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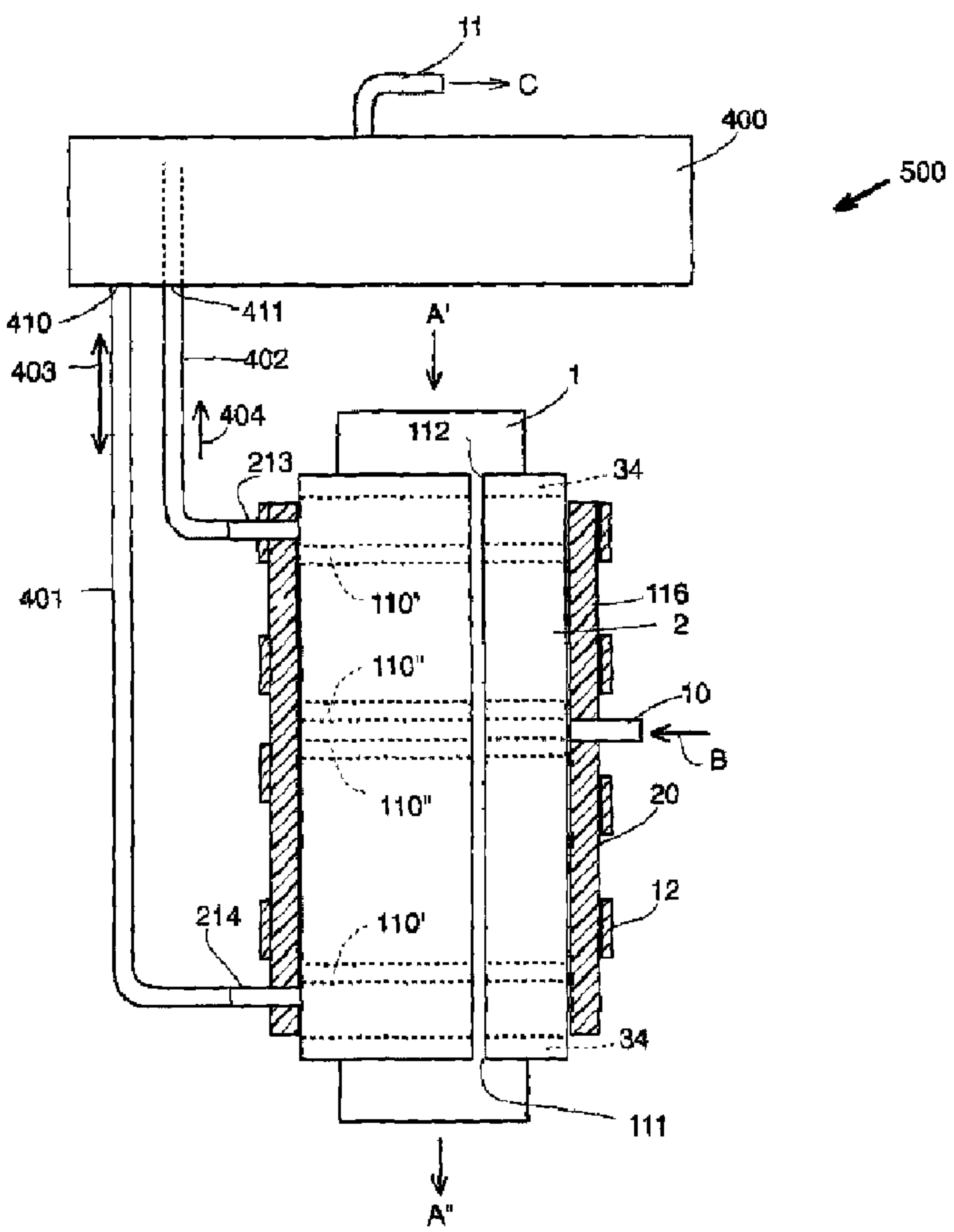

(57) Abrégé/Abstract:
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ABSTRACT

The present invention is a jacket-type drainpipe heat exchanger to heat fresh cold water using the waste heat in the drainwater. Various clamp-on vertical and horizontal embodiments are disclosed including a one- two- half jacket design for installation on operating drainpipes. A further embodiment has protected heat storage. Normal cold water pressure is used to create a high force thermal contact for fast heat transfer. In the vertical embodiments a longitudinal gap in the jacket (or a two-piece jacket) enables clamping movement from an external sleeve and band clamps. Protected heat storage is provided by thermosiphoning with a raised reservoir. A horizontal embodiment discloses a two-piece plastic-copper design. Pre-heated cold water from the exchanger is plumbed to a faucet or water heater so as to reduce energy use and related greenhouse gas emissions. Double-wall construction and venting for visible leak detection satisfies plumbing code requirements. Use on vehicular or other combustion engine exhaust pipes is also contemplated for providing instant interior heat and/ or motor warm-up and/or for other heating requirements.

SPECIFICATIONS

FIELD OF THE INVENTION

Patent applications 2,559,296; 2,611,709; 2,583,161 by the present inventor are also drainpipe heat exchangers.

The present invention is a drainpipe heat exchanger for drainwater heat recovery (DHR) from a building's regular drainpipe plumbing system. It includes a cold-drainwater-protected heat storage reservoir. Also disclosed is a one- and two-piece heat exchanger design that can be installed over existing drainpipes while they remain in full operation. The heat storage reservoir uses the thermosiphon principle and makes DHR available from both continuous plumbing fixture/appliance drain flows, such as a shower or running sink, and batch drain flows, such as from a dishwasher or filled sink. Thermosiphon is a well-known method of passive heat exchange based on natural convection. (See, for example, thermosiphon at Wikipedia.com.)

BACKGROUND OF THE INVENTION

The traditional drainwater heat recovery (DHR) heat exchanger comprises a large diameter central copper tube (as used for drainpipes) wrapped with a small diameter cold water tube also of copper. It is based on the long-known Falling Film principle of heat transfer. In Falling Film heat exchangers, a liquid is ideally made to overflow into the top of a straight, large bore, vertical tube. The flow is meant to be circumferential, flowing down in an even, falling film clinging to the entire inner vertical tube wall, from top to bottom. (More information on falling film heat exchangers can be found at: The Chemical Educator, Vol. 6, No. 1, published on Web 12/15/2000, 10.1007/s00897000445a, © 2001 Springer-Verlag New York, Inc., and, US patent # 4,619,311 to Vasile which discloses a equal flow Falling Film DHR heat exchanger.) The falling film DHR is, in many ways, ideal because it is not blocked by large solids and other matter contained in a building's drainwater. In operation, cold, ground water feeding a water heater first passes through the outer coil of tubing on its way to the heater while drainwater is 'falling' down the inside tube and transferring its heat to the cold water in the outer coil. Thus showering and sink rinsing are the principal appliances/ fixtures where such heat exchangers can work because only then is cold water flowing into the hot water heater exactly while the drain is flowing with the now-dirty used hot water.

However the traditional DHR design is not very cost effective because their payback time or return on investment (ROI) is too long in comparison to other energy saving strategies.

This can be attributed to:

1. Too little use of the expensive heat transfer material, which is usually copper, is actually used for heat transfer. For example thermal contact is limited to a narrow spiral contact strip between the outer coil's (conduit) contact surface with the inner tube's wall. Because heat transfer is a direct function of surface area, this limitation reduces performance which negatively affects ROI. This limitation is so greatly increased when it is laid horizontally which is often necessary (i.e., buildings without basements), that horizontal use is not recommended. Also, in regards the outer coil, the greatest part of the of its total surface area is not used for heat transfer. Only that small inner portion of the circumference actually contacts the drainpipe wall, the remaining, larger, outer portion of the circumference does not do heat transfer at all.

In the instant invention, instead of a coiled tube conduit, sheet copper is used and is formed into a hollow jacket that serves as the cold water 'tube' or conduit. This dramatically lowers cost, while increasing thermal contact area to nearly 100%. For example, a 5 foot long, 4 inch diameter drainpipe, requires only ⅔ the weight of copper for the cold water exchanger; plus sheet-form copper is less expensive by weight than tube-form copper, and, a much higher percentage of that copper is used for heat transfer. Further, the instant invention allows for very compact, small diameter DHR (i.e., for a 1¼ inch diameter sink drainpipe) for individual fixtures and appliances which is not practical with wrapped tube designs due to the bend radius limitation of suitably sized outer tubing. Thus with the instant invention, DHR has offers a shorter ROI allowing for wider use in all size buildings.

2. Lack of heat storage. The traditional DHR only works when both the drainwater and the cold water are flowing simultaneously, such as in showering or running sinks. This referred to as 'continuous' hot water use. It cannot recover heat from 'batch' hot water use such as from appliances/fixtures including wash machines and filled sinks and tubs, since there is nowhere for any meaningful amount of recovered heat to be stored. As a result, only about 40% of the total used hot drainwater (continuous use) is available for DHR with traditional non-storage DHR. And what little heat is stored in the outer coil is lost immediately to any cold drainwater which may flow at any time.

The instant design uses a separate reservoir to receive and store heat from 100% of a building's drainwater no matter if it is from a continuous- or batch use source. This remote heat storage reservoir is mounted above the DHR so as to thermosiphon with the cold water jacket or conduit when hotter drainwater is flowing creating a thermal differential with the reservoir water. No moving parts or controls are required. Further, thermosiphoning provides automatic protection from heat loss to colder drainwater because thermosiphoning stops when the temperature differential is reversed. This further reduces the ROI.

3. The long length of the coil tube (up to 100 feet long) and the fact that it flattens somewhat as it is wound creates internal resistance to flow and an unwanted drop in water pressure for the heater. This then requires either larger, more expensive tubing and/or a manifold arrangement of two or more coils to have multiple, parallel flow, tube coils which again adds cost and negatively affects the ROI.

In the instant invention, the jacket offers a direct flow path from inlet to outlet and the passage can be as small or as large as needed. This eliminates pressure drop and reduces manufacturing cost.

SUMMARY OF THE INVENTION

In a building, a first heat transfer fluid, referred to herein as drainwater, flows through a drainpipe. In the instant drainpipe heat exchanger invention, sheet copper is formed into a chamber or conduit. In one embodiment his chamber or conduit is in the form of a jacket with a longitudinal gap, to encircle a round, vertical drainpipe in the shape of a letter "C" in outline. In a second embodiment it is in the shape of a 'bar' or beam or trough that fits below the flattened, 'D' shaped, bottom portion of a horizontal drainpipe. In both, the spaced inner and outer walls are sealed at the ends and there are inlet and outlet fittings for connection to a second heat transfer fluid which may be under pressure such as the cold water supply for a water heater. The inner wall contacts the drainpipe and matches its shape so as to maximize the area of thermal contact. In the jacket, a longitudinal gap or slit is provided where the inner and outer walls U-bend back on themselves to create the chamber. This gap allows contraction of the heat exchanger's inner wall to clamp tightly onto a circular drain tube. The exterior wall has a stiff outer sleeve around which are several band clamps. The outer still sleeve provides clamping force distribution and heat insulation. The gap allows for intimate contact and easy sliding assembly onto the drainpipe. When connected to the pressurized water supply, the pressure adds to the thermal contact force much like a blood pressure measuring cuff, to further increase the all important rate-of-heat-transfer.

In one application the jacket is slid over and clamped onto the exterior of an existing drainpipe. In another, it is pre-assembled with a drainpipe forming a complete DHR heat exchanger which then replaces a section of existing drainpipe.

In a third embodiment, the instant invention is fabricated in two long half-cylindrical jackets (clam-shell like) which are assembled onto a operating drainpipe without disrupting drainwater flow.

A the second flat embodiment, the instant invention is clamped between the flattened drainpipe and a shaped shoe or filler piece to spread the clamping force along the entire length. Again, the clamping plus the internal water pressure provide high performance thermal contact with the drainpipe.

In a fourth embodiment, for flattened, D-shaped drainpipes, the cold water heat exchanger may be in two parts: an upper hemi-cylindrical plastic sealing portion bonded to a lower flat sheet metal heat transfer portion. This would further lower costs to improve the ROI.

In use, a sink or shower may have the heat exchanger lying horizontally beneath it such that cold water is pre-heated before reaching the cold water faucet. In this way, less too-hot water is needed to mix with the now-warm-cold-water to achieve the desired final comfortable temperature. Less hot water use saves energy and money and pollution, and, if electrically heated, lowers peak power demand.

During fabrication, the sheet copper should be slightly creased diagonally on the inner wall to serve as a vent for visible leak detection (a drip or air-drop onto the floor). The sheet is then formed into a hollow structure either a tubular ‘C’ shape or a flat bar shape. The outer wall of the jacket is pierced to receive soldered-on pipe fittings and the ends are sealed with appropriately shaped copper (tubing, rod or twisted wire), soldered into place. Alternatively, the jacket ends may be squeezed-closed and soldered shut.

The unique, high-force hydraulic clamping action maximizes heat transfer by increasing thermal contact force. For example, if the drainpipe is 3 inches in diameter and the jacket 48 inches long and the cold water is at 50 pounds per square inch pressure, the contact force will be approximately: 3.14 (π) x 3 x 48 x 50 = 22,000 pounds, or 11 tons of contact force!

Not only does such an enormous force provide fast heat transfer over the entire length, but it forces intimate, conforming contact between the form-able sheet metal inner wall and drainpipe wall surfaces that may be imperfectly fitted. This would be extremely difficult or impossible to achieve by any mechanical clamping method.

Where the instant invention is to be installed on an existing drainpipe already permanently in place, the jacket may be made in two halves (or hinged) with duplicate inlet and outlet fittings to connect to the cold water supply. The outer plastic sleeve would also be in two halves (or hinged). In some cases only a lower, half-jacket may be appropriate to reduce cost when using it on a large diameter, round, horizontal drainpipe, for example.

In a sixth embodiment a remote reservoir is part of the pressurized cold water system and is located above the instant vertical or horizontal drainpipe heat exchanger. The reservoir is connected with inlet and outlet tubes to the cold water heat exchanger jacket or conduit. The reservoir preferably has a high, horizontal orientation to provide maximum thermosiphon effect. One tube between the reservoir and heat exchanger terminates low in the reservoir and the other tube terminates above the first. Natural temperature gradients (layering or stratification) in the reservoir means that lower layers are always colder and heavier that upper layers. Thus whenever warm drainwater (first heat transfer fluid) heats the cold water (second heat transfer fluid) in the cold water heat exchanger, it will also be made lighter and will therefore automatically be displaced upward into the reservoir by the heavier colder reservoir water sinking downward. This circulation of reservoir water will continue for as long as a temperature difference exists. In that way the reservoir become heated and the cold water heat exchanger is cooled for best heat transfer.

