(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 677 358 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
08.07.2020 Bulletin 2020/28

(21) Application number: **18886210.6**

(22) Date of filing: **16.10.2018**

(51) Int Cl.:
B21D 26/14 *(2006.01)*

(86) International application number:
PCT/JP2018/038397

(87) International publication number:
WO 2019/111538 (13.06.2019 Gazette 2019/24)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **05.12.2017 JP 2017233421**

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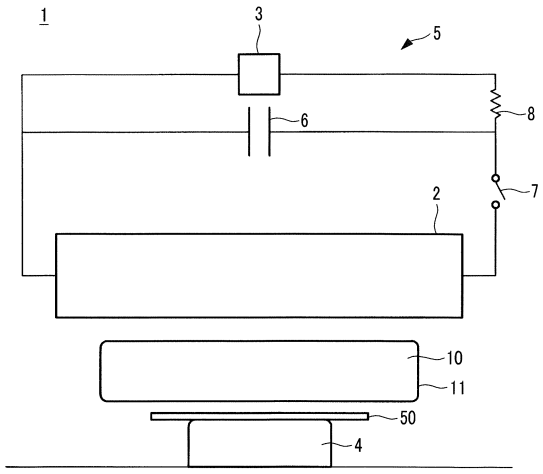
(54) **MOLDING DEVICE**

(57) The objective of the present invention is to provide a molding device capable of performing press-molding accurately with respect to a material to be molded. A molding device (1) is provided with an electromagnetic coil (2), a fluid (10) which is electrically conductive and is installed along a plate-shaped material (50) on one surface side of the plate-shaped material (50), and a molding die (4) which is installed on the other surface side of the plate-shaped material (50) and is formed in such a way as to impart a molded shape to the plate-shaped material (50), wherein an electromagnetic force generated by the electromagnetic coil (2) is caused to act on the fluid (10), and the fluid (10) presses the plate-shaped material (50) against the molding die (4).

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a forming device.

Background Art

[0002] There are many types of aircraft components that configure an aircraft, and in a case where a desired shape is obtained by press forming an aluminum alloy plate, it is necessary to prepare various types of forming dies. As one method of press forming, there is a method in which a forming target material is placed on a male forming die, and the forming target material is pressed by a rubber bag pressurized by a liquid such as oil instead of a female die (rubber forming press). For rubber forming press, it need only prepare the male die as the forming die, and thus rubber forming press is suitable for the production of many kinds in small quantities of aircraft components and the like.

[0003] On the other hand, there is also known a technique of forming a forming target material by using an electromagnetic forming device instead of rubber forming press. In electromagnetic forming, a large current is caused to instantaneously flow through the electromagnetic coil, thereby generating an induced current on a surface of the forming target material arranged along the electromagnetic coil. As a result, an electromagnetic force acts on the surface of the forming target material, and the forming target material moves toward the forming die and is pressed against the forming die.

[0004] PTL 1 discloses that a thin plate is formed into a desired shape by an electromagnetic forming device, and PTL 2 discloses that an electromagnetic force is applied to a predetermined portion of a hollow material in multiple stages by an electromagnetic plastic working method to perform a forming process.

Citation List

Patent Literature

[0005]

[PTL 1] Japanese Unexamined Patent Application Publication No. 2007-296553
[PTL 2] Japanese Unexamined Patent Application Publication No. 6-23442

Summary of Invention

Technical Problem

[0006] In the rubber forming press, the bag pressurized by a liquid presses the forming target material via a rubber plate, and thus the force is not distributed to the entire forming target material, the formation amount is insufficient, and the shape accuracy is not high. Accordingly, a product obtained by forming may have a defective shape or may require a shape correction work. Since the shape correction work is performed by forming a plurality of times or processing by manual operation, there is a problem that time and labor are required. Further, such as a case where a flange with an outwardly projected curved surface (a shrinkage flange) is formed, depending on the formed shape, a compressive force acts on the forming target material at the time of press forming, so that unnecessary wrinkles may occur.

[0007] The present invention is made in view of the above-described circumstances, and an object thereof is to provide a forming device capable of accurately performing press forming on a forming target material.

Solution to Problem

[0008] According to an aspect of the present invention, there is provided a forming device including an electromagnetic coil, a fluid having conductivity and installed on one surface side of a forming target material along the forming target material, and a forming die installed on the other surface side of the forming target material and formed so as to impart a formed shape to the forming target material, in which an electromagnetic force generated by the electromagnetic coil is caused to act on the fluid so that the fluid presses the forming target material against to the forming die.

