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• **Suzuki, Kazushi, Star Micronics Co., Ltd.**
Shizuoka-shi, Shizuoka-ken 422 (JP)

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(74) Representative: **Hackney, Nigel John et al**
Mewburn Ellis,
York House,
23 Kingsway
London WC2B 6HP (GB)

(71) Applicant: **STAR MICRONICS CO., LTD.**
Shizuoka-shi, Shizuoka-ken 422 (JP)

(72) Inventors:
• **Sone, Takahiro, Star Micronics Co., Ltd.**
Shizuoka-shi, Shizuoka-ken 422 (JP)

(54) Lead frame material for electro acoustic transducer

(57) The lead frame material of the present invention does not deteriorate soldering wettability and enables localized heating by soldering through decreased thermal conductivity, and can be used for a lead frame (2) for the electroacoustic transducer. This lead frame

material can be used for forming lead terminals (10A, 10B, 10C and 10D) of the electroacoustic transducer. It is an alloy that contains 32 to 55% Ni by weight and Fe as the primary component of the remainder and has a crystal grain size of 7.0 or more by the grain size number.

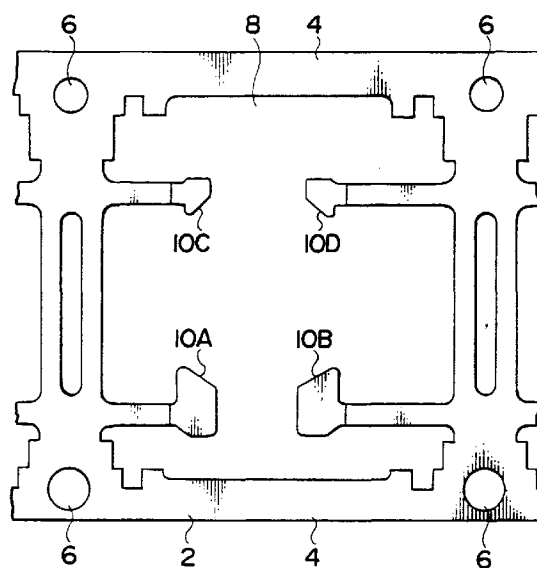


FIG. 1

Description

The present invention relates to a lead frame material for an electroacoustic transducer, forming a lead terminal of the electroacoustic transducer that converts an electric signal into an acoustic wave.

The electroacoustic transducer converts an electric signal into an oscillating magnetic field, and converts it into an acoustic wave. Usually, the electroacoustic transducer is covered with a case made of a synthetic resin, inside of which an electromagnetic converting portion is incorporated. This electromagnetic converting portion converts an electric signal into an oscillating magnetic field, and converts the oscillating magnetic field into an aerial vibration. The lead terminal is to connect this electromagnetic converting portion to an outer circuit.

The electroacoustic transducer is built in a portable phone, etc., and used in announcement for receiving. To cope with the miniaturization of various electronic equipment such as a portable phone, the electroacoustic transducer has been devised to be made thin, small, and light. This kind of electroacoustic transducer trends toward a flat lead terminal that can be used in surface mounting, in replacement of a conventional lead wire system. And, this kind of flat lead terminal is formed by a lead frame material provided with plural lead terminal parts.

Alloys of brass, phosphor bronze and the like have generally been used in the conventional lead frame material. Copper alloy is characterized by being inexpensive, having a high thermal conductivity, having a good solderability, and the like. A high thermal conductivity leads to an advantage to give a good heat radiation when used in an electronic component.

However, this kind of lead frame material brings the following disadvantages when used in the electroacoustic transducer.

The lead frame used in assembling an electroacoustic transducer has a form such that the lead terminals project into a space surrounded by frame guide rails. When this form of lead frame is made of a material having a high thermal conductivity and coil terminals of the electroacoustic transducer are soldered to the lead terminals, heat diffuses into the frame guide rails from the lead terminals so that the localized heating on the lead terminals for connecting the coil terminals is difficult to be achieved. Thus, soldering of the coil terminals to the lead terminals is difficult in normal heating, and it needs to raise the heating temperature or extend the heating time, which can create a risk of a damage by the heat to a resin close to the land of the soldering.

And, the lead frame needs to have a thickness that gains a mechanical strength required for an assembly work and after an outer lead forming; conventionally, the thickness is made comparably thick about 0.2 mm. When this thick lead frame is used, it increases the heat radiation from the lead terminals to the frame guide rails, making the soldering of the coil terminals more difficult. And, this thickness of the lead frame leads to increasing the weight of the electroacoustic transducer as a product, which hinders the electroacoustic transducer from being made smaller and lighter.

And on some conditions, copper alloy composing the lead frame material contains components such as Zn and Be that deteriorate soldering wettability, and these components are separated out with time on the solder plating layer to deteriorate soldering wettability. In order to prevent the components from being separated out, a double layer plating of Ni and Cu becomes necessary.

Preferably the present invention provides a lead frame material for the electroacoustic transducer that does not deteriorate soldering wettability and enables localized heating through decreasing thermal conductivity.

The lead frame material for the electroacoustic transducer according to the first aspect of the present invention is to form lead terminals (10A, 10B, 10C, 10D) of the electroacoustic transducer, which is an alloy that contains 32 to 55% Ni by weight with Fe as the primary component and has a crystal grain size of 7.0 or more by the grain size number.