When cold water is required by the water heater (hot water is being used) the cold water under pressure flows first into the center of the cold water heat exchanger, then through the connecting tubes at each end and into the reservoir, and then out of the reservoir into the water heater. The outlet tube therefore can have two way flow depending on whether thermosiphon or pressure flow is occurring. By having these two flow paths any heat received from the flowing hot drainwater by the cold water conduit will either be picked up directly under forced flow (hot water being used) or by thermosiphonic action (no hot water being used). If cold water is flowing as, for example, in the case of replacing the hot water being used in a shower, it will directly be heated by the hot shower drainwater. If no cold water is flowing but hot drainwater is, the heat will automatically transfer by thermosiphonic action into the reservoir. Here, the heat is stored until some future hot water use causes the now-pre-heated cold water from the reservoir to flow into the water heater to reduce energy use.

In a seventh embodiment the same remote reservoir concept is applied to a horizontal drainpipe heat exchanger. here the reservoir may be vertical or horizontal. In the event that the water heater is properly positioned with appropriate upper and lower water connections, (one somewhat above the other) this embodiment may be plumbed directly to the heater using, for example, T-fittings at the heater's inlet and outlet.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a partial section end view a middle portion of one embodiment of the drainpipe heat exchanger having an upper conduit for drainwater and a lower conduit for cold water with forced thermal contact all along their flat surfaces;

Figures 2, 3, 4 show the same embodiment in a sequence of forming steps to squeeze-close and solder-seal the two end portions of the lower exchanger;

Figure 5 shows the same embodiment in side view showing the sealed ends of the cold water heat exchanger, its lower fittings, and, the adapted ends of the upper conduit that connect to regular round drainpipes, and where the right end is shown to have an added adaptor while the left end is shown to have been formed into a short cylindrical shape, in both cases the flow path is flush such that there is no 'step-up' to impede drainwater flow in or out;

Figure 6 shows an adaptor for the drainwater heat exchanger formed, for example, from a suitable plastic material;

Figure 7 shows an end view of another embodiment where the drainwater heat exchanger's end's are formed to rectangular sockets to receive rectangular solder-type plumbing fittings and a plug, and where the excess material is closed off to be sealed by soldering at the same time that the fitting is inserted, and showing an internal fluid distribution tube enclosed therein;

Figure 8 shows a copper solder-type fitting having one end formed to a rectangular shape for insertion into the end socket;

Figure 9 shows a copper plug to be soldered in unused socket openings;

Figure 10 shows a side view of the same embodiment as figure 7 showing the end location of the drainwater heat exchanger fittings;

Figure 11 shows a top view in section of a cylindrical, jacket-style heat exchanger having a longitudinal gap to allow clamping motion, which would be slid over a drainpipe/ exhaust pipe;

Figure 12 shows a top section view of a two-piece design for clamping about an in-use drainpipe/exhaust pipe;

Figure 13 shows a side view of the embodiment in Fig 11 showing the outer sleeve and band clamps and showing the fluid fittings and the location of the end sealing members;

Figure 14 shows a top view of the sealing ring member made from tube or rod although a stamped sheet design may be more economical in production;

Figure 15 show a side view of the sealing member;

Figure 16 shows a possible use of the joint flange where it has various notches to distribute the fluid flow evenly over the jacket's inner wall so as to maximize heat transfer by maintaining the best temperature differential;

Figure 17 shows a thin, flat cold water (or other fluid) conduit clamped against the flat lower surface of the drainwater conduit;

Figure 18 is a cross section of the same embodiment and showing one internal stiffener in the cold water exchanger to prevent bulging;

Figure 19 is a cross section showing how the drainwater heat exchanger may be a two piece design with the upper, non-heat transfer portion in plastic and the lower heat transfer portion in sheet copper, bonded together along the length, and, with tension walls of sheet copper to transmit the internal pressure in the cold water exchanger to the external clamping member;

Figure 20 is a side view of the same embodiment showing how the drainwater flow may be made to enter from the top at the inlet end and to collect in a cross tube outlet arrangement at the exit end;

Figure 21 shows a perspective view of the outlet fitting of the embodiment;

Figure 22 is a top view looking into the vertical heat exchanger where the cold water is made to flow past a distribution gap formed adjacent an annular ring and the jacket's inner wall so as to sweep the entire surface along its vertical length;

Figure 23 is a cross section side view of the same embodiment showing how the cold water inlet is located between the sealing end cap and the annular ring with the single-sided arrows representing the resulting sheet-like flow;

Figure 24 is an end view of an embodiment of a upper conduit having a lower surface with a gully-shape along flow path, to resist upward bulging from the force of contact generated by the internal pressure in the shaped cold water jacket below;

Figure 25 shows the same embodiment but with an oval shaped lower flow surface;

Figure 26 shows another vertical embodiment with a remote heat storage reservoir connected with tubes for thermosiphoning with the cold water heat exchanger and central feed into the cold water heat exchanger;

Figure 27 shows a horizontal embodiment of a drainpipe heat exchanger with a remote heat storage reservoir;

Figure 28 shows the same embodiment in partial section;

Figure 29 shows the embodiment of Fig 12 but as would be used on a horizontal drainpipe where only a lower half is used (no exterior clamping shown);

Figure 30 shows the same embodiment having a plastic outer wall for fluid containment joined to a metal inner wall for fluid containment and for heat transfer.

DETAILED DESCRIPTION OF THE INVENTION

Vertical drainpipe heat exchangers and horizontal drainpipe heat exchangers are disclosed each with unique embodiments. Each has two conduits in thermal contact. One conduit is a straight pipe or tube that typically carries a waste fluid from which heat is to be recovered, and the second conduit is for the second fluid to which heat is to be transferred (although the heat transfer could be reversed for cooling). Generally the conduits are metal and preferably copper for fast heat transfer. The instant drainpipe heat exchangers may comprise both conduits as a single assembly or just the second conduit which can be fitted to and existing first conduit.

The two conduits are co-operatively shaped and tightly clamped together so as to provide maximum thermal contact area and high thermal contact force again for rapid heat transfer. In the horizontal embodiment the waste conduit is normally on top of the second conduit (waste fluid has heat to be recovered), while in the vertical embodiment the waste conduit is encircled by the second conduit.

One novel feature of the instant invention is the use of the internal water pressure in the cold water conduit to add to the thermal contact force to provide even faster heat transfer. Faster heat transfer makes DHR more cost effective.

In Fig 1 horizontal heat exchanger 200 has an upper drainwater conduit 60 and a lower cold water conduit 50 held tightly together with clamping bands 12 (Figs 5 and 10) around a suitable force distribution sleeve (not shown). Drainwater conduit 60 comprises wall 1 with drainwater A flowing along flattened bottom surface 1' (of wall 1) to thereby form a hemicylinder that transfers heat to fluid B which enters and exists cold water conduit 50 via underside fittings 10, 11 or alternately, via end fittings 80.

In Fig 1-5, 7, 10, cold water conduit 50 is shown being in the shape of a trough made from sheet copper and formed with longitudinal hems 4 that are solder joined to create a generally "C shaped" hemicylindrical conduit with flat surface 5. Hem 4 also serves as a heat conductive fin and, as a result of the bend curvature 6, provides a longitudinal vent to the ambient for leak detection.

In one embodiment, wall 2 of conduit 50 has wings 3 which contact the side of the drainwater conduit 60 to create additional surface for heat transfer. In Figs 2, 3, 4 cold water conduit 50 is shown having a short end portion of hem 4 folded flat in preparation for sealing the ends. The wings 3 are pinched closed and excess metal is pulled into additional seams 3'. In Fig 4 is shown a dotted line 2 that represents the original cold water conduit 50 shape.

In Fig 7 is shown an alternate way of sealing the ends of cold water conduit 50 so as to provide in-line connection sockets 33', 34'. The two sockets at each end (4 in total) are formed on each side of hem 4 using an appropriate mandrel about which the remaining wall 3 and wing 2 are squeezed to bring them together as a seam to be soldered. Appropriate surfaces can be 'tinned' with solder prior to the forming in preparation for final soldering.

In Fig 8, fluid fitting 80 has rectangular end 33 inserted and soldered into socket 33' or 34' (at each end of cold water conduit 50), and has a round end 30 for connecting to standard plumbing. Fitting 80 may also be an end of a longer tube where installation conditions warrant. Alternatively one of the two rectangular shapes 33' and 34' may be blocked with a simple plug 34 as indicated in Fig 9. Interior to cold water conduit 50 and inline with the socket 33' and/or 34' is a fluid distribution tube 35' which extends full length and is closed at the far end and has cross apertures at intervals. The purpose of tube 35' is to distribute fluid B (i.e., cold water) to cause a crossflow creating turbulence and evening out flow velocity across the width of cold water conduit 50.

In Fig 5 horizontal heat exchanger 200 is shown having the upper drainwater conduit 60 made from a flattened tube, and lower cold water conduit 50 (for, say, cold water) formed of sheet material bound together by exterior clamping bands 12. In some uses the upper drainwater conduit 60 may also be formed from sheet to reduce cost. In either case the ends of drainwater conduit 60 can be adapted to connect with existing round drain pipes the right end of the drainwater conduit being shown having a separate, bonded-on adaptor 70, while the left end 70' is shown as having an integrally formed round end 20'. It is important that the drainwater conduit provides a flush flow path especially at the exit end so that solids in the drainwater will not hook and collect at the region of transition from flat to round. This can be achieved by forming a recess in the "D' shaped end of the bonded on adaptor equal to the thickness of the drainwater conduit material. The bonding region is shown at overlap 20'.

Fig 5 shows fluid B, such as cold water for a water heater, entering fitting 10 at the left to counterflow horizontally under the drainwater water conduit 60 and exit via fitting 11 on the right having absorbed (or given up) heat from warmer (or colder) drainwater'. Drainwater A flows horizontally with a first temperature A' at inlet on right side and a different temperature A" at outlet on left side.

Fig 6 shows adaptor 70 having a "D" shaped first end 20' for bonding to drainwater conduit 60 and a round end 20 for connecting to existing drainpipe. Adaptor 70 may also be made of molded rubber with a shaped shoe 22 (shown in dotted outline) under the flat portion 20' to provide even clamping pressure for sealing.

In use, by connecting cold water conduit 50 to a pressurized fluid supply, an enormous thermal transfer contact force is created between the flat surfaces of conduits 50 and 60, restrained by bands 12 (over a stiff sleeve, not shown), to provide exceptional heat transfer therebetween. For example, with a 4 inch wide flat that is 50 inches long and with a pressure of 40 pounds per square inch, the contact force is some 8,000 pounds. This force custom forms typically imperfect flat surfaces 1' and 5 into intimate contact.

With the instant invention, horizontally flowing drainwater, whose valuable heat energy is normally wasted, can be cooled by heat transfer to the cold water supply of the water heater to thereby shorten the time it takes to fully heat hot water which, in turn, saves energy and money and provides more hot water due to faster recovery. It may also be used to cool a flow of warmer water feeding, for example, an ice cube maker, using colder drainwater from a ice-filled sink.

In all figures the drainwater flow or exhaust gas inlet flow is indicated as A' and A'' and the fluid whose temperature is to be changed is B and B'. Heat exchanger 200 may be used to heat or cool fluid B. Although gaps between surfaces are shown in the figures (for clarity) it is understood that there is intimate contact between heat transfer and clamping surfaces.

In Figs 11-13 heat exchanger 100 is a jacket(s) comprising an inner heat transfer wall 5 and outer retaining wall 2 spaced apart for fluid flow therebetween with minimal resistance. This space may be, say, ¼ inch. The walls are contiguous and formed from a single piece of thin sheet metal (copper) using reversing bends 112 and lap joint 5'. This leaves a longitudinal opening or gap 111 between bends 112 to accommodate movement from external mechanical clamping forces and internal hydraulic clamping forces. The jacket may also be formed by extrusion in which case finning 115 (representative fins only, shown in Fig 11) and fluid control elements 114 may be easily included on the inner wall 5 and/or outer wall 2. Outer clamping sleeve 116 with gap 113 closes tightly around and distributes clamping forces from band or hose clamps 12 to prevent expansion or bulging of outer wall 2 from the internal pressure of fluid B such as that from a building's cold water supply. Inner wall 1 is however free to expand every so slightly to provide a tight, intimate thermal contact with drainpipe 1 using that same internal pressure.

In Fig 11, 12 lap joint 5' is a soldered and may include longitudinal joint flange 110 which can act as a fluid flow distribution ring and a stabilizer/spacer for aligning the sheet metal during soldering. Inlets(s) 10 and outlet(s) 11 are connections for fluid B (such as cold water) whose temperature is to be changed. Representative fluid control element 114 may be several in number and take various shapes such as mesh, rods, screen, angles, etc., that direct, for example, flow of fluid B over element 114 as indicated by dashed flow arrow 114', to help effect best heat transfer from inner wall 5 by the fluid 'sweeping' the surface of the inner thermal contact wall as fully as possible. Element(s) 114 may also be used to create turbulent flow which is known to improve heat transfer. Element 114 may also be shaped and located to deflect fluid B inflow at inlet 10 to avoid erosion corrosion of the small area of the inner wall by the fluid impinging on it perpendicularly at full velocity over long years of daily use.

Fig 12 shows the hollow, tubular nature of the heat exchanger 100 as fitted onto a vertical drainpipe 1. Sealing rings 34 are shown in dotted line and are soldered into the annular space between the inner and outer wall ends at top and bottom. Although a tubular shape is shown, other shapes such as oval are contemplated where, for example, fitting clearance is a concern.

Figs 14 and 15 show the sealing member 34 which can be made from rolled rod, tube or twisted wire bundle to fit snugly into the annular space and have a gap 111' to coordinate with gap 111. They may be made by winding a long tube onto a mandrel of the correct diameter into the form of a coil spring and then sawing through the coil to free individual rings which are then made planar as in Fig 15. Dip soldering is a fast method of construction.

Fig 16 shows a method of using the longitudinal joint flange 110 as a flow distributor by providing restriction to flow directly from fitting 10 such that fluid B is forced through spaced vias 120 to travel across inner wall 5 to reach outlet 11 thereby improving heat removal from drainpipe 1. Flange 110 may also simply be more simply double-tapered (not shown) from full width at the center tapering to nil at each end to even out flow along its length, especially if the fittings 10 and 11 are positioned centrally and opposite one another.