[0009] According to this configuration, the fluid having conductivity is installed on one surface side of a forming target material along the forming target material and the forming die is installed on the other surface side of the forming target material. When a current is caused to instantaneously flow through the electromagnetic coil, an induced current is generated in the fluid having conductivity, and the electromagnetic force acts on the fluid. Then, the fluid moves toward the forming die, and the fluid presses the forming target material against the forming die. Therefore, the forming die imparts a formed shape to the forming target material. By generating the electromagnetic force in the fluid, a larger pressing force can be generated in a short time as compared with a case where the forming target material is pressed against the forming die by only a fluid pressure of the fluid. The forming target material is formed at a high speed with a large pressing force by using the electromagnetic force, and thus forming can be performed with high accuracy and the spring back amount is reduced. As a result, the strain correction work after forming can be reduced.

[0010] In the above aspect, the fluid may be a metal powder, a liquid in which a metal powder is dispersed, or a liquefied metal.

[0011] In the above aspect, the fluid may be accommodated in a bag-shaped member.

Advantageous Effects of Invention

[0012] According to the present invention, it is possible to accurately perform press forming on a forming target material.

Brief Description of Drawings

[0013]

Fig. 1 is a longitudinal sectional view showing a forming device according to an embodiment of the present invention.

Fig. 2 is a longitudinal sectional view showing a forming device according to an embodiment of the present invention.

Description of Embodiments

[0014] Hereinafter, a forming device 1 according to an embodiment of the present invention will be described with reference to Figs. 1 and 2.

[0015] The forming device 1 according to the embodiment is a device that imparts a formed shape to a plate-shaped material 50 which is, for example, a forming target material made of an aluminum alloy by using a forming die 4. A formed member 60 formed by the forming device 1 is used for aircraft components and the like.

[0016] As shown in Fig. 1, the forming device 1 according to the embodiment includes an electromagnetic coil 2, a power supply unit 3 that supplies a current to the electromagnetic coil 2, the forming die 4, and the like. The forming device 1 generates an induced current to a conductive material by the electromagnetic coil 2 and causes an electromagnetic force to act, similarly to generally known electromagnetic forming. The operating conditions and the like of the forming device 1 can be set in the same manner as in usual electromagnetic forming.

[0017] The electromagnetic coil 2 is arranged outside a forming surface of the forming die 4. For example, the electromagnetic coil 2 is arranged along the surface of the forming die 4 as shown in Fig. 1. The electromagnetic coil 2 may have a cylindrical shape for example, and the forming die 4 may be arranged inside the electromagnetic coil 2.

[0018] A large current is supplied from the power supply unit 3 to the electromagnetic coil 2. As shown in Fig. 1, a power supply circuit 5 includes a circuit in which a capacitor 6 is installed in parallel with the electromagnetic coil 2 and a switch 7 is installed between a connection point between the power supply unit 3 and the capacitor 6 and the electromagnetic coil 2. In this configuration, when the switch 7 is open, an electric charge is charged from the power supply unit 3 to the capacitor 6 through an electric resistance 8. Then, by closing the switch 7 and discharging an electric charge charged in the capacitor 6, a large current to the electromagnetic coil 2 is generated.

[0019] A fluid 10 is a material having conductivity and fluidity. The fluid 10 is accommodated in a rubber bag 11, for example. The fluid 10 is, for example, a metal powder or a liquid in which a metal powder is dispersed. The metal powder is, for example, an iron powder. The liquid is oil, for example, and fluidity and rust prevention are ensured. In the liquid in which a metal powder is dispersed, a ratio of the metal powder to the liquid is preferably 50% by mass or more, and if possible, 75% by mass or more. Although there is a possibility that a load pressure at the time of forming is reduced, even in a case where the material has a value smaller than the above described example, it can be applied as the fluid 10 as long as forming can be performed by the material. Further, the fluid 10 may be a low melting point metal. A low melting point metal is, for example, lead or tin. By setting an environment of the forming device 1 to an environment with equal to or more than the melting point of the fluid 10 which is a low melting point metal, the fluid 10 can be used in a fluidized and liquefied state.

[0020] The fluid 10 is placed on one surface side of the plate-shaped material 50 which is the forming target material, and the forming die 4 is installed on the other surface side of the plate-shaped material 50 with the plate-shaped material 50 interposed therebetween.

