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

(11) EP 1 210 991 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 158(3) EPC

(43) Date of publication:
05.06.2002 Bulletin 2002/23

(21) Application number: **00917405.3**

(22) Date of filing: **21.04.2000**

(51) Int Cl.7: **B21B 13/10**, B21B 31/20, B21B 1/16

(86) International application number:
PCT/JP00/02613

(87) International publication number:
WO 00/64604 (02.11.2000 Gazette 2000/44)

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE

(30) Priority: **22.04.1999 JP 11543699**

(71) Applicants:
- **Plant Engineering Yoshida Kinen Co.,ltd.**
  Mobara-shi, Chiba 297-0033 (JP)
- **NHK Spring Co., Ltd.**
  Yokohama-shi, Kanagawa 236-0004 (JP)

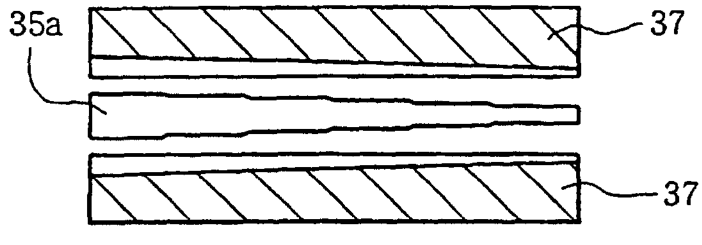
(72) Inventors:
- **ISOZAKI, Iwao**
  Plant Eng. Yoshida Kinen Co., Ltd.
  Chiba 297-0033 (JP)
- **FURUYAMA, Tsutomu NHK Spring Co., Ltd.**
  Yokohama-shi Kanagawa 236-0004 (JP)
- **KATSUYAMA, Akira NHK Spring Co., Ltd.**
  Yokohama-shi Kanagawa 236-0004 (JP)
- **TANGE, Akira NHK Spring Co., Ltd.**
  Yokohama-shi Kanagawa 236-0004 (JP)

(74) Representative:
Dreiss, Fuhlendorf, Steimle & Becker
Patentanwälte,
Postfach 10 37 62
70032 Stuttgart (DE)

(54) TAPERED BODY FORMING METHOD AND ROLLING DEVICE

(57) A rolling device (11) capable of forming and opening a clearance (33) for rolling, wherein a material (35a) having a cross-section diameter varying in axial direction is formed, and a tapered finished product (35b) is formed of the material (35a) by die forging, whereby a reduction ratio of the cross-sectional area of the material (35a) formed by die forging is less than that obtained by forming a material havinga cross-section diameter uniform in axial direction by die forging only and, in addition, the finished product (35b) can be formed in a short time and thus a tapered body excellent in characteristics and quality can be formed at a low cost.

Fig.5B



EP 1 210 991 A1

Description

Technical Field

[0001] The present invention relates to a method of forming a tapered body with a continuously tapered circumferential surface, and a rolling device for plastically working a material with rolls.

Background Art

[0002] Conventionally, it is general that a tapered rod is formed by die forging or cutting a material having a cross-section diameter uniform in the axial direction, and that a tapered tube is also formed by die forging descried above. In a rolling device in which a material is rolled as it is inserted in a clearance surrounded by the outer surfaces of a plurality of rolls, the rolling clearance in which the material is to be inserted is conventionally formed fixedly, and only a finished product having a cross-section diameter uniform in the axial direction can be obtained.

[0003] When compared to die forging which is plastic working, with cutting, the tissue of the material does not get finer by working, and a finished product with a high toughness cannot be obtained. The surface smoothness is low unless polishing or the like is added as a post step. When a stress is generated in the finished product, it becomes concentrated in a coarse portion of the surface. Even if a coil spring is formed of a tapered steel rod, a coil spring with a sufficiently large fatigue strength cannot be obtained. In these respects, die forging is overwhelmingly advantageous to cutting. In addition, in cutting, the yield is lower than that of die forging because cutting chips are produced, leading to a high manufacturing cost of the finished product.

[0004] When a tapered rod is formed by die forging of a material with a cross-section diameter uniform in the axial direction, the following problems arise. More specifically, in die forging, heat is generated when the material is deformed by stamping. Since the cross-section area of the material has a large reduction ratio, the generated heat value is also large. If the number of times of stamping per unit time is increased in order to particularly shorten the formation time for a tapered rod, sometimes the finished product reaches a temperature of as high as about 400°C to 500°C.

[0005] As a result, the material or composition of the formed tapered rod may vary. Since the reduction ratio of the cross-section area of the material is large, deformation of the material may exceed the deformability of the material, and the formed tapered rod may have cracked. Therefore, with die forging of a material having a cross-section diameter uniform in the axial direction, a tapered rod excellent in characteristics and quality is difficult to form.

[0006] In die forging, the amount of deformation of the material caused by one stamping operation is small, and accordingly the working speed is low, so a tapered rod is difficult to form within a short period of time. In addition, due to a mechanical load attributed to an increased reduction ratio of the cross-section area of the material and to a thermal load applied by the high-temperature finished product, the forging die tends to degrade easily and has a short service life. Because of these reasons, in die forging of a material with a cross-section diameter uniform in the axial direction, a tapered rod is difficult to form at a low cost.

[0007] It is, therefore, an object of the present invention to provide a tapered body forming method which can form a tapered body excellent in characteristics and quality at a low cost, and a rolling device which can be used for the same.