Fig 12 shows the cold water conduit in two halves with inlets 10 and outlets 11 on each half. The outer sleeve 116 and clamps 12 of Fig 11 are not shown. The outer sleeve 112 would of course be in two pieces either separate or hinged for ease of assembly onto the drainpipe in a building while it remains in operation. The sealing rings 34 (not shown in Fig 12) would of course be four in number each being a half ring, one at each of the four ends.

Fig 17 shows another embodiment of horizontal heat exchanger 200 where the cold water conduit 2 comprises a sheet copper duct or tube in the form of a flat, rectangular hollow strip.

It is sealed at each end and preferably has flow-formers to ensure that the cold water flows as a flat sheet of water across the entire width of the heat transfer surface so as to keep the surface as cool as possible, thereby maximizing delta T for faster heat transfer.

Fig 18 shows a cross section of the same embodiment where the drainwater conduit is shown to be a flattened, hemi-cylindrical tube 1 forced into intimate, conforming thermal contact with cold conduit 2 using shaped pressure distribution shoes 130, 131 and clamp bands 12.

In the embodiments shown in Fig 18 and 19, and all embodiments of the horizontal drainwater heat exchanger, the cold water conduit may have internal baffles 2" comprising one or more flattened tubes soldered between the top and bottom surfaces that will prevent excessive bulging of the conduit in reaction to the water pressure inside. This will help maintain flat drainwater heat exchange surfaces.

In Fig 19 drainwater conduit 1 is comprised of a trough-like lower portion in sheet copper through which heat transfer takes place and a U-shaped plastic upper portion bonded 1b thereto, the two creating a hybrid drainpipe of rounded rectangular or hemicylindrical form. This embodiment is for the lowest cost device. Interior longitudinal supports 1c act to transmit bulging force from cold water conduit 2 to shoe 130 and bands 12 thereby maintaining a flat profile for the trough. Supports 1c may be wavy to create a desirable turbulent flow. Supports 1c also act as fins to extend heat transfer surface area. Supports 1c may be eliminated and baffles 2" in the cold water exchanger may be used to prevent pressure bulging of the flat surfaces.

Fig 20 shows the same embodiment with different drainpipe connection fittings. Inlet 200" is a vertical right angle inlet centered on plastic top 1a and outlet 200' is a horizontal right angle fitting shown in more detail in Fig 21, having an end cap and a slot 201 which matches the shape of the end of heat exchanger 1, 1a, 1b (Fig 19) and is bonded and sealed thereto. A slight slope to outlet 200' carries away the final drainwater drips to leave drainwater conduit 1 dry.

In Fig 22 vertical heat exchanger 100 has an inner wall 5 (heat transfer surface) and ring-shaped flow distribution ring 110' which provides an even annular gap 120' adjacent wall 5. End seals 34 (Fig 23) and flow distribution ring 110' are spaced apart vertically creating a circular chamber into which flows fluid B, which then must leave the chamber in a full curvilinear sheet flow B' (half arrows) against inner wall 5 so as to sweep heated (or cooled) fluid towards the outlet, which is similarly configured. This ensures that a maximum temperature differential, or delta T, can be maintained to optimize heat transfer. This annular flow control arrangement may be used to advantage in all the aforementioned heat exchangers including the two-piece embodiment of Fig 12. In the case of horizontal heat exchangers 200 the distribution ring would take the form of a rectangular bridge held a small distance below the heat transfer surface by stand-off elements.

Figs 24 and 25 show variations on the profile of the flow surface 1' of the drainwater conduit 1 with the purpose of stiffening the flow surface 1' to resist upward bulging from the expansive potential of the pressurized cold conduit below. The cold water conduit 2 is shown to be conforming in shape so as to maintain maximum thermal contact.

Fig 26 shows a vertical drainpipe heat exchanger 500 having a remote heat storage reservoir 400 which is always pressurized with the cold water supply B and lies in series with the cold water flow into, say, a water heater. Outlet 11 connects to external plumbing to provide pre-heated water C to a water heater or other fixture/appliance. Cold water B enters via fitting 10 into jacket or conduit 2. Two central flow distribution rings 110' ensure that the up and down vertical flow through jacket 2 is adjacent inner heat transfer wall where it then passes under two additional upper and lower flow distribution rings 110' into the collection area (between end seal 34 and ring 110') and out through fittings 213 and 214. Now cold water B (preheated by drainpipe 1, or not) passes through connecting tubes 401 and 402 into reservoir 400 via fittings 410 and 411 respectively. Tube 402 terminates higher in reservoir 400 than tube 401. Thus tube 402 terminates in the warmer, lighter layers of water filling reservoir 400.

In operation four scenarios are possible:

1. Hot water is being used and used hot drainwater A' is flowing, such as in showering. Here the cold water B will be pre-heated in jacket 2 and flow upwards through tubes 401 and 402 (arrows 403, 404) into reservoir 400 and out outlet 11.

2. Hot water is being used but no drainwater is flowing such as when filling a wash machine. Here the cold water B simply passes through jacket 2 and through tubes 401 and 402 into reservoir 400 and outlet 11 (arrows 403, 404). With fitting 11 on top, any previously recovered heated water will be the first to flow out because it is lighter and rises.

3. Hot drainwater A' is flowing but no hot water is being used, such as when an appliance drains. Then, if the in water B in jacket 2 is being heated by drainwater A' and is thereby made lighter, thermosiphoning will automatically take place, whereby any water in reservoir 400 which is colder than that in jacket 2, will cause the heavier cold water to sink down tube 401 (arrow 403) into jacket 2 via fitting 214, then travel up through jacket 2 picking up heat and out outlet 213 to return to the upper region of reservoir 400 via tube 402. This continues as long as there is a temperature differential (weight difference) between the water in the reservoir and the water in the jacket, that is as long as heated drainwater continues to flow. The net result is that the water in the reservoir is heated ready to flow into a water heater or other appliance/fixture

4. Cold drainwater is flowing. The water in the jacket 2 is the first to become cold and therefore also becomes heavier. Thermosiphoning cannot occur with the reservoir 400

since cold water cannot rise into it and therefore whatever heat is present in the reservoir will not be lost to the cold drainwater. This automatic cessation of thermosiphoning provides protected heat storage for the recovered heat in the reservoir.

Cold water reservoir 400 may be the reservoir may be a rectangular shape or a square tube shape or a cylindrical shape and mounted or hung some distance from the drainpipe heat exchanger and as high as practical, such as being hung from a ceiling. This will increase thermosiphon action (speed the flow) to improve performance provided tubes 401, 402 are of sufficient diameter. In such cases tubes 401 and 402 should be well insulated to maintain the best temperature differential and to prevent heat loss to the ambient.

In the event that it is desired to discard heat, as in, for example, a cold water drinking fountain, the arrangements may be reversed so that the coldest water remains in the reservoir ready to move to the drinking outlet. Then, the reservoir would be below the heat exchanger and the tubes 401 and 402 arranged such that hotter water in the reservoir rises to be cooled by colder drainwater from the fountain and returns cooler, thus keeping the reservoir cool and the drinking water cold as desired.

Fig 29 shows how drainpipe heat exchanger 600 is a half jacket with a continuous inner and outer wall 2, 5 that may be used on the bottom portion of a horizontal drainpipe 1 such as one of copper or steel (cast iron) carrying drainwater A. Cold water B passes through exchanger 600 on its way to the water heater. This minimizes material and so improves the ROI. In Figs 29 and 30 none of the required external clamps or reinforcing sleeves are shown for added clarity.

Fig 30 shows exchanger 700 of composite construction where inner wall 2 is metal joined to a thick outer wall 222 made of plastic to further reduce cost and improve ROI.

The embodiments of an invention in which an exclusive property or privilege is claimed is defined as follows:

1. A method of storing heat recovered from a fluid-filled, jacket-style drainpipe heat exchanger having an upper fluid fitting and a lower fluid fitting, the steps comprising:

a. providing at least one additional fluid fitting between said upper and lower fluid fittings on the jacket;

b. connecting the additional fitting to a supply of a fluid;

c. providing a remote reservoir filled with the fluid and having first and second conduits, said first conduit extending between said upper fluid fitting and said remote reservoir, said second conduit extending between said lower fluid fitting and said remote reservoir, said first conduit terminating within said reservoir at a higher point than said second conduit;

d. providing at least one additional fluid fitting to said reservoir for connection to a fluid using apparatus; and

e. the arrangement being such that a temperature differential between the reservoir and the jacket will initiate convective flow therebetween.