[0021] By causing a large current to instantaneously flow through the electromagnetic coil 2, an induced current is generated on the surface of the fluid 10 arranged along the electromagnetic coil 2. As a result, an electromagnetic force acts on the fluid 10, the fluid 10 moves toward the forming die 4, and the fluid 10 and the plate-shaped material 50 are pressed against the forming die 4.

[0022] Before forming, the plate-shaped material 50 which is the forming target material is placed on the forming surface of the forming die 4. The forming die 4 is a male die and imparts the formed shape to the plate-shaped material 50.

[0023] In the forming method using the forming device 1 according to the embodiment, first, the plate-shaped material 50 is placed on the forming surface of the forming die 4 as shown in Fig. 1. Furthermore, the fluid 10 is placed on an upper surface of the plate-shaped material 50 placed on the forming die 4.

[0024] Next, a current is supplied to the electromagnetic coil 2. As a result, an induced current is generated on the surface of the fluid 10 and an electromagnetic force acts on the fluid 10, so that the fluid 10 moves toward the forming die 4, and the fluid 10 presses the plate-shaped material 50 against the forming die 4. At this time, the fluidity of the fluid 10 decreases, and the fluid 10 can strongly press the plate-shaped material 50. Thereby, as shown in Fig. 2, the plate-shaped material 50 is formed along the forming die 4 to form the formed member 60. After pressing the plate-shaped material 50 for a predetermined time, the supply of a current is cut off, whereby the action of the electromagnetic force on the fluid 10 can be stopped. Accordingly, fluidity of the fluid 10 is restored.

[0025] As described above, according to the forming device 1 according to the embodiment, by generating the electromagnetic force in the fluid 10, a larger pressing force can be generated in a short time as compared with a related rubber forming press in which the plate-shaped material is pressed against the forming die by only a fluid pressure of the fluid.

[0026] Stated another way, the plate-shaped material 50 is formed at a high speed with a large pressing force by using the electromagnetic force acting on the fluid 10, and thus the plate-shaped material can be formed in a shape along the forming die 4 with high accuracy and the spring back amount is reduced in the resulting formed member 60. In particular, in the case of an aluminum alloy, it is a material having a higher breaking elongation as the strain rate becomes higher, and has a great effect of reducing the spring back amount by being formed at a high speed. Therefore, since the insufficiency of the formation amount of the formed member 60 is unlikely to occur, the strain correction work after forming can also be reduced. In addition, since forming can be accurately performed, the formed member 60 can be formed without generating unnecessary wrinkles even in a case of forming a flange (a shrinkage flange) having an outwardly projected curved surface. A magnesium alloy (such as AZ80) is known as a material having a higher breaking elongation as the strain rate increases, in addition to an aluminum alloy, and an effect of reducing the spring back amount can be obtained.

[0027] In the above embodiment, the case where the formed member 60 is formed for the first time from the unprocessed plate-shaped material 50 has been described, but the present invention is not limited thereto. For example, the present invention can be applied to a case where the forming die 4 is pressed against the processed formed member 60 to correct the shape of the formed member 60.

Reference Signs List

[0028]

1: forming device
2: electromagnetic coil
3: power supply unit
4: forming die
5: power supply circuit
6: capacitor
7: switch
8: electric resistance
10: fluid
11: bag
50: plate-shaped material
60: formed member

Claims

1. A forming device comprising:

an electromagnetic coil;
a fluid having conductivity and installed on one surface side of a forming target material along the forming target material; and
a forming die installed on the other surface side of the forming target material and formed so as to impart a formed shape to the forming target material,
wherein an electromagnetic force generated by the electromagnetic coil is caused to act on the fluid so that the fluid presses the forming target material against to the forming die.

2. The forming device according to Claim 1, wherein the fluid is a metal powder, a liquid in which a metal powder is dispersed, or a liquefied metal.

