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(54) EXTRUSION OF A METAL ALLOY CONTAINING COPPER AND ZINC

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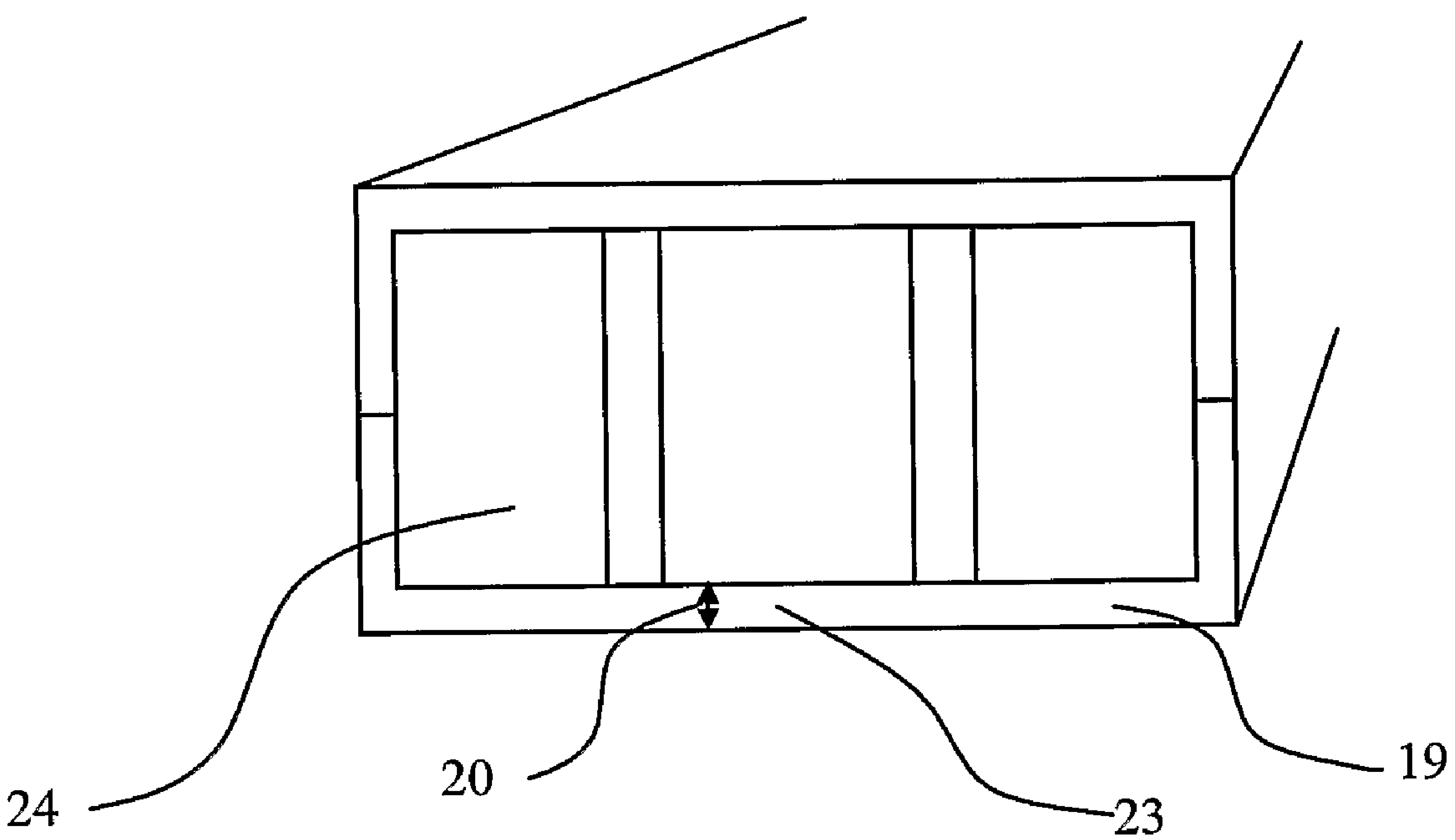
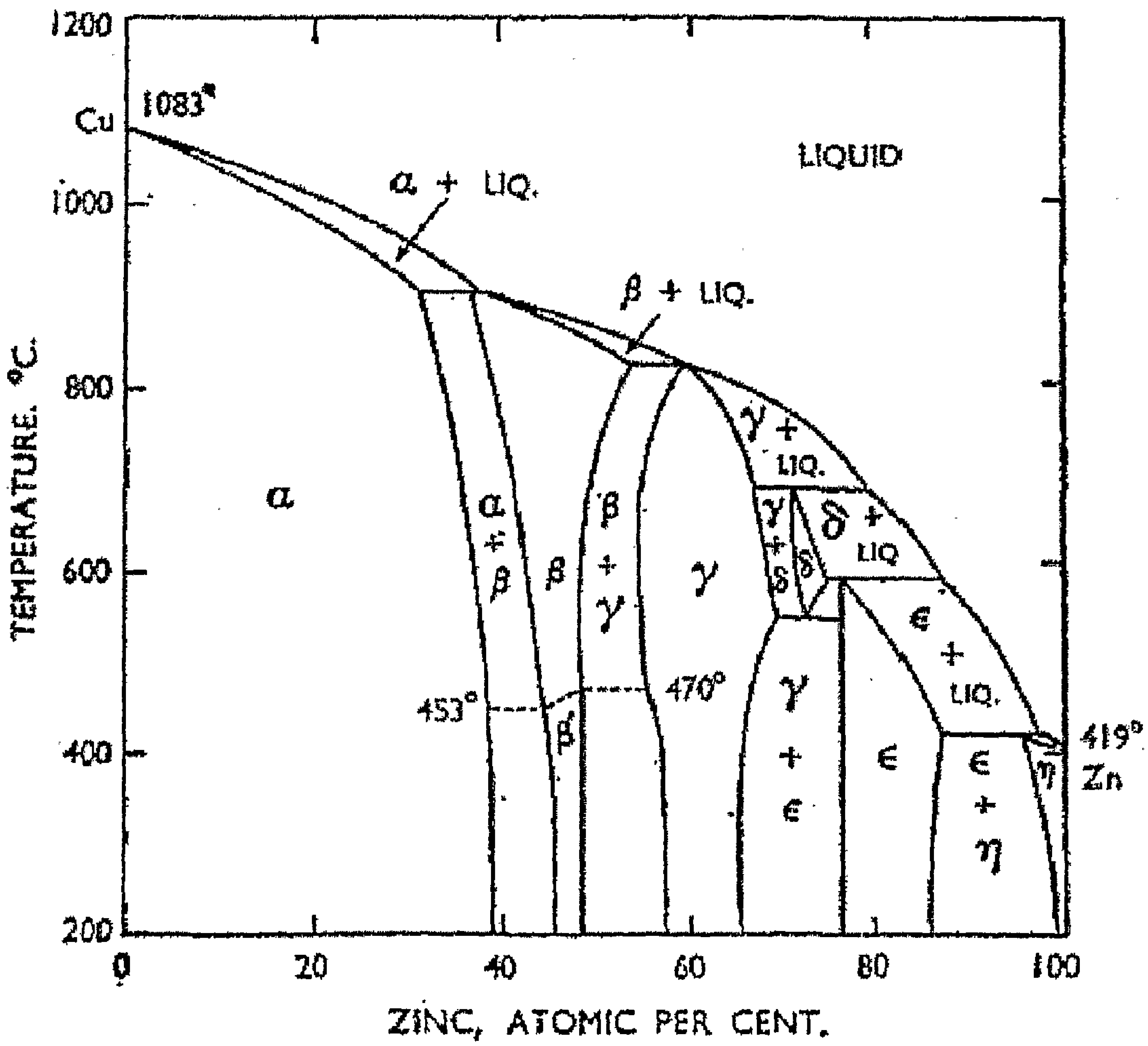
(57) ABSTRACT

