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(54) **Metal hollow member and method for manufacturing the same**

(57) A metal hollow member having a plurality of hollow portions extending in a longitudinal direction thereof and communication apertures formed in a partitioning wall partitioning adjacent hollow portions is formed by: extruding a molten extrusion material through a die comprising a female die for forming an outer peripheral portion of the metal hollow member and a male die including a plurality of hollow-portion-forming protrusions corresponding to the plurality of hollow portions; and intermittently supplying fluid insoluble in the molten extrusion material into the partitioning wall from a bottom portion of a groove formed between the adjacent hollow-portion-forming protrusions while extruding the molten extrusion material, whereby the plurality of communication apertures are formed by fluid-released-apertures from which the fluid is released.

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a metal hollow member with a plurality of hollow portions used as, for example, a multi-bored flat tube made of aluminum or its alloy as a heat exchanging tube for heat exchangers, and also relates to a method for manufacturing the metal hollow member.

2. Description of Related Art

[0002] As a condenser for use in car air-conditioners, a laminate type heat exchanger with a core portion 54 as shown in Fig. 11A *is* used widely. The core portion 54 includes a pair of headers 51A and 51B disposed apart from each other at a predetermined distance, a plurality of fiat heat exchanging tubes 52 with both ends in fluid communication with the headers 51A and 51B and corrugated fins 53 arranged in parallel between adjacent heat exchanging tubes 52.

[0003] The heat exchange medium introduced from the inlet 56 passes through the core portion 54 constituted by the heat exchanging tubes 52 in a meandering manner because of the existence of partitions 55 provided in the headers 51A and 51B while exchanging heat with ambient air. In order to enhance the thermal conductivity of the heat exchanging medium passing through the heat exchanging tubes 52, the inside of each heat exchanging tube 52 is generally divided into a plurality of parallel passages to decrease the hydraulic diameter thereof.

[0004] As such an exchanging tube, it is known to use, for example, an extruded tube made of an aluminum or its alloy hollow extruded article, a laminate type tube having a plurality of parallel passages formed by expanding non-joined portions of laminated brazing sheets with compressed air and a tube having parallel passages formed by inserting an corrugated inner fin into a flat tube and brazing the fin therein. Among these heat exchanging tubes, extruded tubes are widely used from the point of view of an easy mass-production. As shown in Fig. 11B, the inside of the extruded tube 52 is divided into a plurality of passages 58a-58d (four passages in the illustrated embodiment shown in Fig. 11B) by a plurality of partitioning walls 52a extending along the longitudinal direction of the tube 52.

[0005] in a condenser including such multi-bored flat tubes 52, however, assuming that air flows in the direction of the arrow (a) as shown in Fig. 11B, the air passing through the core portion 54 becomes higher in temperature by receiving heat from the tubes 52 as the air advances toward the leeward side of the core portion 54. Therefore, the temperature difference between the heat exchanging medium and the ambient air at the most windward side passage 58a of each tube 52 and the most leeward side passage 58d thereof becomes remarkable. Thus, the heat exchanging medium passing through the most windward side passage 58a will be cooled too much by exchanging heat with the low temperature ambient air, resulting in deteriorated heat exchange efficiency as a whole condenser.

[0006] On the other hand, in evaporators, the heat exchanging medium passing through the most windward passage 58a will exchange heat with high temperature ambient air to be overheated, which also deteriorates heat exchange efficiency as a whole evaporator in the same way as in condensers.

[0007] Under the circumstances, for the purpose of enhancing heat exchanging efficiency as a whole heat exchanger, there is a proposal that heat exchanging medium is mixed among the passages of each heat exchanging tube to thereby equalize the temperature of the heat exchanging medium as a whole tube.

[0008] One example for manufacturing such a heat exchanging tube will be explained as follows. As shown in Fig. 12A, first, a hollow extruded member 60 is formed by extrusion so as to have a channel-shaped portion 61 at one side thereof. Then, an aperture-forming chisel 62, etc. is inserted in the tube 60 through the channel-shaped portion 61 along the tube-width direction to form communication apertures 64 in each partitioning wall 52a partitioning adjacent passages 58a-58d, as shown in Fig. 12A. Thereafter, as shown in Fig. 12B, both side pieces 61a and 61a of the channel portion 61 are rounded such that the edges thereof abut against each other, and then the abutted portion 63 is joined by electric-resistance welding, etc. to form a passage 58d.

[0009] Another example for manufacturing the aforementioned heat exchanging tube will be explained as follows. As shown in Fig. 13, first, a pair of extruded members 70a and 70b having cross-sectional configurations corresponding to those obtained by dividing a tube into two parts in the thickness direction are formed by extrusion. Then, cutout portions 72 are formed in the protruding walls, which will constitute partitioning walls 52a of the tube in the aforementioned members, at predetermined intervals. Thereafter, both the extruded members 70a and 70b are placed one on another and brazed to form a heat exchanging tube having communication apertures formed by the cutout portions 72 between adjacent passages.

[0010] According to the aforementioned conventionally proposed multi-bored flat tube, however, it is required to perform the aforementioned aperture-forming processing or the aforementioned cutout-portion-forming processing for forming communication apertures between adjacent passages, and thereafter it is further required to perform the aforementioned bending and welding processing or the aforementioned brazing processing. As will be apparent from the above explanations, since many steps are required to manufacture those tubes, considerable labor and time are required, which increases the manufacturing cost and eliminates the merits of mass-production and cost reduction obtained by using extruded articles.

[0011] In view of the aforementioned circumstances, the inventors of the present invention have repeatedly performed detailed experiments and researches in order to efficiently and economically manufacture a metal hollow member having a plurality of hollow portions extending in the longitudinal direction thereof and communicating apertures by which adjacent hollow portions communicate with each other. Consequently, an epoch-making manufacturing method in which communicating apertures by which adjacent hollow portions communicate with each other can be formed simultaneously with the extrusion of the metal extruded hollow member when manufacturing the metal hollow material as an extruded article, and then the present invention was accomplished.

SUMMARY OF THE INVENTION

[0012] It is an object of the present invention to provide a metal hollow member which is an integrally extruded metal article having a plurality of hollow portions extending in a longitudinal direction thereof and a partitioning wall partitioning adjacent hollow portions provided with communication apertures by which adjacent hollow portions communicate with each other.

[0013] It is another object of the present invention to provide a method for easily manufacturing the aforementioned metal hollow member.

[0014] According to a first aspect of the present invention, a metal hollow member 1 comprises an integrally extruded metal article having a plurality of hollow portions 10 extending in a longitudinal direction of the metal article 1, wherein a partitioning wall 11 partitioning the adjacent hollow portions 10 and 10 is provided with communication apertures 12 by which adjacent hollow portions 10 and 10 communicate with each other at predetermined intervals, the communicating apertures 12 being apertures formed while the partitioning wall 11 is being extruded.

[0015] With this metal hollow member, when fluid is introduced into this metal hollow member, the fluid passing through the hollow portions 10 will be mixed through the communication apertures 12. Accordingly, when the metal hollow member 1 is used as, for example, a heat exchanging tube for heat exchangers, the heat exchanging medium, which usually causes a temperature gradient between the windward side passages (hollow portions) and the leeward side passages (hollow portions), will be mixed each other, causing an equalization of the temperature of the heat exchanging medium in the entire tube, which results in improved heat exchanging efficiency of the heat exchanger as a whole.

[0016] Furthermore, in this metal hollow member 1, the partitioning wall 11 partitioning adjacent hollow portions 10 and 10 is provided with communication aperture 12 formed at the time of the extrusion of the metal hollow member 1. Therefore, it is not required to perform any drilling or cutting processing for forming communication apertures 12, and/or any bending, welding or brazing processing after the extrusion.

[0017] In the aforementioned metal hollow member 1, it is preferable that the plurality of hollow portions 10 are arranged in parallel with each other in a widthwise direction of the extruded metal article and that the communication apertures 12 formed in the adjacent partitioning walls 11 and 11 are shifted each other in a longitudinal direction of the extruded metal article. With this structure, since the fluid passing through the hollow portions 10 will be mixed more efficiently, in cases where the metal hollow member is used as, for example, a heat exchanging tube for heat exchangers, the temperature of the heat exchanging medium passing through the hollow portions 10 will be more equalized in the entire tube, resulting in further enhanced heat exchanging efficiency of the heat exchanger as a whole.

[0018] According to a second aspect of the present invention, a method for manufacturing a metal hollow member 1 having a plurality of hollow portions 10 extending in a longitudinal direction of the metal hollow member 1 and communication apertures 12 formed in a partitioning wall 11 partitioning adjacent hollow portions 10 and 10 includes the steps of: extruding molten extrusion material through a die comprising a female die 3 for forming an external periphery of the metal hollow member 1 and a male die 2 including a plurality of hollow-portion-forming protrusions 2a corresponding to the plurality of hollow portions 10; and intermittently supplying fluid insoluble in the molten extrusion material into the partitioning wall 11 from a bottom portion of a groove formed between the adjacent hollow-portion-forming protrusions 2a while extruding the molten extrusion material, whereby the plurality of communication apertures 12 are formed by fluid-released-apertures from which the fluid is released.

[0019] According to the aforementioned method, the communication apertures 12 are formed in the partitioning wall 11 partitioning adjacent hollow portions 10 and 10 simultaneously with the extrusion of the metal hollow member 1. Therefore, it is not required to perform any drilling or cutting processing for forming communication apertures 10, and/or any bending, welding or brazing processing of an extruded article.

[0020] Furthermore, the aforementioned communication apertures 12 are formed by the fluid-released-apertures from which the fluid is released. Accordingly, the intervals of the communication apertures 12 to be formed in each partitioning wall 11 can be arbitrarily adjusted by controlling the intervals of the fluid supplying (injection) timing. Furthermore, the size of each communication aperture 12 can also be adjusted by controlling each supplying (injection) amount of the fluid, and an oval or elongated communication aperture 12, for example, can also be formed by making each fluid supplying (injection) time longer.

[0021] Furthermore, it is also possible to form the communication apertures 12 of the adjacent partition walls 11 and 11 in a longitudinally shifted manner by controlling the fluid supplying (injection) timing of each fluid outlet 6 or two groups of fluid outlets 6 each group consLituting every other outlets 6, or by differentiating the fluid supplying (injection) timing of the fluid outlets 6 due to the different length of the fluid supplying passage corresponding to each fluid outlet 6.

[0022] In the aforementioned method for manufacturing a metal hollow member, it is preferable that the aforementioned male die 2 comprises a holding die 23, a mandrel 21 including a pair of half-divided base members 20 and 20 held by the holding die 23, a plurality of rigid pins 28 each having a front end constituting the hollow-portion-forming protrusion 2a and pinched between the pair of half-divided base members 20 and 20 along a fore-and-aft direction, a fluid outlet 6 formed at the bottom portion of the groove, and a fluid passage connecting an outside of the male die 2 with the fluid outlet 6, wherein a part of the passage is formed on opposing surfaces of the half-divided base members 20 and 20 at a location between the adjacent rigid pins 28 and 28.