Disclosure of Invention

[0008] With a tapered body forming method according to the present invention, a tapered body is formed by die forging from a material with a cross-section diameter varying in an axial direction. When compared to a case wherein a tapered body is to be formed by only die forging from a material with a cross-section diameter uniform in an axial direction, the reduction ratio of the cross-section area of the material during die forging is small. Therefore, the generated heat value during die forging is small, and when a tapered body is formed, its material or composition does not change easily. When a tapered body is formed, it does not easily crack. As a result, a tapered body excellent in characteristics and quality can be formed.

[0009] The material for die forging is formed by rolling with a working speed higher than that of die forging. When compared to a case wherein a tapered body is to be formed by only die forging from a material with a cross-section diameter uniform in the axial direction, a tapered body can be formed within a short period of time. The mechanical and thermal loads acting on the forging die during die forging are small. Thus, the forging die does not degrade easily and has a long service life. As a result, the tapered body can be formed at a low cost.

[0010] In a rolling device according to the present invention, the rolling clearance of a plurality of roll groups sequentially arranged in the transfer direction of the material sequentially decreases in the transfer direction, and a press-down mechanism is provided for forming the clearance by moving a plurality of rolls close to each other and for opening the clearance by moving the plurality of rolls away from each other. Rolling by the roll groups can be performed and interrupted at an arbitrary time point during transfer of the material. Therefore, the material can be rolled into a finished product with a cross-sectional shape nonuniform in the axial direction.

[0011] If the press-down mechanism forms and opens the clearance independently in units of roll groups, the time intervals and sequence of formation and opening of the clearance which are performed by the roll groups adjacent to each other in the transfer direction of the material can be controlled. Therefore, the material can be rolled into a finished product in which the sequence with which different cross-sectional shapes appear in the axial direction and the duration of one cross-sectional shape in the axial direction are controlled.

Brief Description of Drawings

[0012]

Figs. 1A to 1E are schematic views showing the first period of a rolling process in a tapered body forming method according to an embodiment of the present invention;
Figs. 2A to 2F are schematic views showing the second period of the rolling process in the tapered body forming method according to the embodiment;
Figs. 3A to 3C are schematic views showing the third period of the rolling process in the tapered body forming method according to the embodiment;
Figs. 4A to 4C are schematic views showing the fourth period of the rolling process in the tapered body forming method according to the embodiment;
Figs. 5A to 5D are schematic views showing a die forging process in the tapered body forming method according to the embodiment;
Fig. 6 is a perspective view showing an entire rolling device according to an embodiment of the present invention;
Fig. 7 is a partially sectional front view of the main part of the rolling device according to the embodiment; and
Fig. 8 is a partial sectional view of the main part of the rolling device according to the embodiment.

Best Mode of Carrying Out the Invention

[0013] An embodiment of the present invention which is applied to a tapered body forming method and a rolling device that can be used for the same will be described below with reference to Figs. 1A to 8. Fig. 6 shows the entire structure of a rolling device 11 according to this embodiment. In the rolling device 11, five roll groups 12 are sequentially arranged on a base 13 in the material transfer direction for rolling. Each roll group 12 is made up from four rolls 14 having outer peripheral grooves, and an AC servo motor 15 is connected to the rolls 14 of each roll group 12 through reduction gears 16, couplings 17, and the like.

[0014] Figs. 7 and 8 show one roll group 12. In the roll group 12, the rolls 14 and driving gears 21 on the two surfaces of each roll 14 are supported by roll chucks 22 through bearings (not shown), and the roll chucks 22 are accommodated in an X-shaped groove 24 of a frame 23. The frame 23 is connected to a gear case 26 through a plurality of bolts 25, and input gears 27 for receiving a driving force from the couplings 17 and transmitting it to the driving gears 21 are arranged in the gear case 26.

[0015] Single acting hydraulic pistons 31 as part of press-down mechanisms for the roll chucks 22 and rolls 14 are attached to the frame 23, and hydraulic pressure supply ports 32 continuous to the hydraulic pistons 31 are connected to a hydraulic circuit (not shown). As the hydraulic circuit, a circuit including a hydraulic pump for generating a hydraulic pressure, pipes for distributing the hydraulic pressure from the hydraulic pump to the hydraulic pressure supply ports 32, selector valves arranged between the pipes and the hydraulic pressure supply ports 32, a control means for controlling the selector valves at a predetermined timing with a computer or cam mechanism, and the like can be utilized.

[0016] When the hydraulic pistons 31 press down the roll chucks 22 and rolls 14 and the four rolls 14 move close to each other such that their outer surfaces are sequentially continuous, a circular clearance 33 surrounded by the outer surfaces of the rolls 14 is formed at the center of the four rolls 14, as shown in Fig. 7. The material to be rolled is inserted in the clearance 33. The clearances 33 of the five roll groups 12 sequentially decrease in the material transfer direction for rolling.

[0017] The input gears 27 are fixed in the gear case 26. The positions of the input gears 27 in the gear case 26 are determined such that when the rolls 14 are pressed down, the center-to-center distances between the corresponding driving gears 21 and input gears 27 become minimum. Therefore, when each roll 14 is pressed down, the teeth of either one of the driving gear 21 and input gear 27 do not excessively enter the spaces among the teeth of the other one.

