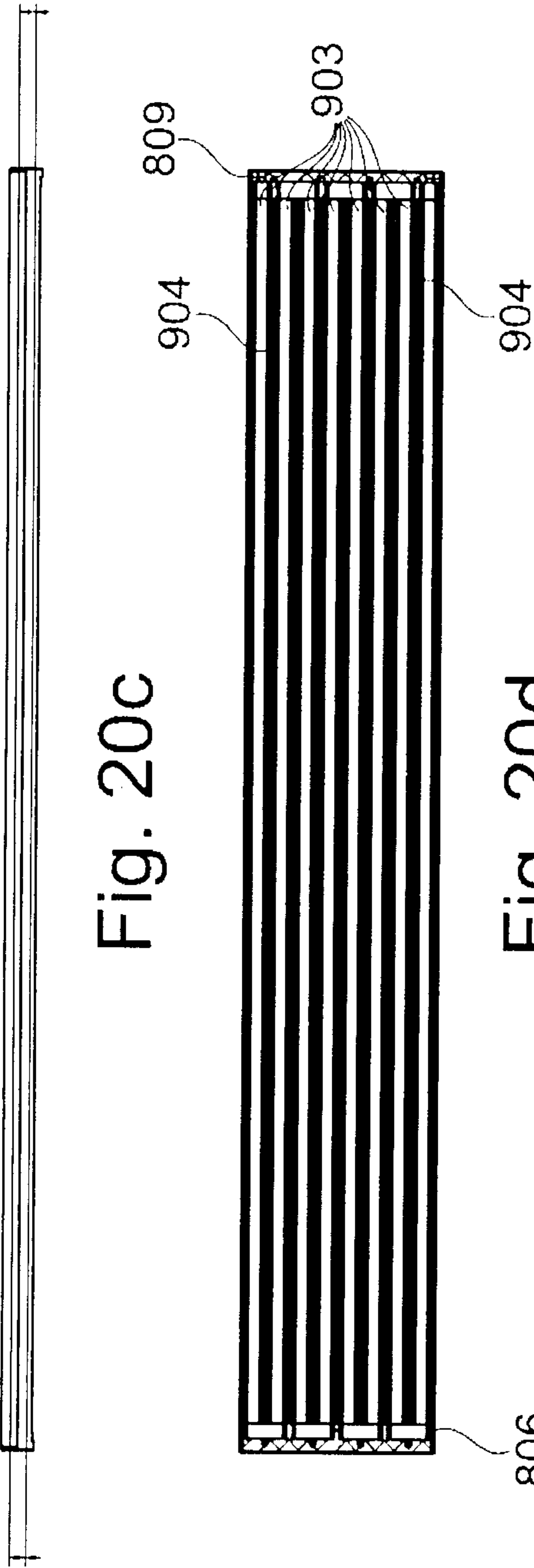


Fig. 20d