[0023] In this case, it becomes possible to use half-divided base members 20 and 20 made of relatively less expensive materials. Furthermore, when the hollow-portion-forming protrusion 2a is damaged or becomes defective, it is possible to change the rigid pin 28 only. In addition, the mandrel 21 equipped with the fluid passage can be easily manufactured.

[0024] In the aforementioned method for manufacturing a metal hollow member, it is preferable that the male die 2 comprises a holding die 23 including a ring portion 23a, a bridge portion 23b integrally formed in the ring portion 23a so as to cross the ring portion 23a and material introducing holes 25 and 25 formed at both sides of the bridge portion 23a, a mandrel 21 having the plurality of hollow-portion-forming protrusions 2a and inserted into a holding slit 26 formed in the bridge portion 23b, a lid member 22 covering a rear end of the mandrel 21 inserted in the holding slit 26, a fluid outlet 6 formed at the bottom portion of the groove, a fluid passage formed in the holding die 23, the lid member 22 and the mandrel 21 so as to connect an outside of the male die 2 with the fluid outlet 6, and a pipe 9 fitted in a connecting portion connecting a portion of the fluid passage formed in the lid member 22 and a portion of the fluid passage formed in the mandrel 21.

[0025] In this case, since the pipe 9 is fitted in a connecting portion connecting a portion of the fluid passage formed in the lid member 22 and a portion of the fluid passage formed in the mandrel 21, there is no fear that the fluid introduced in the fluid passage leaks from a gap or clearance between the lid member 22 and the mandrel 21 to be mixed into the molten extrusion material via the matcrial introducing holes 25 and 25.

[0026] In the aforementioned method for manufacturing a metal hollow member, it is preferable to use gas as the fluid insoluble in molten extrusion material.

[0027] In this case, although the gas enters into the partitioning wall 11 partitioning adjacent hollow portions 10 and 10 when the metal hollow member 1 is being extruded to form the communication aperture 12, since the gas is automatically diffused into ambient air when the extruded member comes out of the extrusion die D1-D4, it becomes unnecessary to remove the gas after the extrusion as in cases where materials (molten liquid) which solidifies at room temperature is used as the fluid.

[0028] In the aforementioned method for manufacturing a metal hollow member, the fluid passage may include an inlet side passage 7a and a plurality of outlet side passages 75a-75d diverged from the inlet side passage 7a and each communicated with each fluid outlet 6, and wherein adjacent outlet side passages 75a-75d may be different in length, whereby the gases are injected from the adjacent fluid outlets 6 and 6 with a time lag in accordance with a length difference between the adjacent outlet side passages 75a-75d when the gas is introduced into the inlet side passage 7a.

[0029] In this case, since the fluid for forming the communication apertures 12 is the gas with compressibility, when the gas is introduced into the inlet side passage 7a, the propagation time of the pressure to the fluid outlet 6 differs depending on the passage length of the outlet side passages 75a to 75d. As a result, the supplying (injection) timing of the gas from the longer passage will be delay than that of the gas from the shorter passage. Accordingly, the communication apertures 12 will be formed in the adjacent partitioning walls 11 and 11 in a longitudinally shifted manner.

[0030] Other objects and the features will be apparent from the following detailed description of the present invention with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] The present invention will be more fully described and better understood from the following description, taken with the appended drawings, in which:

[0032] Fig. 1 is a partially broken perspective view showing a metal hollow member according to a first embodiment of the present invention;

[0033] Fig. 2 is an entire cross-sectional view showing an extrusion die used for a method of manufacturing a metal hollow member according to a first embodiment of the present invention;

[0034] Fig. 3 is a cross-sectional view taken along the line 3-3 in Fig. 2;

[0035] Fig. 4 is a perspective view showing a mandrel of a male die and a main body of a female die constituting an extrusion die according to the first embodiment;

[0036] Fig. 5 is an entire cross-sectional view showing a second embodiment of an extrusion die used for a method for manufacturing a metal hollow member according to the present invention;

[0037] Fig. 6 is a perspective view showing the mandrel of the male die constituting the extrusion die according to the second embodiment;

[0038] Fig. 7 is an entire cross-sectional view showing a third embodiment of an extrusion die used for a method for manufacturing a metal hollow member according to the present invention;

[0039] Fig. 8 is a cross-sectional view taken along the line 8-8 in Fig. 7;

[0040] Fig. 9A is a cross-sectional view showing a principal part of the extrusion die according to the third embodiment and Fig. 9B is a cross-sectional view taken along the line B-B in Fig. 9A;

[0041] Fig. 10A is a plan view showing a mandrel of an extrusion die according to a fourth embodiment used for a method for manufacturing a metal hollow member according to the present invention, Fig. 10B is an entire front view thereof and Fig. 10C is an entire side view thereof;

[0042] Fig. 11 is an entire front view showing an embodiment of a laminate type heat exchanger according to a related art, and Fig. 11B is a partial perspective view of a core portion of the heat exchanger;

[0043] Figs. 12A and 12B show a conventional method for forming communication apertures in partitioning walls of an extruded multi-bored flat tube, wherein Fig. 12A is a cross-sectional view showing the extruded multi-bored flat tube before the aperture forming processing, and wherein Fig. 12B is a cross-sectional view showing the tube after the communication forming processing; and

[0044] Fig. 13 is an exploded perspective view showing a conventional processing for manufacturing a multi-bored flat tube having communication apertures in partitioning walls.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0045] A metal hollow member and a method for manufacturing the metal hollow member according to the present invention will be explained concretely with reference to the attached drawings.

[0046] Fig. 1 shows an aluminum metal hollow member which can be used as a multi-bored flat tube for heat exchangers, and Figs. 2 to 10 show extrusion dies used for manufacturing the aforementioned metal hollow member.

[0047] The metal hollow member 1 shown in Fig. 1 is a flat tube with rounded lateral ends and includes a plurality of hollow portions 10 (five hollow portions 10 in this illustrated embodiment) partitioned by a plurality of partitioning walls 11 (four partitioning walls in this illustrated embodiment) extending in the longitudinal direction of the tube. Each partitioning wall 11 is provided with communication apertures 12 by which adjacent hollow portions 10 and 10 communicate with each other at certain intervals. The positions of these communication apertures 12 of the adjacent partitioning walls 11 and 11 are shifted in the longitudinal direction of the hollow member 1 to form an alternate arrangement as a whole.

[0048] This metal hollow member 1 is an integrally extruded aluminum alloy article with communication apertures 12 formed during the extrusion. Accordingly, the metal hollow member 1 has no joined portion formed after the extrusion, such as brazed portions or welded portions.

[0049] When such a metal hollow member 1 is used as a multi-bored flat heat exchanging tube for heat exchangers, the heat exchanging medium passing through the parallel hollow portions 10 will be mixed via the communication apertures 12 formed in the partitioning walls 11. Therefore, the temperature of the heat exchanging medium will be equalized in the tube as a whole while exchanging heat with ambient air. Thus, the heat exchanging medium will not be cooled too much in a condenser or overheated too much in an evaporator in the passages (hollow portions) located at the upper stream side of the air flow, resulting in enhanced heat exchanging efficiency as a whole heat exchanger.

[0050] The metal hollow member 1 according to the present invention is not limited to the aforementioned multi-bored flat tube used for heat exchangers as shown in Fig. 1, and can be used as various applications in which communication apertures are required between adjacent hollow portions or the existence of such communication apertures is advantageous. The external configuration of the metal hollow member 1, the number and position of the hollow portions 10, the size and the interval of the communication aperture can be designed arbitrarily according to the application. Furthermore, the communication apertures 12 of the adjacent partitioning walls may be formed at the same longitudinal position of the metal hollow member 1.

[0051] It should be noted, however, that the alternate arrangement of the communication passages 12 of the metal hollow member 1 as shown in Fig. 1 causes the fluid passing through the hollow portions 10 to be more equally mixed via the communication apertures 12. This enhances temperature equalization of the heat exchanging medium as a whole tube, resulting in an improved heat exchanging efficiency of the heat exchanger.

[0052] Figs. 2 and 3 show a first embodiment of an extrusion die D1 used for manufacturing the multi-bored flat metal hollow member 1 as shown in Fig. 1. In these figures, the reference numerals 2 to 5 denote a male die for forming the hollow portions 10 of the metal hollow member 1, a female die for forming the external configuration of the metal hollow member 1, a backup die disposed on the extrusion-front-side surface of the female die 3, and a cylindrical cover surrounding the peripheries of the aforementioned male die 2, female die 3 and backup die 4.

[0053] The male die 2 includes a mandrel 21 made of cemented carbide, a lid member 22, a holding die 23 and an outside ring 24. The female die 3 includes a female die main body 31 made of cemented carbide and a holding ring 32.

[0054] The mandrel 21 of the male die 2 has a generally flat configuration as shown in Fig. 4, and includes a front part 21a integrally provided with a plurality of generally rectangular shaped hollow-portion-forming protrusions 2a disposed parallel with each other at its front end and a relatively thicker and wider rear part 21b. At the bottom of each partitioning-wall-forming groove 2b formed between adjacent hollow-portion-forming protrusions 2a, a fluid outlet 6 is formed. Provided in the mandrel 21 are an inlet side passage 70 formed in the rear part 21b from its one side so as to extend in the widthwise direction and outlet side passages 71 diverted from the inlet side passage 70 and communicated with each fluid outlet 6.

[0055] The holding die 23 constituting the male die 2 includes a ring portion 23a and a bridge portion 23b integrally formed in the ring portion 23a so as to cross the ring portion 23a. Both the spaces beside the bridge portion 23b constitute material introducing holes 25 and 25. The mandrel 21 is fitted in a mandrel holding slit 26 formed in the bridge portion 23b from its backside and held therein, and a lid member 22 is disposed on the rear end of the mandrel 21 so as to cover and seal it. In this state, the mandrel 21 is held in the mandrel holding slit 26 with its front side portion having the hollow-portion-forming protrusions 2a protruded from the mandrel holding slit 26.

[0056] Furthermore, the aforementioned holding die 23 is provided with a pair of engaging keys 23c and 23c at opposing portions of the external periphery of the holding die 23, and is concentrically fitted in the outside ring 24 with the engaging keys 23c and 23c engaged with engaging grooves 24a and 24a formed in the internal periphery of the outside ring 24 in a non-rotatable manner. Drilled through the ring portion 23a, the outside ring 24 and the cylindrical cover 5 disposed outside the outside ring 24 are radially extending fluid passages 7a-7c which are linearly communicated with the inlet side passage 70. These fluid passages 7a to 7c, the inlet side passage 70 and the outlet side passages 71 formed in the mandrel 21 constitute a fluid introducing passage 7 for supplying fluid for forming the communication apertures 12 to the fluid outlets 6 from outside. The reference numeral 8 denotes a fluid introduction tube fitted in the fluid introducing passage 7 from the outside of cylindrical cover 5.