[0018] When the press-down operations for the roll chucks 22 and rolls 14 by the hydraulic pistons 31 are canceled, the rolls 14 move apart from each other, and the clearance 33 opens by pressing toward the hydraulic pistons 31 with the material inserted into the clearances 33. The press-down operations for the roll chucks 22 and rolls 14 can be performed and canceled by the hydraulic pistons 31 independently in units of roll groups 12. The frame 23 has cooling oil supply ports 34 through which cooling oil is supplied to the material subjected to rolling in the clearance 33.

[0019] Figs. 1A to 5D show a tapered body forming method according to this embodiment. In Figs. 1A to 4C, the rolls 14 of the five roll groups 12 sequentially arranged in the material transfer direction for rolling in the rolling device 11 are exemplified as rolls 14a to 14e, and among the four rolls 14 of each roll group 12, only the pair of opposing rolls 14 are shown.

[0020] Initially, all the rolls 14a to 14e are pressed down, as indicated by solid arrows in Figs. 1A to 1E. As a material 35 is transferred through the rolls 14a to 14e of the respective roll groups 12, it is rolled such that its diameter sequentially narrows down, as shown in Figs. 1A to 1E, so the material 35 is worked into a stepped shape in which the cross-section diameter varies stepwise in the axial direction. As the material 35, a rod, a pipe, or the like made of a metal, plastic, ceramic material, or the like can be used.

[0021] Note that all the rolls 14a to 14e need not be pressed down from the beginning as indicated by the solid arrows in Figs. 1A to 1E. The rolls 14 can be pressed down by the hydraulic pistons 31 independently in units of roll groups 12, as described above. Hence, the rolls 14a to 14e may be sequentially pressed down by the hydraulic pistons 31 at least before the material 35 passes them.

[0022] Since immediately after the rolls 14e start rolling, if the press-down amounts of all the rolls 14a to 14e are gradually decreased simultaneously along with transfer of the material 35, the material 35 is worked into a tapered shape in which the cross-section diameter varies continuously in the axial direction.

[0023] After that, as the material 35 is transferred, as shown in Fig. 2A, when the leading end of the material 35 has passed the last rolls 14e and is separated from them by a predetermined distance, that is, when a predetermined-length portion of the material 35 is rolled to have the minimum diameter, the press-down operations for all the rolls 14a to 14e are canceled simultaneously, as indicated by arrows of alternate long and short dashed lines in Fig. 2B.

[0024] As a result, the rolls 14a to 14e only slide on the outer surface of the material 35 and then interrupt rolling of the material 35 temporarily. Such intermission and execution of rolling can be performed at an arbitrary time point by the hydraulic pistons 31 controlled by the hydraulic circuit. The transfer amount of the material 35 is measured by the amounts of rotation of the rolls 14a to 14e, the amounts of rotation of measurement rolls (not shown) which are arranged before and after the five roll groups 12 and rotate upon coming into contact with the outer surface of the material 35, or the like.

[0025] After that, as shown in Fig. 2C, when a break point 36a of the material 35 worked into a stepped shape has passed the first rolls 14a and is separated from them by a predetermined distance, only the rolls 14a are pressed down, and rolling with the rolls 14a is resumed, as shown in Fig. 2D. A portion of the material 35 which is between the leading end and the break point 36a is worked into a stepped shape tapered in the transfer direction of the material 35. The material 35 is cut at the break point 36a or a break point formed afterwards by a fly cutter (not shown) arranged at the exit of the rolling device 11.

[0026] As shown in Fig. 2E, when that portion of the material 35 which is closer to the trailing end side than the break point 36a and for which rolling with the rolls 14a is resumed first has passed the second rolls 14b and is separated from them by a predetermined distance, the rolls 14b are pressed down, and rolling with the rolls 14b is resumed, as shown in Fig. 2F.

[0027] After that, as shown in Figs. 3A to 4C, rolling with the rolls 14c to 14e is sequentially resumed with the same operation as that described above. The rolls 14a to 14e in Fig. 4C are in the same state as the rolls 14a to 14e of Fig. 2A. Then, the press-down operations for all the rolls 14a to 14e are canceled simultaneously, in the same manner as in Fig. 2B. The portion between the break point 36a and a break point 36b is worked into a stepped shape tapered in a direction opposite to the transfer direction of the material 35.

[0028] When the portion between the break points 36a and 36b is to be rolled, as rolling with each of the rolls 14a to 14e is to be resumed, if the press-down amounts of the rolls 14a to 14e are gradually increased along with transfer of the material 35, the portion between the break points 36a and 36b is worked into a tapered shape continuously tapered in the direction opposite to the transfer direction of the material 35.

[0029] The material 35 rolled with the rolling device 11 in the above manner is cut by the fly cutter at the exit of the rolling device 11 into a predetermined length, as described above. At this time, if the material 35 is cut at each of the break points 36a and 36b, a material 35a which is tapered in only one direction from one end toward the other end, and is thus suitable for formation of a conical coil spring or the like can be obtained, as shown in Fig. 5A.

[0030] If the material 35 is cut at only the break point 36b, a material which is tapered in two directions from the center toward the two ends and is thus suitable for formation of a Barrel-shaped spring or the like can be obtained. At which portion the material 35 is to be cut is appropriately selected in accordance with the kind of finished product for which the material is to be utilized.

