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(54) CLOSING METHOD AND CLOSING MACHINE

(57) In a closing machine (1) for closing an open end of a work piece (9) by pressing a die (4) heated by a high frequency heating device (2) against the work piece (9) rotating about an axial center, the die (4) comprises a die main body (601) which contacts the work piece (9) and a holder (611) which surrounds the die main body (601). The die main body (601) is formed from cemented carbide whereas the holder (611) is formed from a steel material. The holder (611) is subjected to induction heating by the high-frequency heating device (2), whereas the die main body (601) is heated by heat transfer from the holder (611).

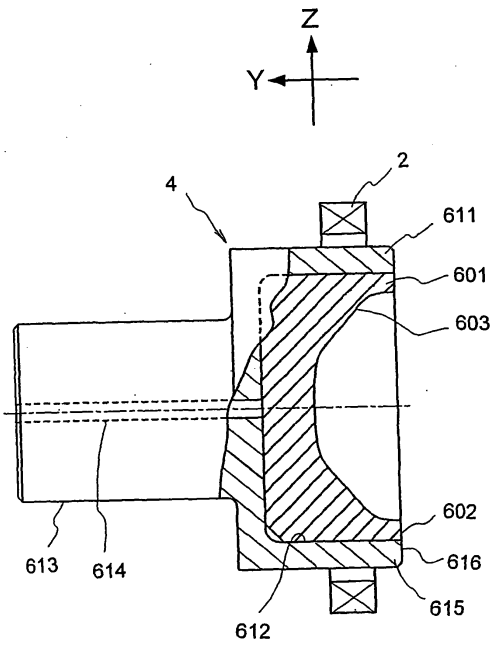

FIG.5

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Description

FIELD OF THE INVENTION

[0001] This invention relates to an improvement in a closing method and a closing machine for closing an open end of a metal pipe material.

BACKGROUND OF THE INVENTION

[0002] In a closing method, a work piece constituted by a metal pipe material is rotated and a die is pressed against the work piece while the work piece is heated. Thus, the work piece undergoes plastic deformation as it gradually approaches the die.

[0003] A closing machine used in the closing operation comprises an outer diameter chuck that holds an outer peripheral surface of the work piece, and a chuck spindle that drives the outer diameter chuck to rotate together with the work piece. The work piece is closed by pressing the rotating die against the work piece at an offset to the rotating work piece.

[0004] The closing method and closing machine described above are disclosed in JP2002-153930A.

[0005] In a conventional closing machine, the die is subjected to induction heating using a high-frequency heating device, and when the die reaches a high temperature of 300°C or more, the work piece is heated by pressing the die against the work piece. Thus, the work piece is closed.

[0006] However, the die used in this conventional closing machine is formed with a steel material such as hot die steel or the like, for example, as the material that is subjected to induction heating by the high-frequency heating device, and therefore the wear resistance of the die is poorer than that of a die formed from cemented carbide, for example, leading to a reduction in the life of the die.

[0007] It is therefore an object of this invention to provide a closing method and a closing machine in which the life of a die is extended.

SUMMARY OF THE INVENTION

[0008] This invention provides a closing method for closing an open end of a work piece by pressing a die heated by a high frequency heating device against the work piece rotating about an axial center, characterized in that a die main body of the die, which contacts the work piece, is formed from a non-ferrous metal, whereas a holder surrounding the die main body is formed from a ferrous metal, and the holder is subjected to induction heating by the high-frequency heating device whereas the die main body is heated by heat transfer from the holder.

[0009] This invention also provides a closing machine for closing an open end of a work piece by pressing a die heated by a high frequency heating device against the work piece rotating about an axial center, characterized in that the die comprises a die main body which contacts the work piece and a holder which surrounds the die main body, the die main body is formed from a non-ferrous metal, the holder is formed from a ferrous metal, and the holder is subjected to induction heating by the high-frequency heating device whereas the die main body is heated by heat transfer from the holder.

[0010] According to this invention, the die comprises the die main body that contacts the work piece and the holder that surrounds the die main body, the die main body is formed from a non-ferrous metal, the holder is formed from a ferrous metal, and during a closing operation, the holder is subjected to induction heating by the high-frequency heating device whereas the die main body is heated by heat transfer from the holder. Hence, the die main body that is pressed against the work piece does not have to be subjected to induction heating through electromagnetic induction, and can be formed from a non-ferrous metal having high wear resistance. As a result, the life of the die can be greatly extended, and closing operations can be performed continuously over a long time period, enabling an improvement in production efficiency.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

FIG. 1 is a side view of a closing machine, illustrating an embodiment of this invention.
FIG. 2 is a plan view of the closing machine.
FIG. 3 is a front view of the closing machine.
FIGs. 4A - 4H are views showing closing processes.
FIG. 5 is a sectional view of a die.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] This invention will now be described in further detail with reference to the attached drawings.