2. The method of Claim 1 wherein said fluid is potable water.

3. The method of Claim 2 wherein said fluid using apparatus is a water heater.

4. The method of Claim 2 wherein said fluid using apparatus is a faucet.

Fig 1

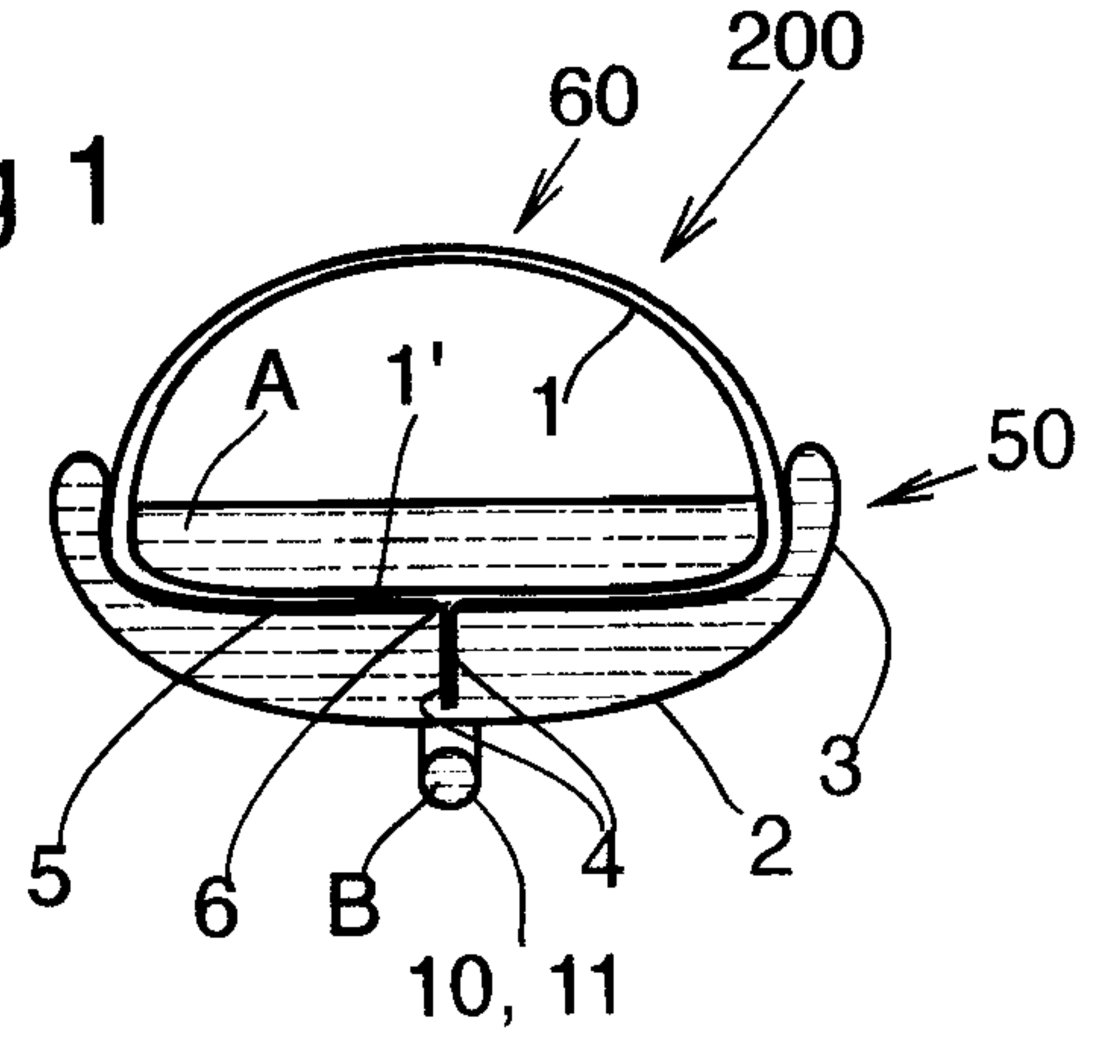


Fig 2

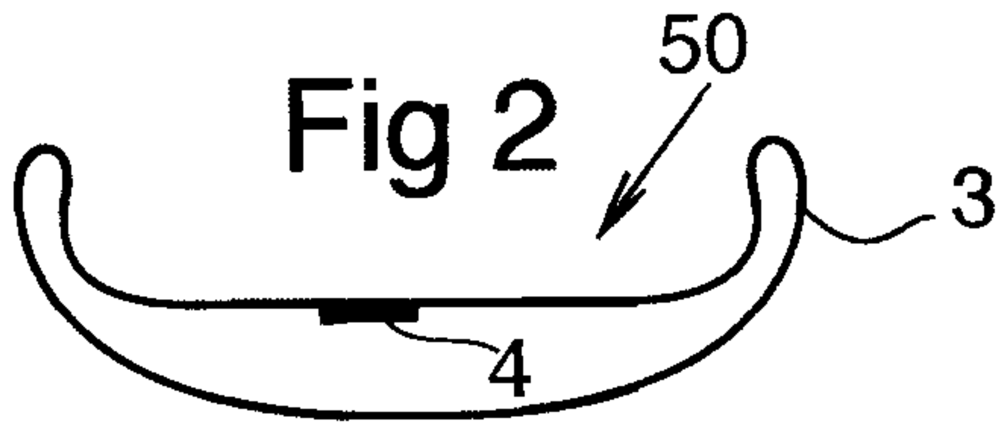


Fig 3

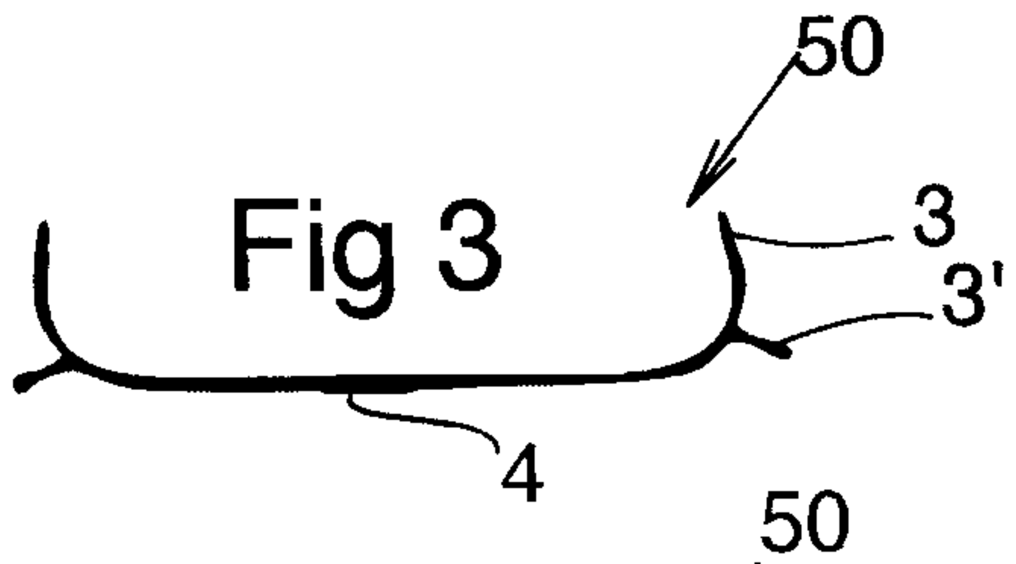


Fig 4

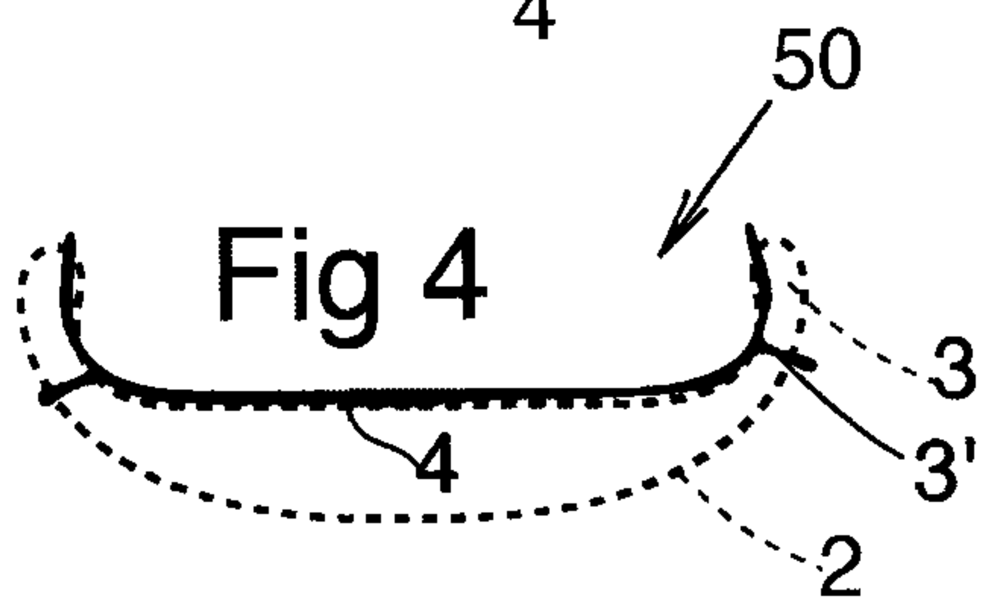


Fig 7

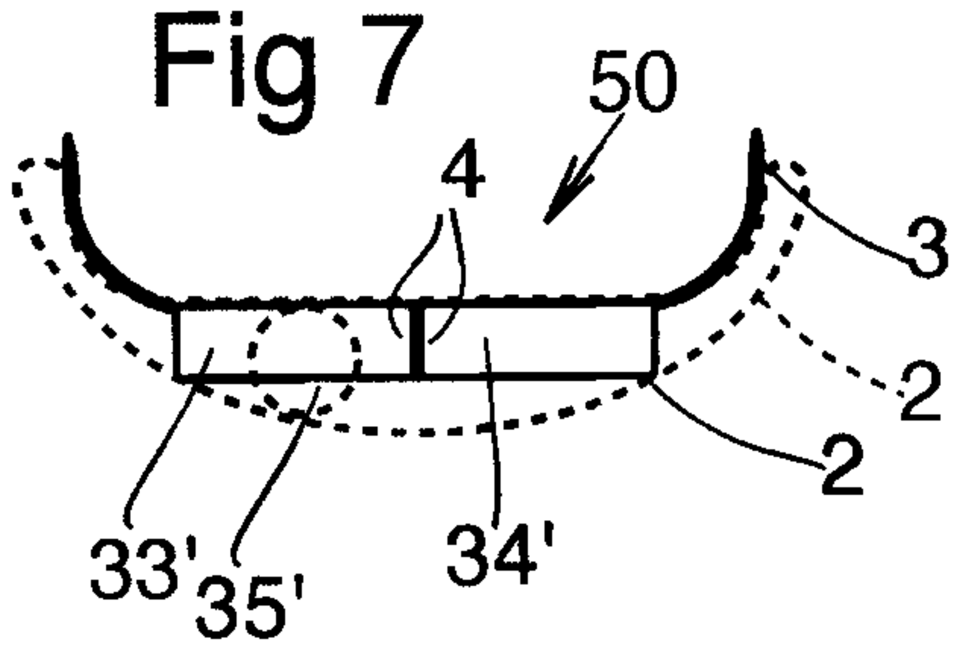


Fig 8

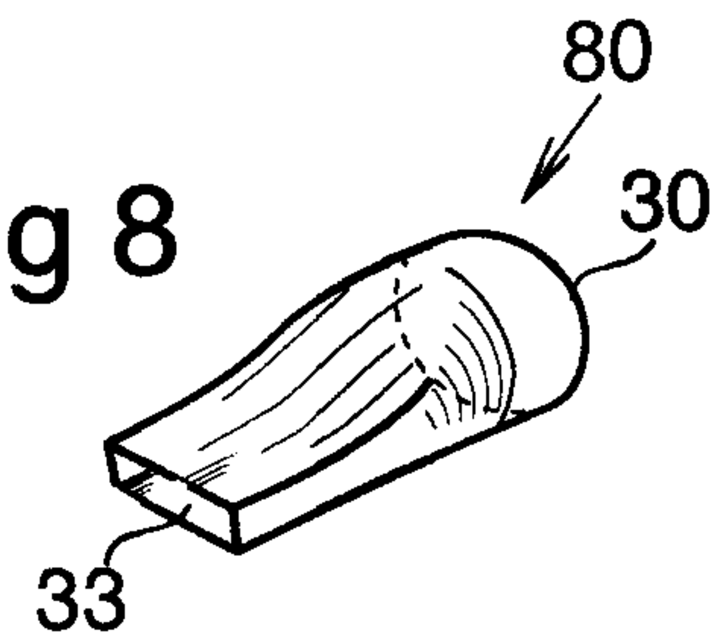


Fig 6

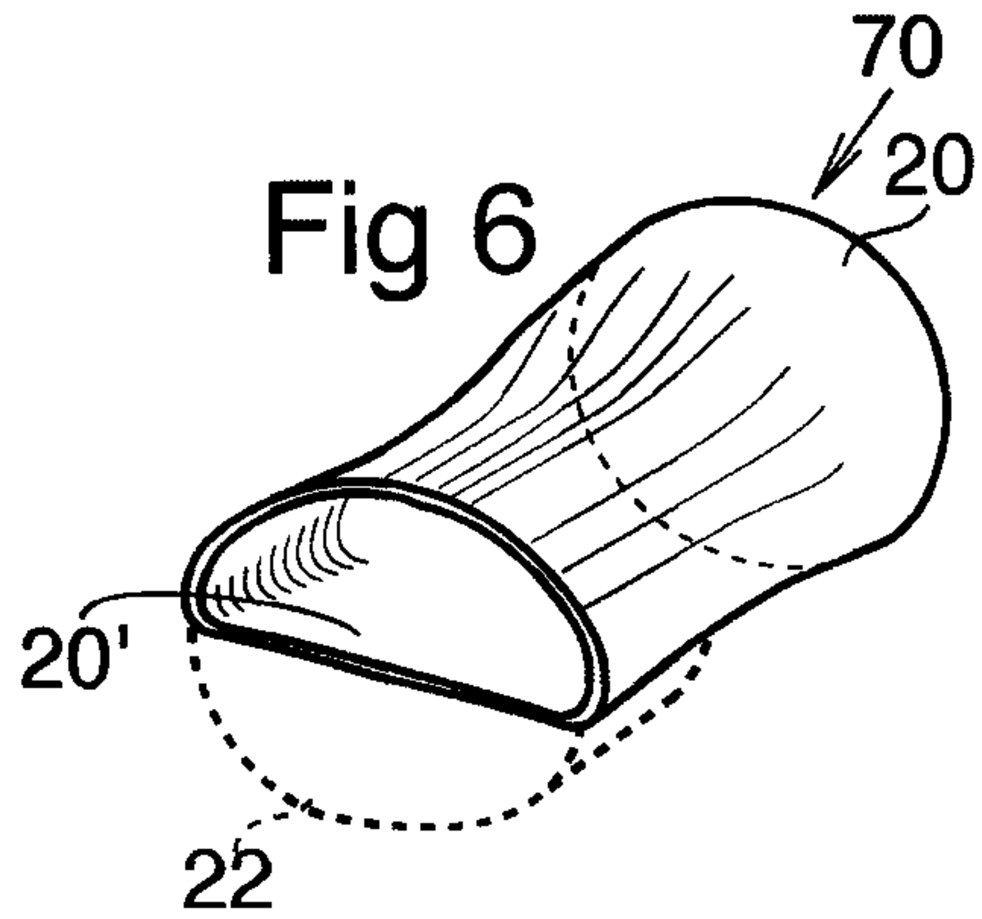
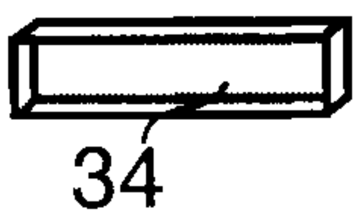


Fig 9



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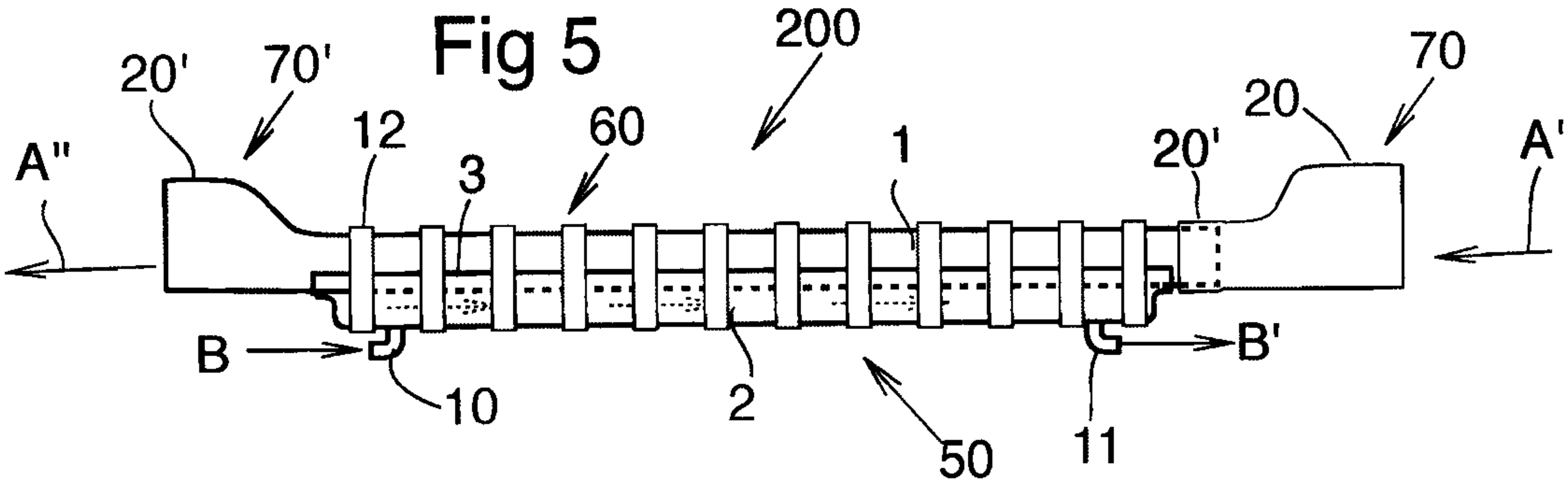
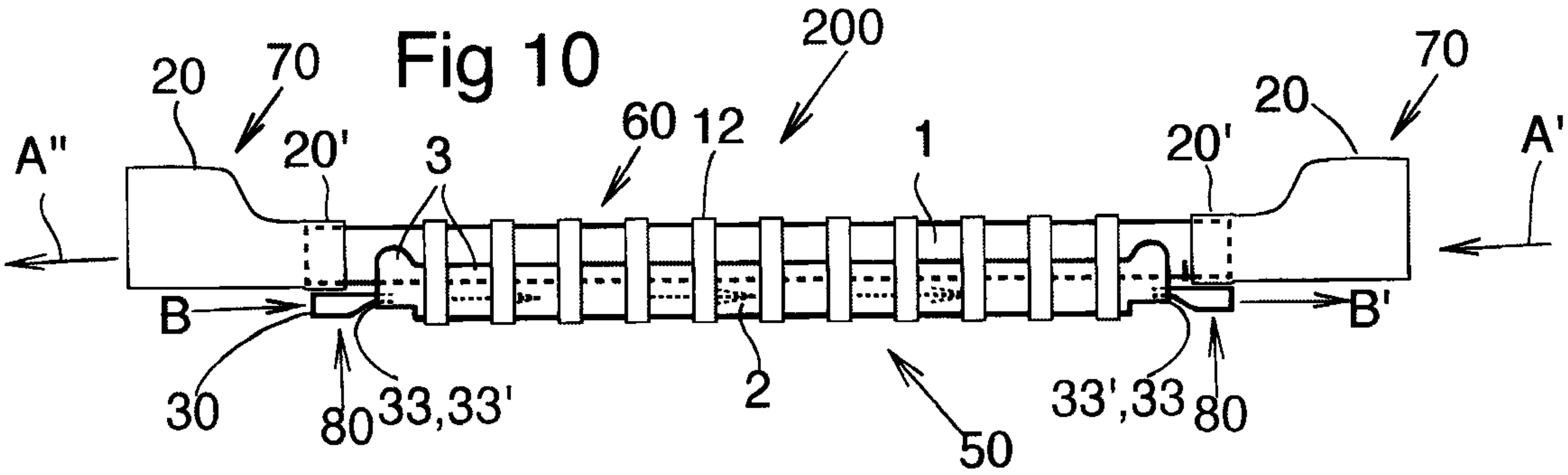