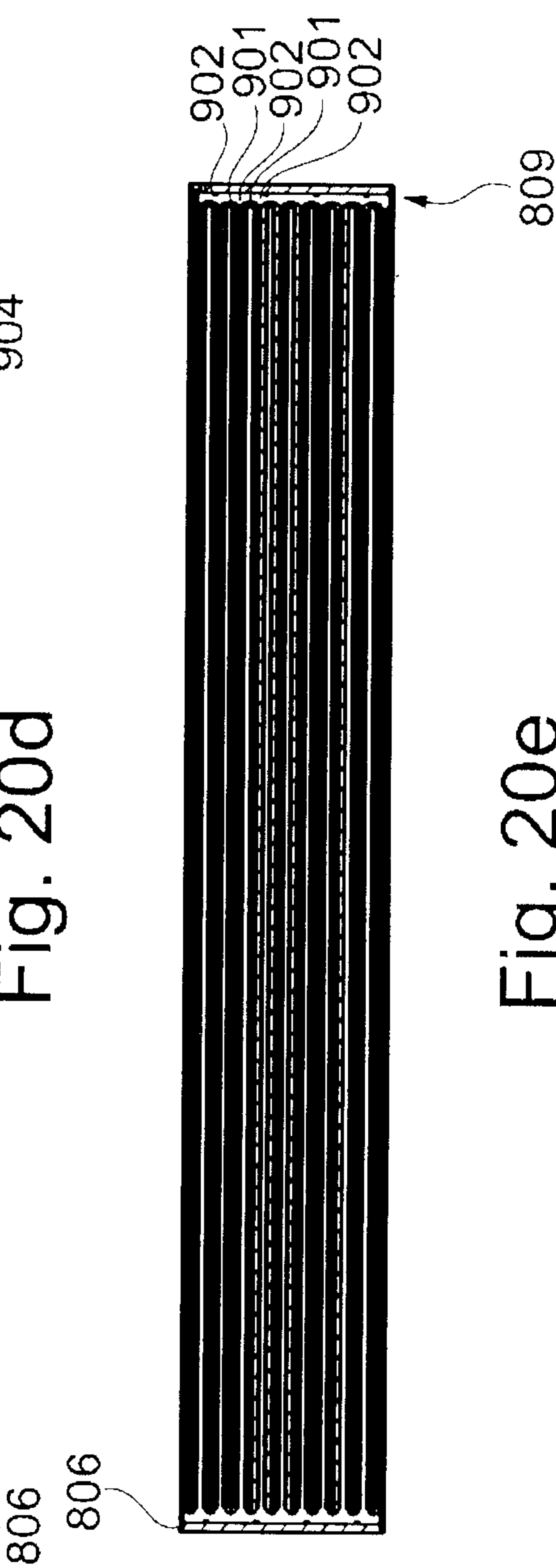
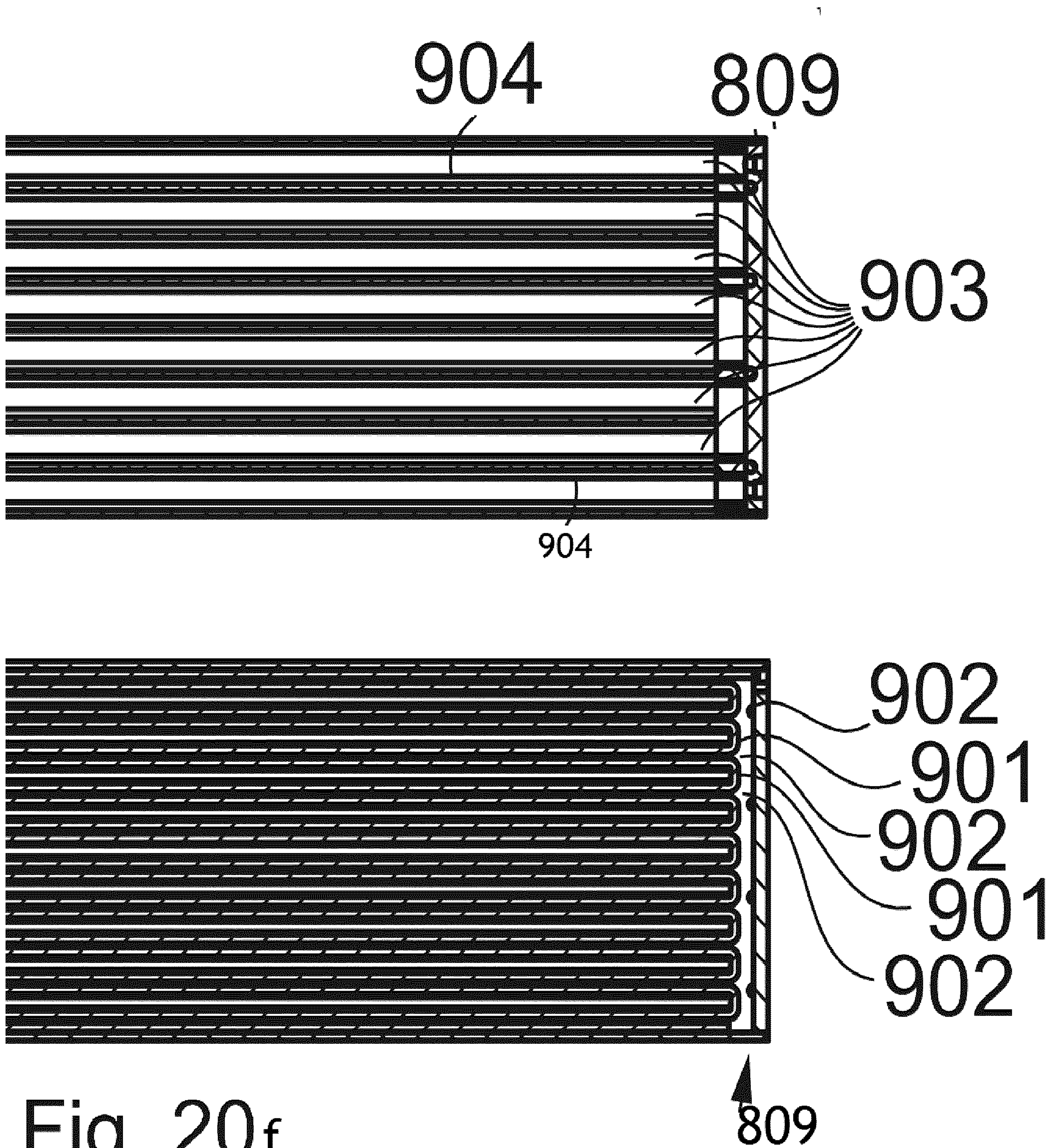