[0031] Thereafter, in this embodiment, the material 35a is loaded in a forging die 37 with a tapered inner surface, as shown in Fig. 5B. The forging die 37 shown in Figs. 5B to 5D is divided only in the vertical direction. If the material 35a is long in the axial direction, a forging die divided not only in the vertical direction but also in the axial direction of the loaded material 35a may be used. The material 35a is stamped with the forging die 37, as shown in Fig. 5C, and a tapered finished product 35b is removed from the forging die 37, as shown in Fig. 5D.

[0032] As is apparent from Figs. 1A to 4C as well, in the rolling process of this embodiment, the material 35 is worked alternately into a portion where the material 35 is tapered in the transfer direction of the material 35 and a portion where the material 35 is tapered in a direction opposite to the transfer direction of the material 35. Hence, the material 35 that is wound in a coiled manner can be worked continuously. Therefore, the characteristic feature of rolling that the working speed is higher than in die forging can be effected.

[0033] In the above embodiment, in the step of Fig. 2B, the press-down operations for all the rolls 14a to 14e are canceled simultaneously. Alternatively, the press-down operations may be sequentially canceled from the rolls 14e toward the rolls 14a. In this case, even if the rolls 14a to 14e are arranged at the same distances from each other as those of the embodiment described above, that portion of the finished material 35 which has a cross-section diameter constant in the axial direction becomes longer than in the above embodiment.

[0034] Conversely, if the press-down operations are canceled from the rolls 14a toward the rolls 14e, that portion of the finished material 35 which has a cross-section diameter constant in the axial direction becomes shorter than in the above embodiment. Furthermore, as the press-down operations for the rolls 14a to 14e are to be canceled sequentially, when the time intervals of the canceling operation are not uniform, even if the rolls 14a to 14e are arranged equidistantly, that portion of the finished material 35 which has a cross-section diameter constant in the axial direction does not have a uniform length.

[0035] In the above embodiment, on the base 13, the five roll groups 12 are sequentially arranged in the transfer direction of the material 35 for rolling. Alternatively, roll groups 12 in a necessary number other than 5 may be sequentially arranged in accordance with the quality, the target finishing shape, or the like of the material 35. In the above embodiment, each roll group 12 is made up from the 4 rolls 14. Alternatively, each roll group 12 may be made up from 2 or 3 rolls 14 in accordance with the target cross-sectional shape of the material 35 or the like.

[0036] In the above embodiment, the hydraulic pistons 31 and the like are used as the press-down mechanisms for the roll chucks 22 and rolls 14. Alternatively, feed screws or the like which are controlled by motors may be used as the press-down mechanisms. In the above embodiment, the material 35 is worked with the rolling device 11 in order to form the material 35a which is to be formed into the tapered finished product 35b with the forging die 37. Alternatively, the rolling device 11 can naturally be used only for forming the material 35a with a cross-section diameter varying stepwise or continuously in the axial direction into a final finished product.

Industrial Applicability

[0037] For example, the present invention can be utilized for forming a tapered steel rod suitable for forming a Barrel-shaped spring or conical coil spring serving as a coil spring for an automobile suspension system.

Claims

1. A tapered body forming method comprising the steps of:

   forming a material with a cross-section diameter varying in an axial direction by rolling; and
   forming a tapered body from the material by die forging.

2. A tapered body forming method according to claim 1, in which the material with the cross-section diameter varying stepwise in the axial direction is formed by the rolling.

3. A tapered body forming method according to claim 1, in which the material with the cross-section diameter varying continuously in the axial direction is formed by the rolling.

4. A rolling device in which

   a plurality of rolls are provided to roll a material which is inserted in a clearance surrounded by sequentially continuous outer surfaces of the rolls,
   a plurality of roll groups each made up from a plurality of rolls are arranged sequentially in a transfer direction of the material for rolling,
   the clearance of the roll groups sequentially decreases in the transfer direction, and
   a press-down mechanism is provided for forming the clearance by moving the plurality of rolls close to each other and for opening the clearance by moving the plurality of rolls away from each other.

5. A rolling device according to claim 4, wherein the press-down mechanism performs the forming and the opening independently in units of roll groups.

6. A rolling device according to claim 5, wherein the press-down mechanism performs the opening simultaneously in all the roll groups.

7. A rolling device according to claim 5, wherein the press-down mechanism performs the opening sequentially in units of the roll groups in a direction opposite to the transfer direction.

8. A rolling device according to claim 5, wherein the press-down mechanism performs the opening sequentially in units of roll groups in the transfer direction.