Fig 10



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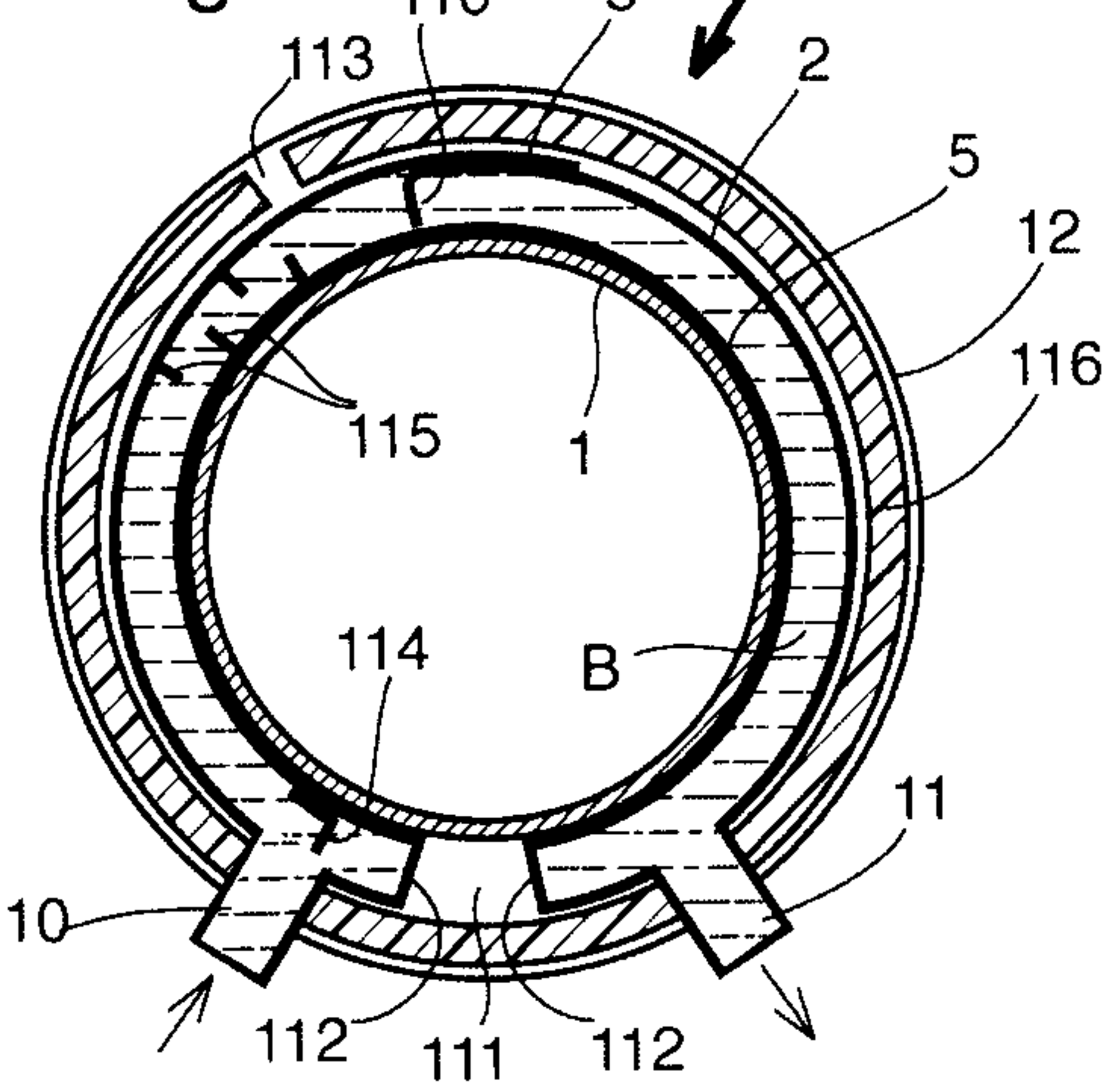
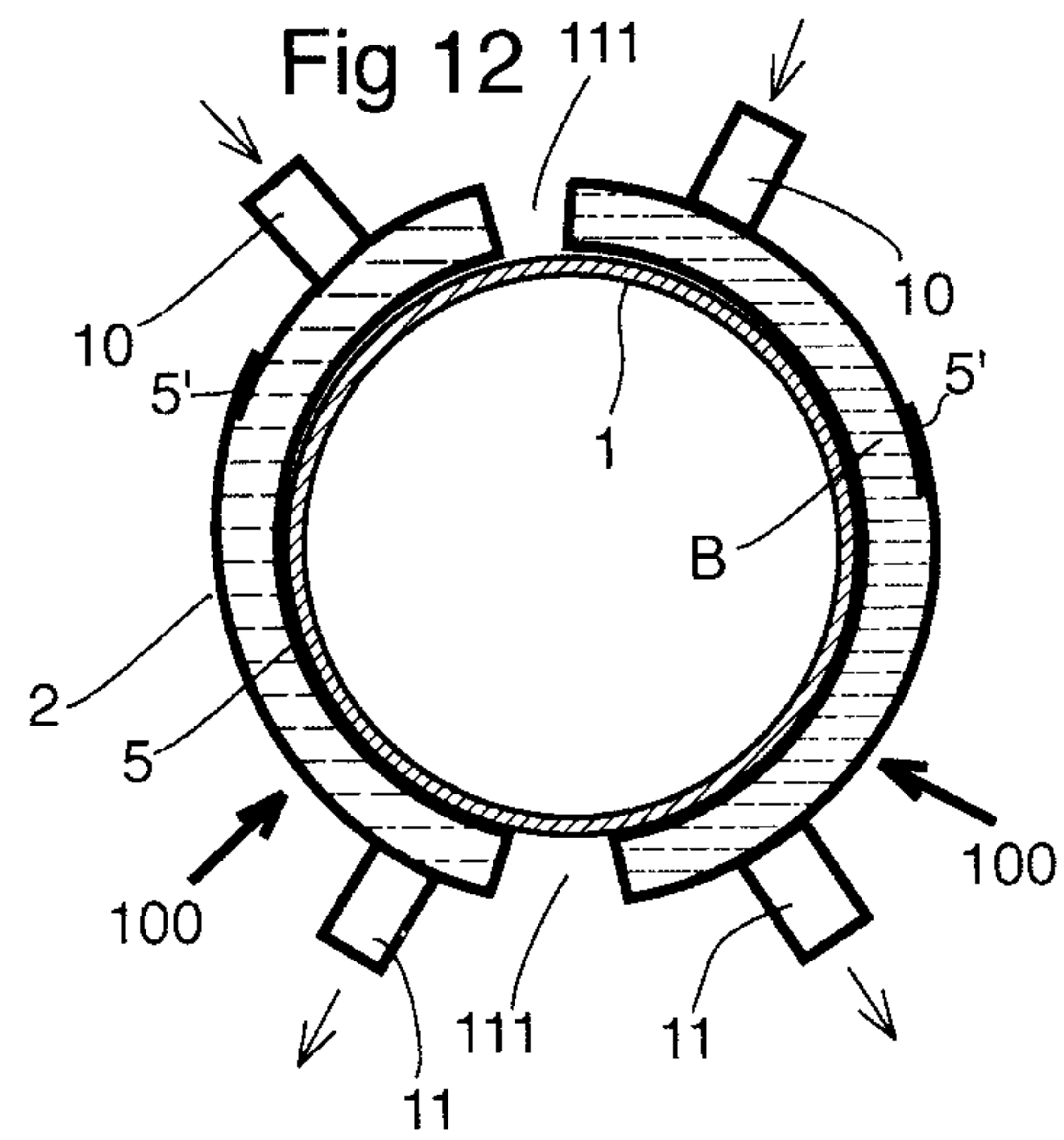


Fig 12



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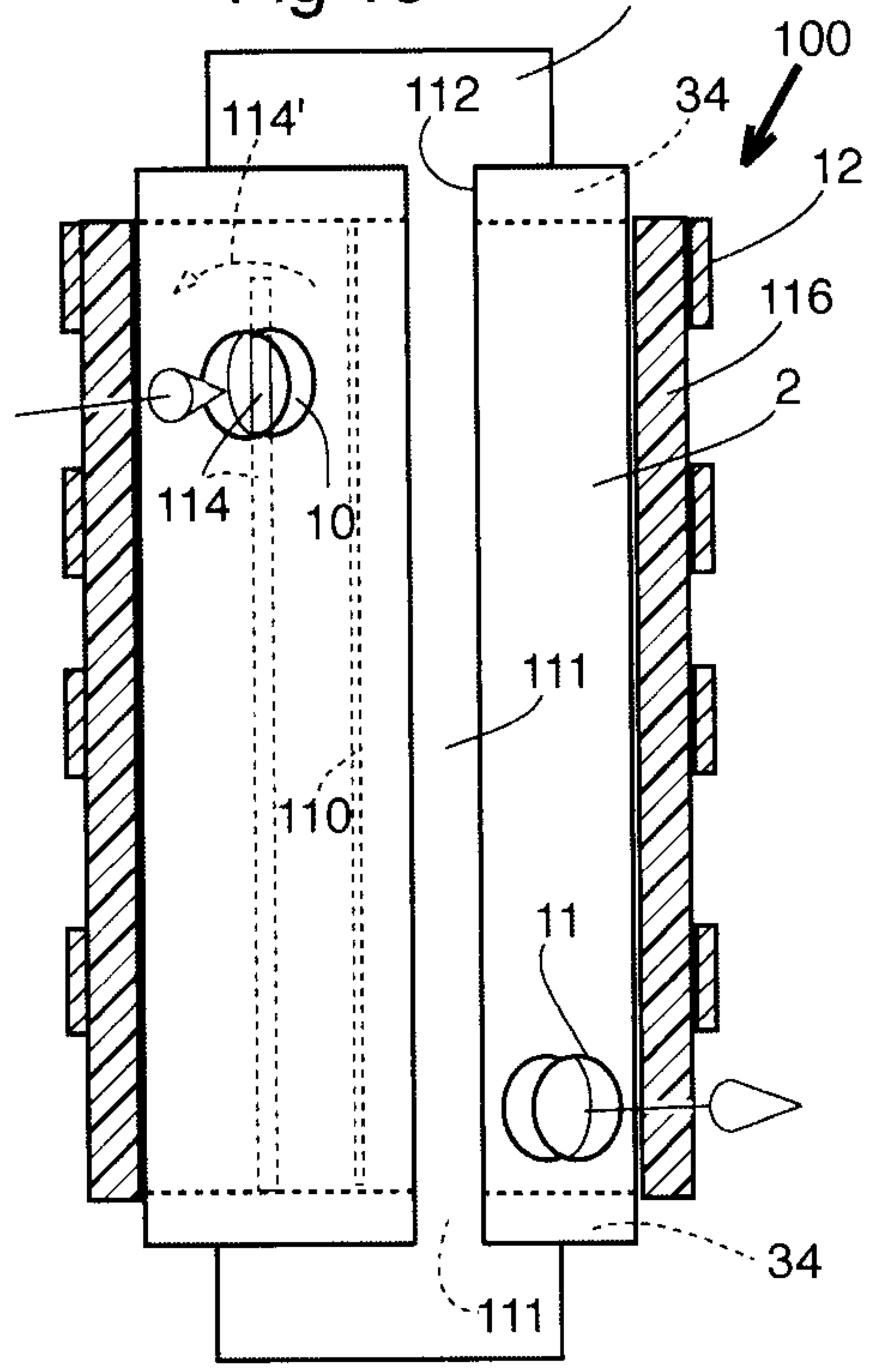