Fig. 20e



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Fig. 20_f

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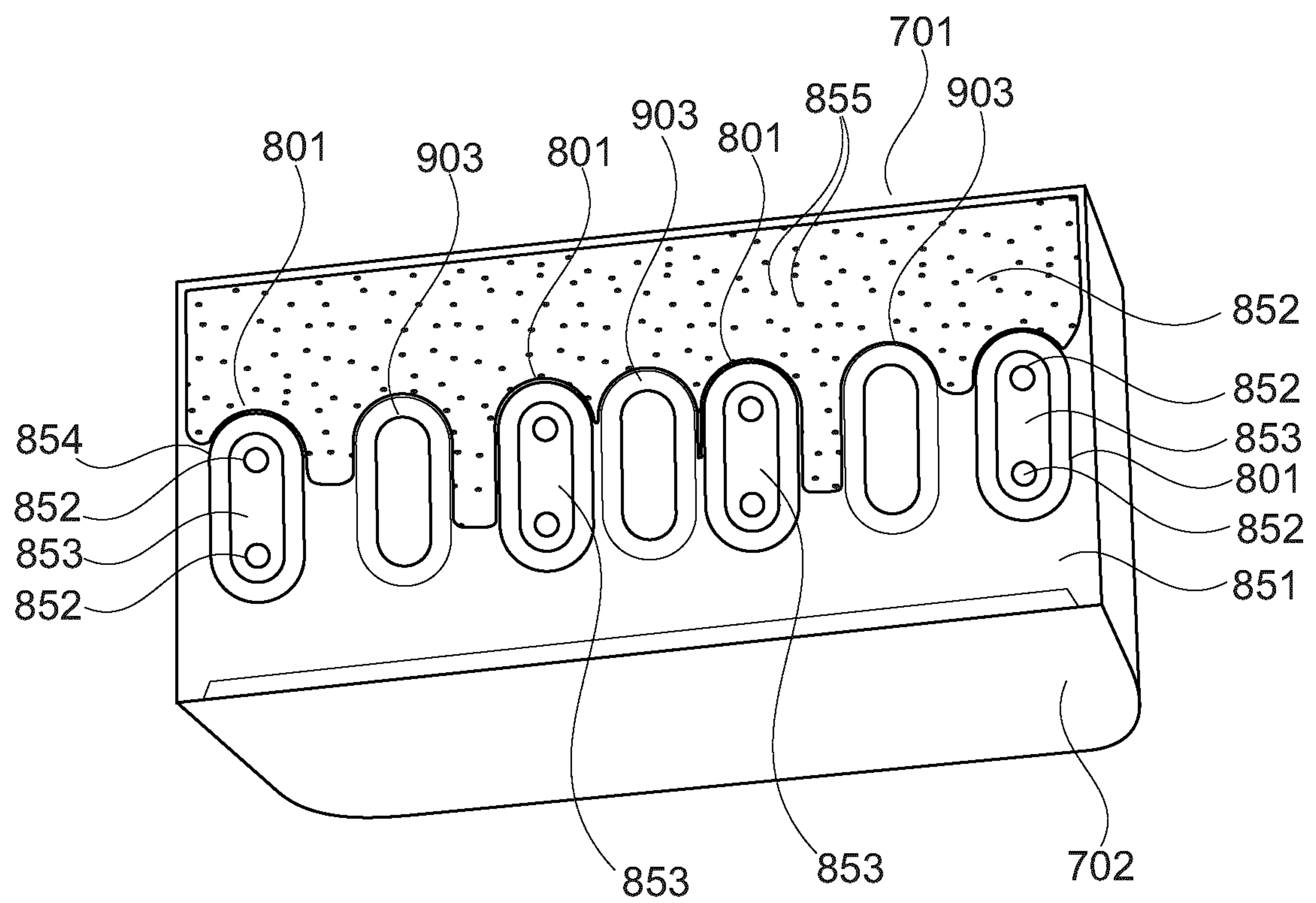