The invention relates to a method for producing a metal alloy product (19) containing at least some amount of β-phase brass by extrusion, a metal alloy product produced by extrusion of metal alloy containing at least some amount of β-phase brass, an extrusion die (15) for extrusion of a metal alloy containing copper and zinc, and at least some amount of β-phase, an extrusion device, and a use of a metal alloy for extrusion.





1200
1000
800
600
400
200
Cu
1083°
LIQUID
α + LIQ.
β + LIQ.
γ + LIQ.
δ + LIQ
ε + LIQ.
α
α + β
β
β + γ
γ
γ + δ
δ
453°
470°
β'
γ + ε
ε
ε + η
η
419°
Zn
0
20
40
60
80
100
TEMPERATURE, °C.
ZINC, ATOMIC PER CENT.

FIG. 1

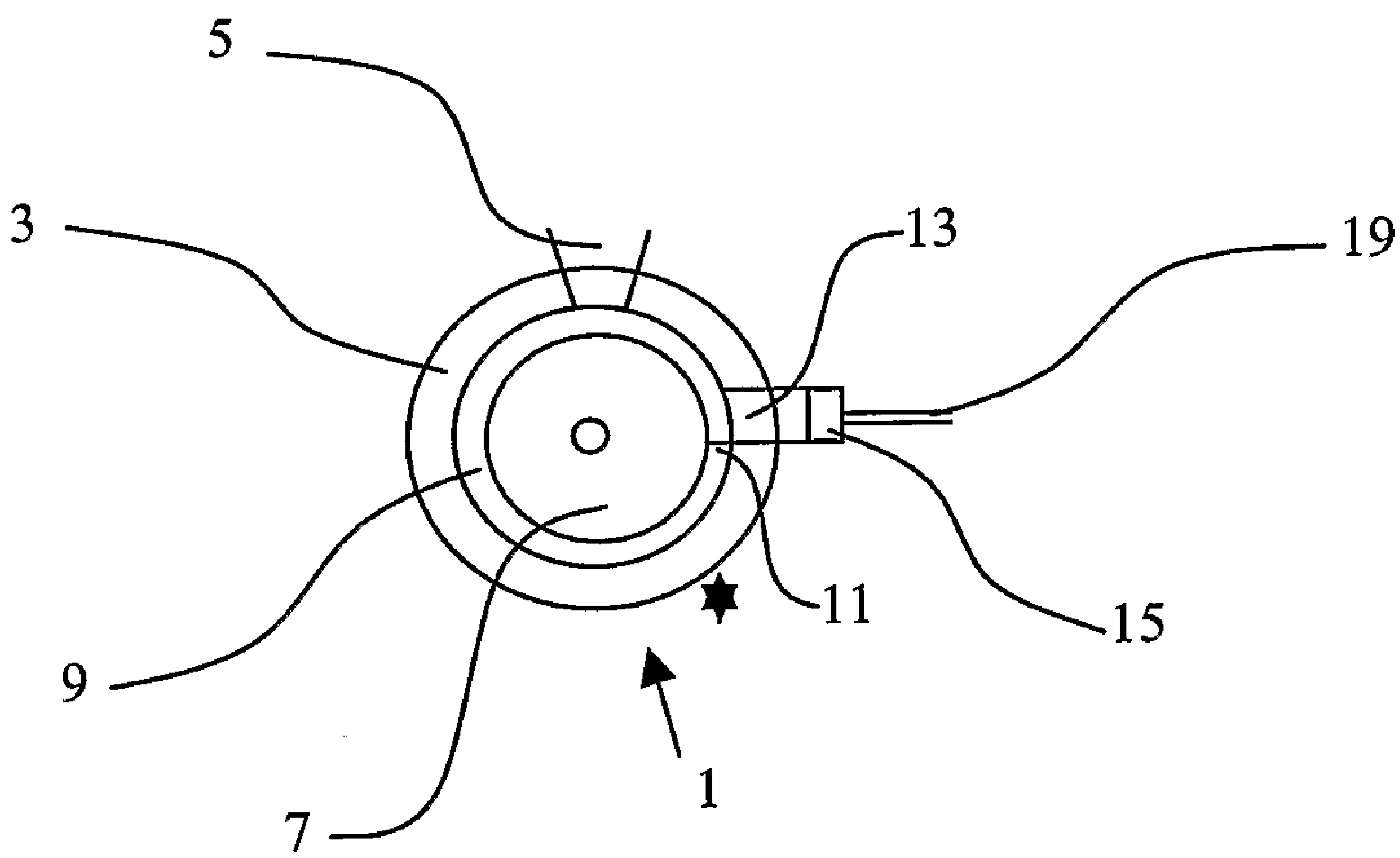


Fig. 2

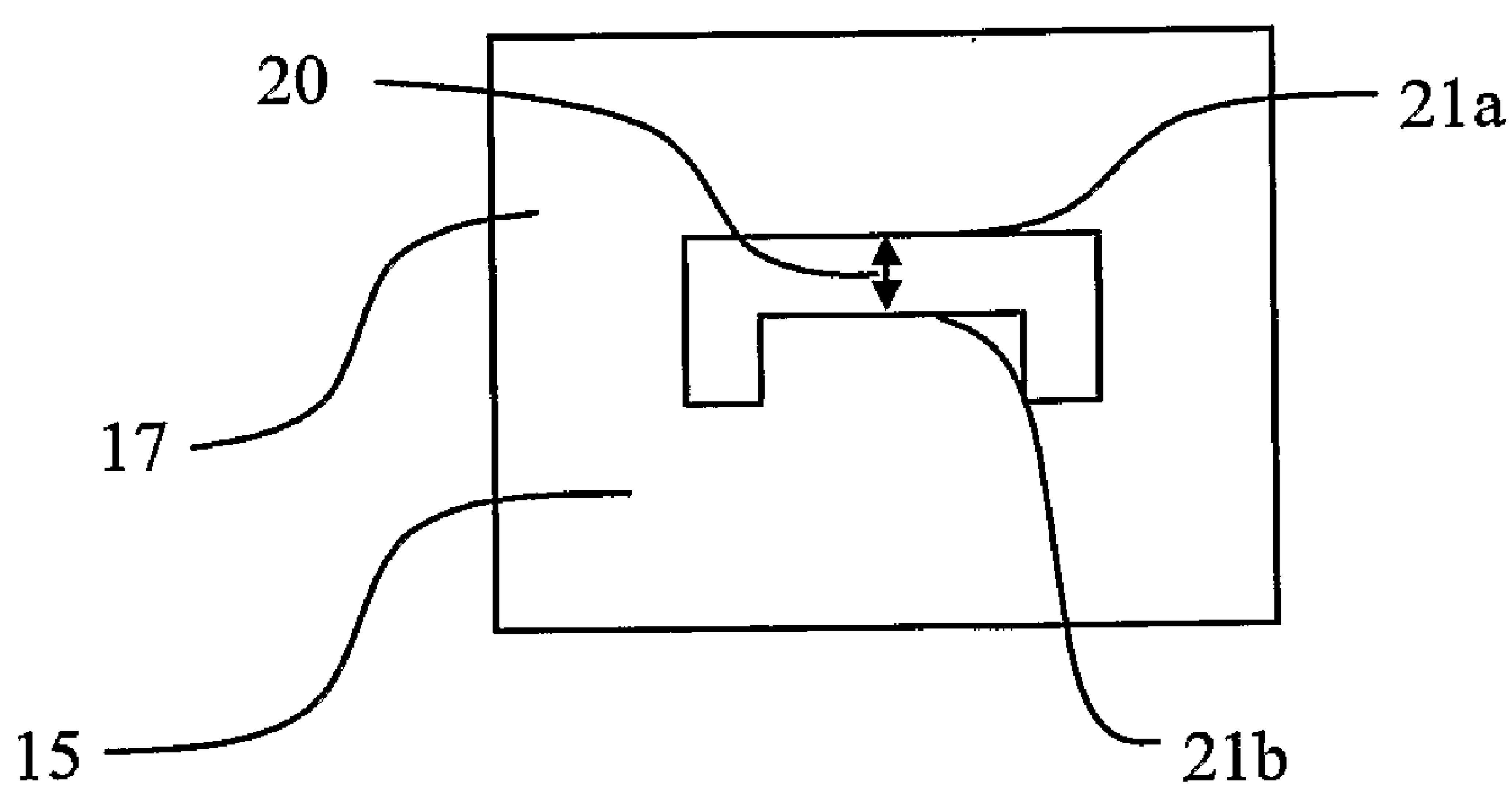


Fig. 3

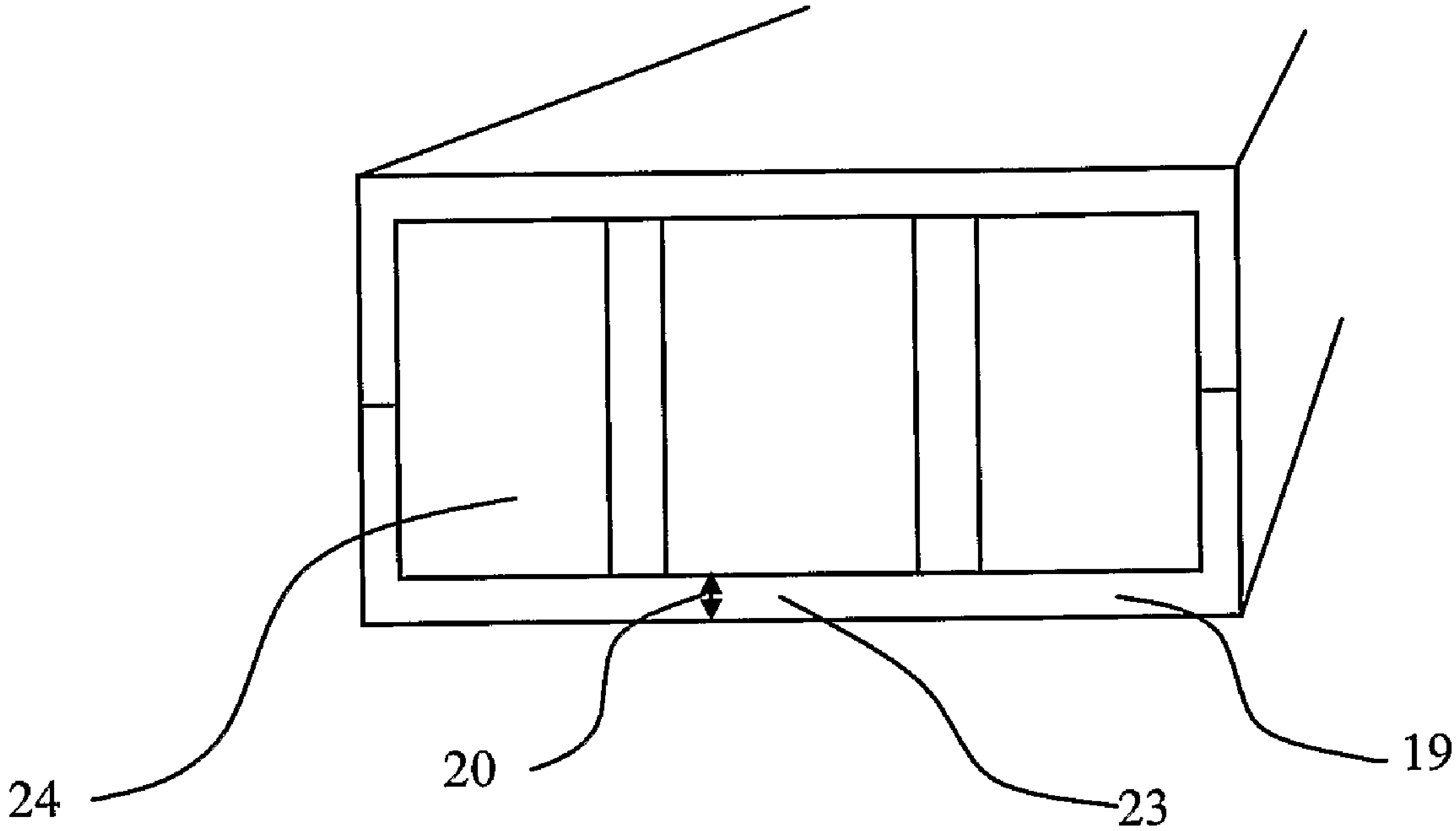


Fig. 4

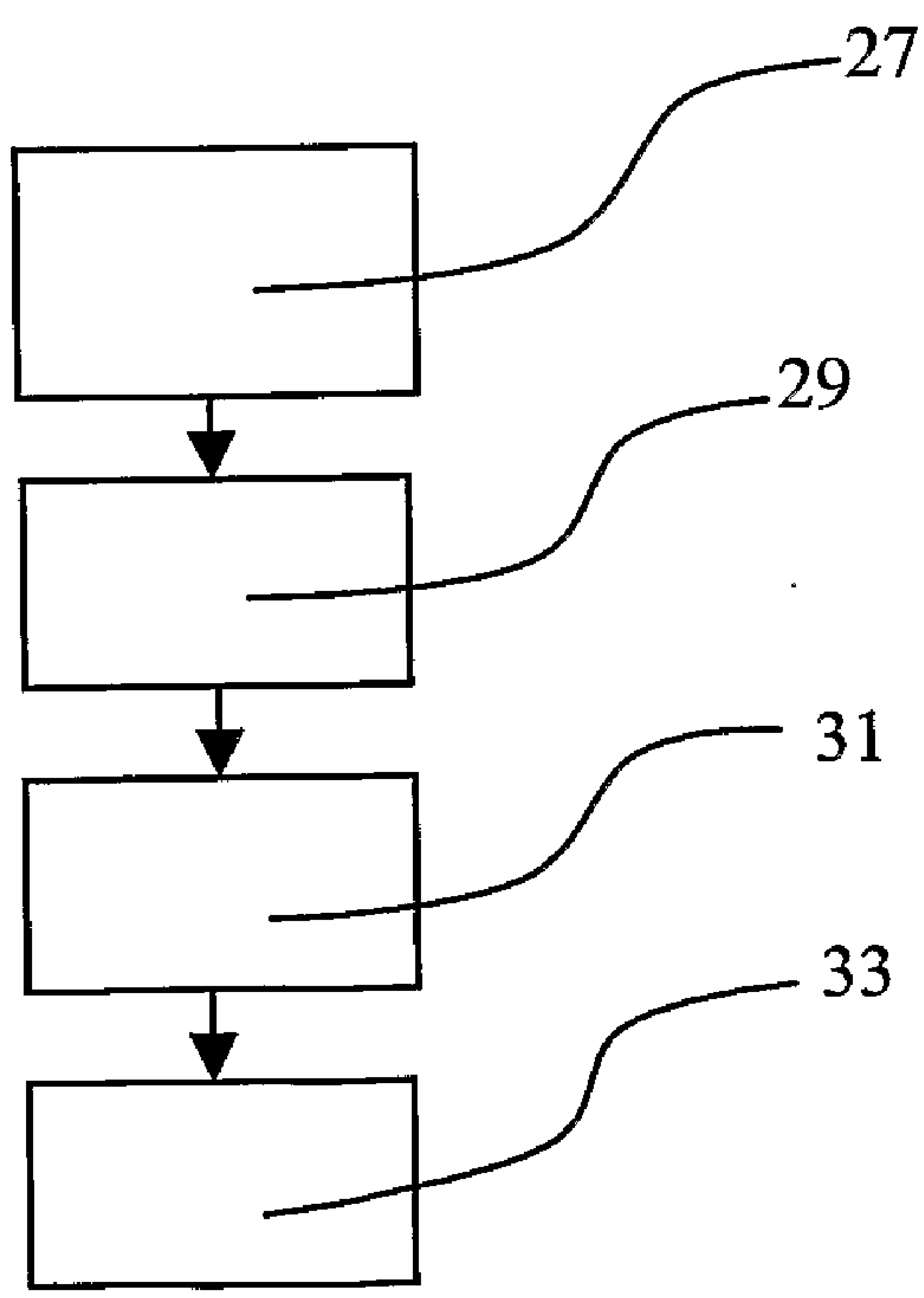


Fig. 5

EXTRUSION OF A METAL ALLOY CONTAINING COPPER AND ZINC

[0001] The present invention relates to extrusion of a metal alloy containing copper and zinc, to products produced by extrusion of a metal alloy containing copper and zinc, and to an extrusion die.

PRIOR ART

[0002] Extrusion is a process by which long straight metal parts can be produced. The cross sections that can be produced vary from solid round, rectangular, to L-shapes, T-shapes, tubes and many other types. Extrusion is done by squeezing metal in a closed cavity