Fig 14

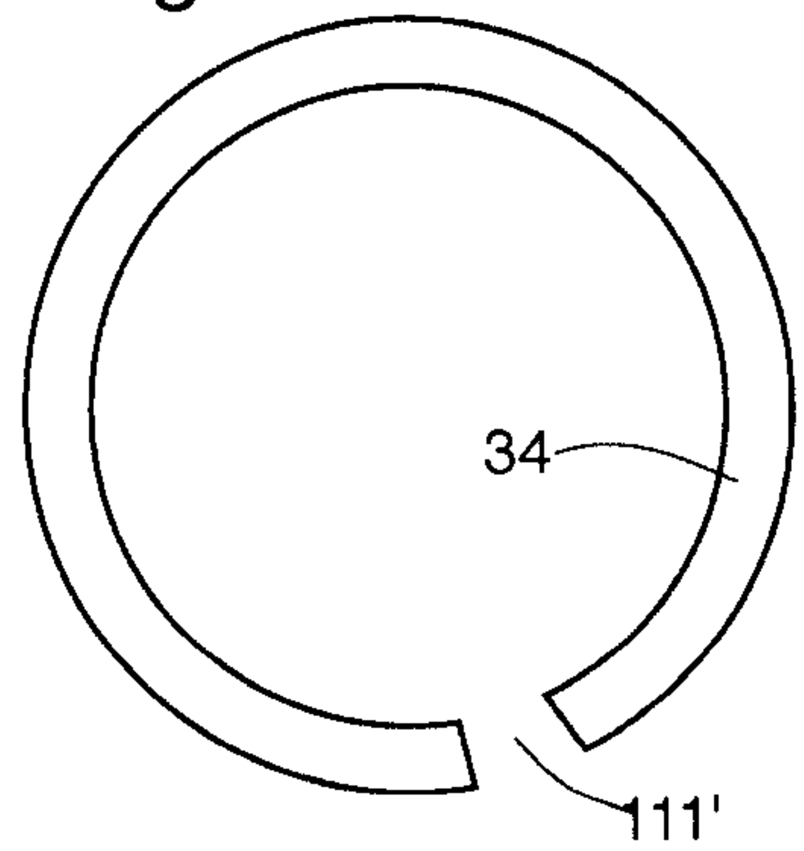


Fig 15

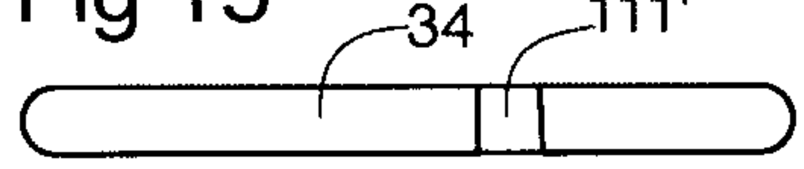
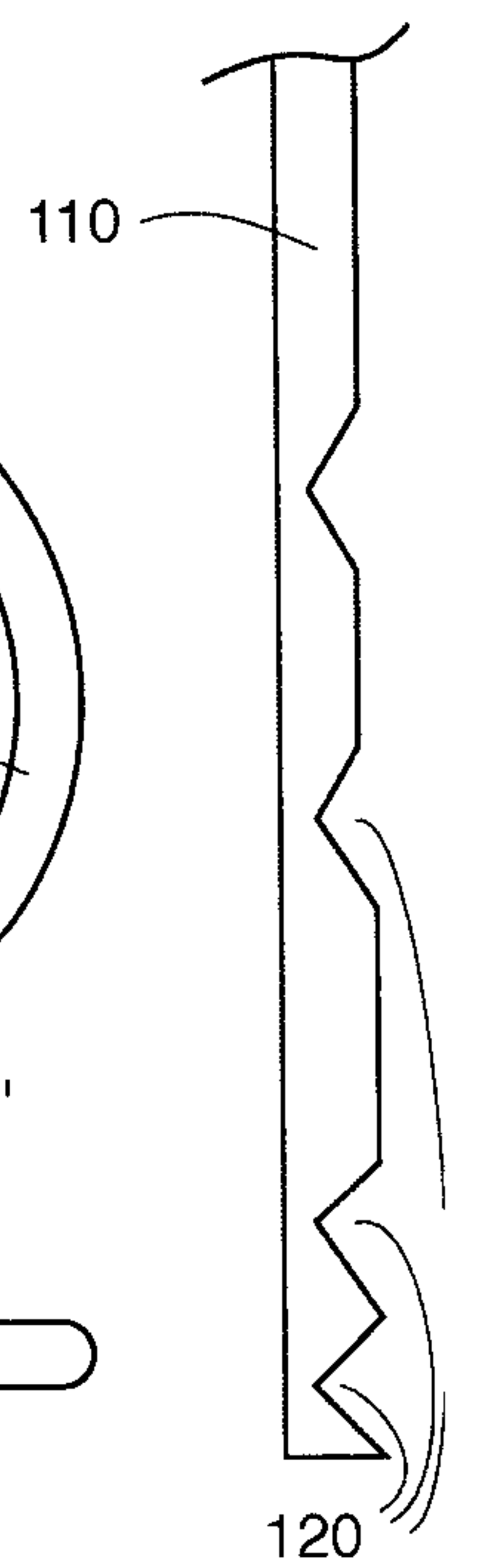


Fig 16



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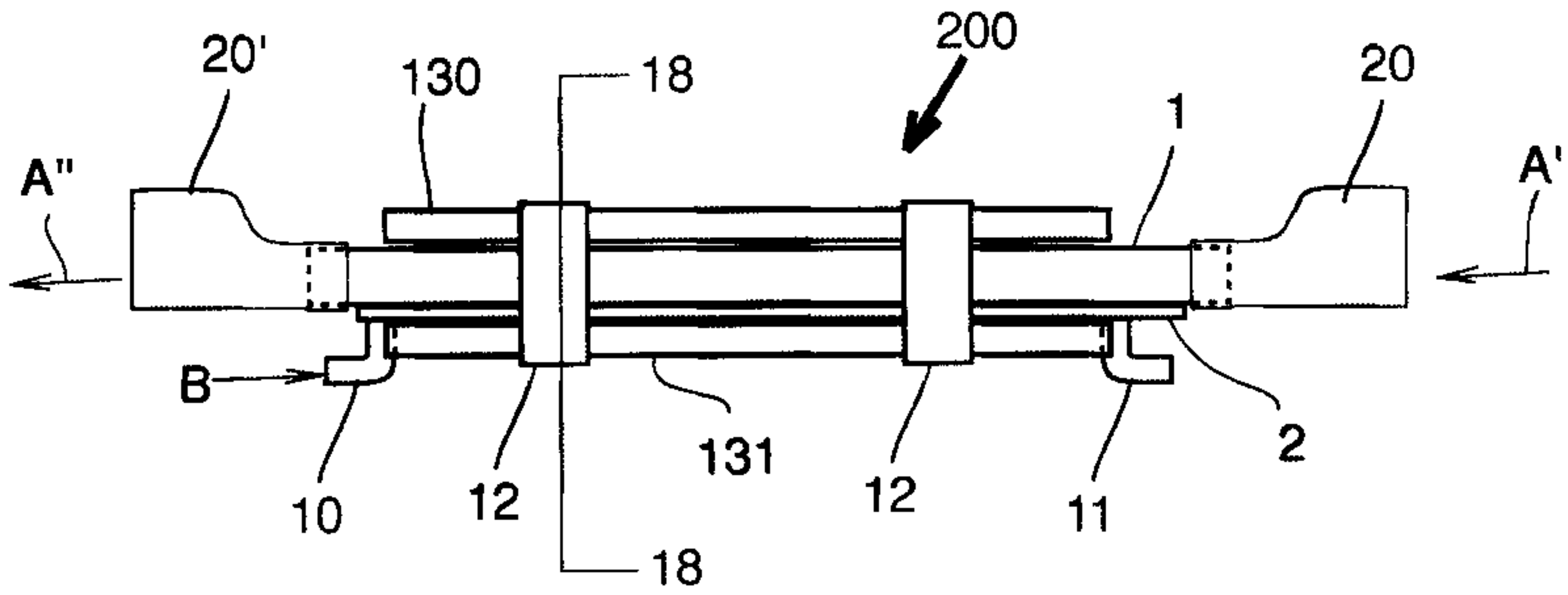
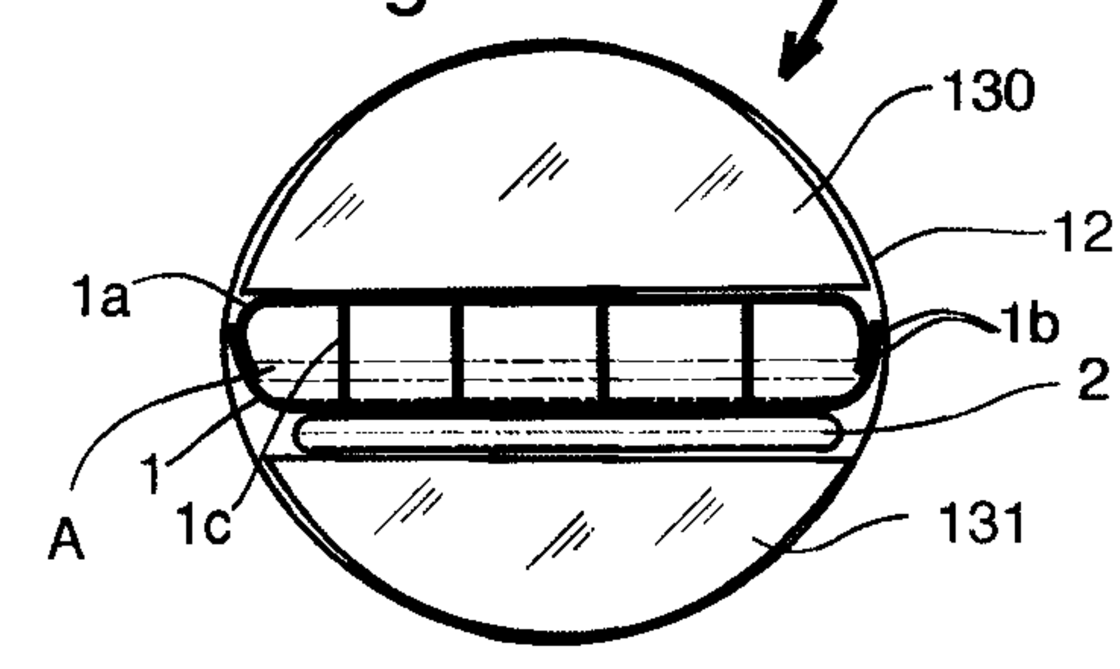


Fig 19



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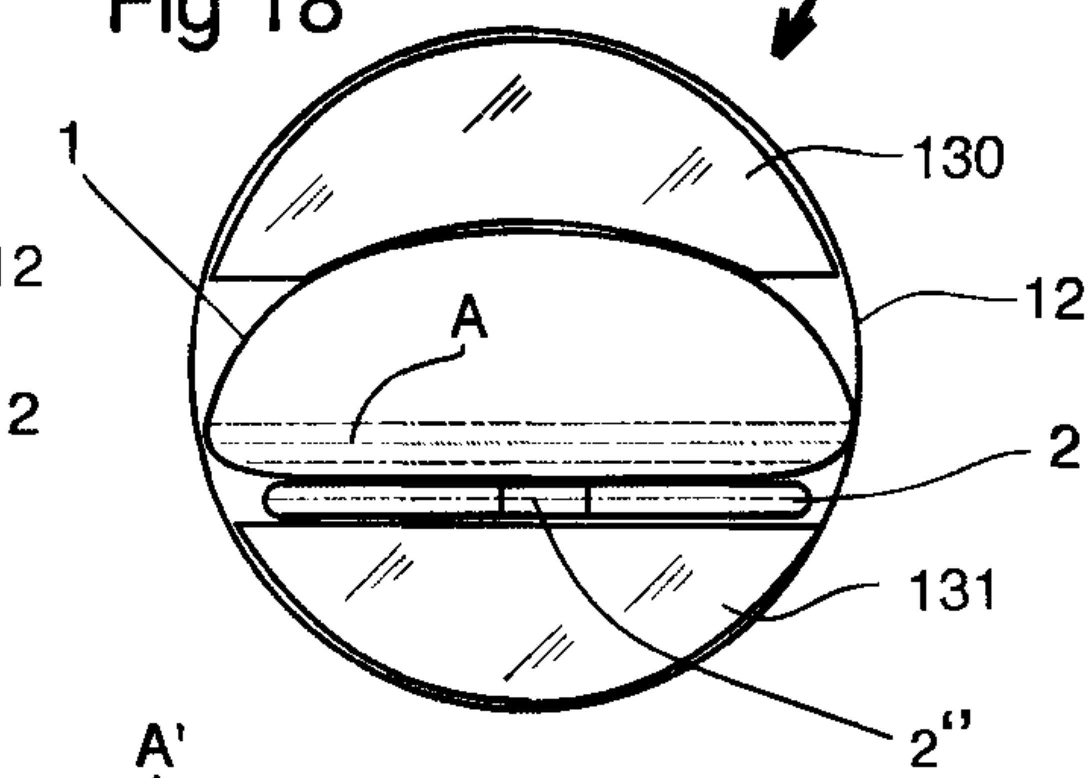

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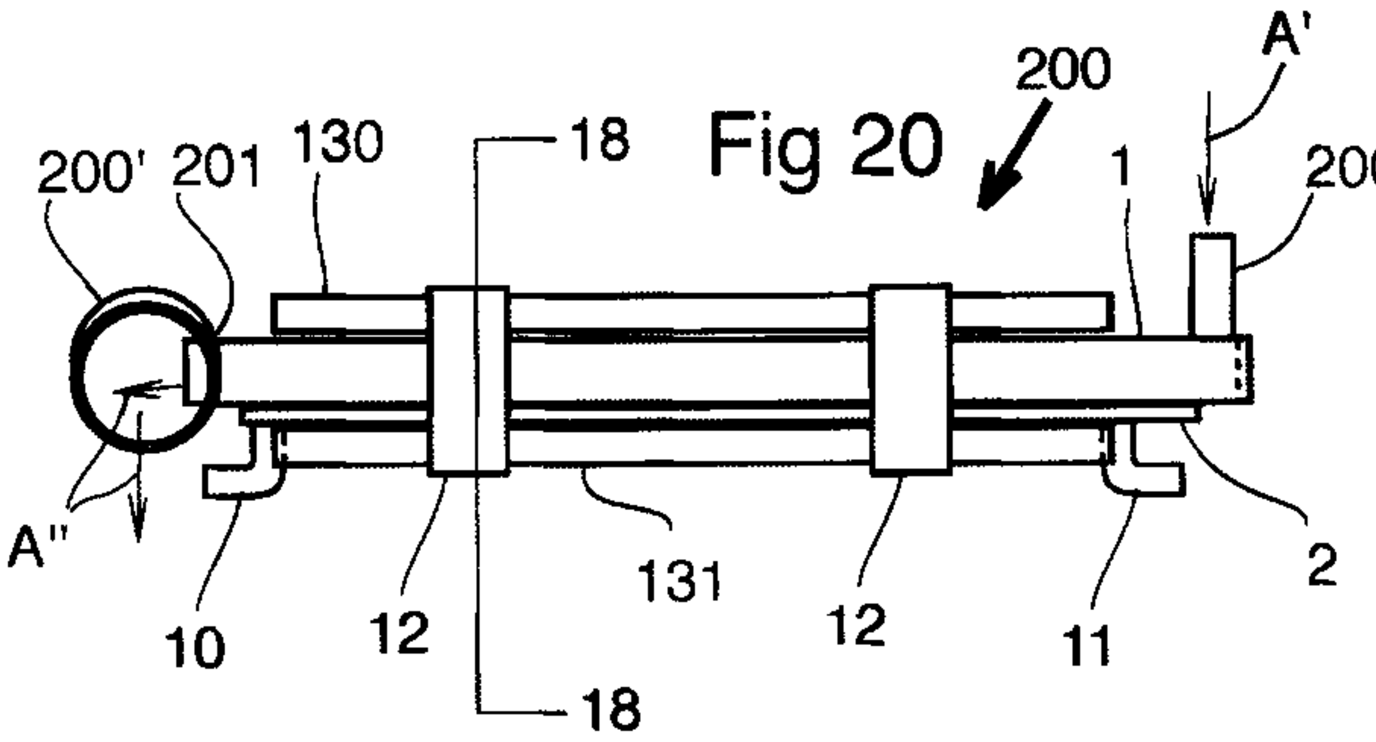

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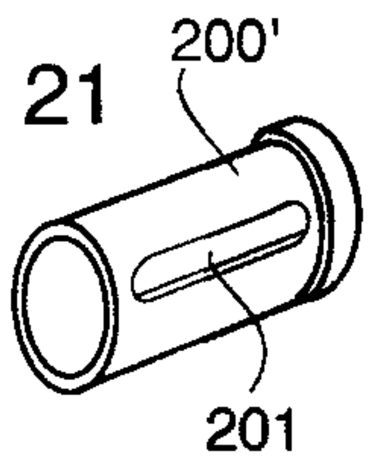