[0013] FIGs. 1 to 3 show the overall constitution of a closing machine 1. In FIGs. 1 to 3, three axes, namely X, Y, and Z, are set orthogonal to each other. It is assumed that the X axis extends in a substantially horizontal lateral direction, the Y axis extends in a substantially horizontal front-rear direction, and the Z axis extends in a substantially vertical direction. The overall constitution of the closing machine 1 will now be described.

[0014] Two chuck spindles 20 which drive a work piece 9 to rotate about its axial center, and a single die driving device 40 which drives a die 4, are provided in a central portion of the closing machine 1. The chuck spindles 20 perform a reciprocating motion in the X axis direction relative to a pedestal 3 via a chuck spindle moving device 30, to be described later, thereby moving alternately to the central portion of the closing machine 1 so as to bring the work piece 9 face to face with the die 4.

[0015] The closing machine 1 performs a closing op-

eration to close an open end of the work piece 9 by heating the work piece 9, which is constituted by a metal pipe material, using a high-frequency heating device 2, and pressing the die 4 against the rotating work piece 9 such that the work piece 9 undergoes plastic deformation.

[0016] A thrust stopper moving device 60, which is positioned in front of the chuck spindle 20 for closing the work piece 9 so as to support an end portion of the work piece 9, and a core moving device 50, which moves a core 5 inside the work piece 9, are provided in the central portion of the closing machine 1.

[0017] A pair of conveyors 18 and a work piece introducing device 10 are provided respectively on the left and right rear portions of the working machine 1. The work piece 9 is conveyed forward in the Y axis direction by each of the conveyors 18 and then conveyed forward in the Y axis direction by each of the work piece introducing devices 10, which are capable of movement in the Y axis direction. Thus, the work piece 9 is introduced into and gripped by the respective left and right chuck spindles 20.

[0018] While one of the chuck spindles 20 is positioned in the central portion of the working machine 1 during a closing operation, the other chuck spindle 20 is positioned on either the left or right end portion of the closing machine 1 so as to receive the work piece 9 conveyed by the respective work piece introducing devices 10.

[0019] A discharge device 17 for discharging the work piece 9 following the closing operation is provided at the front portion of the closing machine 1. The discharge device 17 causes a hand 13 gripping the work piece 9 to reciprocate in the X axis direction relative to the pedestal 3 such that the work piece 9, which is pushed out from the left and right chuck spindles 20, is conveyed to a conveyor 19 disposed on the right-hand front portion of the closing machine 1.

[0020] Once the closing operation is complete, the work piece 9, which is at a high temperature of 1000°C or more, is conveyed to a cooling device 70 (see FIG. 3) by the conveyor 19 and cooled by the cooling device 70. The cooling device 70 is provided on the front right side of the closing machine 1.

[0021] FIGs. 4A to 4G show a series of processes performed by the closing machine 1 to close the work piece 9. Each process of this closing method will now be described in sequence.

[0022] Referring to FIG. 4A, an inner diameter chuck 8 of the work piece introducing device 10 is inserted into the work piece 9 such that the inner diameter chuck 8 grips the inner peripheral surface of the work piece 9.

[0023] Referring to FIG. 4B, the work piece introducing device 10 causes the inner diameter chuck 8 to advance in the Y axis direction such that the work piece 9 is inserted into an outer diameter chuck 7 of the chuck spindle 20. Thus, the outer diameter chuck 7 grips the outer peripheral surface of the work piece 9.

[0024] Referring to FIG. 4C, the work piece introducing device 10 causes the inner diameter chuck 8 to retreat in the Y axis direction such that the inner diameter chuck 8 is extracted from the work piece 9. Next, the chuck spindle moving device 30 moves the chuck spindle 20 in the X axis direction until the work piece 9 is stopped in an operation position facing the die 4.

[0025] Referring to FIG. 4D, the thrust stopper moving device 60 moves a thrust stopper 6 to a thrust operation reference position supporting a base end portion 9b of the work piece 9.

[0026] Referring to FIG. 4E, the core moving device 50 introduces the core 5 into the inside of the work piece 9.

[0027] Referring to FIG. 4F, the chuck spindle 20 drives the work piece 9 and the core 5 to rotate. Meanwhile, the die 4 is pressed against the heated work piece 9 by the die driving device 40. Thus, a tip end portion 9a of the work piece 9 is steadily reduced in diameter between the die 4 and the core 5 such that finally, the tip end portion 9a of the work piece 9 closes to form a bottom portion 9c.