3. The forming device according to Claim 1 or 2, wherein the fluid is accommodated in a bag-shaped member.

FIG. 1

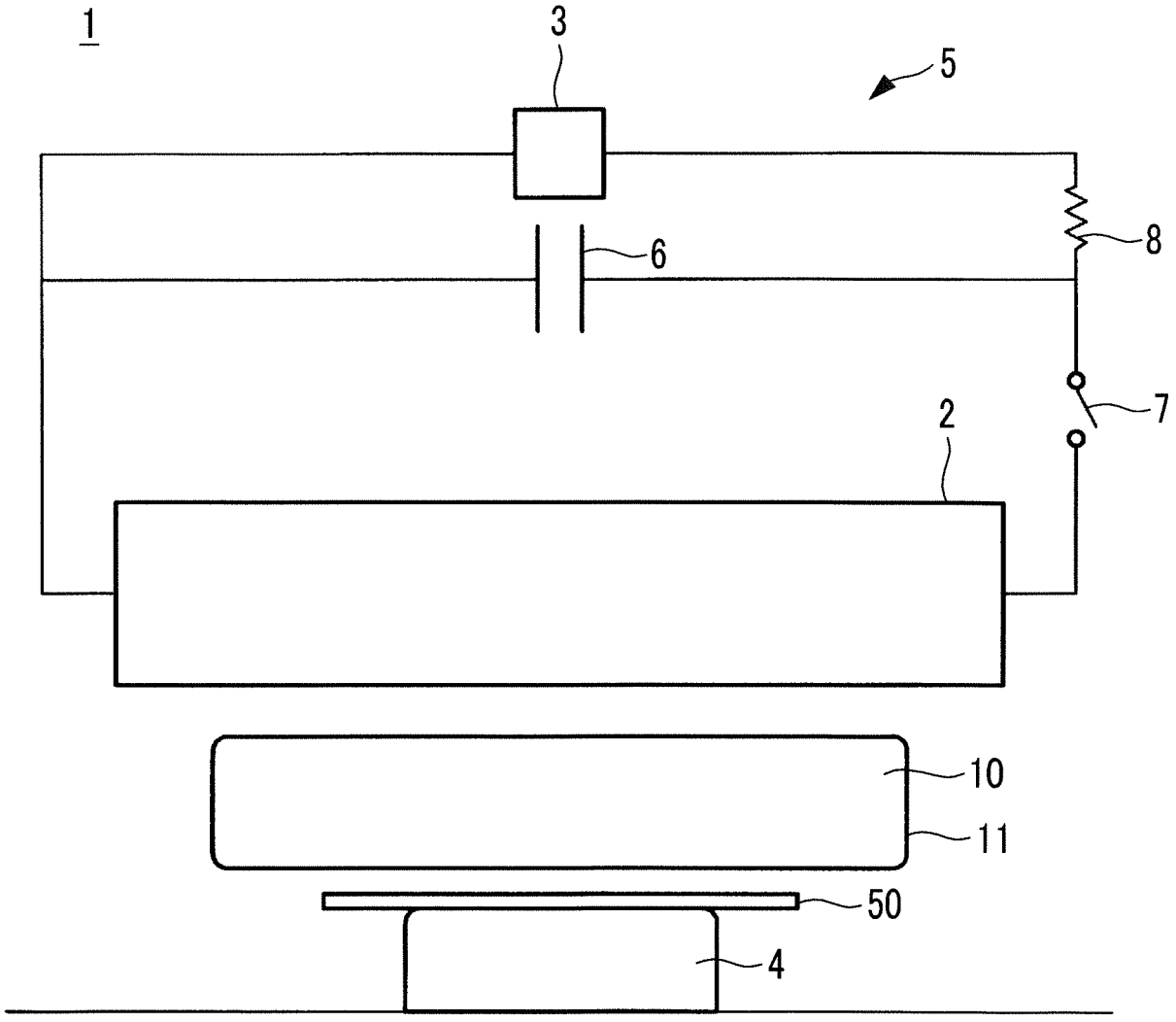
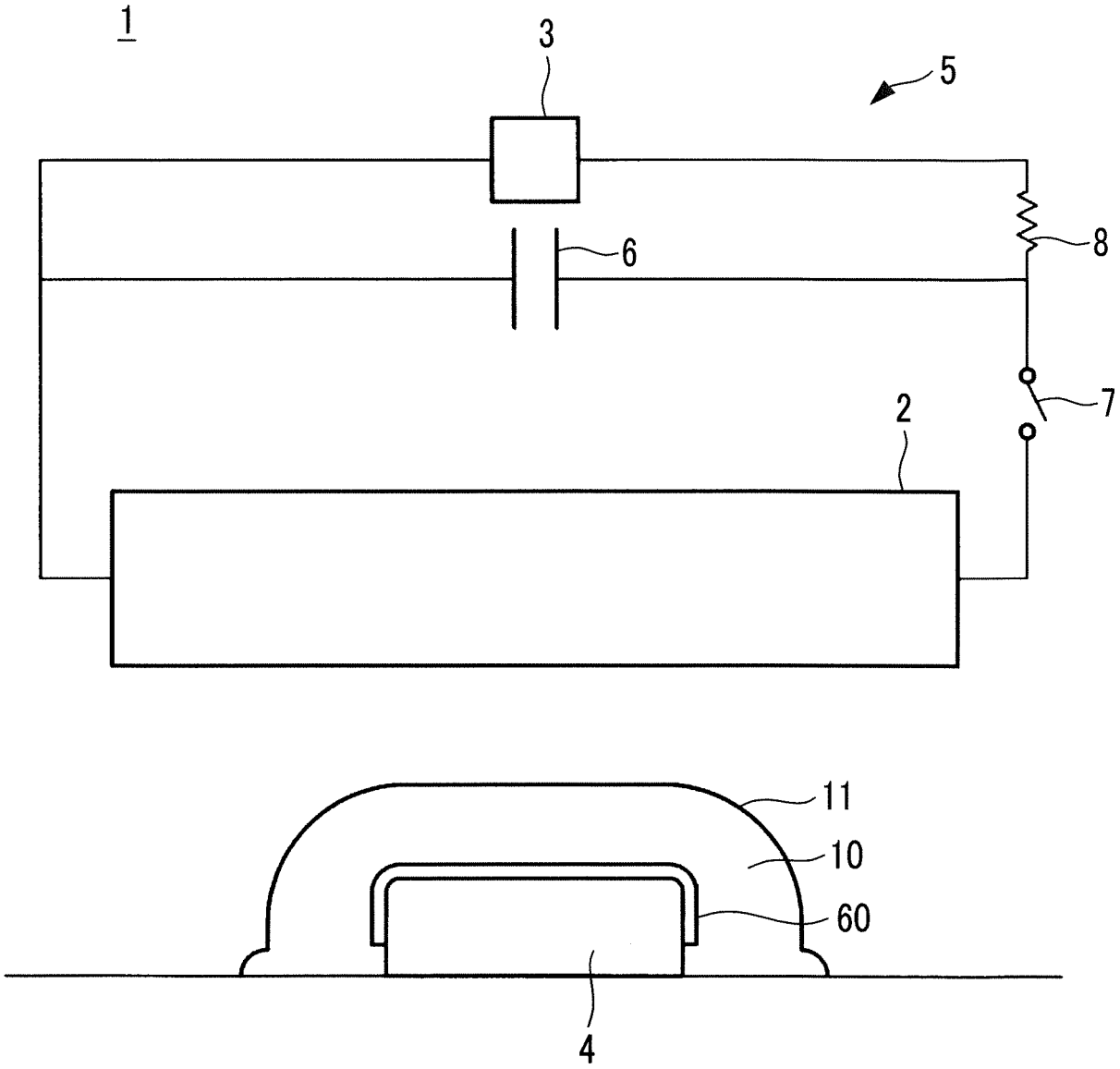