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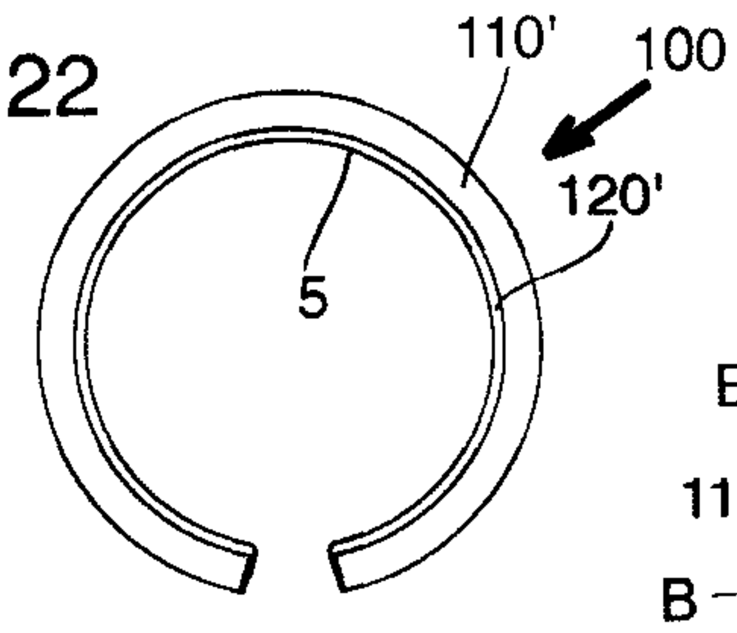

Fig 23

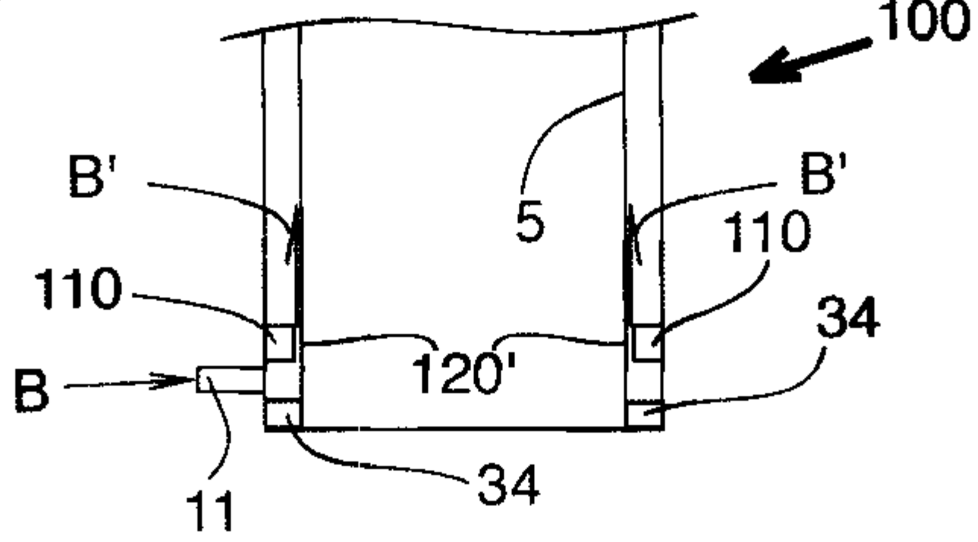

Fig 24

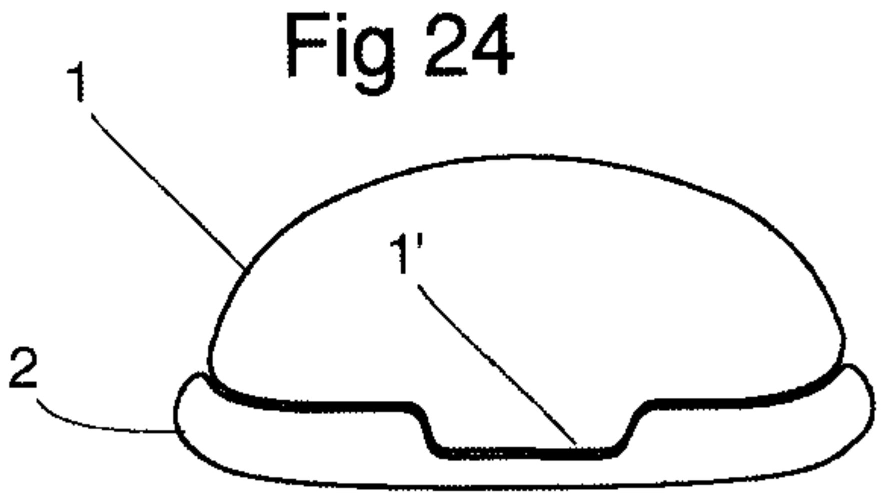

Fig 25

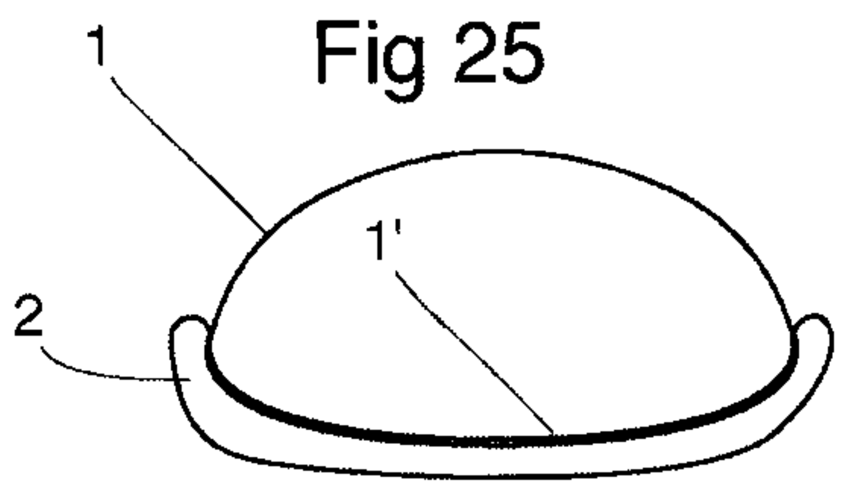

Fig 26

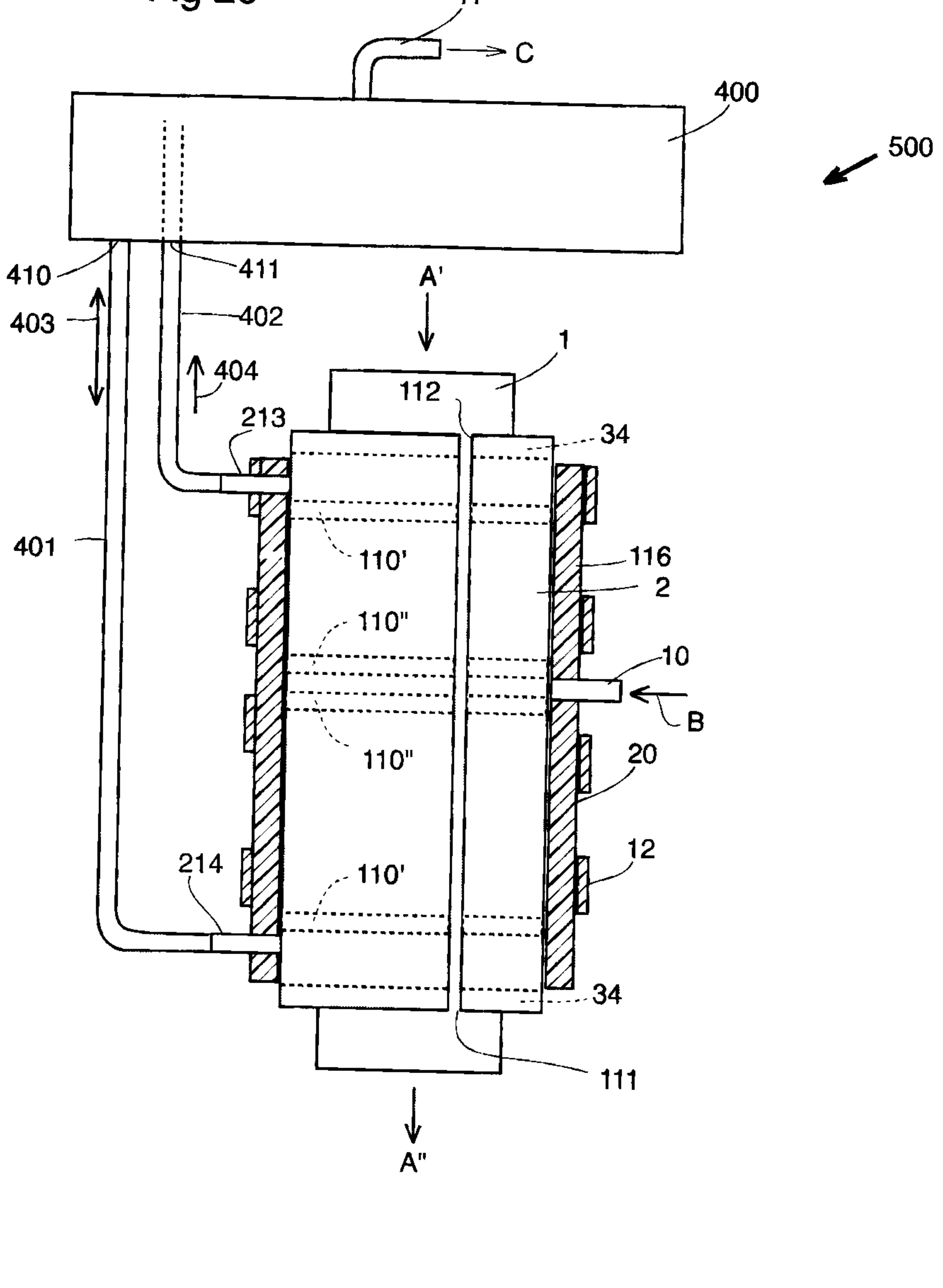
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Fig 27

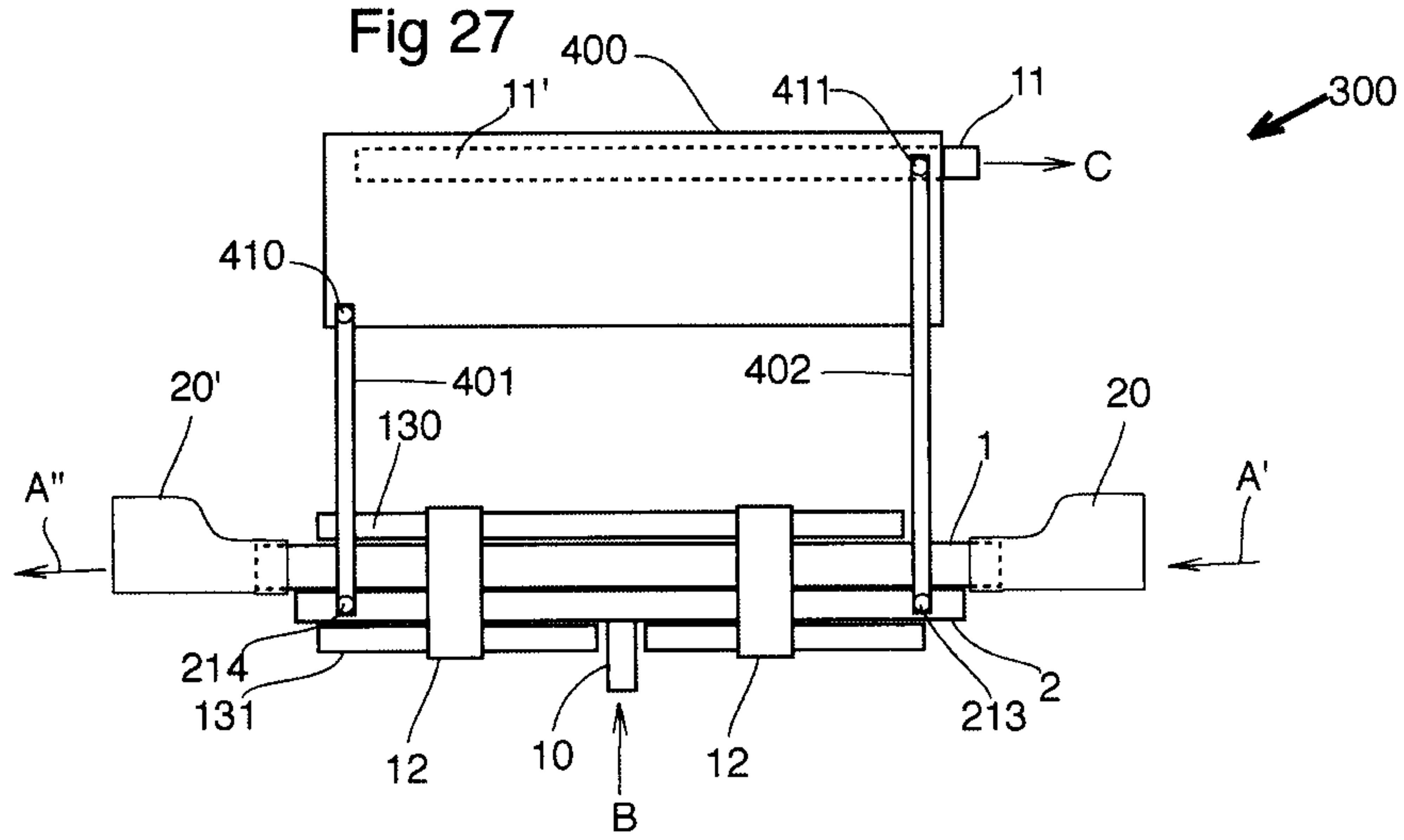
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Fig 28