[0028] Referring to FIG. 4G, the die driving device 40 moves the die 4 rearward in the Y axis direction away from the work piece 9. Meanwhile, the thrust stopper moving device 60 moves the thrust stopper 6 forward in the Y axis direction away from the thrust operation reference position, and the core moving device 50 removes the core 5 from the inside of the work piece 9.

[0029] To close another work piece 9 thereafter, the chuck spindle moving device 30 moves the chuck spindle 20 in the X axis direction such that the work piece 9 faces the inner diameter chuck 8, as shown in FIG. 4A. Then, as shown in FIG, 4B, the work piece introducing device 10 causes the inner diameter chuck 8 to advance in the Y axis direction such that the base end portion 9b of the unclosed work piece 9 abuts against the bottom portion 9c of the closed work piece 9, and thus the closed work piece 9 is pushed out of the outer diameter chuck 7.

[0030] To terminate the closing operation of the work piece 9, the work piece introducing device 10 causes the inner diameter chuck 8 to advance in the Y axis direction, as shown in FIG. 4H, such that the inner diameter chuck 8 abuts against the bottom portion 9c of the closed work piece 9, and thus the closed work piece 9 is pushed out of the outer diameter chuck 7.

[0031] The overall constitution of the closing machine 1 was described above.

[0032] Next, the constitution of the die 4 shown in FIG. 5 will be described.

[0033] The die 4 is constituted by a die main body 601 that contacts the work piece 9 and a holder 611 that surrounds the die main body 601, which are formed separately from each other.

[0034] The die main body 601 is formed from cemented carbide serving as a non-ferrous metal. The cemented carbide is formed by blending and sintering metallic carbide powder and a non-ferrous metal powder such as tungsten, vanadium, titanium, tantalum, or cobalt, for example, and has high resistance to heat and wear.

[0035] The die main body 601 has a disk-shaped outer form, and comprises a molding recessed portion 603 which comes into contact with the work piece 9 and is formed as a recessed indent in an end face 602 of the die main body 601 facing the work piece 9. During a closing operation, the tip end portion 9a of the work piece 9 is narrowed along the molding recessed portion 603.

[0036] The holder 611 is formed from a steel material serving as a ferrous metal. The holder 611 is induction heated by the high-frequency heating device 2, and the die main body 601 is heated through heat transfer from the holder 611. Hot die steel, for example, is used as the steel material.

[0037] The holder 611 comprises a cylindrical die outer wall portion 615 that surrounds the die main body 601, a recessed portion 612 forming a recessed indent relative to an end face 616 of the die outer wall portion 615, a shaft portion 613 that is gripped by a chuck, not shown in the drawing, of the die driving device 40, and a hole 614 penetrating the shaft portion 613 in the Y axis direction.

[0038] The die main body 601 is joined to the recessed portion 612 of the holder 611 by shrink-fitting. During the shrink-fitting operation, air existing between the recessed portion 612 and the die main body 601 escapes through the hole 614.

[0039] An induction coil of the high-frequency heating device 2 is formed in a ring shape surrounding the die outer wall portion 615 of the holder 611 at a remove therefrom, and is provided concentrically with the die 4.

[0040] The closing machine 1 is constituted as described above, and next, an action thereof will be described.

[0041] In the closing machine 1, the chuck spindle 20 drives the work piece 9 and the core 5 to rotate while the high-frequency heating device 2 subjects the die 4 to induction heating. The die driving device 40 then presses the die 4 against the work piece 9 while rotating the die 4 at an offset to the work piece 9 in order to close the work piece 9. Thus, as shown in FIG. 4F, the tip end portion 9a of the work piece 9 is gradually narrowed along the molding recessed portion 603 between the die 4 and the core 5 such that finally, the tip end portion 9a of the work piece 9 forms the closed bottom portion 9c.

[0042] During this closing operation, the high-frequency heating device 2 subjects the die 4 to induction heating through electromagnetic induction. When a high-frequency current is caused to flow through the induction coil of the high-frequency heating device 2, high-frequency magnetic flux is generated in the die 4, and a high current is induced in the steel holder 611 by the high-frequency magnetic flux. Thus, Joule heat is generated such that the holder 611 self-heats. Meanwhile, the die main body 601, which is constituted by cemented carbide serving as a non-ferrous metal, is not subjected to induction heating through electromagnetic induction, but is heated by heat transfer from the holder 611.