through a tool, known as a die, using either a mechanical or hydraulic press. Extrusion produces compressive and shear forces in the stock. No tensile stress is produced, which makes high deformation possible without tearing the metal. The cavity in which the raw material is contained is lined with wear resistant material. This can withstand the high radial loads that are created when the material is pushed through the die.

[0003] The extrusion can be done by a cold extrusion or by a hot extrusion. Cold extrusion is the process done at room temperature or at slightly elevated temperatures. This process can be used for most materials subject to the condition that it is possible to design robust enough tooling that can withstand the stresses created by extrusion. Examples of the metals that can be extruded are lead, aluminium alloys, copper, titanium, molybdenum, and vanadium. Examples of parts that are cold extruded are collapsible tubes, aluminium cans, cylinders and gear blanks. The advantages of cold extrusion are that no oxidation takes place and that good mechanical properties are obtained due to severe cold working, and that a good surface finish is obtained with the use of proper lubricants.

[0004] Hot extrusion is done at fairly high temperatures, approximately 50 to 75% of the melting point of the metal. The pressures can range from 35-700 MPa. Due to the high temperatures and pressures and its detrimental effect on the die life as well as other components, good lubrication is necessary. Oil and graphite work at lower temperatures, whereas at higher temperatures glass powder is used.

[0005] The extrusion described is usually carried out for only one individual object at a time. A continuous extrusion process has been developed, in which the material is extruded by means of a rotating wheel. The material is fed into and contained inside a circumferential groove of the wheel, until an abutment forces the metal to flow out of the groove and through the extrusion die. Due to the almost adiabatic situation in the tools, the material is heated above the re-crystallization temperature by the internal friction created, even if the feed material is initially at room temperature. The continuous extrusion process is only available for metals with low melting points, such as aluminium and substantially pure copper. It is normally not possible to extrude hard metals, such as brass containing copper and zinc, with a continuous extrusion process, due to the high extrusion pressures needed, which will ultimately destroy the extrusion dies. Furthermore, the continuous process also fails when more complicated shapes are to be extruded.

[0006] In EP 1,035,227 the production of a brass pipe is shown. The brass pipe comprises both an α-phase brass and a β-phase brass. The α-phase brass contains lower amounts of zinc, and is the phase normally used in brass products. β-phase brass is a brass containing a higher percentage of zinc, and is harder than the α-phase. The combination of α-phase brass and β-phase brass disclosed in EP 1,035,227 is used in order to improve the polishability of the finished pipe. The document also teaches that it is possible to extrude the combination, since the β-phase brass is soft at high temperatures. Thus the pressure needed for the extrusion is reduced, making extrusion possible.

SUMMARY OF THE INVENTION

[0007] One object of the present invention is to achieve an inexpensive production of products containing a metal alloy of copper and zinc and comprising complex shapes.

[0008] According to one aspect of the invention, this object is achieved with the method according to claim **1**. According to a second aspect of the invention, this object is achieved with a metal alloy product according to claim **13**. According to a third aspect of the invention, this object is achieved with an extrusion die according to claim **15**. According to a fourth aspect of the invention, this object is achieved with an extrusion die according to claim **17**. According to a fifth aspect of the invention, this object is achieved with a use of a metal alloy according to claim **18**.