[0057] As also shown in Fig. 4, the main body 31 of the female die 3 has a round external periphery and an extruded article passing elongated hole 31a at the central portion thereof. The elongated hole 31a is gradually enlarged from the rear end thereof towards the front end thereof. At the inner periphery of the rear end of the elongated hole 31a, a protruded edge 31b for forming the external periphery of the aforementioned metal hollow member 1 is integrally formed. The main body 31 is provided with a pair of key grooves 31c and 31c at the opposing positions of the external periphery thereof, and is concentrically fitted in the holding ring 32 in a non-rotatable manner.

[0058] The aforementioned male die 2, the female die 3 and the backup die 4 are concentrically disposed in the cylindrical cover 5 with their end surfaces fitted each other, as shown in Fig. 2 and Fig. 3. An extruded article passing hole 4a formed in the backup die 4 gradually expanding from the rear end side toward the front end side is concentrically disposed in front of the extruded member passing hole 31a of the female die 3. In this arranged state, the tip ends of the hollow-portion-forming protrusions 2a of the mandrel 21 held in the holding die 23 are disposed inside the protruded edge 31b of the extruded article passing elongated hole 31a of the female die 3. Furthermore, between the holding die 23 of the male die 2 and the rear end surface of the main body 31 of the female die 3, a material flow space 27 surrounding the protruded front portion of the mandrel 21 is formed.

[0059] In the aforementioned extrusion die D1, a mouthpiece (not shown) for introducing extrusion material is fitted on the rear face of the holding die 23 of the male die 2. and then molten extrusion material, such as molten aluminum or its alloy, is introduced into the material introducing holes 25 and 25. Thereafter, the extrusion die D1 is incorporated in an extruding machine, and extrusion material is continuously pressed into the extrusion die D1 at a predetermined introducing amount rate to form a metal extruded member 1.

[0060] Thereby, the material extruded from the gap between the external periphery of the hollow-portion-forming protrusions 2a and the internal periphery of the protruded edge 31b of the female die 3 forms the external configuration of the metal extruded member 1. At the same time, the material extruded from each gap between adjacent hollow-portion-forming-protrusions 2a and 2a, i.e., each partitioning-wall-forming groove 2b, forms the partitioning wall 11 of the metal extruded member 1. Thus. the hollow portions 10 corresponding to the hollow-portion-forming protrusions 2a are formed in the metal extruded member 1.

[0061] In the present invention, during the extrusion processing, fluid for forming communication apertures is introduced into the fluid introducing passage 7 from the outside via the fluid introduction tube 8, and this fluid is intermittently injected from each fluid outlet 6. Thus, the fluid enters into the material of the partitioning wall 11 which is being extruded. Accordingly, fluid-released-apertures from which the fluid was released after the extrusion constitute the communication apertures 12 by which adjacent hollow portions 10 and 10 communicate with each other. In this case, however, the communication apertures 12 are formed at the same longitudinal position of all the partitioning walls 11.

[0062] Accordingly, with this method, it becomes completely unnecessary to perform various processing which will be usually required in a conventional method after the extrusion of the metal hollow member, such as drilling processing or cutout processing for forming communication apertures in partitioning walls partitioning adjacent holes, bending processing of the extruded article. welding or brazing processing the extruded article. Furthermore, since the communication apertures 12 are formed by the fluid-released-apertures from which the fluid was released, the intervals of the communication apertures 12 in each partitioning wall 11 can be arbitrarily adjusted by controlling the intermittent injection timing of the fluid. In addition, it is possible to arbitrarily control the size of the communication aperture 12 by adjusting each injection amount of the fluid. Furthermore, for example, an elongated communication aperture 12 can also be formed by setting the injection time longer.

[0063] As the aforementioned fluid for forming the communication apertures, any fluid that is insoluble in molten extrusion material such as aluminum alloy can be use. For example, gas such as air or nitrogen gas, liquid of a high boiling point which will not evaporate at the molten-metal temperature such as a heat-resistant oil or molten liquid which is solid material at normal temperature and is lower in fusing point as compared with the extrusion material, can be used. Among the aforementioned fluid, it is preferable to use gas because of the following reasons. Although gas forms the communication apertures 12 by entering into the material of the partitioning wall 11, the gas formed the communication apertures 12 will be automatically diffused into the ambient air after the extrusion of the extruded article, which eliminates the labor for removing the fluid after the extrusion which will be required in cases where liquid or molten material which solidifies at ordinary temperature is used.

[0064] Next, another embodiments of extrusion dies used for a method of manufacturing the metal hollow member according to the present invention will be explained. In these extrusion dies D2 to D4, the structure is the same as that of the aforementioned embodiment except for the structures of the mandrel 21 of the male die 2 and the fluid introducing passage 7. Accordingly, in the following description, the same reference numeral will be allotted to the portion corresponding to the portion of the extrusion die D1, and the explanation will be omitted.

[0065] The mandrel 21 of the male die 2 of the extrusion die D2 according to the second embodiment shown in Fig. 5 includes a pair of half-divided base members 20 and 20 and rigid pins 28 pinched between the pair of half-divided base members 20 and 20 and disposed parallel with each other along a fore-and-aft directions. The front portion of each rigid pin 28 protruded from the half-divided base members 20 and 20 constitutes the hollow-portion-forming protrusion 2a, and the gap formed between the adjacent rigid pins 28 and 28 constitutes the partitioning-Wall-forming groove 2b.

[0066] In this mandrel 21, as shown in Fig. 6, outlet side passages 72 extending in the fore-and-aft direction are formed on the opposing surfaces of the pair of half-divided base members 20 and 20 pinching the rigid pins 28 therebetween so as to be located between adjacent rigid pins 28 and 26, and the front end of each outlet side passage 72 is opened at the bottom of each partitioning-wall-forming groove 2b as the fluid outlet 6.

[0067] On the other hand, between the rear end surface of the mandrel 21 and the front end surface of the lid member 22, an inlet side passage 73 is formed by a groove formed on the lid member 22. This inlet side passage 73 is communicated with the outlet side passages 72, and the radially extending fluid passages 7a to 7c drilled in the ring portion 23a of the holding die 23, the outside ring 24 and the cylindrical cover 5 are linearly communicated with the inlet side passage 73 to constitute a sequence of fluid introducing passage 7.

[0068] With the aforementioned extrusion die D2, since the load caused when forming the hollow portions during the extrusion processing will be imparted mainly to the rigid pins 28, it becomes possible to use relatively cheap material for the pair of half-divided base members 20 and 20 of the mandrel 21 by using cemented carbide for the rigid pins 28. Furthermore, even if the hollow-portion-forming protrusion 2a is damaged or becomes defective, it is possible to cope with it by replacing only the rigid pin 28, and the manufacturing the mandrel 21 with the fluid outlet side passages 72 can be easily performed. This brings such advantages that the manufacturing and maintaining costs can be decreased.

[0069] In the third embodiment of the extrusion die D3 shown in Figs. 7 to 9, outlet side passages 72 corresponding to the fluid outlets 6 are drilled in the mandrel 21 of the male die 2 in the fore-and-aft direction. On the other hand, the lid member 22 has an inlet side passage 73 linearly communicated with radially extending fluid passages 7a to 7c formed in the ring portion 23a, the outside ring 24 and the cylindrical cover 5 and outlet side passages 72 diverted from the inlet side passage 73 corresponding to the outlet side passages 72 of the mandrel 21. As best shown in Fig. 9A, one end portion of a pipe 9 is fitted in each outlet side passage 74 of the lid member 22, and the remaining portion thereof is fitted in the outlet side passage 72 of the mandrel 21.

[0070] In this extrusion die, since the extrusion die has material introducing holes 25 and 25 at both sides of the bridge portion 23b, if the fluid introduced into the fluid introducing passage 7 with high pressure leaks out via a gap or clearance between the lid member 22 and the mandrel 21. this fluid will be mixed with molten material to cause a deterioration of the quality of the metal hollow member 1. In this extrusion die D3, however, since the pipe 9 is disposed so as to bridge the outlet side passage 74 of the lid member 22 and that of the mandrel 21, there is no fear that the fluid introduced into the fluid introducing passage 7 leaks out from the clearance or gap between the lid member 22 and the mandrel 21, which can prevent a deterioration of the quality of the extruded article due to the mixture of the fluid.

[0071] In an extrusion die D4 according to the fourth embodiment shown in Figs. 10A-10C, similar to the extrusion die D2, the mandrel 21 of the male die 2 includes a pair of half-divided base members 20 and 20 and a plurality of rigid pins 28a-28e having front end portions as the hollow-portion-forming protrusions 2a pinched between the pair of half-divided base members 20 and 20 and arranged in parallel with each other along the fore-and-aft direction. Between the opposing surfaces of the half-divided base members 20 and 20, outlet side passages 75a-75d are formed. The rigid pins 28a-28e are different in length, and the length gradually increases from the shortest pin 28a to the longest pin 28e.

[0072] Furthermore, each of all the outlet side passage 75a-75d extends rearward from respective fluid outlet 6, and makes a right-angled turn at the location slightly behind the back end of each rigid pin 28a-28e to reach one side surface of the mandrel 21. Then, all of the outlet side passages 75a-75d communicate with the inlet side passage 7a of the holding die 23 through the distribution space 76. Thus, the flow length gradually increases from the shortest passage 75a towards the longest passage 75d.

[0073] In the extrusion of the metal hollow member 1 by using the aforementioned extrusion die D4, when gas such as air or nitrogen gas for forming communication passages is intermittently introduced into the fluid introducing passage 7, the pressure propagation time to the fluid outlet 6 differs depending on the length of the fluid passages 75a-75d. Accordingly, for every one introduction of the fluid, the gas will be injected from the outlet 6 of the shortest outlet side passage 75a first, and the ejection timing of the fluid gradually delays towards the longest outlet side passage 75d. Therefore, in the obtained metal hollow member 1, communication apertures 12 of the adjacent partitioning walls 11 are shifted in the longitudinal direction of the member 1.

[0074] In order to form communication apertures 12 in adjacent partitioning walls 11 at the longitudinally different positions, other than the aforementioned method that uses an extrusion die D4 having fluid passages 75a-75d different in length and uses gas as communication forming apertures, it may be possible to adopt a method in which the intermittent fluid injection timing is automatically controlled by fluid open-and-close mechanism, such as a solenoid controlled valve, interposed in the fluid introducing passage for each fluid outlet 6 or every other fluid outlet 6. In this controlling method using the fluid passage open-and-close mechanism, it is possible to use not only gas but also liquid (including molten liquid) as the fluid.

[0075] Furthermore, in the method for manufacturing a metal hollow member according to the present invention, as an extrusion die, it is possible to use not only the aforementioned dies D1 to D4 but also various dies which are different from the aforementioned dies D1-D4 in divided configuration and combination structure of a male die 2 and a female die 3, number, position and cross-section of the hollow-portion-forming protrusion 2a and fluid passage structure of the fluid introducing passage 7,

[0076] The metal hollow member according to the present invention includes an integrally extruded metal article having a plurality of hollow portions 10 extending in a longitudinal direction thereof and a partitioning wall 11 partitioning the adjacent hollow portions 10 and 10 provided with communication apertures 12 by which adjacent hollow portions 10 and 10 are communicated with each other at predetermined intervals. Accordingly, when the metal hollow member 1 is used as, for example, a heat exchanging tube for heat exchangers, the heat exchanging medium, which usually causes a temperature gradient between the windward side passage (hollow portion) and the leeward side passage (hollow portion), will be mixed each other, causing an equalization of the temperature of the heat exchanging medium in the whole tube, which results in improved heat exchanging efficiency as a whole heat exchange. Furthermore, in this metal hollow member 1, since the partitioning wall 11 partitioning adjacent hollow portions 10 and 10 is provided with communication aperture 12 formed at the time of the extrusion of the metal hollow member, it is not required to perform any drilling or cutting processing for forming communication apertures, and/or any bending, welding or brazing processing after the extrusion.