9. A rolling device according to claim 7 or 8, wherein time intervals in the openings are not uniform.

Fig.1A

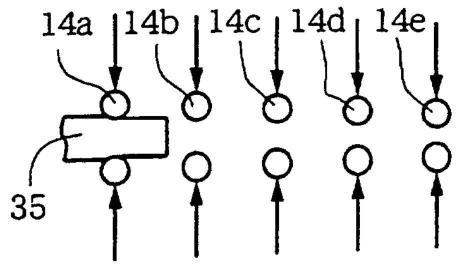


Fig.1B

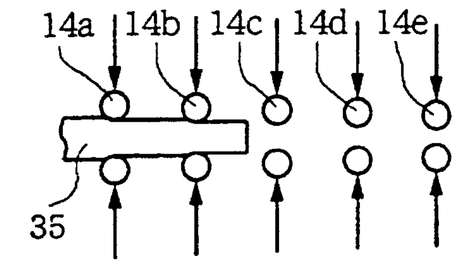


Fig.1C

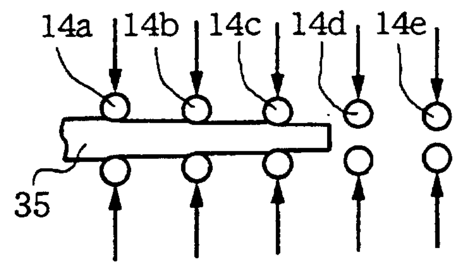


Fig.1D

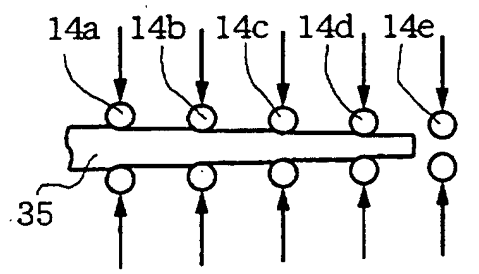


Fig.1E

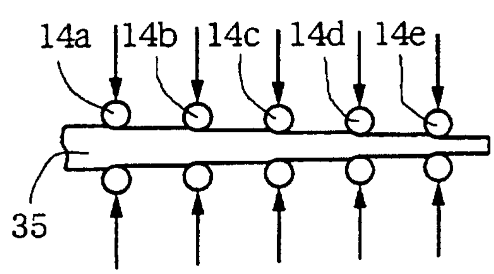


Fig.2D

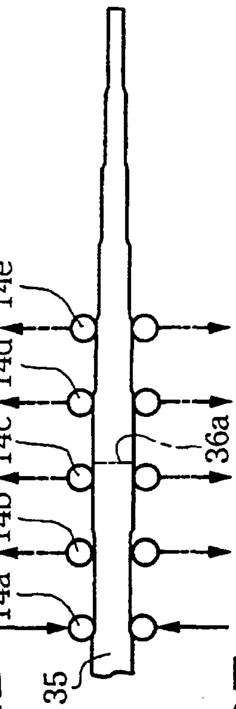


Fig.2E

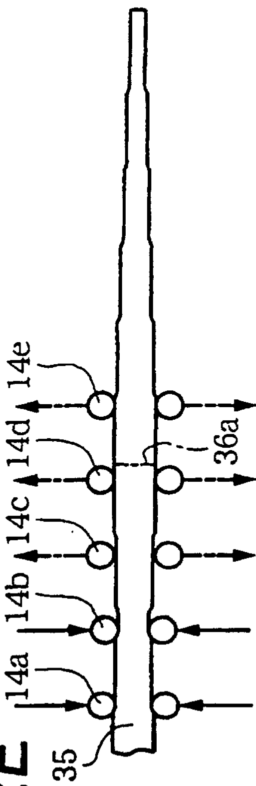


Fig.2F

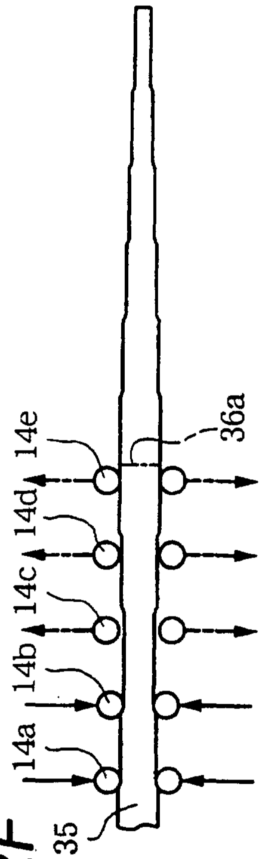


Fig.2A

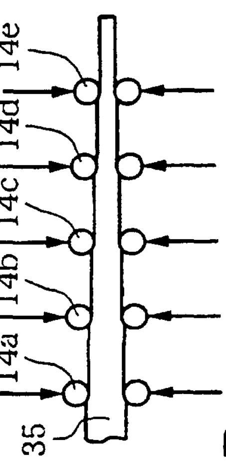


Fig.2B

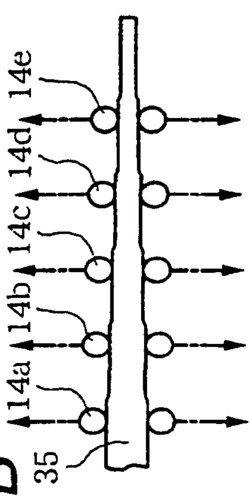
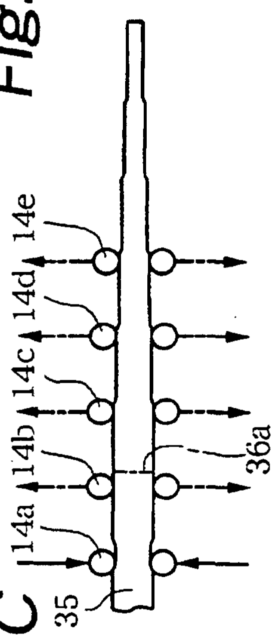