[0043] The holder 611 comprises the cylindrical die outer wall portion 615 surrounding the die main body 601, and the induction coil of the high-frequency heating device 2 is provided so as to surround the die outer wall portion 615. Thus, the high-frequency heating device 2 can subject the die outer wall portion 615 to effective induction heating through electromagnetic induction, and the die outer wall portion 615 can heat the die main body 601 effectively through heat transfer.

[0044] The die main body 601 that is pressed against the work piece 9 is formed from cemented carbide, which has greater wear resistance than a steel material, and therefore the life of the die 4 can be extended approximately fourfold in comparison with a conventional die constituted by hot die steel. As a result, closing operations can be performed continuously over a long time period, enabling an improvement in production efficiency.

[0045] Moreover, the die main body 601 is harder than a steel material, and therefore wear on the work piece 9 during a closing operation can be reduced.

[0046] Further, the non-ferrous metal forming the die main body 601 is not limited to cemented carbide, and a ceramic material or the like may be used.

INDUSTRIAL APPLICABILITY

[0047] The closing method and closing machine of this invention are not limited to a closing operation such as that described above, for closing an open end of a work piece, and may be used in a spinning operation to reduce the diameter of a work piece by pressing a die against the rotating work piece.

Claims

1. A closing method for closing an open end of a work piece (9) by pressing a die (4) heated by a high frequency heating device (2) against the work piece (9) rotating about an axial center, **characterized in that**:

   a die main body (601) of the die (4), which contacts the work piece (9), is formed from a non-ferrous metal, whereas a holder (611) surrounding the die main body (601) is formed from a ferrous metal; and
   the holder (611) is subjected to induction heating by the high-frequency heating device (2) whereas the die main body (60 1) is heated by heat transfer from the holder (611).

2. A closing machine (1) for closing an open end of a work piece (9) by pressing a die (4) heated by a high frequency heating device (2) against the work piece (9) rotating about an axial center, **characterized in that**:

the die (4) comprises a die main body (601) which contacts the work piece (9), and a holder (611) which surrounds the die main body (601);
the die main body (601) is formed from a non-ferrous metal;
the holder (611) is formed from a ferrous metal; and
the holder (611) is subjected to induction heating by the high-frequency heating device (2) whereas the die main body (601) is heated by heat transfer from the holder (611).

3. The closing machine (1) as defined in Claim 2, **characterized in that** the die main body (601) is formed from a cemented carbide.

4. The closing machine (1) as defined in Claim 2, **characterized in that** the holder (611) comprises a cylindrical die outer wall portion (615) which surrounds the die main body (601), and an induction coil of the high-frequency heating device (2) is provided so as to surround the die outer wall portion (615).