[0077] In cases where the plurality of hollow portions 10 are arranged in parallel with each other in a widthwise direction of the extruded metal article and that the communication apertures 12 formed in the adjacent partitioning walls 11 and 11 are shifted each other in a longitudinal direction thereof, since the fluid passing through the hollow portions 10 will be mixed more efficiently. For example, in cases where the metal hollow member is used as a heat exchanging tube for heat exchangers. the temperature of the heat exchanging medium passing through the hollow portions will be more equalized as a whole tube, resulting in further enhanced heat exchanging efficiency as a whole heat exchanger.

[0078] The method for manufacturing a metal hollow member according to the present invention includes the steps of: extruding molten extrusion material through a die comprising a female die 3 for forming an outer periphery of the metal hollow member 1 and a male die 2 including a plurality of hollow-portion-forming protrusions 2a corresponding to the plurality of hollow portions 10; and intermittently supplying fluid insoluble in the molten extrusion material into the partitioning wall 11 from a bottom portion of a groove formed between the adjacent hollow-portion-forming protrusions 2a while extruding the molten extrusion material, whereby the plurality of communication apertures 12 are formed by fluid-released-apertures from which the fluid is released.

[0079] Accordingly, the communication apertures 12 are formed in the partitioning wall 11 partitioning adjacent hollow portions 10 and 10 simultaneously with the extrusion of the metal hollow member 1. Therefore, it is not required to perform any drilling or cutting processing for forming communication apertures, and/or any bending, welding or bsazing processing of an extruded article. Furthermore, since the aforementioned communication apertures 12 are formed by the fluid-released-apertures from which the fluid is released, the intervals of the communication apertures 12 to be formed in each partitioning wall 11 can be arbitrarily adjusted by controlling the intervals of the fluid supply (injection) timing. Furthermore, the size of each communication aperture 12 can also be adjusted by controlling each injection amount of the fluid, and an oval or elongated communication aperture 12, for example, can also be formed by making the fluid injection time longer.

[0080] Furthermore, it is also possible to form the communication apertures 12 in the adjacent partition walls 11 and 11 in a longitudinally shifted manner by controlling the fluid supply (injection) timing of each fluid outlet 6 or two groups of fluid outlets 6 each group constituting every other outlets 6, or by differentiating the fluid supply (injection) timing of each fluid outlet 6 due to the different length of the fluid passage corresponding to each fluid outlet 6.

[0081] In cases where the aforementioned male die 2 comprises a holding die 23, a mandrel 21 including a pair of half-divided base members 20 and 20 held by the holding die 23, a plurality of rigid pins 28 each having a front end constituting the hollow-portion-forming protrusion 2a and pinched between the pair of half-divided base members 20 and 20 along a fore-and-aft direction, a fluid outlet 6 formed at the bottom portion of the groove, and a fluid passage connecting an outside of the male die with the fluid outlet 6, wherein a part of the passage is formed on opposing surfaces of the half-divided base members 20 and 20 at a location between the adjacent rigid pins 28 and 28, it becomes possible to use half-divided base members 20 and 20 made of relatively less expensive materials. Furthermore, when the hollow-portion-forming protrusion 2a is damaged or becomes defective, it is possible to change the rigid pin 28 only. In addition, the mandrel 21 equipped with the fluid passage can be easily manufactured.

[0082] Furthermore, in cases where the male die 2 comprises a holding die 23 including a ring portion 23a, a bridge portion 23b integrally formed in the ring portion 23a so as to cross the ring portion and material introducing holes 25 and 25 formed at both sides of the bridge portion 23a, a mandrel 21 having the plurality of hollow-portion-forming protrusions 2a, the mandrel 21 being inserted into a holding slit 26 formed in the bridge portion 23b, a lid member 22 covering a rear end of the mandrel 21 inserted in the holding slit 26, a fluid outlet 20 formed at the bottom portion of the groove, a fluid passage formed in the holding die 23, the lid member 22 and the mandrel 21 so as to connect an outside of the male die 2 with the fluid outlet 6, and a pipe 9 fitted in a connecting portion connecting a portion of the fluid passage formed in the lid member 22 and a portion of the fluid passage formed in the mandrel 21, since the pipe 9 is fitted in a connecting portion connecting a portion of the fluid passage formed in the lid member 22 and a portion of the fluid passage formed in the mandrel 21, there is no fear that the fluid introduced in the fluid passage leaks from a gap or clearance between the lid member 22 and the mandrel 21 to be mixed into the melt extrusion material via the material introducing holes 25 and 25.

[0083] In cases where fluid insoluble in molten extrusion material is used as the aforementioned fluid, although the gas enters into the partitioning wall 11 partitioning adjacent hollow portions 10 and 10 when the metal hollow member 1 is being extruded to form the communication aperture 12, since the gas is automatically diffused into the ambient air when the extruded member comes out of the extrusion die D1-D4, it becomes unnecessary to remove the gas after the extrusion like in cases where materials (molten liquid) which solidifies at room temperature is used as the fluid.

[0084] In cases where the fluid passage includes an inlet side passage 70 and a plurality of outlet side passages 75a-75d diverged from the inlet side passage 70 and each communicated with each of the fluid outlet 6, and wherein adjacent outlet side passages 75a-75d are different in length, whereby the gas is injected from the adjacent fluid outlets 6 and 6 with a time lag in accordance with a length difference between the adjacent outlet side passages 75a-75d when the gas is introduced into the inlet side passage 70, since the fluid for forming the communication apertures 12 is gas with compressibility, when the gas is introduced into the inlet aide passage 70, the propagation time of Lhe pressure to the fluid outlet 6 differs depending on the passage length of the outlet side passages 75a to 75d. As a result, the injection timing of the gas from the longer passage will be delay than that of the gas from the shorter passage. Accordingly, the communication apertures 12 will be formed in the adjacent partitioning walls 11 and 11 in a longitudinally shifted manner.

[0085] This application claims priority to Japanese Patent Applications Nos. 2000-201746 filed on July 4, 2000, the disclosure of which is incorporated by reference in its entirety.

[0086] The terms and descriptions in this specification are used only for explanatory purposes and the present invention is not limited to these terms and descriptions. It should be appreciated that there are many modifications and substitutions without departing from the spirit and the scope of the present invention which is defined by the appended claims.

Claims

1. A metal hollow member, comprising:

an integrally extruded metal article having a plurality of hollow portions extending in a longitudinal direction of said metal article,

wherein a partitioning wall partitioning adjacent hollow portions is provided with communication apertures by which said adjacent hollow portions are communicated with each other at predetermined intervals, said communicating apertures being apertures formed while said partitioning wall is being extruded.

2. The metal hollow member as recited in claims 1, wherein said plurality of hollow portions are arranged in parallel with each other in a widthwise direction of said extruded metal article, and wherein said communication apertures formed in adjacent partitioning walls are shifted each other in a longitudinal direction of said extruded metal article.

3. The metal hollow member as recited in claim 1, wherein said communication aperture is a fluid-released-aperture formed by fluid entered into said partitioning wall while said partitioning wall is being extruded and then released therefrom, and wherein said fluid is insoluble in molten extrusion material of said metal article.

4. The metal hollow member as recited in claim 2, wherein said communication portion is a fluid-released-aperture formed by fluid entered into said partitioning wall while said partitioning wall is being extruded and then released therefrom, and wherein said fluid is insoluble in molten extrusion material of said metal article.

5. The metal hollow member as recited in claim 1. wherein said communication aperture is a gas-released-aperture formed by gas entered into said partitioning wall while said partitioning wall is being extruded and then released therefrom.

6. The metal hollow member as recited in claim 2, wherein said communication aperture is a gas-released-aperture formed by gas entered into said partitioning wall while said partitioning wall is being extruded and then released therefrom.

7. The metal hollow member as recited in any one of claims 1 to 6, wherein said metal hollow member is a multi-bored flat tube for use in heat exchangers.

8. The metal hollow member as recited in claim 7, wherein said metal hollow member is made of aluminum or its alloy.

9. A method for manufacturing a metal hollow member having a plurality of hollow portions extending in a longitudinal direction of said metal hollow member and a plurality of communication apertures formed in a partitioning wall partitioning adjacent hollow portions, said method. comprising:

extruding molten extrusion material through a die comprising a female die for forming an outer peripheral portion of said metal hollow member and a male die including a plurality of hollow-portion-forming protrusions corresponding to said plurality of hollow portions; and
intermittently supplying fluid insoluble in said molten extrusion material into said partitioning wall from a bottom portion of a groove formed between said adjacent hollow-portion-forming protrusions while extruding said molten extrusion material, whereby said plurality of communication apertures are formed by fluid-released-apertures from which said fluid is released.

10. The method for manufacturing a metal hollow member as recited in claim 9, wherein said male die comprises a fluid outlet formed at said bottom portion of said groove and a fluid passage connecting an outside of said male die with said fluid outlet.

11. The method for manufacturing a metal hollow member as recited in claim 9, wherein said male die comprises:

a holding die;

a mandrel including a pair of half-divided base members held by said holding die;
a plurality of rigid pins each having a front end constituting said hollow-portion-forming protrusion and pinched between said pair of half-divided base members along a fore-and-aft direction;
a fluid outlet formed at said bottom portion of said groove; and
a fluid passage connecting an outside of said male die with said fluid outlet,

wherein a part of said fluid passage is formed on opposing surfaces of said half-divided base members at a location between said adjacent rigid pins.

12. The method for manufacturing a metal hollow member as recited in claim 9, wherein said male die comprises:

a holding die including a ring portion, a bridge portion integrally formed in said ring portion so as to cross said ring and material introducing holes formed at both sides of said bridge portion;

a mandrel having said plurality of hollow-portion-forming protrusions, said mandrel being inserted into a holding slit formed in said bridge portion;

a lid member covering a rear end of said mandrel inserted in said holding slit;

a fluid outlet formed at said bottom portion of said groove;

a fluid passage formed in said holding die, said lid member and said mandrel so as to connect an outside of said male die with said fluid outlet; and

a pipe fitted in a connecting portion connecting a portion of said fluid passage formed in said lid member and a portion of said fluid passage formed in said mandrel.

13. The method for manufacturing a metal hollow member as recited in any one of claims 9 to 12, wherein gas insoluble in molten extrusion material is used as said fluid.