Fig.2C



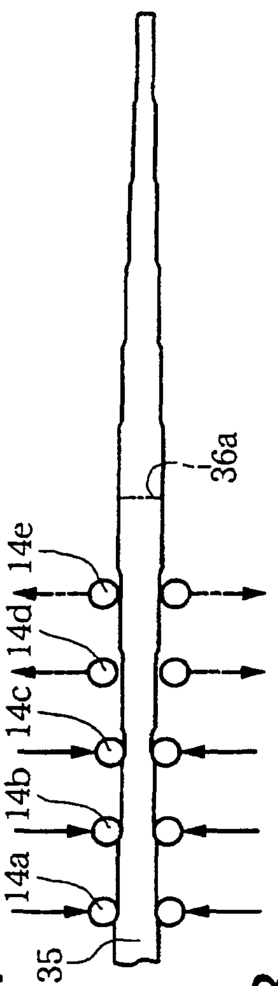


Fig.3A

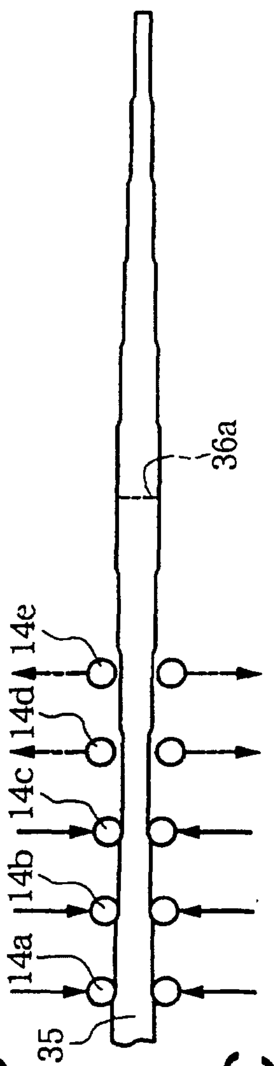


Fig.3B

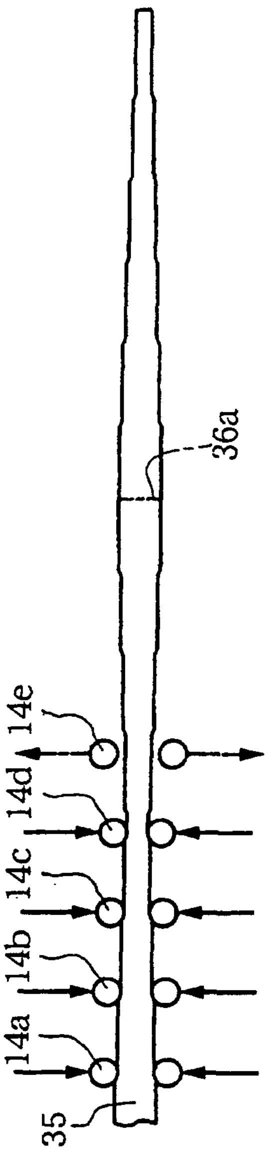


Fig.3C

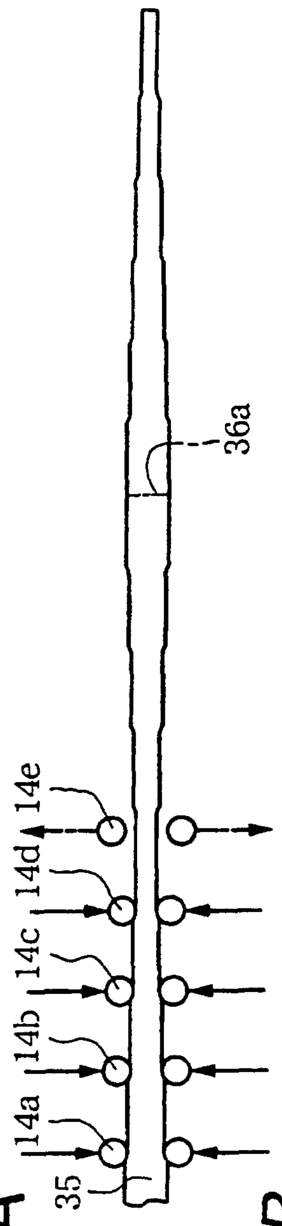