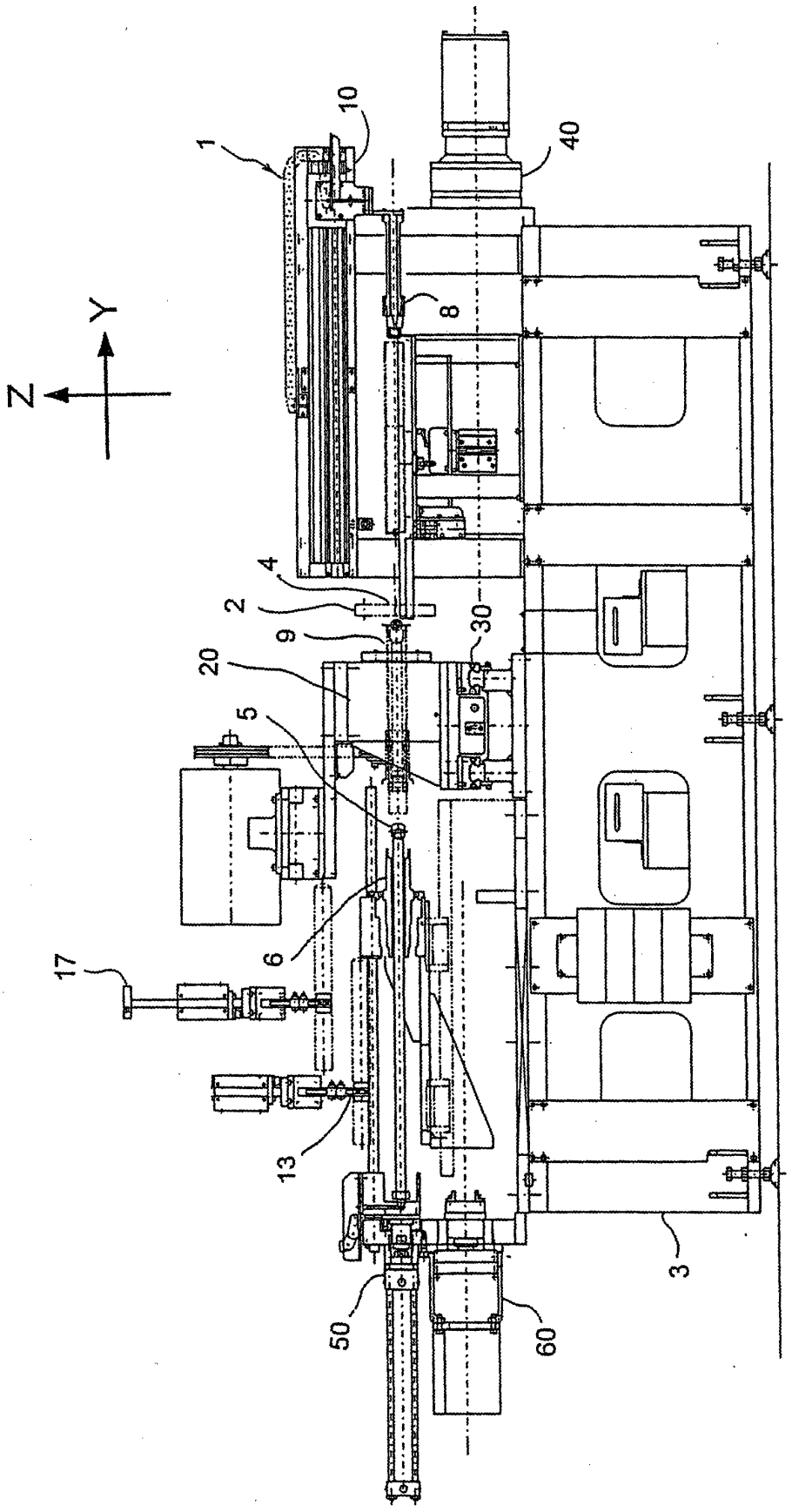


FIG.1

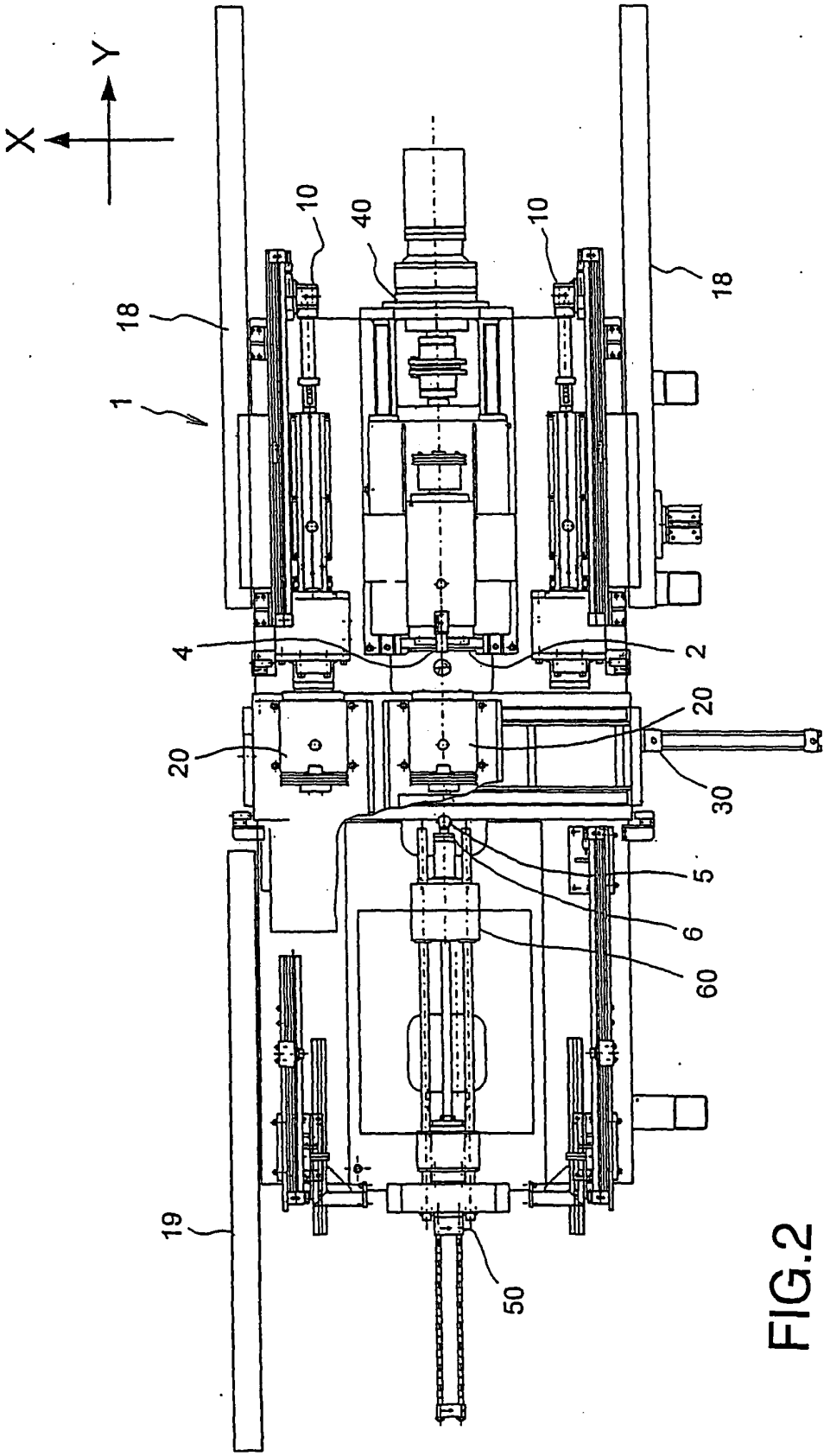


FIG.2

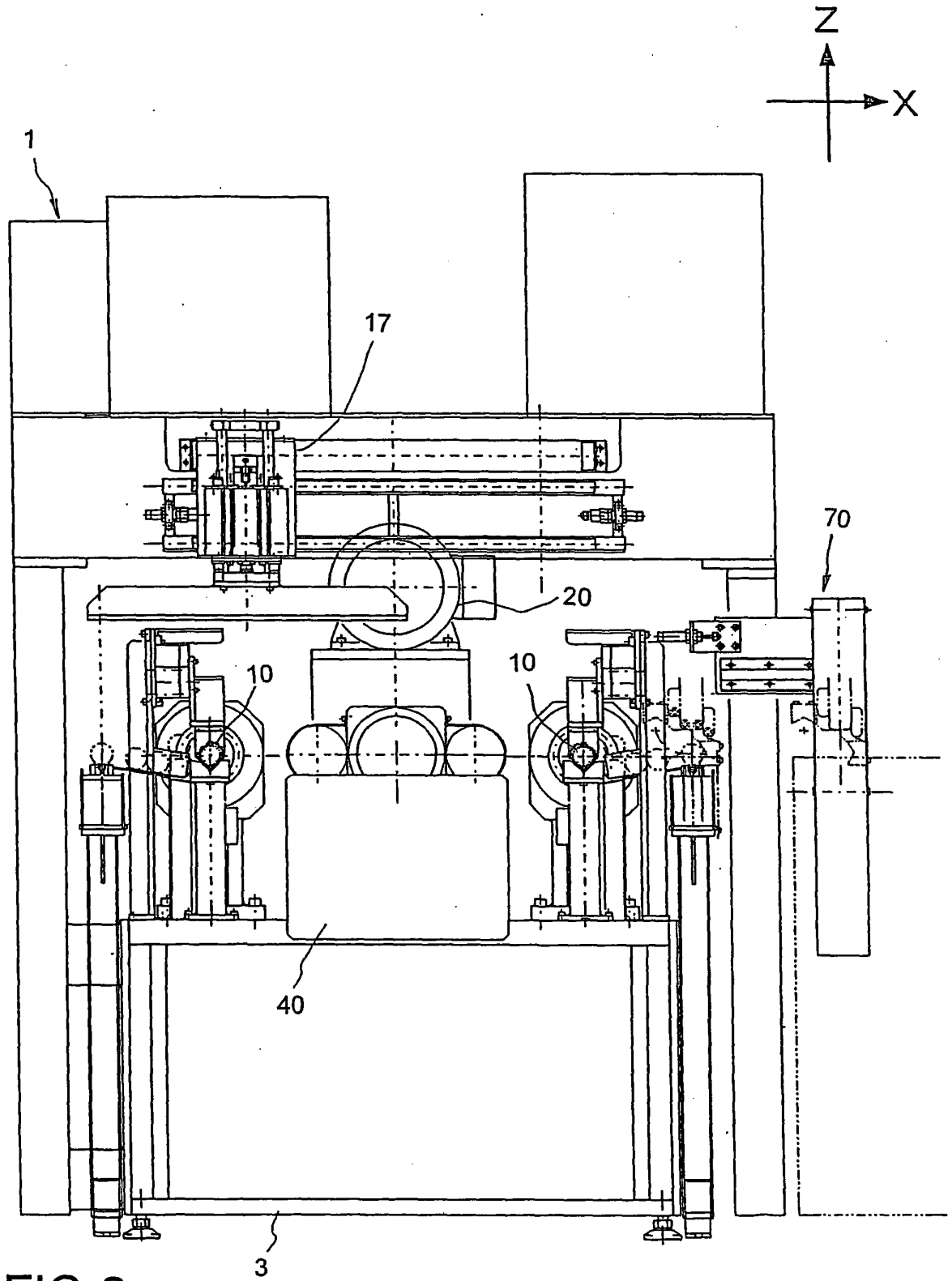


FIG.3

FIG. 4A

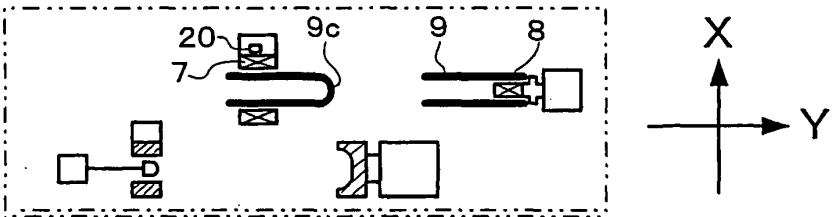