14. The method for manufacturing a metal hollow member as recited in claim 13, wherein said fluid passage includes an inlet side passage and a plurality of outlet side passages diverged from said inlet side passage and each communicated with each of said fluid outlets, and wherein adjacent outlet side passages are different in length, whereby said gases are injected from said adjacent fluid outlets with a time lag in accordance with a length difference between said adjacent outlet side passages when said gas is introduced into said inlet side passage.

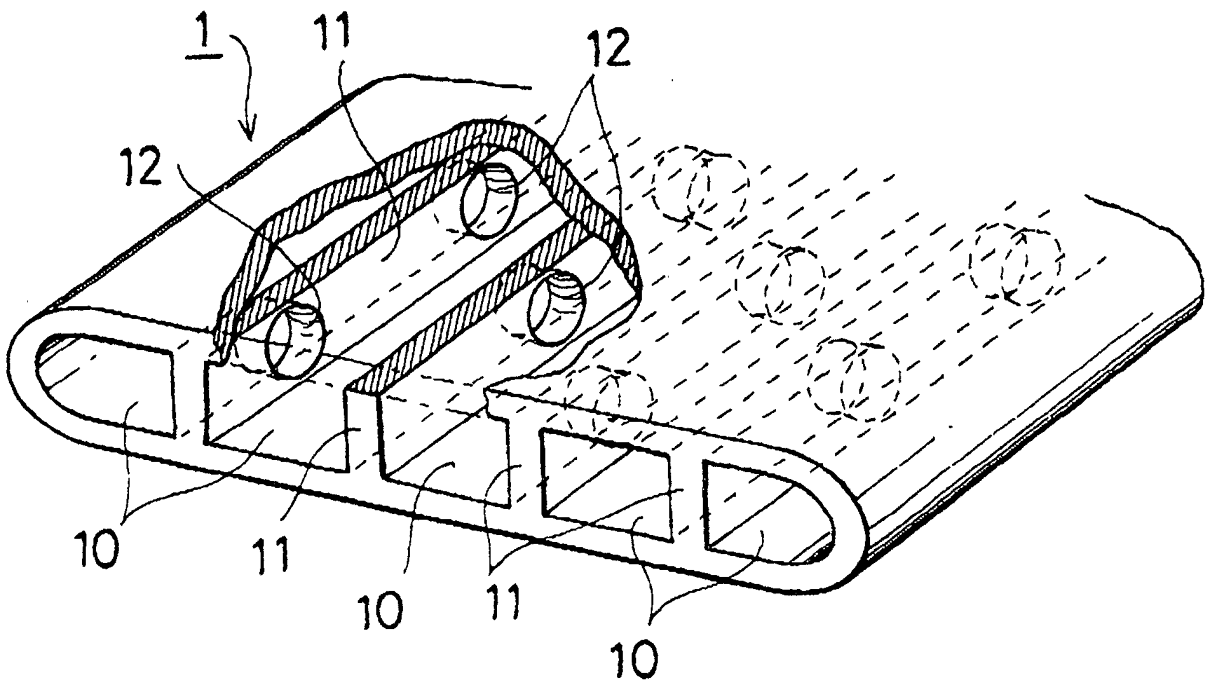
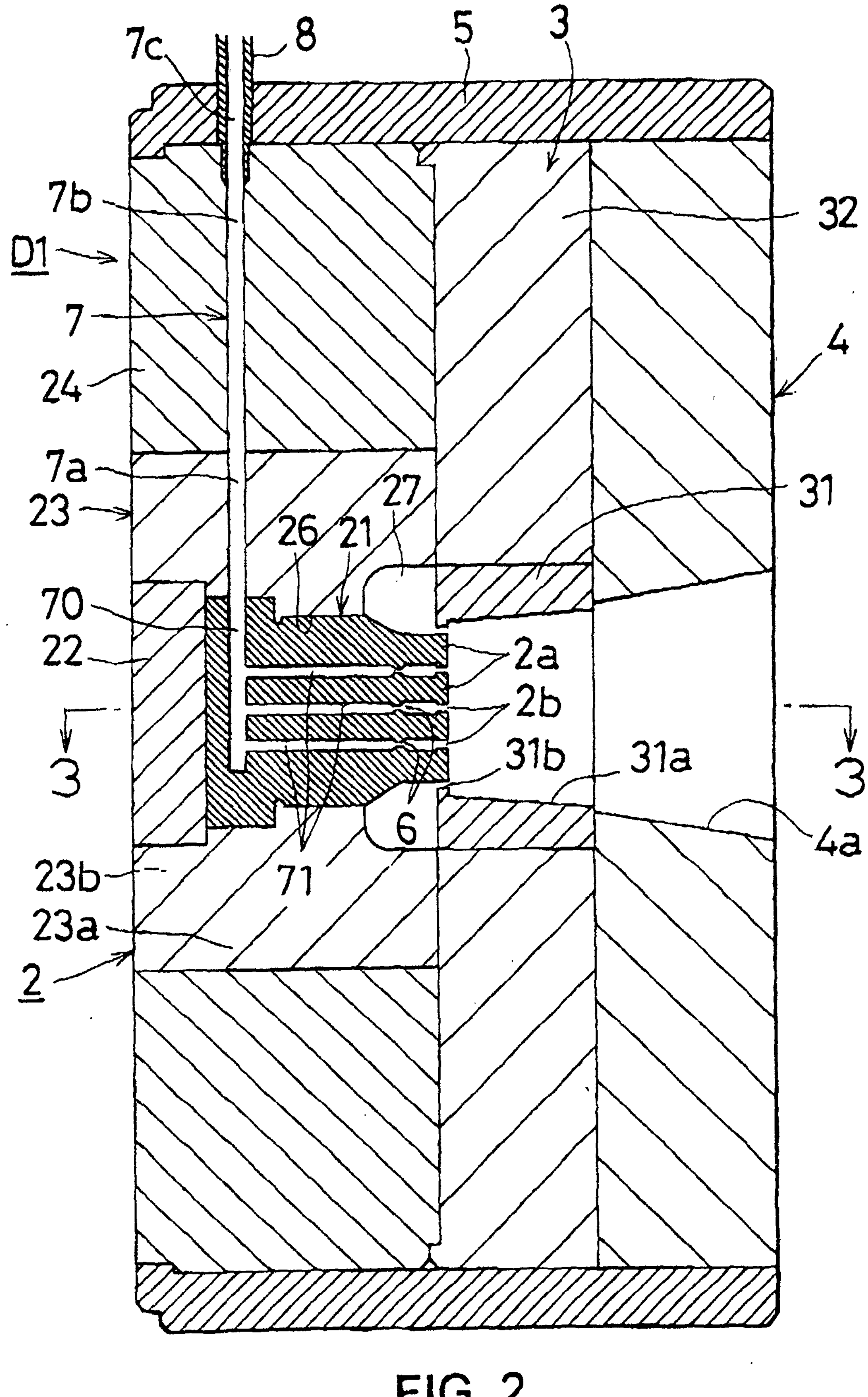


FIG. 1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7b
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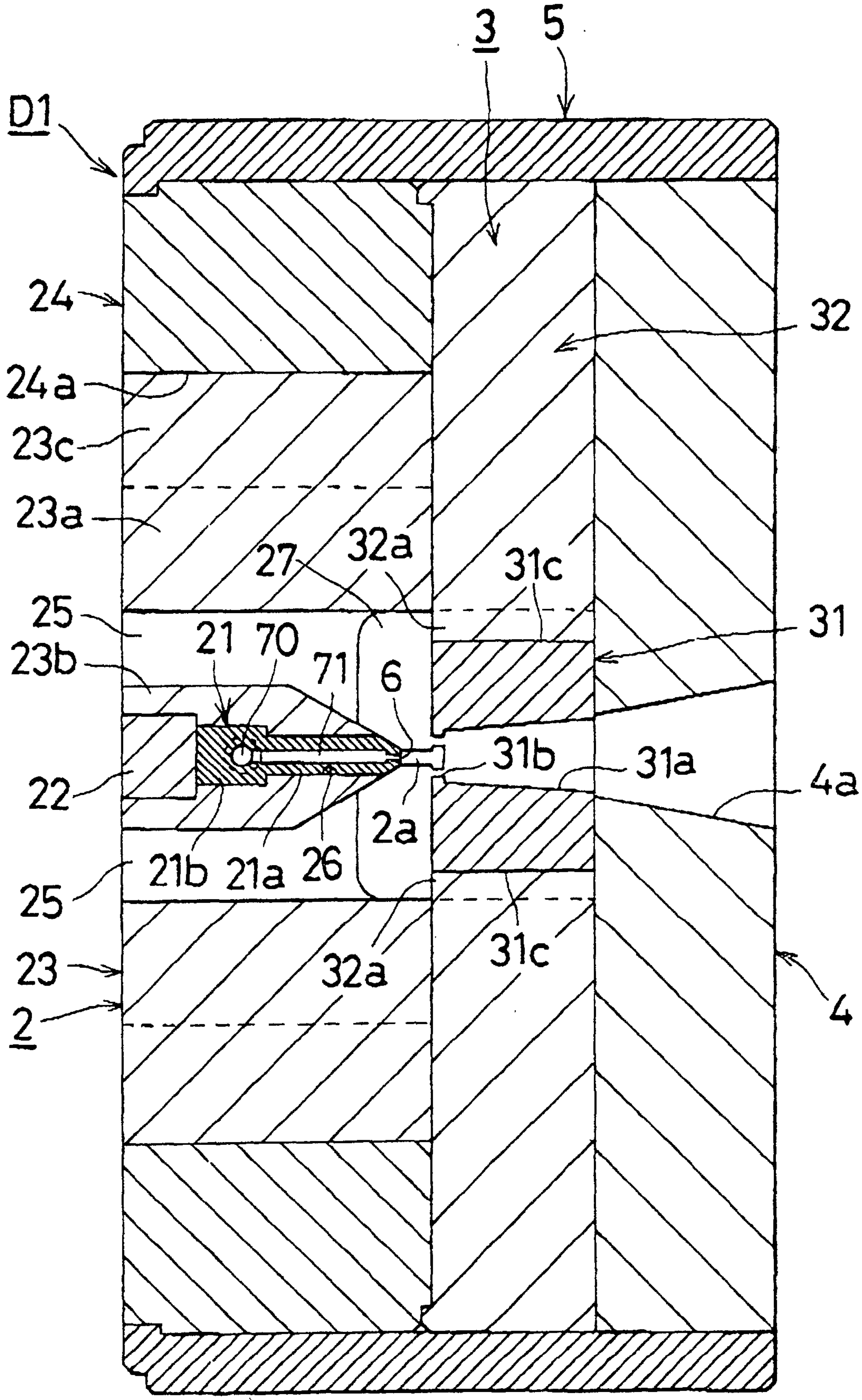
2