Fig.4A

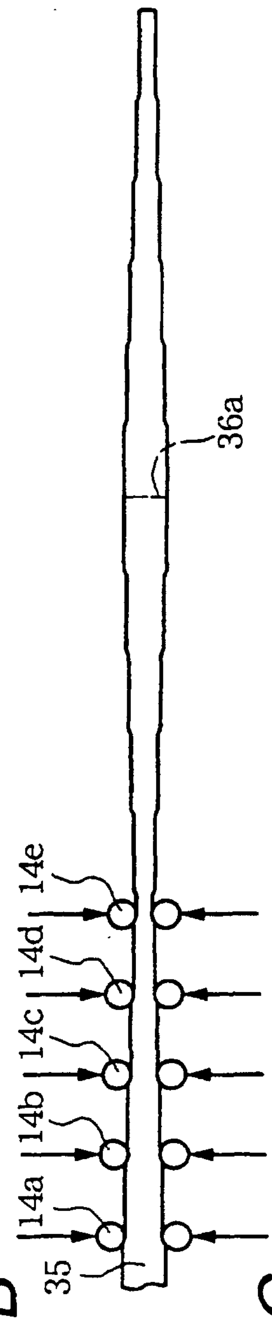


Fig.4B

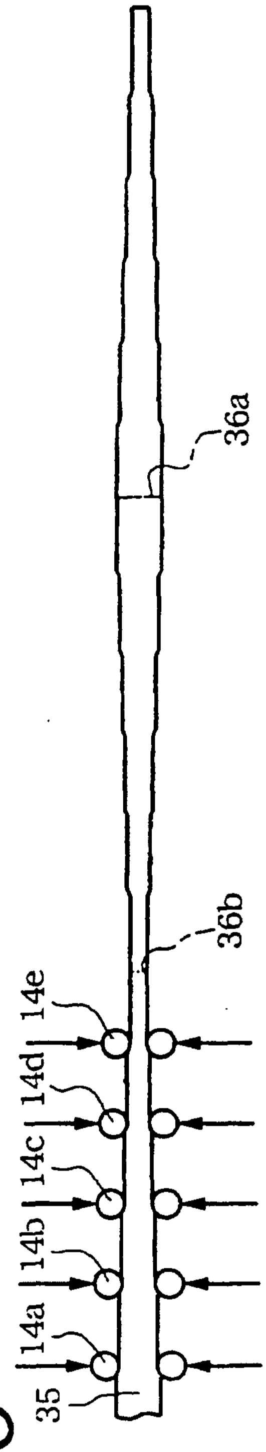


Fig.4C

Fig.5A

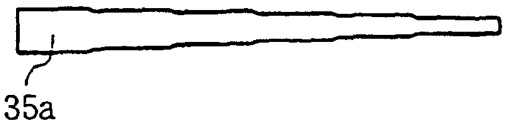


Fig.5B

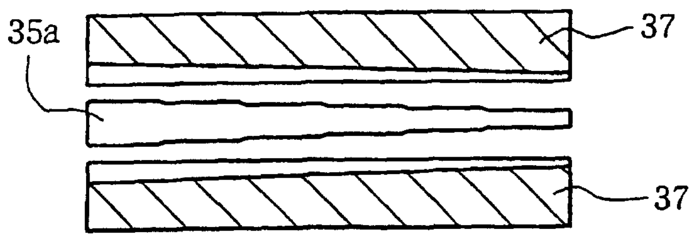