FIG. 4B

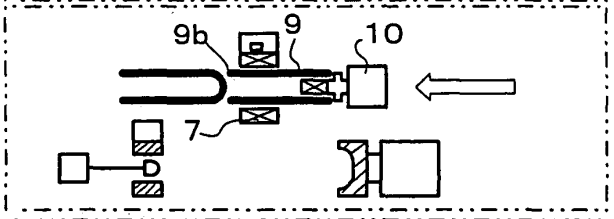


FIG. 4C

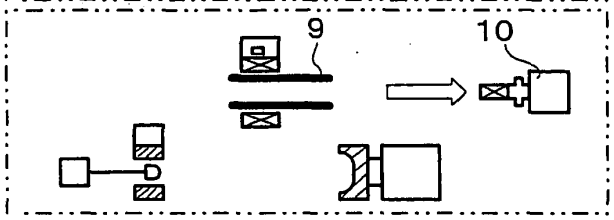


FIG. 4D

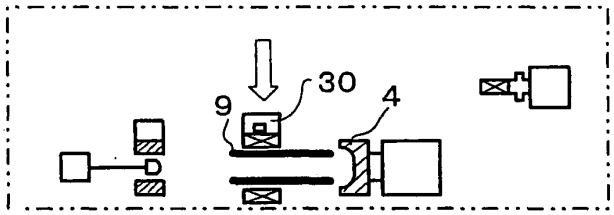


FIG. 4E