This composition lowers thermal conductivity and heat radiation to enable a localized heating required for soldering. A prolonged heating at a high temperature becomes unnecessary so that a damage to the case made of a resin can be prevented, thereby enhancing the reliability of the electroacoustic transducer. Further, the lead frame material can be made thin, lowering heat radiation, facilitating local heating in soldering, and reducing the material usage per product.

The lead frame material for the electroacoustic transducer according to the second aspect of the present invention is to form lead terminals (10A, 10B, 10C, 10D) of the electroacoustic transducer, which is an alloy that contains 32 to 55% Ni by weight, 1.0% or less Mn by weight, 1.0% or less Si by weight, and 0.05% or less C by weight, with Fe as the primary component, having a crystal grain size of 7.0 or more by the grain size number.

This composition does not contain a component to deteriorate soldering wettability, which facilitates a substrate plating to enhance a barrier effect, and reduces the double layers of Ni-plating and Cu-plating to a single layer of Ni-plating.

The present invention will be fully understood from the detailed description given below and from the accompanying drawings of the preferred embodiment of the invention, which, however, should not be taken to limit the specific embodiment, but are for explanation and understanding.

Fig. 1 is a plan view showing a part of the lead frame;

Fig. 2 is a plan view showing a resin-molded base part on the lead frame;

Fig. 3 is a perspective view showing a resin-molded base part on the lead frame;

Fig. 4 is an exploded perspective view showing the mounting of a magnet, supporting ring, and diaphragm onto the base part;

Fig. 5 is a plan view showing the soldering of coil terminals to lead terminals on the lead frame;

Fig. 6 is a perspective view showing the mounting of a case onto the base part on the lead frame;

Fig. 7 is a perspective view showing an electroacoustic transducer formed on the lead frame; and

Fig. 8 is a perspective view showing the electroacoustic transducer that is separated from the lead frame and has lead terminals formed thereon.

The frame material for the electroacoustic transducer is an alloy that contains 32 to 55% Ni by weight, 1.0% or less Mn by weight, 1.0% or less Si by weight, 0.05% or less C by weight, and other unavoidable impurities, Fe being as the primary component of the remainder, and has a crystal grain size of 7.0 or more by the grain size number.

As other substances except for the unavoidable impurities, one or more of Al, Ti, V, Nb, Ta, Cr, Co, Cu, Mo, W, and B may be added by 0.01 to 2.0% in total. Adding these substances can increase the mechanical strength of the alloy composing the lead frame material, thereby decreasing the thickness to about 0.13 mm without deformation.

The crystal grain size is defined as 7.0 or more by the grain size number so as to prevent deformation in a fine press work after the lead frame material of the electroacoustic transducer is thinly made.

a. Forming of the Lead Frame Material

As the lead frame material for the electroacoustic transducer, an Fe - Ni alloy containing 36% Ni, 42% Ni, and 50% Ni as the basic components is fused in vacuum, which thereafter are processed through casting, forging and hot rolling, and then cold rolling and annealing are repeatedly applied to form 0.13 mm thick rolled materials. As another embodiment, an Fe-Ni alloy containing 29% Ni and 17% Co as primary ingredients is fused in vacuum to form a rolled material of 0.13 mm by repeatedly applying cold rolling and annealing after casting, forging and hot rolling.

b. Forming of the Lead Frame

A lead frame is formed by applying a press work to the rolled material produced by the foregoing process. Fig. 1 shows the lead frame as one example. The lead frame 2 is applied with an electroless plating as a substrate plating, on the surface of which solder plating is applied.

This lead frame 2 is provided with the frame guide rails 4 on both the outer edges, guide holes 6, a space 8 sandwiched between the frame guide rails 4, and plural lead terminal parts 10A, 10B, 10C, and 10D projecting into the space 8. The lead terminal parts 10A to 10D are processed into the lead terminals.

c. Resin Molding of the Base Part

As shown in Figs. 2 and 3, a base part 12 is formed on the lead frame 2. That is, the lead frame 2 is mounted on the mold, and a yoke 14 and the lead terminals 10A, 10B, 10C, and 10D are formed by the insert molding. In this case, the surface of the yoke 14 and the soldering surfaces of the lead terminals 10A, 10B, 10C, and 10D are exposed above the base part 12. And, the yoke 14 is provided with a pole 16 in advance.

d. Assembling and Soldering of the Coil Terminals

As shown in Fig. 4, a coil 18 is wound around the pole 16 on the lead frame 2. The supporting ring 20, magnet 22, and diaphragm 24 are made in advance. The supporting ring 20 is glued inside the base part 12 molded on the lead frame 2, and the magnet 22 is mounted inside of the supporting ring 20, and the diaphragm 24 is mounted on the supporting ring 20. The coil terminals 26A, 26B are soldered on the lead terminals 10A, 10B as shown in Fig. 5.

e. Bonding Process of the Case

A case 28 is molded of a synthetic resin, and placed on the base part 12 on the lead frame 2 as shown in Fig. 6. And, as shown in Fig. 7, the case 28 is joined on the base 12 by the ultrasonic bonding. This bonding may be replaced by glue. The electroacoustic transducer is produced on the lead frame 2, as shown in Fig. 8, by this bonding.

f. Separation from the Lead Frame 2

The lead terminal parts 10A, 10B, 10C, and 10D are cut off from the lead frame 2, which thereafter be formed as

the lead terminals of the electroacoustic transducer, thus completing the electroacoustic transducer.