[0009] It has now been realized that by increasing the zinc content in the metal alloy containing copper and zinc, and by adjusting the temperature conditions, so that the metal alloy contains at least some amount of β-phase during the extrusion, it is possible to extrude the metal alloy into fine and/or complex shapes. In particular it is possible to extrude a metal alloy containing a β-phase into a product having at least one wall section with a thickness smaller than or equal to 0.5 cm in a direction perpendicular to the direction of extrusion of the product. This is due to the softness of the β-phase at elevated temperatures. In fact, it has been realized that the ability of extruding β-phase brass even surpasses the ability of extruding brass with very low contents of zinc, which normally are softer than brass with higher contents of zinc.

[0010] Hence, by extruding β-phase metal alloy through an extrusion die comprising an opening shaped so that the distance between at least two opposite sides of the opening is smaller than or equal to 1 cm, it is possible to extrude a wide number of different products having fine or complex shapes comprising wall sections that are very thin. Such products have hitherto not been possible to manufacture by extrusion. Thus, a less expensive and faster method of production is achieved. Previously, due to the hardness of brass, only low-zinc content brasses have been extruded, and only with simple and large shapes such as large pipes, bars and beams, with a wall thickness in the order of 1 dm or larger. In fact it has now been realized, that by increasing the content of zinc so that the metal alloy comprises a β-phase, it is possible to extrude a metal alloy product comprising a wall section having a thickness in the direction perpendicular to the extrusion direction, which is smaller than or equal to 0.3 cm, more preferably smaller than 1 mm, even more preferably smaller than 0.7 mm, and most preferably smaller than 0.5 mm.

[0011] In one embodiment of the invention the metal alloy containing copper and zinc is extruded at a temperature higher than 450° C.

[0012] In another embodiment the metal alloy is extruded at a temperature higher than 550° C. In a preferred embodiment the metal alloy is extruded at a temperature higher than 600° C. By increasing the temperature the softness of the β-phase increases. In fact, at higher temperatures, the extrusion capability of the β-phase metal alloy increases to such a degree, that it is possible to extrude products having a wall thickness smaller than or equal to 0.5 mm, preferably smaller than or equal to 0.3 mm.

[0013] In one embodiment the metal alloy is extruded at a temperature lower than 900° C. In another embodiment the metal alloy is extruded at a temperature lower than 800° C. In a preferred embodiment the metal alloy is extruded at a temperature lower than 700° C. Thus it is ensured that the metal alloy product will retain its shape after the metal alloy has been extruded through the opening in the die, since the metal alloy is sufficiently stiff to retain its shape.

[0014] Preferably the metal alloy is preheated before extrusion to a temperature between 500° C. and 700° C. Since the β-phase is soft, the shear forces during extrusion are too small to increase the temperature of the metal alloy to a suitable extrusion temperature. Thus by preheating the metal alloy, a better extrusion temperature may be achieved in a simple way.

[0015] According to one embodiment the metal alloy comprises more than or equal to 35 weight-% of zinc. In another embodiment the metal alloy comprises more than or equal to 38 weight-% of zinc. In a preferred embodiment the brass comprises more than or equal to 42 weight-% of zinc. The balance is copper and inevitable impurities. Hence it is ensured that the metal alloy comprises sufficient amount of β-phase brass to ensure sufficient softness during extrusion. In fact, by extruding brass comprising a sufficient amount of zinc, the β-phase brass is sufficiently soft, so that it is possible to extrude a metal alloy product having a wall thickness smaller than 0.2 mm.

[0016] According to one embodiment of the invention the metal alloy comprises less than or equal to 55 weight-% of zinc. In one embodiment the metal alloy comprises less than or equal to 50 weight-% of zinc. In one preferred embodiment the metal alloy comprises less than or equal to 48 weight-% of zinc. Thus it is ensured that the zinc content is not too high, ensuring that the metal alloy will comprise a β-phase and not a γ-phase during the extrusion. A γ-phase is much harder than the β-phase at all temperatures, and thus a presence of γ-phase in the metal alloy would be detrimental during extrusion. Furthermore it is ensured that the finished product will not be too brittle for its intended use.

[0017] According to one embodiment the metal alloy is extruded in a continuously operated extrusion device. Preferably, the extrusion device comprises a wheel with a circumferential groove adapted for receiving and conducting the metal alloy. By using a β-phase brass it is possible to extrude the metal alloy continuously. By extruding brass continuously the cost of extrusion decreases, which decreases the cost for the products. Previously in the prior art, brass has only been extruded in batches.

[0018] According to one embodiment an elongated multiform metal alloy product is produced. By using β-phase brass it has now been realized that complex shapes, such as multiform elongated products, may be extruded, which grants a very inexpensive production method for producing elongated multiform products. Preferably a multi-port or multi-channel profile is produced. Preferably the multi-channel profile is adapted to be used in a tube comprising several smaller channels inside the tube. Thus it is possible to raise the pressure inside the tube, without needing to increase the wall thickness of the tube. Preferably the multi-channel profile or tube is adapted for use in a heat transport device, such as a heat exchanger or heat pump. Preferably the multi-channel profile or tube is adapted for use in a vehicle heat exchanger, and is produced by extrusion of brass containing at least some amount of β-phase metal alloy. Such multi-channel tubes are usually flat, with a height of no more than 1 cm, preferably no more than 0.5 cm, and most preferably no more than 2 mm, and a width of no more than 25 cm, preferably no more than 10 cm, and most preferably no more than 5 cm. Usually, such tubes or profiles have a wall thickness smaller than or equal to 1 mm. Previously such tubes or profiles have not been possible to produce in brass by extrusion.

[0019] In one embodiment a multi finned elongated product is produced. Preferably, the multi fin profile is adapted for use in a heat transport device, such as a heat exchanger or heat pump. The fins are preferably adapted to extend into a volume of gas, such as air, in order to facilitate transport of heat between the air and the multi fin product.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The invention is now to be explained as a non-limiting example of the invention with reference to the attached drawings.