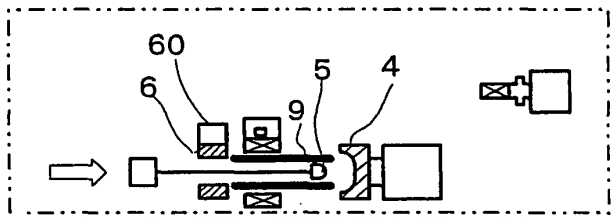


FIG. 4F

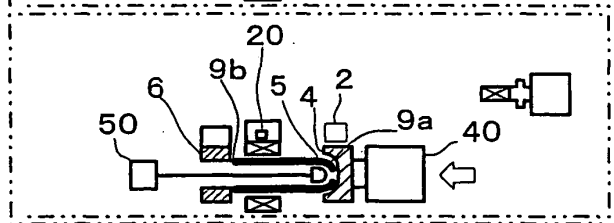


FIG. 4G

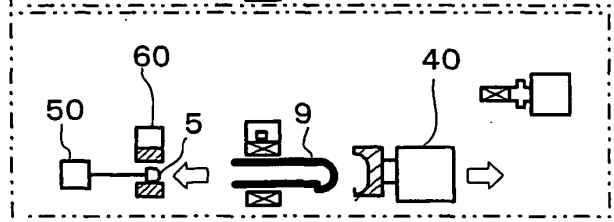
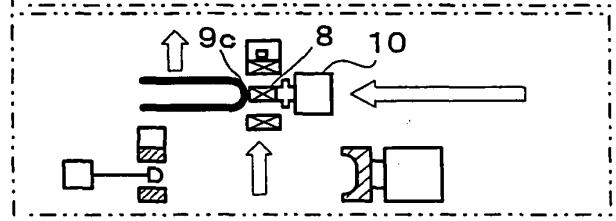