Test pieces are made of the lead frame material obtained at the process a for a material property test. Electroacoustic transducers are made according to the processes a to f for performing an evaluation test. The test piece is made in a strip form of 10 mm width in the rolling direction and 100 mm length. These are shown in the embodiment 1 to 4 in Table 1.

Using the foregoing test pieces and electroacoustic transducers, a material property test and an evaluation test were performed. The contents of the test are shown below: items a to e relate to the material property, items f to h relate to the evaluation test, and item i is an overall evaluation.

- a. tensile strength
- b. 0.2% yield strength
- c. Vickers hardness
- d. crystal grain size
- e. thermal conductivity
- f. deformation at press work
- g. damage of resin during the soldering of coil terminals
- h. soldering wettability: after putting the test piece for 24 hours at a temperature of 150° C, the test piece was dipped for two seconds in a melted solder of 235° C, and more than 95% wettability is evaluated to be good.
- i. overall evaluation: a case in which the results of all the evaluation tests (f to h) are good is judged to be good.

As clearly illustrated in the comparison chart of the embodiments 1 to 4 with the comparison examples 1 to 6 (Table 1), the lead frame material of the present invention has a higher mechanical strength than the conventional lead frame material using Cu alloy, and deformation, etc., at press work and assembly is not caused. Since the thermal conductivity is lower than that of a Cu alloy, quantity of heat during soldering the coil terminals can be reduced, which prevents damages to the resin case. The soldering time is actually reduced to be 1.6 seconds compared with 2.5 seconds required for the conventional products, that is, about 64% saving of time for processing. These characteristics help restrict a thermal conduction from outside, for example, in applying a reflow soldering to the electroacoustic transducer, and protect the electroacoustic transducer from a thermal damage.

And, as to the variation with time of the soldering wettability of the lead terminal, a 150° C, 24 hour aging test confirmed that there was not any deterioration on the soldering wettability.

As described above, the following effects are obtained by the present invention.

- a. Since the thermal conductivity can be lowered, heat radiation from the lead terminal during soldering can be restricted; therefore, quantity of heat required for soldering the coil terminal to the lead terminal can be reduced, which prevents thermal damage and deterioration to the case made of a synthetic resin, thereby leading to reduced man-hour.
- b. The thickness of the lead material can be reduced to be about 0.13 mm from 0.2 mm, which restricts heat radiation from the lead terminal parts and brings similar effects as in the foregoing a. Since the material usage per product can be reduced, the total production cost can be reduced, which compensates a high cost of the material with reduction of the cost of products.
- c. Since the lead frame material does not contain components to deteriorate the soldering wettability, reliability of soldering is improved.
- d. Double layer substrate plating as the measure to prevent the components to deteriorate the soldering wettability from separating out to the solder plating layer to enhance the barrier effect can be a single layer. Namely, the plating layer needs only one Ni plating layer while the conventional product needs a double layer of Ni plating and Cu plating, and further the layer can be made thinner.

While specific embodiments of the present invention have been illustrated and described herein, it is realized that numerous modifications and changes will occur to those skilled in the art. It is therefore to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit and scope of the invention.

DATA OF MATERIAL PROPERTY					EVALUATION RESULT			
SAMPLE	TENSILE STRENGTH N/mm ²	0.2% YIELD STRENGTH N/mm ²	VICKERS HARDNESS HV	CRYSTAL GRAIN SIZE G.S. No	THERMAL CONDUCTIVITY cal/cm/sec/°C	DEFORMATION AT PRESS WORK	DAMAGE OF RESIN DURING SOLDERING COIL TERMINALS	TOTAL EVALUATION
Fe-36Ni alloy	EMBODIMENT 1	570	520	155	7.5			
		620	560	195	9.0			
		660	600	217	10.5			
Fe-42Ni Alloy	COMPARISON EXAMPLE 1	490	290	140	6.0			
	EMBODIMENT 2	560	510	164	7.5			
		640	580	206	8.5			
Fe-50Ni Alloy	COMPARISON EXAMPLE 2	500	300	144	6.0			
	EMBODIMENT 3	600	540	199	8.0			
		700	630	245	11.5			
Fe-29Ni-17Co Alloy	COMPARISON EXAMPLE 3	520	310	160	6.5			
	EMBODIMENT 4	610	550	201	7.5			
		710	650	230	11.0			
BRASS (C2600)	COMPARISON EXAMPLE 4	530	320	140	6.5			
	COMPARISON EXAMPLE 5	380	320	84	8.5			
		440	380	120	10.5			
PHOSPHOR BRONZE (C5210)	COMPARISON EXAMPLE 6	590	490	182	12.0			
		580	460	175	9.0			

Table 1

Claims

1. A lead frame material for an electroacoustic transducer, for forming lead terminals (10A, 10B, 10C and 10D) of the electroacoustic transducer, wherein the lead frame material is an alloy that contains 32 to 55% Ni by weight and Fe as the primary component of the remainder and has a crystal grain size of 7.0 or more by the grain size number.
2. A lead frame material for an electroacoustic transducer as claimed in claim 1, wherein the lead frame material is an alloy that contains 32 to 55% Ni by weight, 1.0% or less Mn by weight, 1.0% or less Si by weight, 0.05% or less C by weight, and Fe as the primary component of the remainder, having a crystal grain size of 7.0 or more by the grain size number.