FIG. 2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2
4

FIG. 3

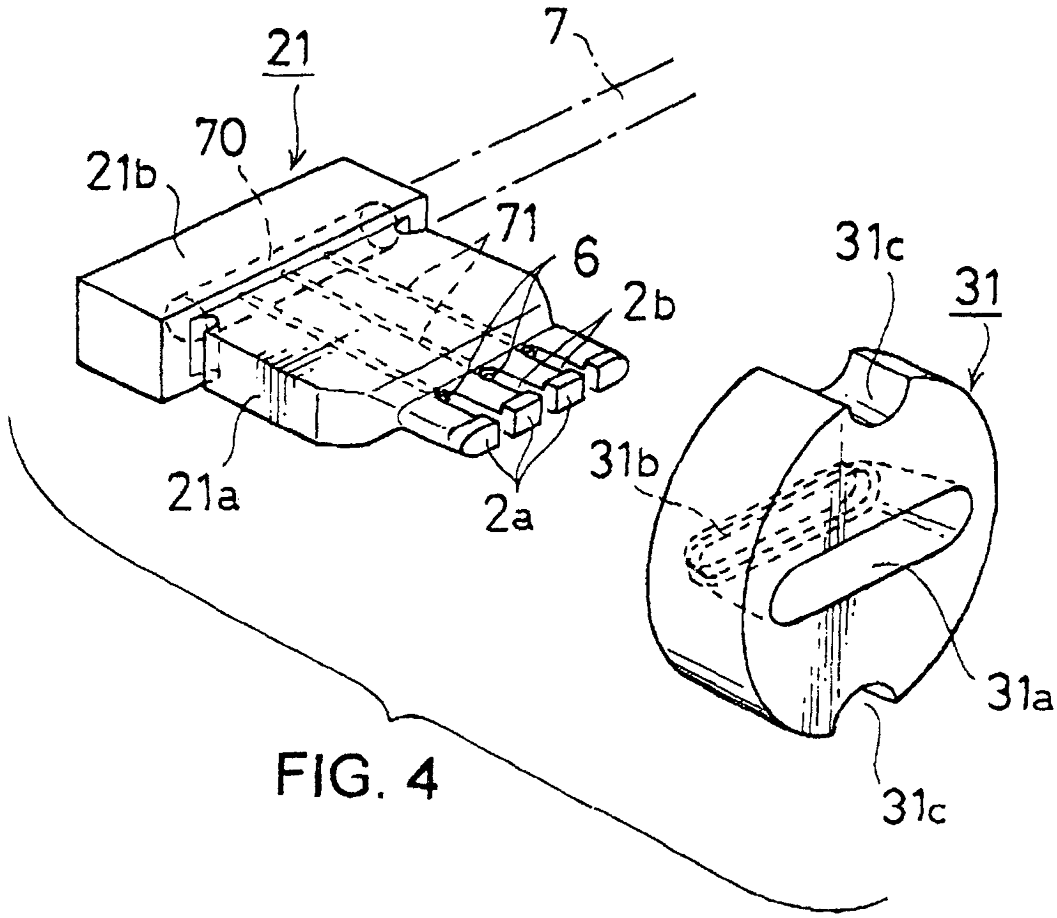
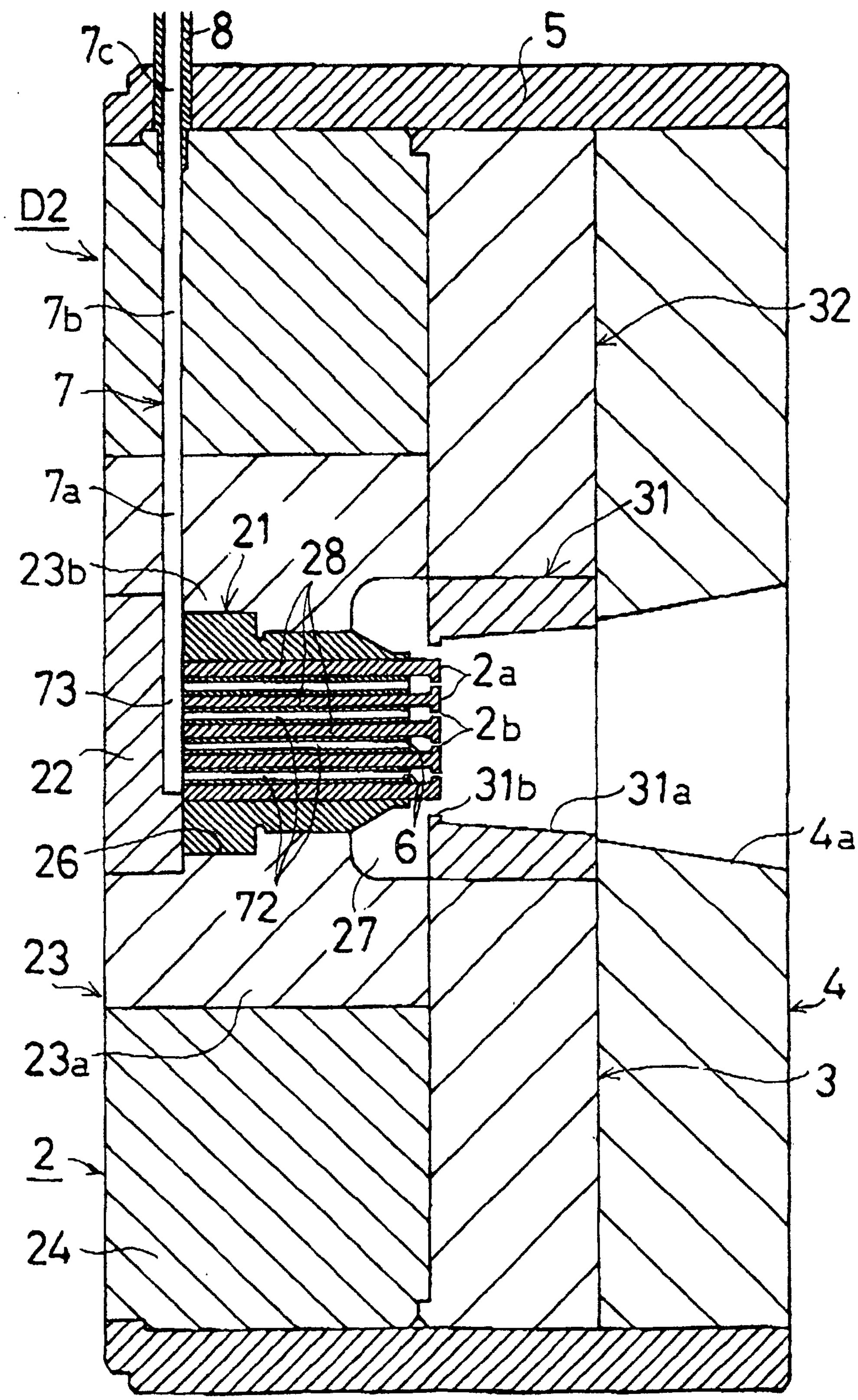


FIG. 4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26
6
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27
23
4
23a
3
2
24

FIG. 5

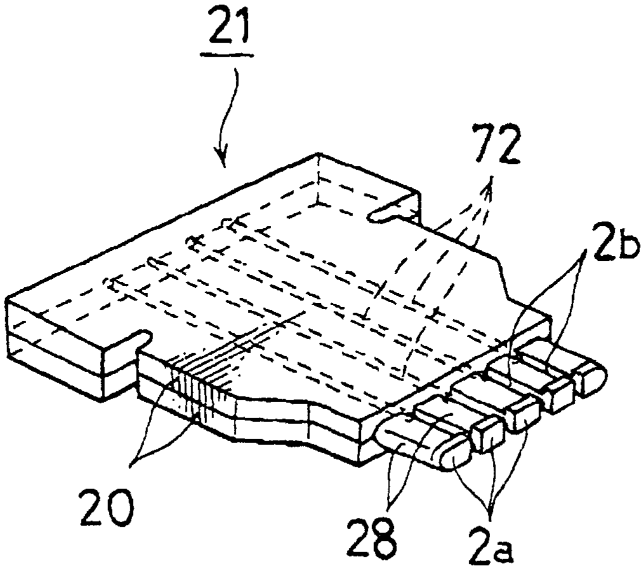
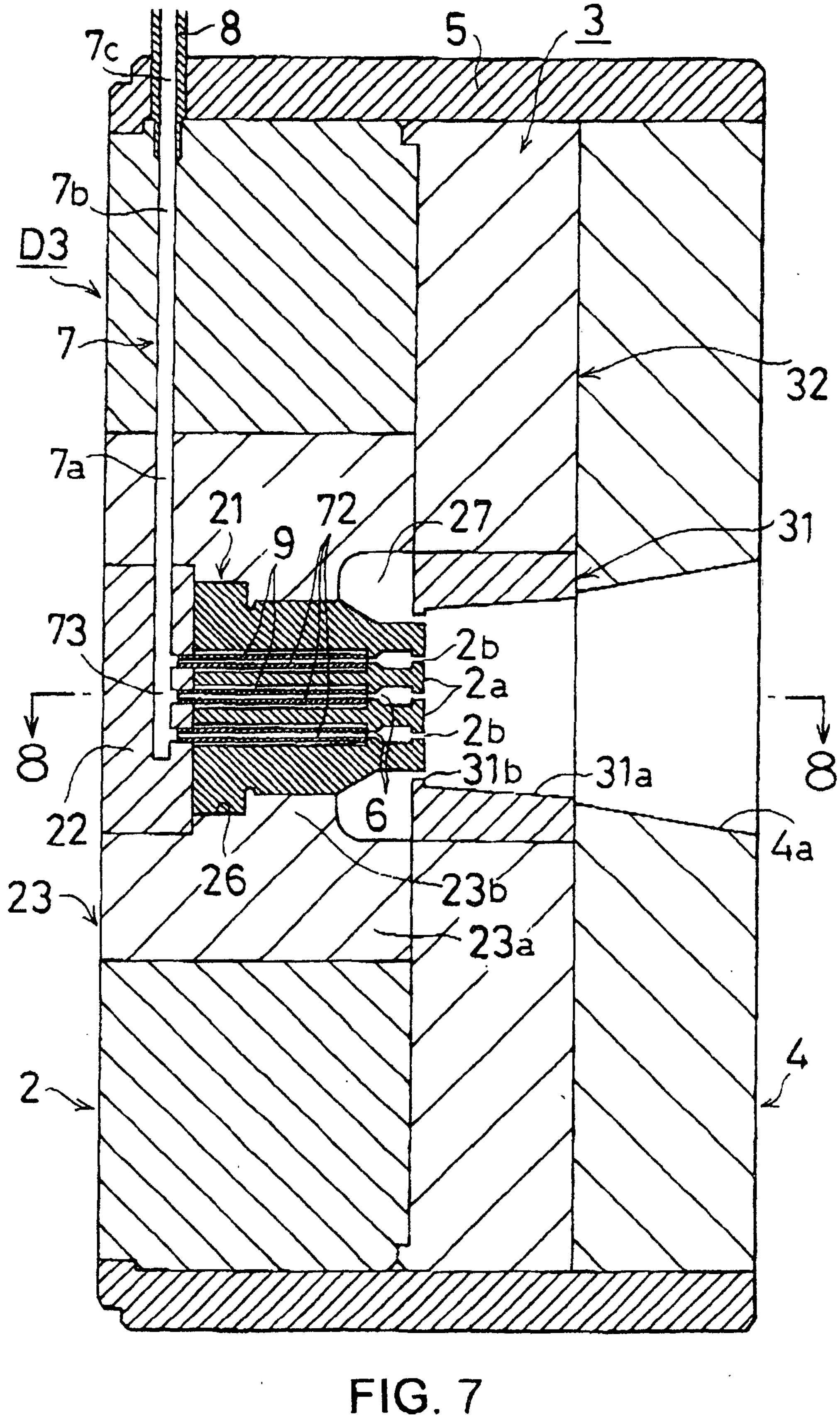