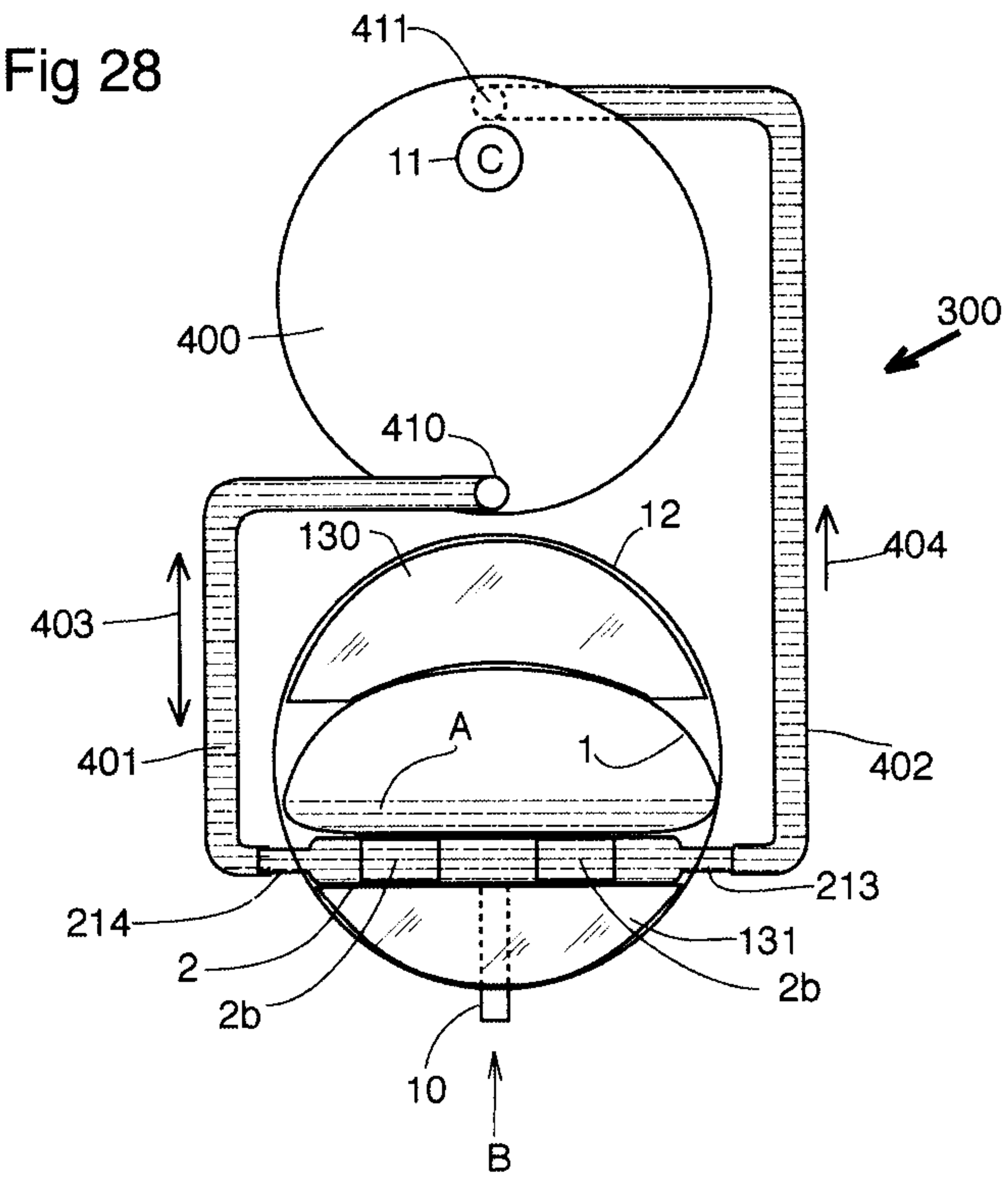
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Fig 29

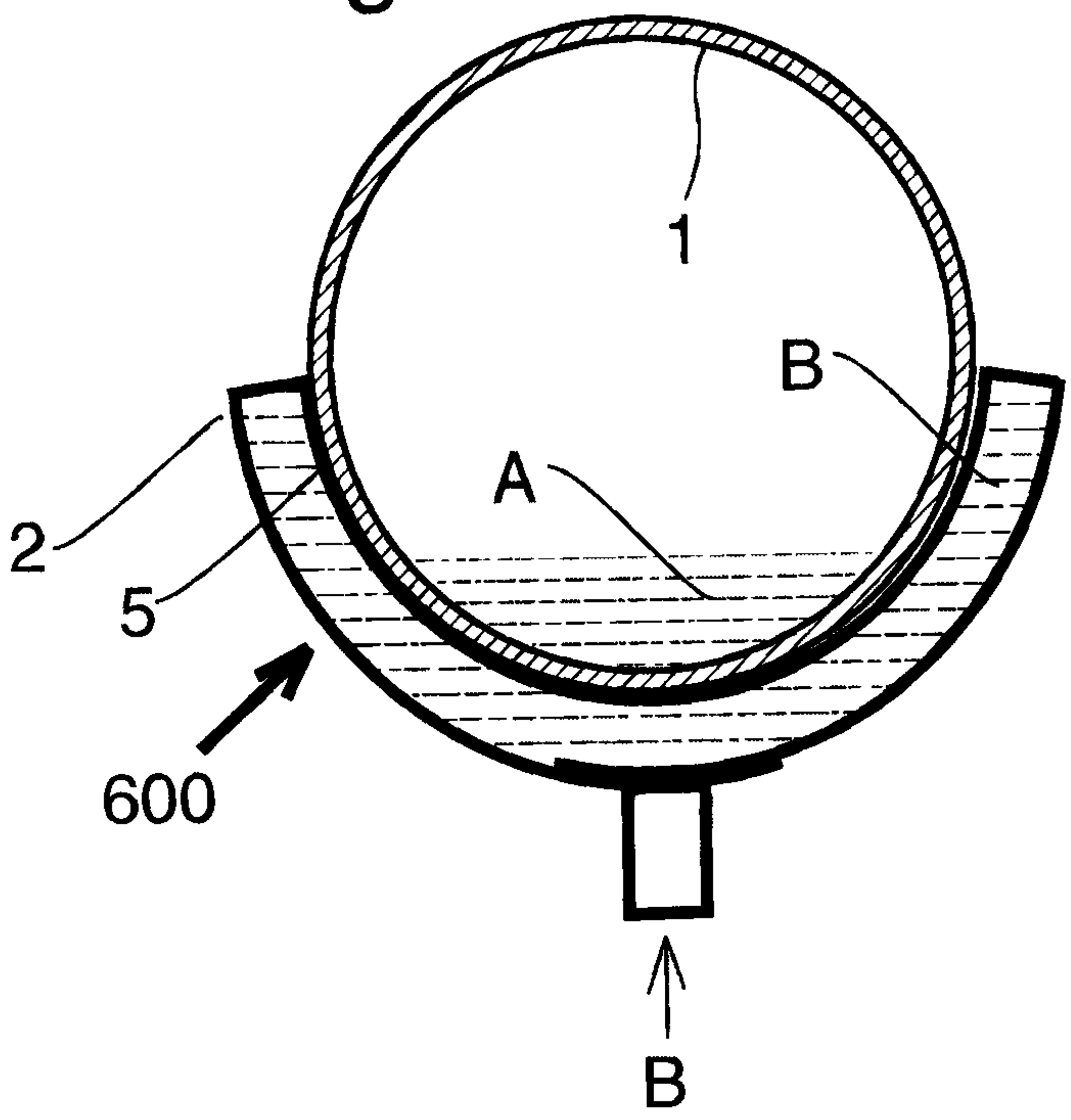
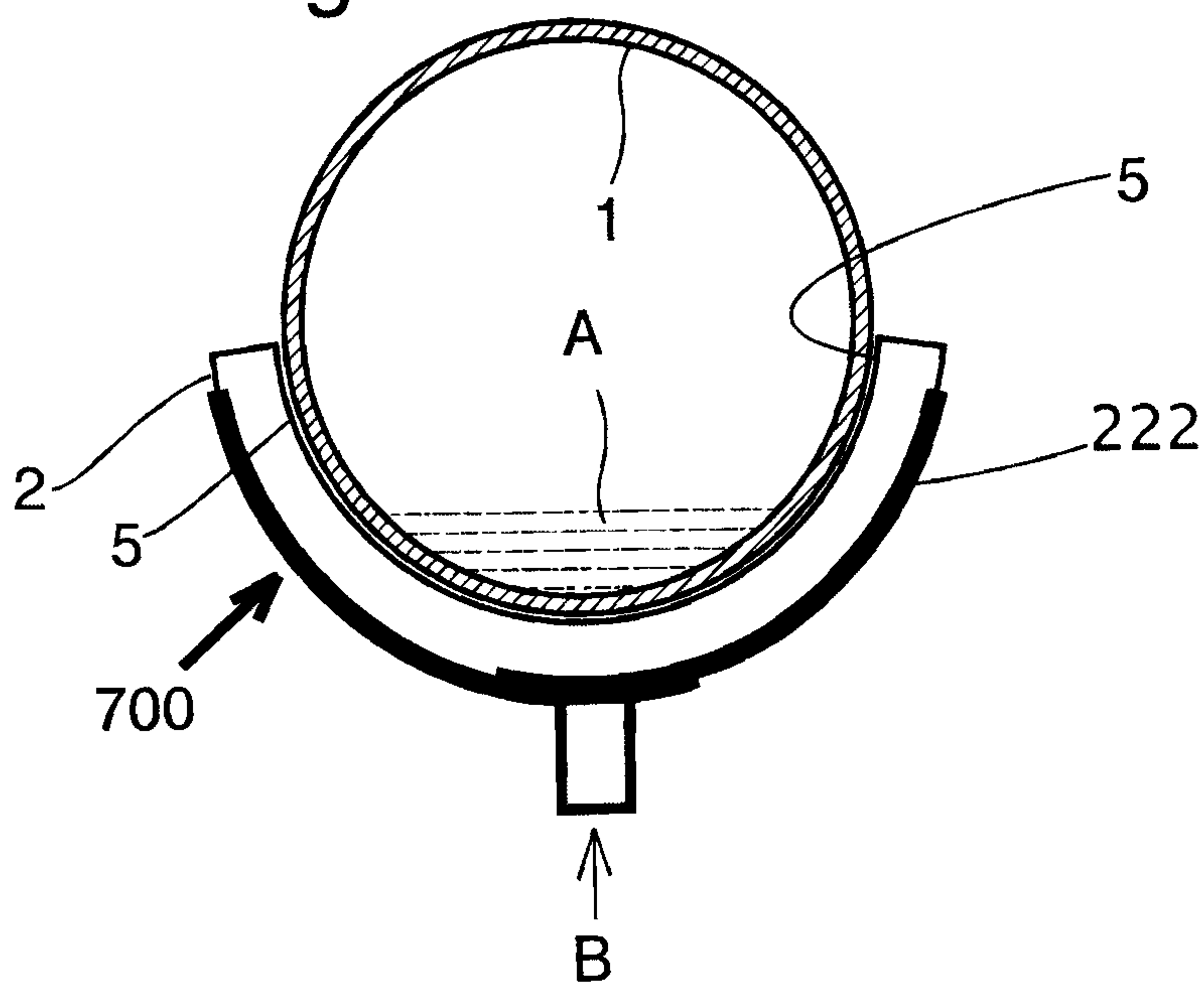
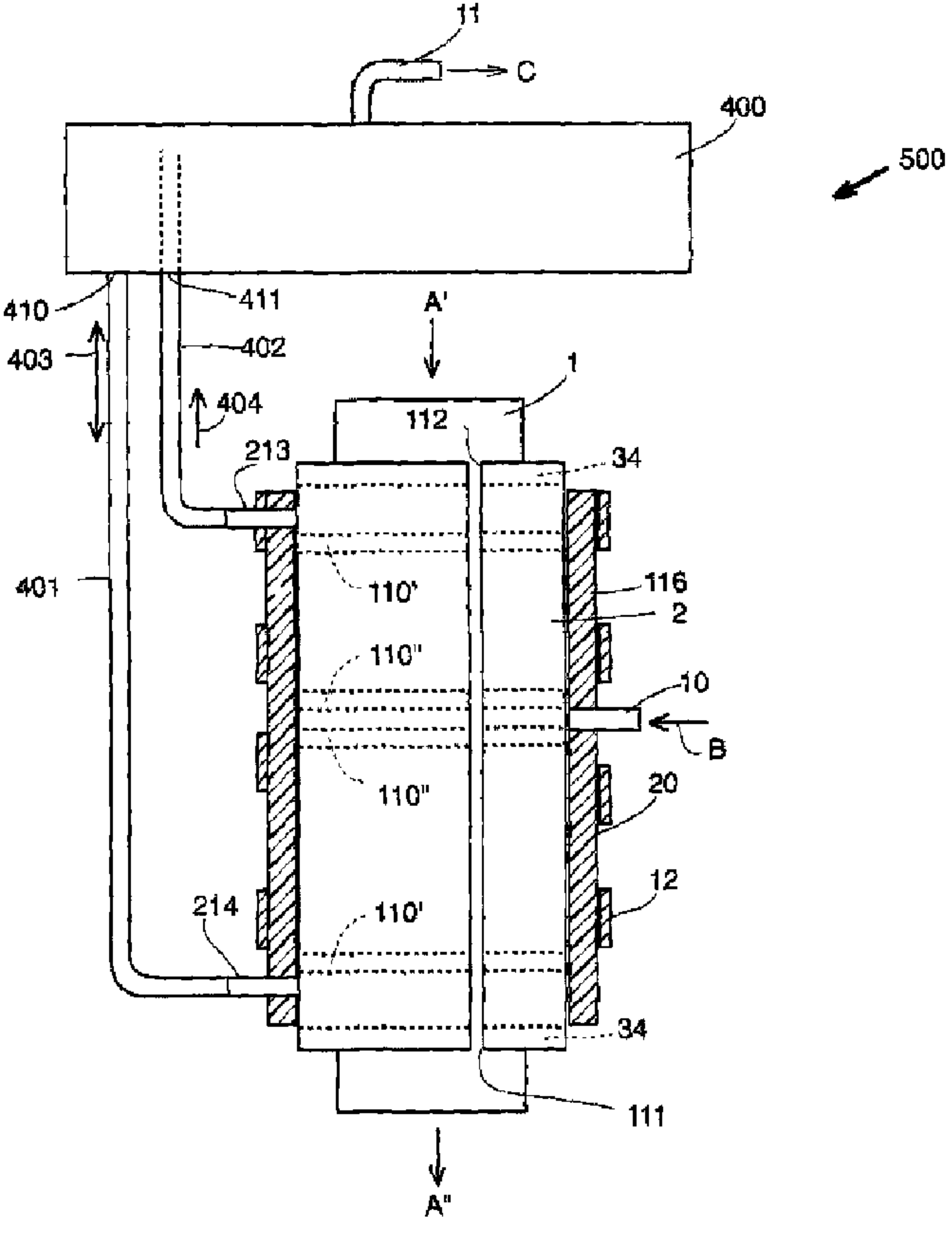


Fig 30





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