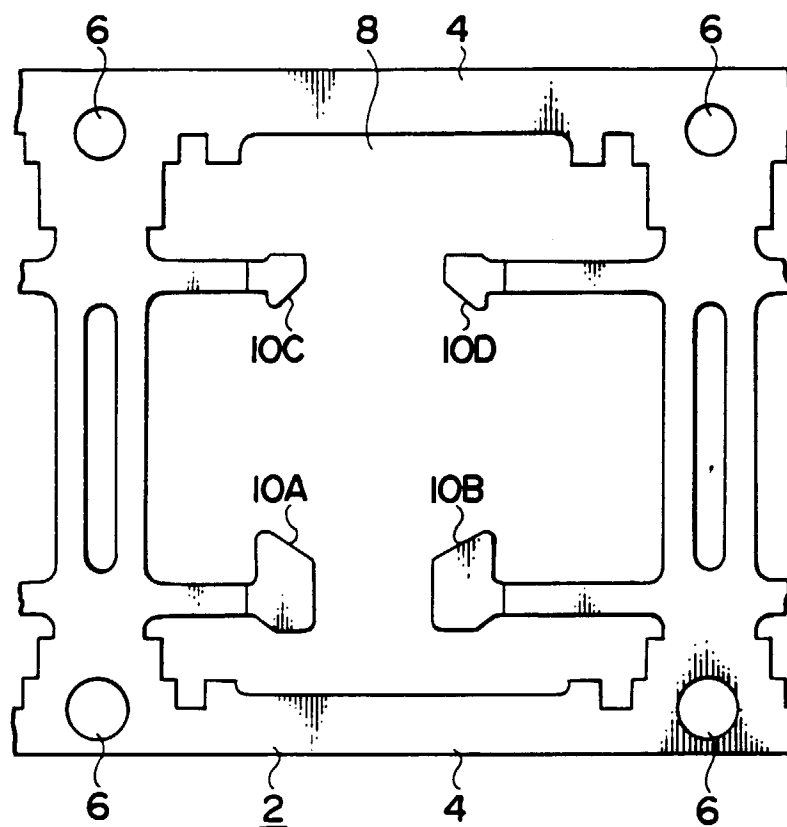


FIG. 1

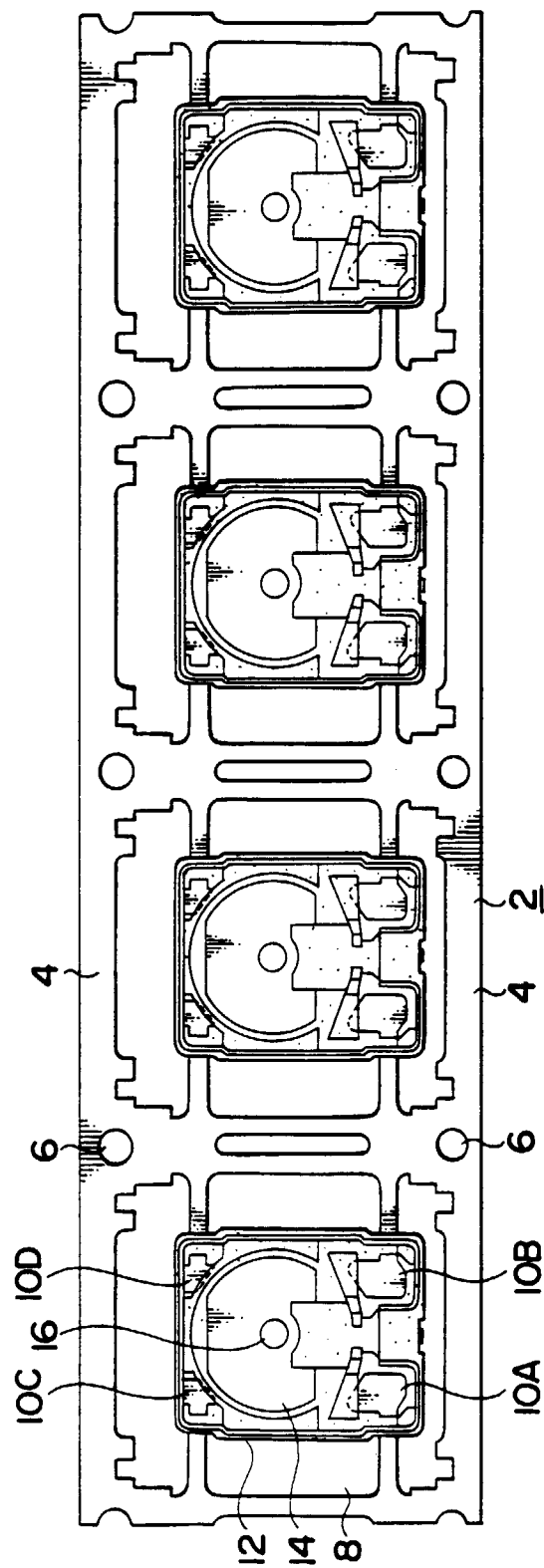


FIG. 2

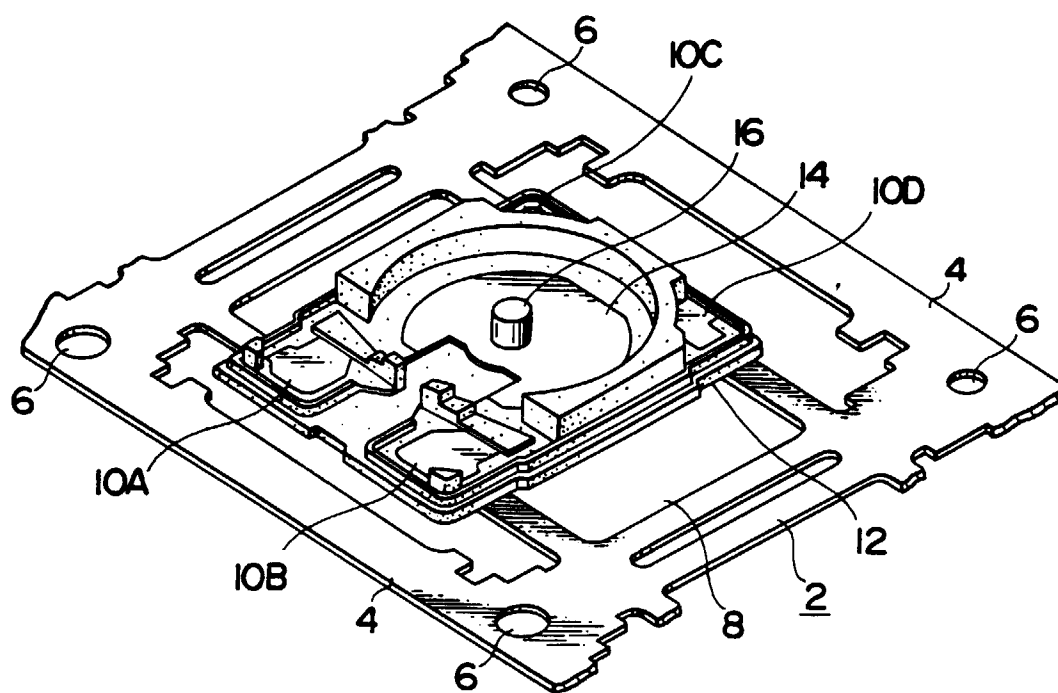


FIG. 3

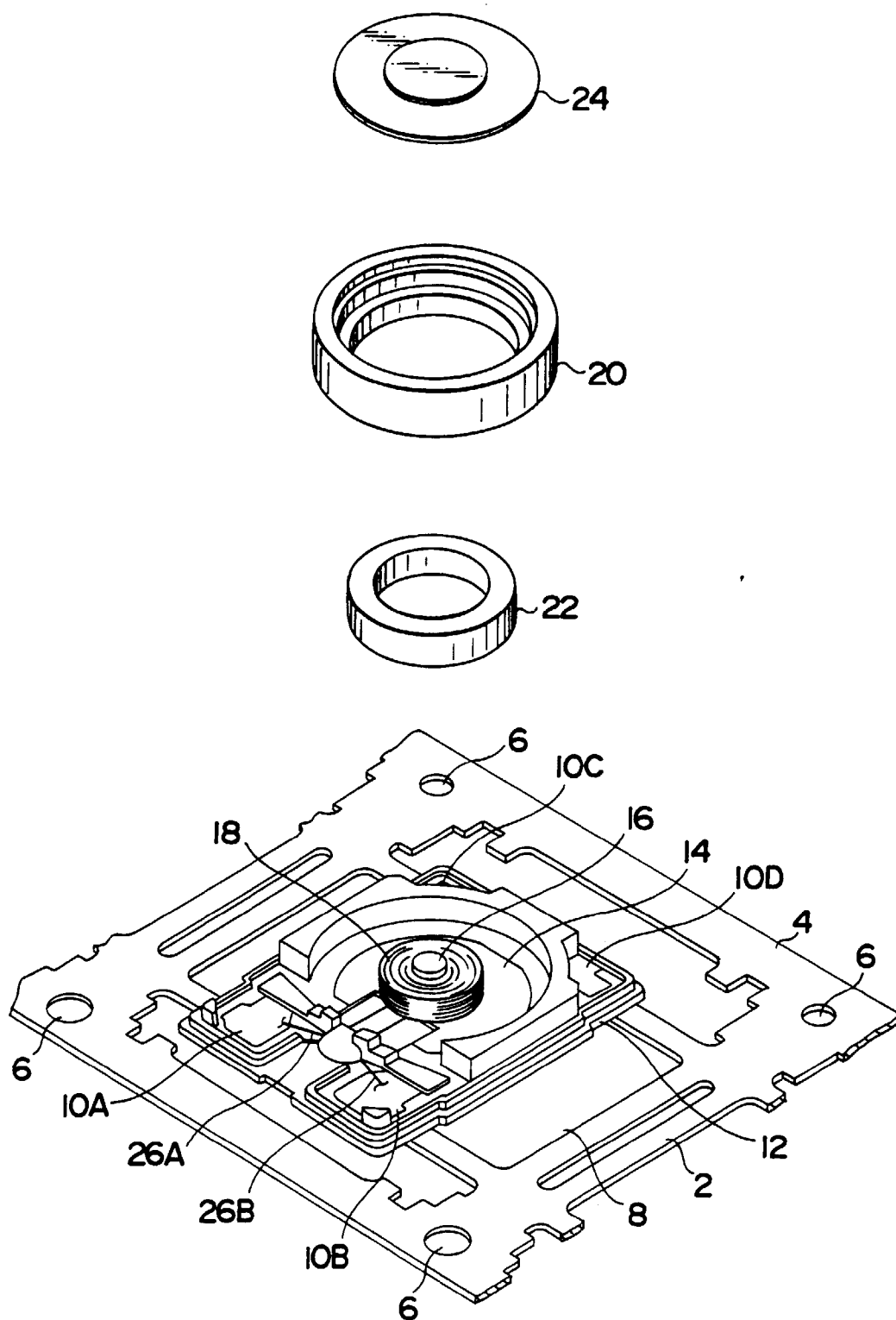


FIG. 4

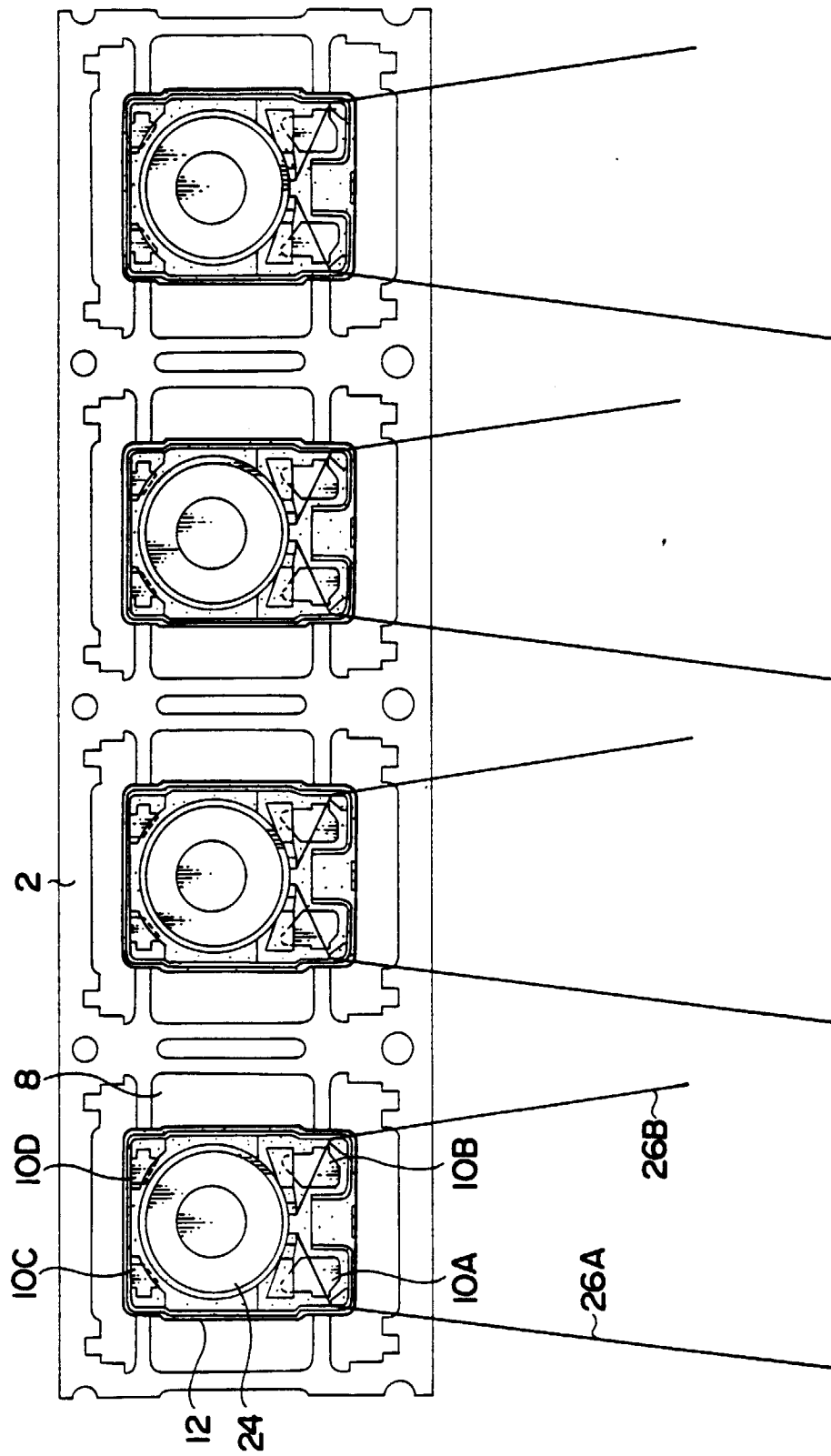


FIG. 5

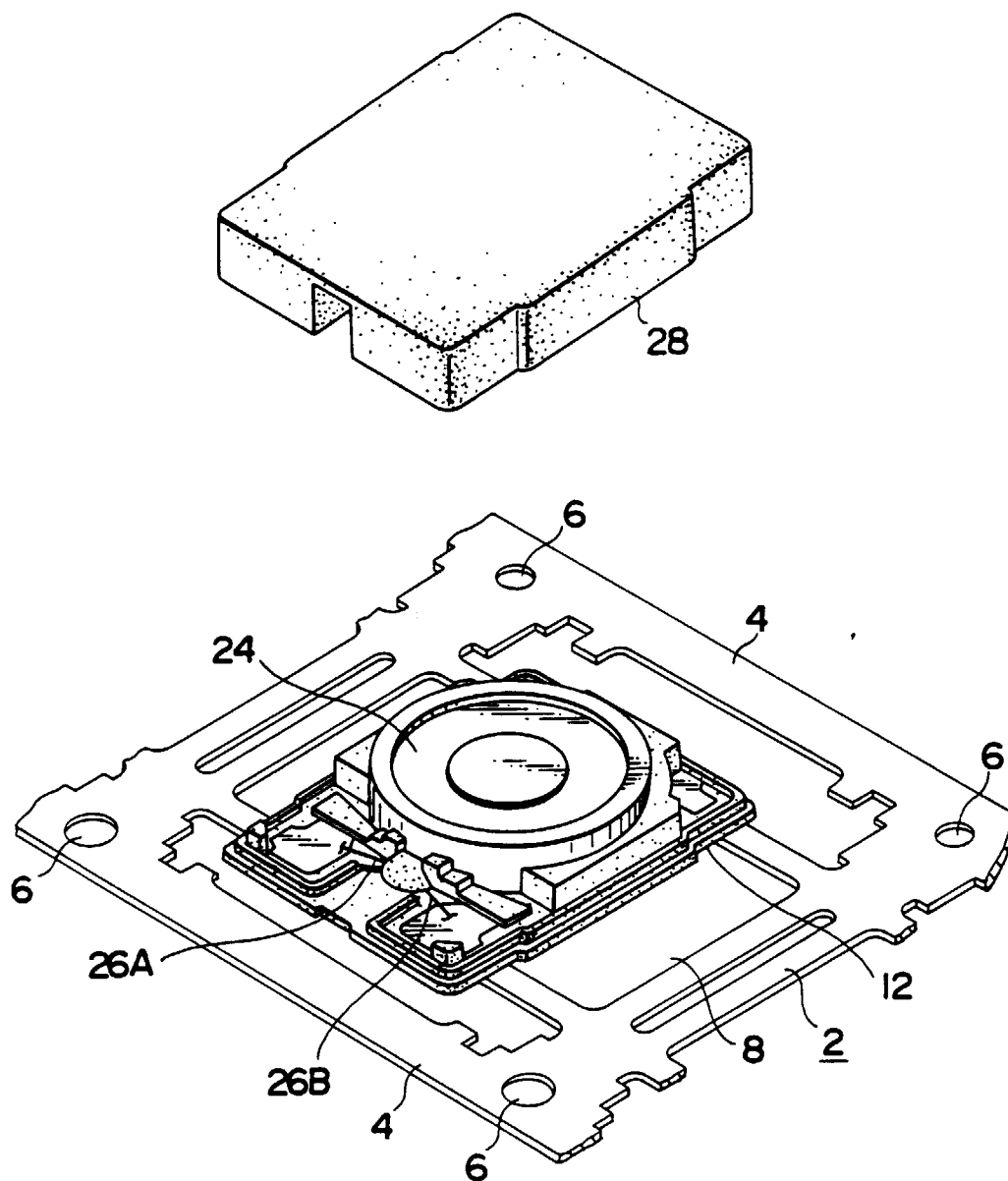


FIG. 6

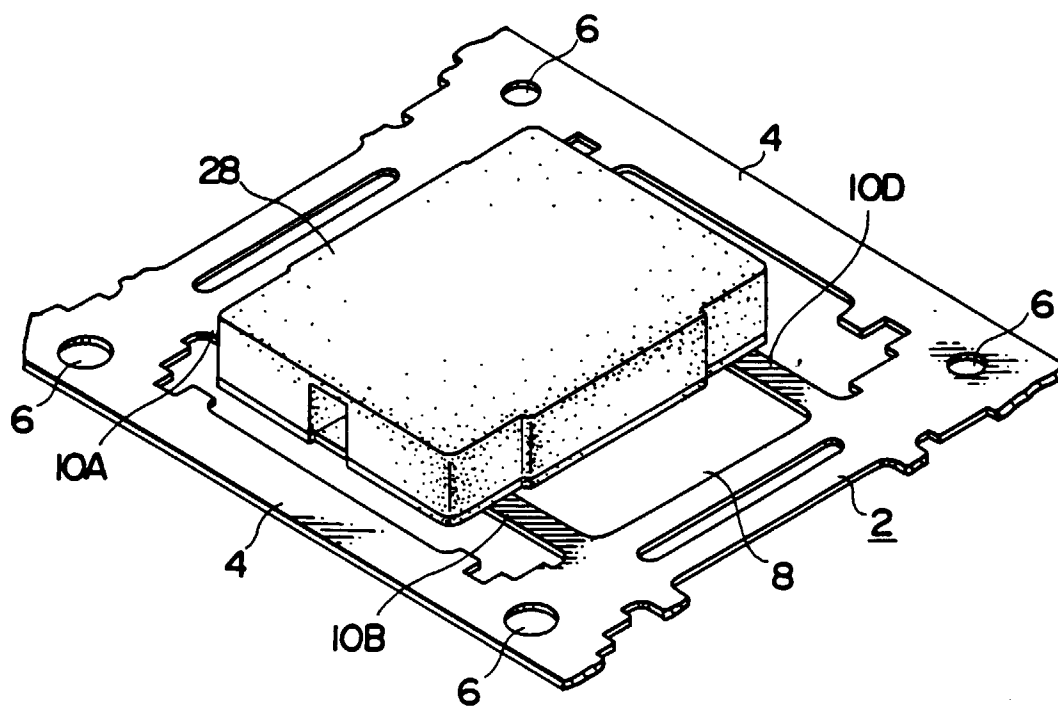


FIG. 7

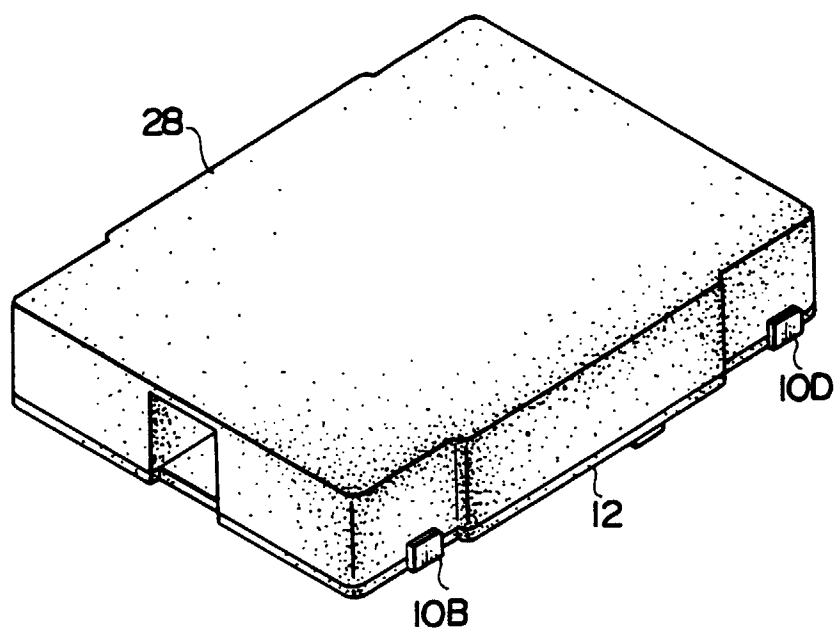


FIG. 8



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EUROPEAN SEARCH REPORT

Application Number
EP 96 30 6952