FIG. 6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31
73
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26
23b
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23a
4
2

FIG. 7

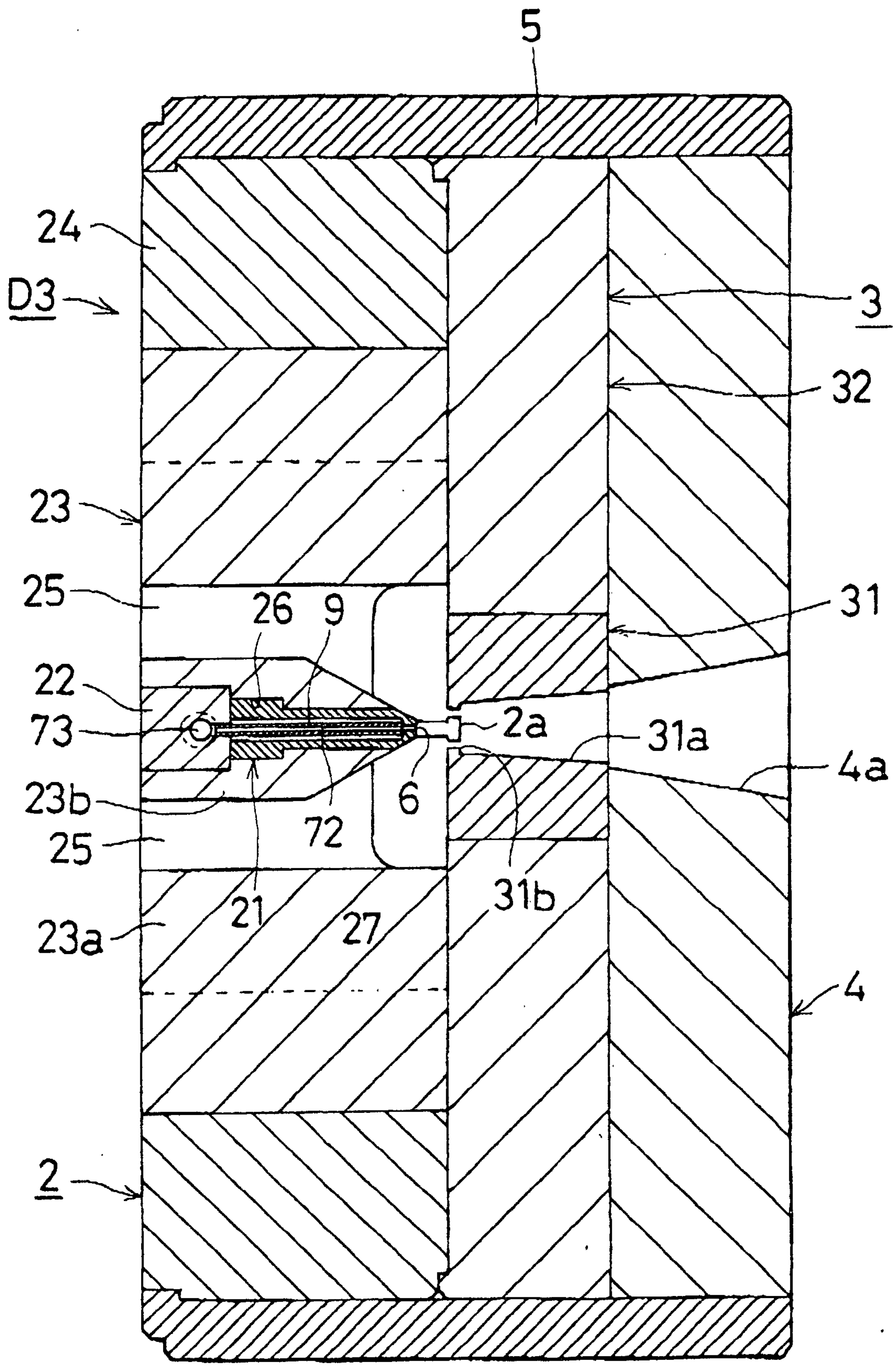

FIG. 8

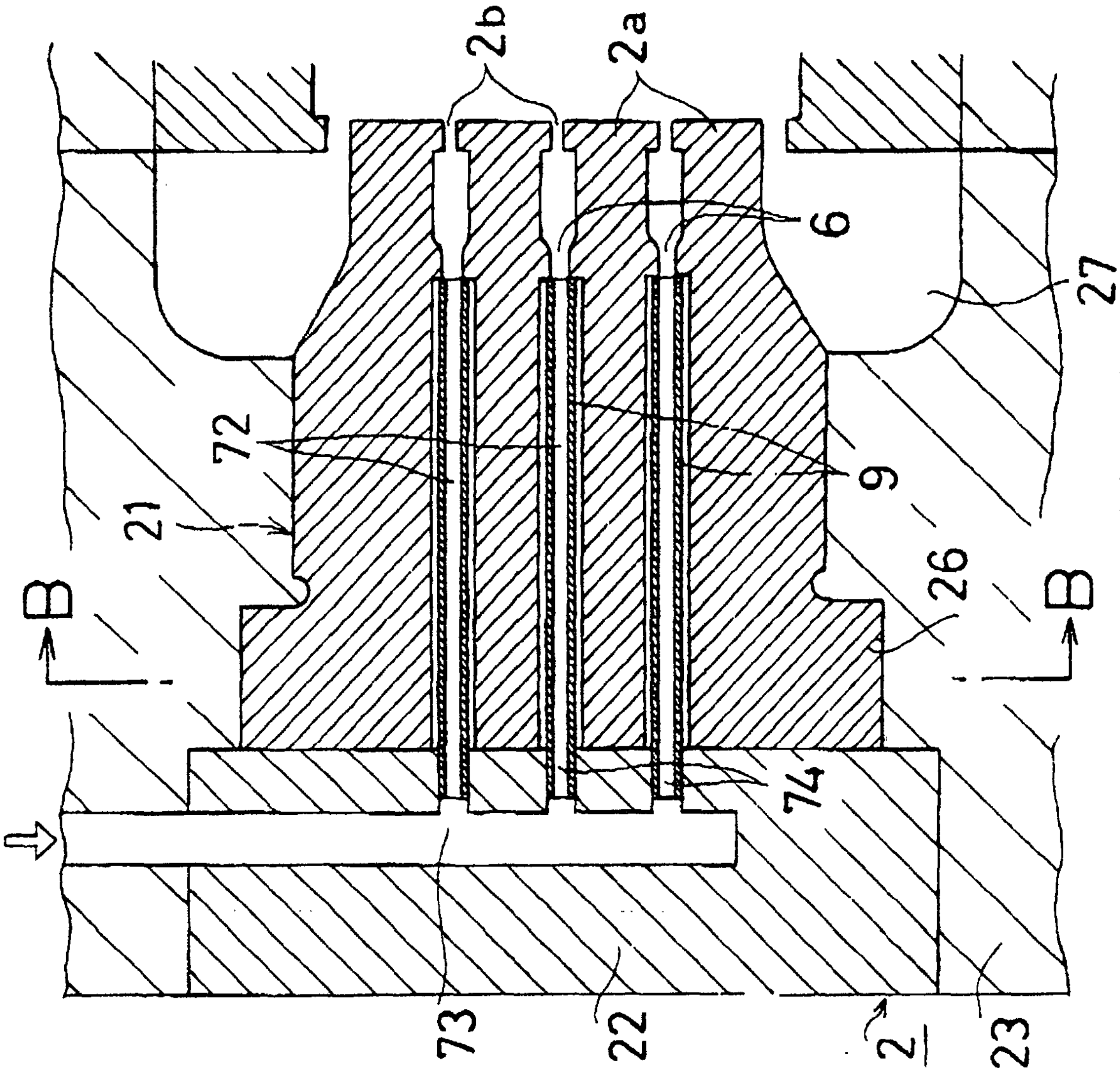

FIG. 9A

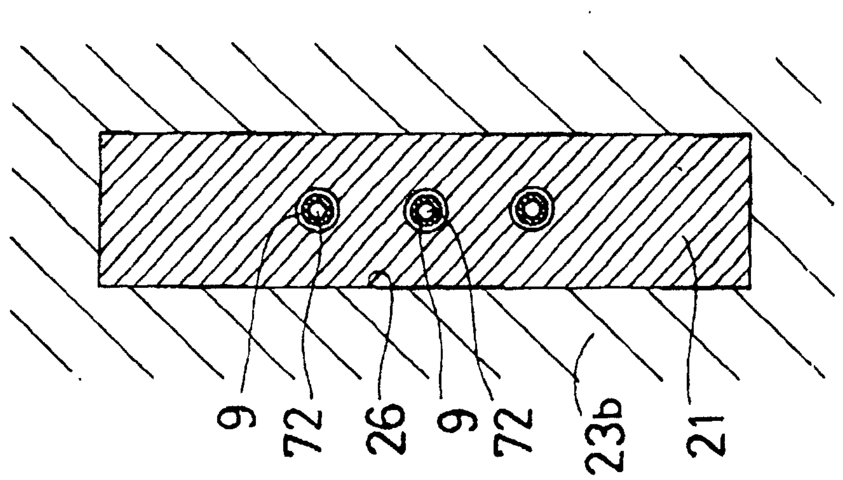

FIG. 9B

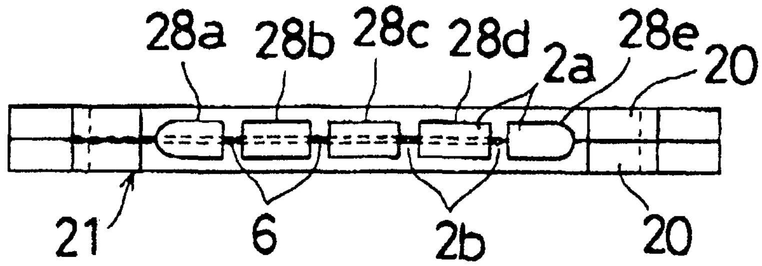

FIG.10B