FIG. 2



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/038397

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. B21D26/14(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int. Cl. B21D26/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2018
Registered utility model specifications of Japan	1996-2018
Published registered utility model applications of Japan	1994-2018

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3888098 A (THE BOEING COMPANY) 10 June 1975, column 1, line 9 to line 49, column 2, line 41 to line 62, column 5, line 39 to line 54, column 5, line 68 to column 6, line 31, column 8, line 67 to column 9, line 40, fig. 4 (Family: none)	1-3
A	US 3618350 A (THE BOEING COMPANY) 09 November 1971, column 4, line 63 to column 5, line 15 (Family: none)	1-3

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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Date of the actual completion of the international search	Date of mailing of the international search report
10.12.2018	25.12.2018
Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/038397

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2000-507159 A (PULSAR WELDING LTD.) 13 June 2000, page 24, line 11 to line 17 & US 5824998 A, column 10, line 61 to column 11, line 6 & WO 1997/022426 A2 & EP 868233 A2 & DE 69620787 T2 & KR 10-2000-0064506 A & ES 2177818 T3 & CN 1207695 A & RC 2178349 C2	1-3
A	JP 55-156622 A (JAPAX INC.) 05 December 1980, page 2, upper left column, line 14 to page 2, lower left column, line 9, fig. 2A, 2B (Family: none)	1-3
A	FR 2570303 A1 (LEROY, Maurice) 21 March 1986, page 3, line 33 to page 4, line 5 (Family: none)	1-3
A	JP 2001-246424 A (JAPAN AIRCRAFT MFG CO., LTD.) 11 September 2001, paragraphs [0002]-[0006], [0021]-[0027] (Family: none)	1-3

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2007296553 A **[0005]**
- JP 6023442 A **[0005]**