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	PATENT ABSTRACTS OF JAPAN vol. 010, no. 203 (C-360), 16 July 1986 & JP-A-61 044157 (NIPPON MINING CO LTD), 3 March 1986, * abstract * & DATABASE WPI Section Ch, Week 8615 Derwent Publications Ltd., London, GB; Class L03, AN 86-098321 * abstract *	1,2	H04R1/06
X	PATENT ABSTRACTS OF JAPAN vol. 015, no. 056 (C-0804), 8 February 1991 & JP-A-02 285054 (HITACHI METALS LTD), 22 November 1990, * abstract * & DATABASE WPI Section Ch, Week 9102 Derwent Publications Ltd., London, GB; Class L03, AN 91-011672 * abstract *	1,2	
X	PATENT ABSTRACTS OF JAPAN vol. 016, no. 566 (C-1009), 8 December 1992 & JP-A-04 221020 (NIPPON MINING CO LTD), 11 August 1992, * abstract * & DATABASE WPI Section Ch, Week 9238 Derwent Publications Ltd., London, GB; Class L03, AN 92-313559 * abstract *	1,2	
The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 27 January 1997	Examiner Nieuwenhuis, P
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		I : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPF FORM 150 01/92 (P/0101)



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EUROPEAN SEARCH REPORT

Application Number
EP 96 30 6952

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	PATENT ABSTRACTS OF JAPAN vol. 016, no. 581 (C-1012), 21 December 1992 & JP-A-04 231419 (NIPPON MINING CO LTD), 20 August 1992, * abstract * & DATABASE WPI Section Ch, Week 9240 Derwent Publications Ltd., London, GB; Class L03, AN 92-326884 * abstract *	1,2	
X	--- PATENT ABSTRACTS OF JAPAN vol. 014, no. 308 (E-0947), 3 July 1990 & JP-A-02 100354 (HITACHI METALS LTD), 12 April 1990, * abstract * & DATABASE WPI Section Ch, Week 9021 Derwent Publications Ltd., London, GB; Class L03, AN 90-159436 * abstract *	1	
A	--- EP-A-0 650 308 (STAR MFG CO) 26 April 1995 * column 2, line 3 - column 5, line 54; figures 1-3 * -----	1,2	
The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 27 January 1997	Examiner Nieuwenhuis, P
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document	

EP 0 FORM 1503 01/82 (P4/C01)