[0021] FIG. **1** shows a phase diagram for a metal alloy containing copper and zinc, showing the temperatures and zinc contents for different phases of the metal alloy.

[0022] FIG. **2** shows an extrusion device for extrusion of a metal alloy product.

[0023] FIG. **3** shows the extrusion die in FIG. **2** and an extruded profile for use in a vehicle heat exchanger.

[0024] FIG. **4** shows a cross-section of an extruded metal alloy product containing copper and zinc, and at least some amount of β-phase, according to the invention.

[0025] FIG. **5** shows a method for producing a metal alloy product by extrusion according to the invention in a schematic block diagram.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0026] In FIG. **1** a phase diagram for a metal alloy containing copper and zinc is shown. The zinc contents of the metal alloy, and the temperatures suitable for extrusion according to the invention, are the zinc contents and temperatures, which give a metal alloy containing at least some amount of β-phase. Preferably, the zinc content and the temperature is selected to correspond to the area marked as a pure β-phase, and/or the area marked as a combination of an α-phase and a β-phase. The area marked as a combination of a β-phase and a γ-phase should be avoided due to the hardness of the γ-phase.

[0027] Furthermore, the temperature limit for obtaining a soft β-phase is shown by the dotted line at the temperature between 450° C. and 470° C. However it is preferable to extrude the metal alloy in a temperature above 500° C., preferably above 550° C. and most preferably above 600° C., in order to ensure a sufficient softness.

[0028] The phase diagram also shows the temperature of melting of the metal alloy containing β-phase, at a temperature about 900° C. Since the β-phase becomes too soft at high temperatures close to the melting point, it is preferable to extrude the β-phase metal alloy at a temperature below 800° C., and most preferably below 700° C. The most preferable interval for extrusion according to the invention is therefore between 600° C. and 700° C.

[0029] From the phase diagram it is shown that at least some amount of β-phase is obtained at the line dividing the α-phase area and the α-phase and β-phase area. Thus, the metal alloy should contain at least 35% zinc by weight in order to ensure that at least some amount of β-phase is present during the extrusion. Preferably, however, the metal alloy should contain a larger amount of β-phase brass, and thus it is preferable that the zinc content is higher than 38 weight-%. Most preferably, at least 90% β-phase is present in the metal alloy product to ensure sufficient softness, and thus it is preferable that the metal alloy contains at least 42% zinc by weight, the balance being copper and inevitable impurities. It should be noted that the allowable zinc content interval for obtaining a β-phase are larger at higher temperatures, and for the purpose of the invention, it is the presence of a β-phase at the temperature of extrusion that is important.

[0030] In order to ensure that the final product is not too brittle, and to ensure that no detrimental amounts of γ-phase are present during extrusion, it is preferable that the amount of zinc is no more than 50% zinc by weight, and most preferably not more than 48% zinc by weight.

[0031] In FIG. **2** an extrusion device **1** for continuous extrusion of a metal alloy containing copper and zinc according to the invention is shown. The extrusion device **1** comprises a hollow cylinder **3**, which comprises an inlet **5**, and a rotatable wheel **7**, provided with a groove **9** along its circumference, arranged inside the hollow part of the cylinder **3**. The device also comprises an abutment **11** arranged inside the groove **9**, and an extrusion chamber **13** arranged in connection with the abutment **11**, which chamber **13** is ended with an extrusion die **15**. The extrusion die **15** comprises an opening **17**, shaped so that the distance **20** between at least two opposite sides **21***a*, **21***b* of the opening **17** is smaller than or equal to 0.5 cm. The extrusion die **15** is explained in greater detail in connection with FIG. **3**.

[0032] During extrusion, a pre-heated metal alloy of copper and zinc, and containing at least some amount of β-phase, is fed into the inlet **5**, and into the groove **9** of the wheel **7**. The wheel **7** is rotated by a driving device, not shown, which press the metal alloy forward towards the abutment **11**, so that the metal alloy continues into the extrusion chamber **13**. The continuing building up of pressure inside the extrusion chamber **13** presses the metal alloy towards the extrusion die **15**, and the opening **17**. Thus the metal alloy is squeezed through the opening **17**, meaning that the metal alloy is extruded and receives a similar shape as the shape of said opening. Thus the extruded metal alloy product **19**, which comprises at least some amount of β-phase, is shaped so that the product **19** comprises at least one wall section with a thickness smaller than or equal to 0.5 cm.

[0033] In FIG. **3** one example of an extrusion die **15** is shown. The extrusion die **15** is made by a hard, durable, and wear resistant material, which can also withstand high temperatures. In this example the extrusion die is heated to a temperature higher than 600° C., in order to ensure a sufficient extrusion temperature. The extrusion die **15** is provided with an opening **17**, which is shaped so that the distance **20** between at least two opposite sides **21***a*, **21***b* of the opening is smaller than or equal to 0.5 cm. In this example the extruded product is a profile adapted for use in a multi-channel tube for vehicle heat exchangers. In this example, the distance between two opposite sides **21***a*, **21***b* of the extrusion die **15** is therefore smaller than 0.5 mm, in order to ensure a short distance between the two mediums that are to be heat exchanged. Thus the multi-channel tube, metal alloy product comprising at least some amount of β-phase, have at least one wall section having a thickness smaller than or equal to 0.5 mm. Thus, according to the invention, products with very complex shapes and/or thin wall sections may be produced by extrusion in a very efficient and inexpensive way.