FIG. 4H



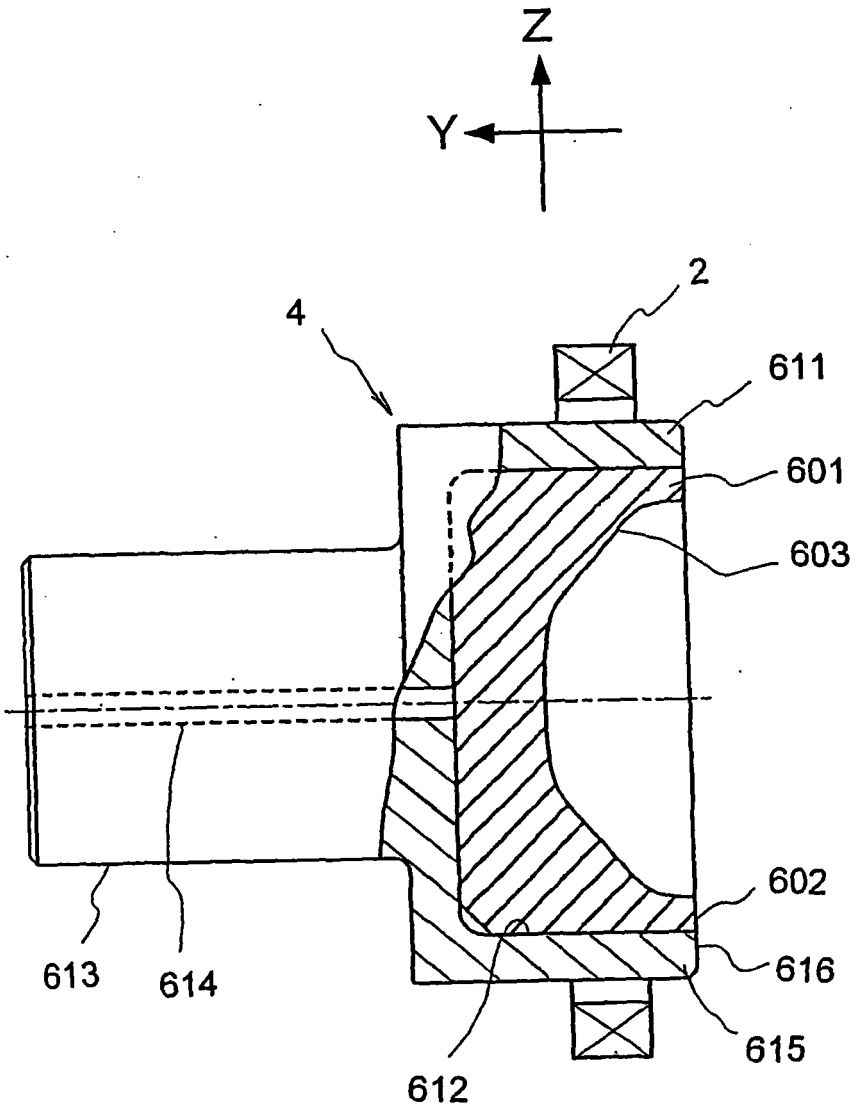


FIG.5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/307267

A. CLASSIFICATION OF SUBJECT MATTER
B21D41/04(2006.01), ***B21D22/14***(2006.01), ***B21D24/00***(2006.01), ***B21D37/01***(2006.01), ***B21D51/18***(2006.01)

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)
B21D41/04(2006.01), ***B21D22/14***(2006.01), ***B21D24/00***(2006.01), ***B21D37/01***(2006.01), ***B21D51/18***(2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2006
Kokai Jitsuyo Shinan Koho 1971-2006 Toroku Jitsuyo Shinan Koho 1994-2006

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.
A	JP 2002-192277 A (Kayaba Industry Co., Ltd.), Par. Nos. [0034] to [0038]; Fig. 3 & US 2004/045778 A1 & EP 1355080 A1 & WO 2002/052166 A1	1-4
A	JP 2003-200241 A (Tokico Ltd.), 15 July, 2003 (15.07.03), Par. Nos. [0008] to [0010]; Fig. 5 (Family: none)	1-4

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

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
03 July, 2006 (03.07.06)	11 July, 2006 (11.07.06)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/307267

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 2003-509181 A (Smith & Nephew Richards Inc.), 11 March, 2003 (11.03.03), Par. No. [0047] & US 6742236 B1 & EP 1409177 A1 & WO 2001/021338 A1 & AU 7481400 A & CN 1390162 A & CA 2385585 A & AU 776593 B	1-4
A	JP 2005-342725 A (Hitachi, Ltd.), 15 December, 2005 (15.12.05), Par. Nos. [0016] to [0023]; Fig. 1 (Family: none)	1-4

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

REFERENCES CITED IN THE DESCRIPTION

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- JP 2002153930 A **[0004]**