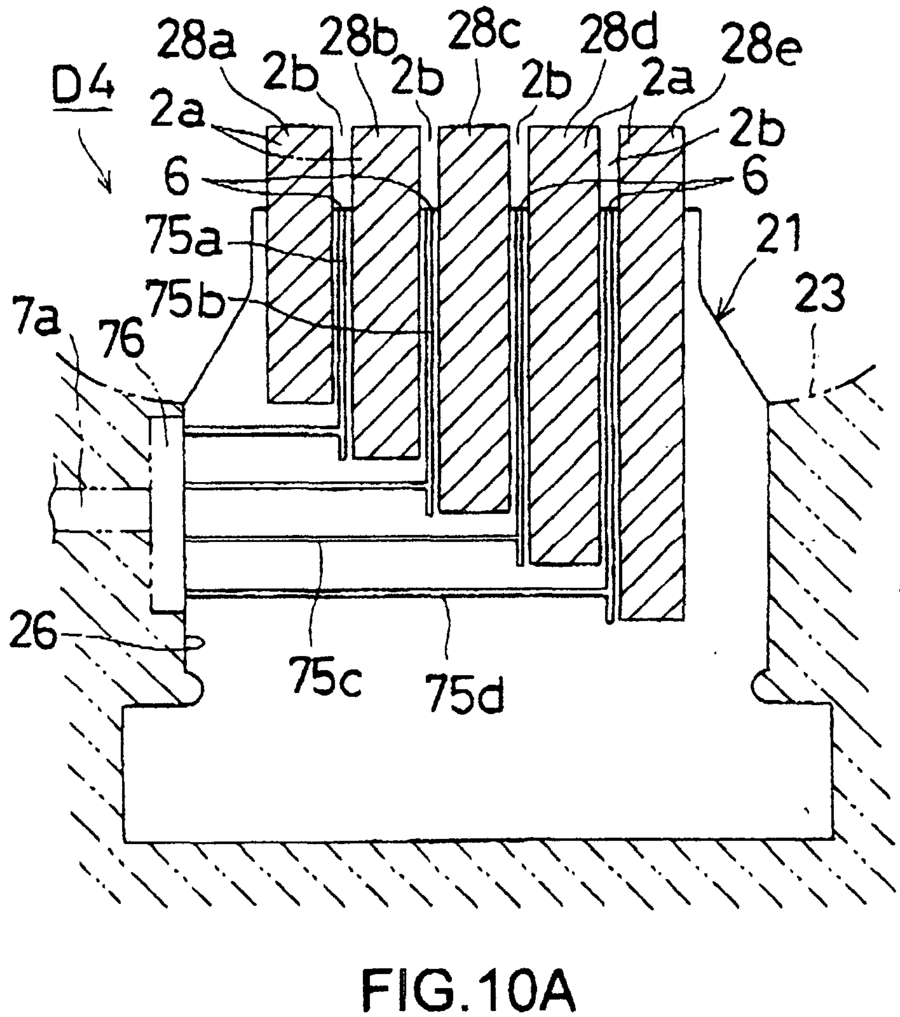

FIG.10A

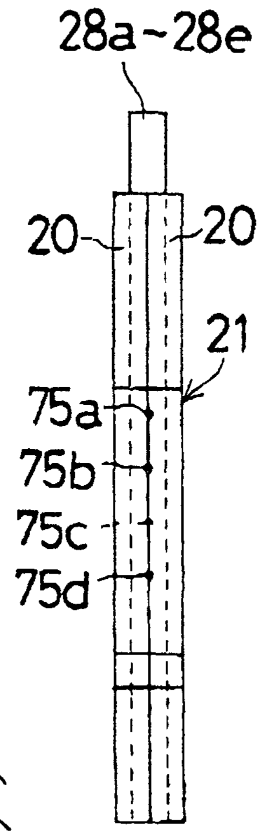

FIG.10C

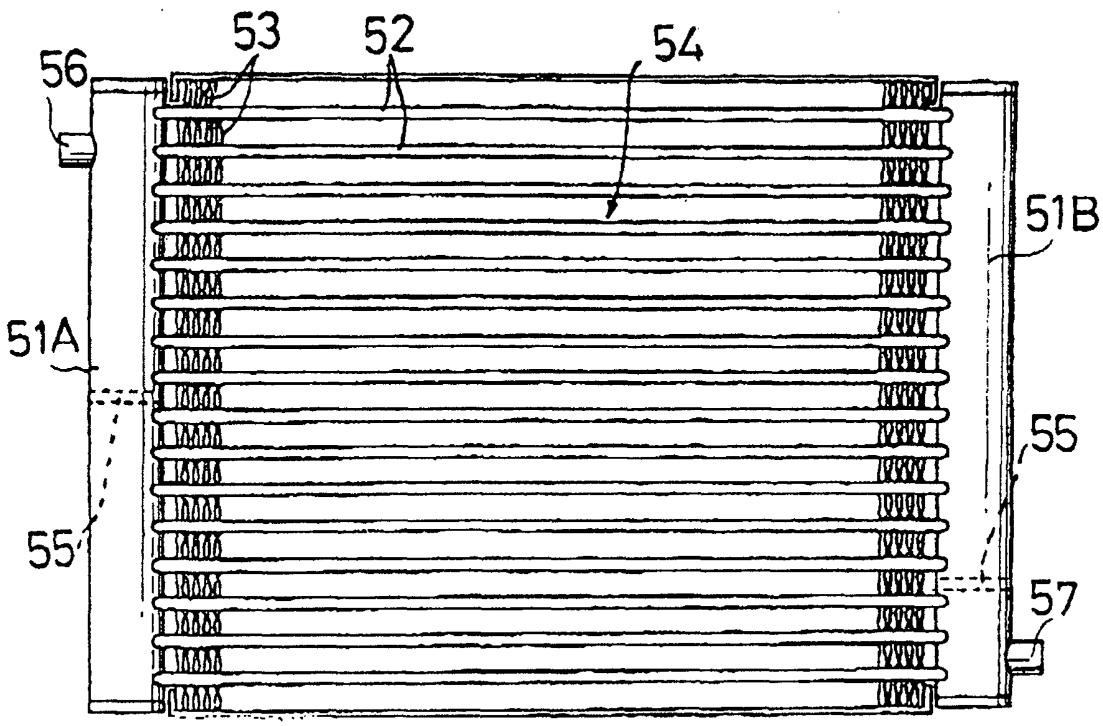

FIG.11A
(RELATED ART)

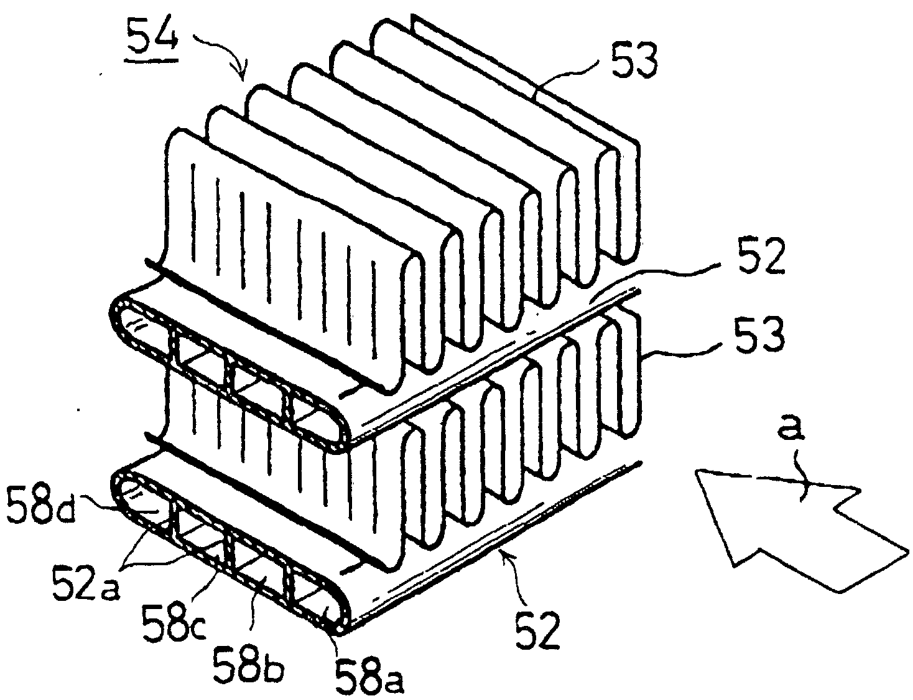

FIG.11B
(RELATED ART)

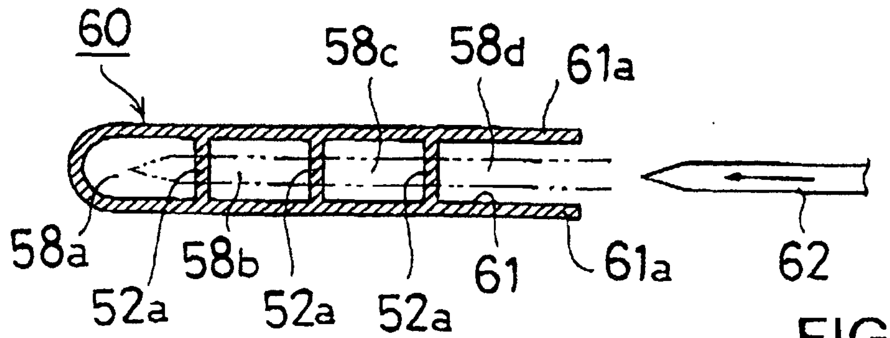

FIG.12A
(RELATED ART)

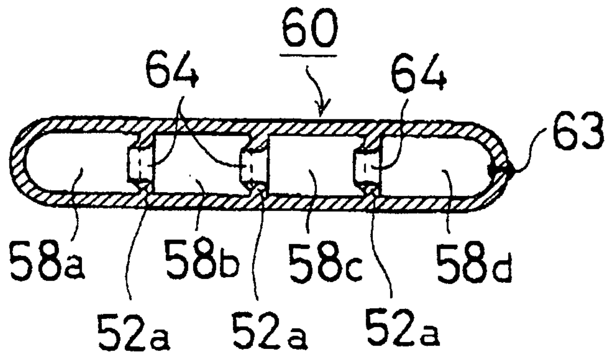

FIG.12B
(RELATED ART)

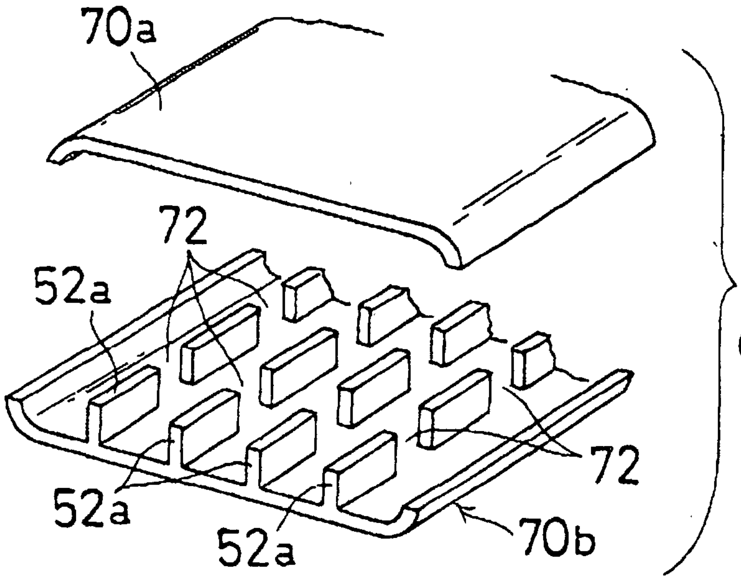

FIG.13
(RELATED ART)