[0034] Furthermore, the opening is shaped so that the distance **20** between two opposite sides **21***a*, **21***b* of the extrusion die **15** is larger than or equal to 0.05 mm, preferably larger than 0.1 mm and most preferably larger than 0.3 mm. Thus it is ensured that the thickness of wall section of the product is sufficiently thick in terms of durability.

[0035] In FIG. **4** a cross-section of an extruded metal alloy product **19** containing copper and zinc, and at least some amount of β-phase according to the invention is shown. The product comprises a wall **23** having a thickness **20** in a direction perpendicular to the direction of extrusion, which is smaller than or equal to 0.5 mm. In this example the product **19** is a profile for a multi-channel tube **24**. In this example the multi channel tube is adapted for use in a heat exchanger. In this example, the multi channel tube is adapted for use in a vehicle heat exchanger between the cooling liquid and the air.

[0036] In FIG. **5** a method according to the invention is shown. In a first step **27** a metal alloy comprising at least 38 weight-% of zinc, and the balance being copper and inevitable impurities, is pre-heated to a temperature of at least 600° C. In a second step **29** the metal alloy is fed into an extrusion device comprising an extrusion die. In this example the metal alloy is fed continuously into the extrusion device. In a third step **31** the metal alloy is extruded through at least one extrusion opening in said extrusion die, the opening being shaped so that the distance between at least two opposite sides of the opening is smaller than or equal to 0.5 cm. In this example the distance is smaller than or equal to 0.7 mm. In a fourth step **33** the extruded metal alloy is cut into metal alloy products of suitable length. Subsequently the metal alloy products are cooled to an appropriate temperature, for example room temperature.

[0037] The invention is not limited to the embodiments shown herein, but may be varied within the framework of the following claims.

[0038] For example, extrusion methods and devices are well known in the art, and any differences or improvements between the extrusion methods or devices according to the art, relative to the schematic method and device shown in this description, should be considered as being inside the scope of the description and claims.

[0039] Furthermore, even if the description mainly shows a metal alloy comprising mostly copper and zinc, the metal alloy may also comprise other alloying elements, as long as at least some β-phase is present in the alloy.

1. A method for producing a metal alloy product comprising:

feeding (**29**) a metal alloy containing copper and zinc, and at least some amount of β-phase brass to an extrusion die, and

extruding (**31**) the metal alloy containing the β-phase through at least one extrusion opening in said extrusion die (**15**), the opening (**17**) being shaped so that the distance between at least two opposite sides of the opening is smaller than or equal to 1 mm.

2. A method according to claim **1**, wherein the distance is smaller than or equal to 0.3 cm, preferably smaller than or equal to 1 mm, and most preferably smaller than or equal to 0.7 mm.

3. A method according to claim **1**, wherein the metal alloy is extruded at a temperature higher than 450° C., preferably higher than 550° C., and more preferably higher than 600° C.

4. A method according to claim **1**, wherein the metal alloy is extruded at a temperature lower than 900° C., preferably lower than 800° C., and more preferably lower than 700° C.

5. A method according to claim **1**, wherein the method comprises:

pre-heating (**27**) the metal alloy before extrusion to a temperature between 500° C. and 700° C.

6. A method according to claim **1**, wherein the metal alloy comprises more than or equal to 35 weight % of Zinc, preferably more than or

equal to 38 weight % of Zinc, and most preferably more than or equal to 42 weight % of Zinc, the balance being copper and inevitable impurities.

7. A method according to claim **1**, wherein the metal alloy comprises less than or equal to 55 weight % of Zinc, preferably less than or equal to 50 weight % of Zinc, and most preferably less than or equal to 48 weight % of Zinc.

8. A method according to claim **1**, wherein the method comprises extruding the metal alloy in a continuously operated extrusion device (**1**).

9. A method according to claim **1**, wherein the method comprises producing an elongated multiform product (**19**).

10. A method according to claim **1**, wherein the method comprises producing a multi-port or multichannel profile (**19**).

11. A method according to claim **10**, wherein the method comprises producing a multi-channel profile (**19**) or tube (**24**) adapted for use in a heat transport device, such as a heat exchanger or heat pump.

12. A method according to claim **1**, wherein the method comprises producing a multi-channel profile (**19**) or tube (**24**) adapted for use in a vehicle heat-exchanger by extrusion of a metal alloy containing copper and zinc, and at least some amount of β-phase brass.

13. An extruded metal alloy product containing copper and zinc, and at least some amount of β-phase, wherein the product (**19**) comprises at least one wall section (**23**) with a thickness smaller than or equal to 1 mm.

14. An extruded metal alloy product according to claim **13**, wherein the product is a profile (**19**) for a multichannel tube (**24**) adapted for use in a heat transporting device.

15. An extrusion die adapted for extrusion of a metal alloy containing copper and zinc, and at least some amount of β-phase, wherein the die (**15**) is shaped with an extrusion opening (**17**) shaped so that the distance between at least two opposite sides (**21** *a*, **21** *b*) of the opening is smaller than or equal to 1 mm.

16. An extrusion die according to claim **15**, wherein the extrusion die (**15**) is adapted to be used in a continuously operated metal alloy extrusion device (**1**).

17. An extrusion device adapted for extrusion of a metal alloy comprising copper and zinc, and at least some amount of β-phase, wherein the extrusion device (**1**) comprises an extrusion die (**15**) provided with an extrusion opening (**17**) shaped so that the distance between at least two opposite sides (**21** *a*, **21** *b*) of the opening is smaller than or equal to 1 mm.

18. A use of a metal alloy containing copper and zinc, and at least some amount of β-phase in the extrusion of a metal alloy product having a wall section (**23**) with a thickness smaller than or equal to cm 1 mm.

* * * * *