Fig. 21

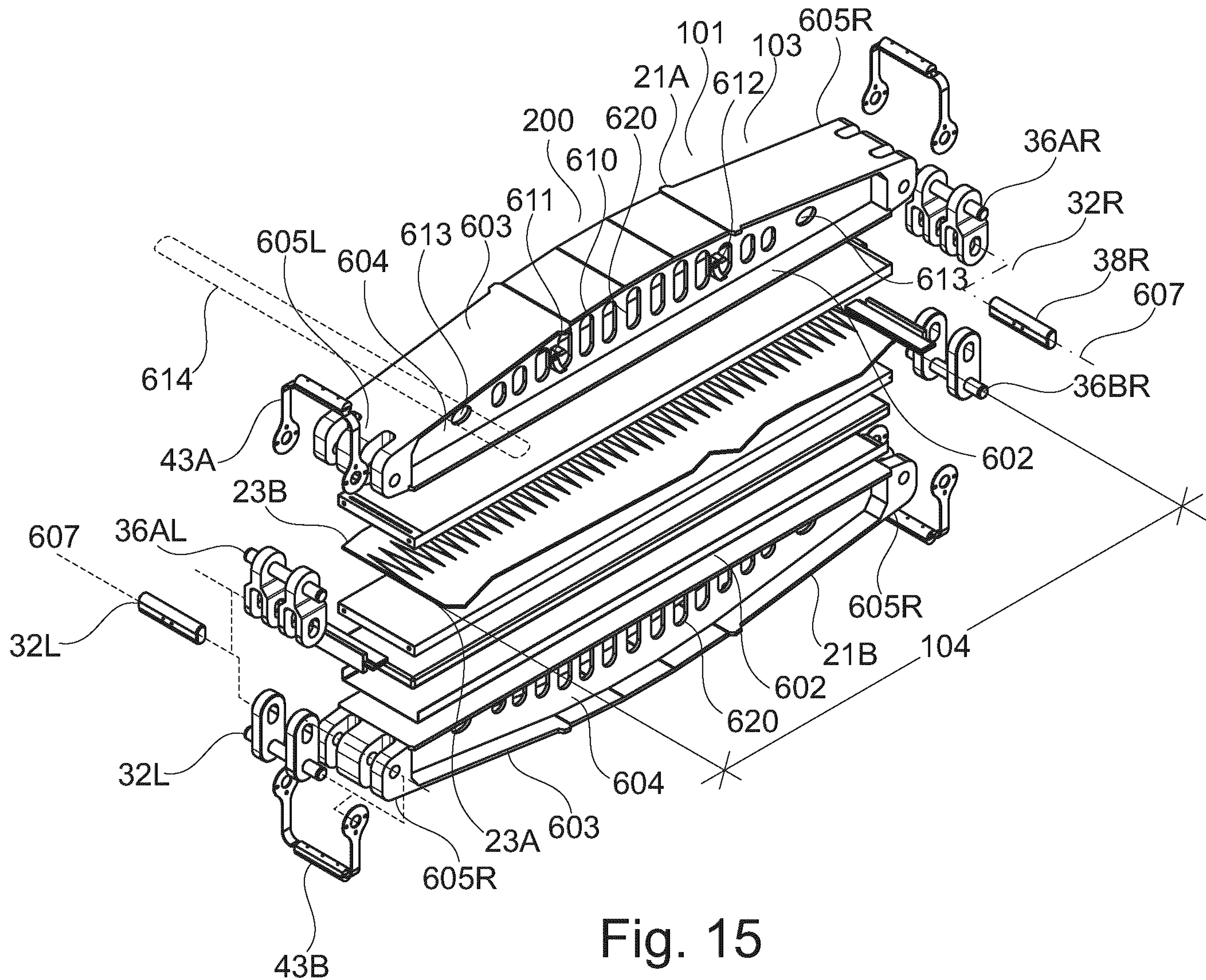


Fig. 15