Fig.5C

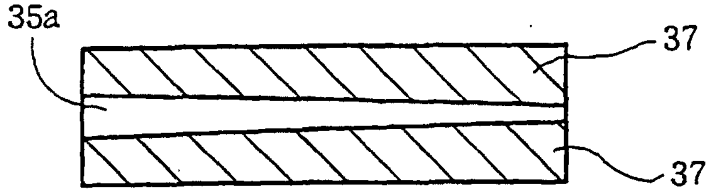


Fig.5D

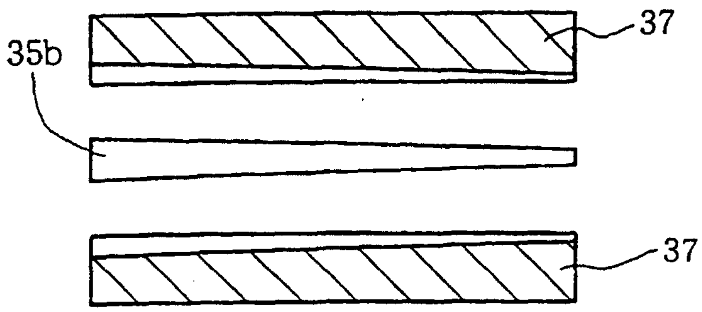


Fig.6

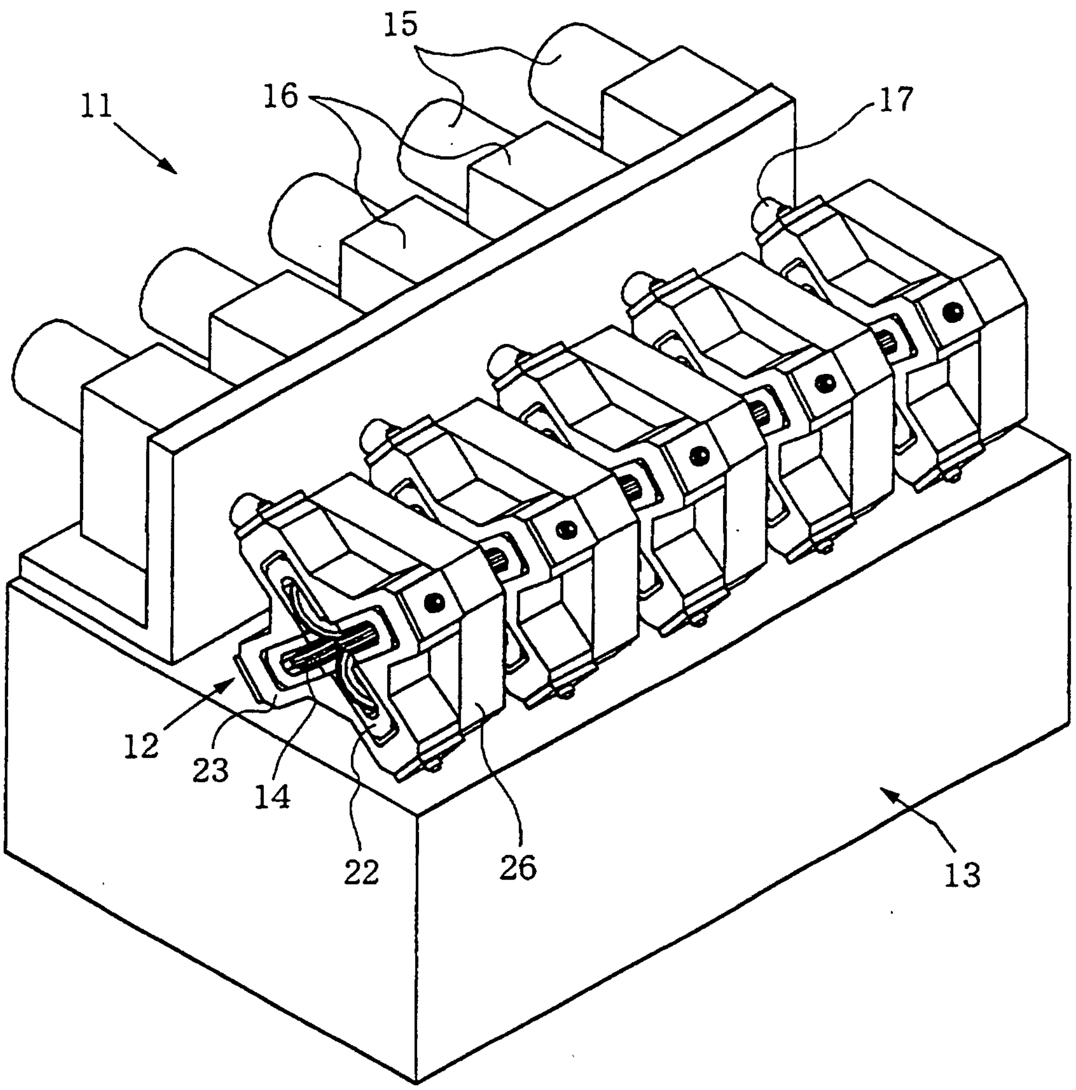


Fig.7

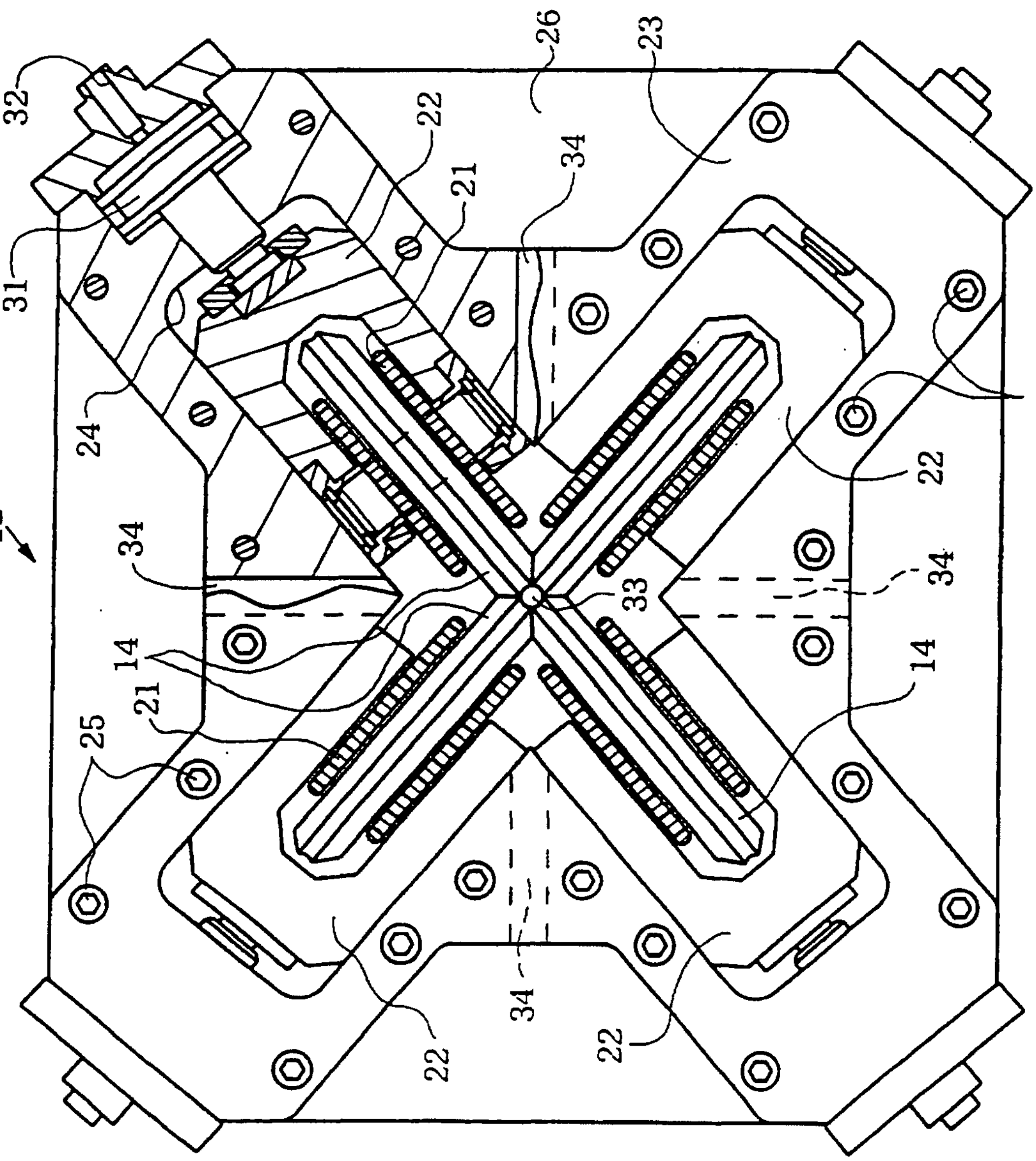
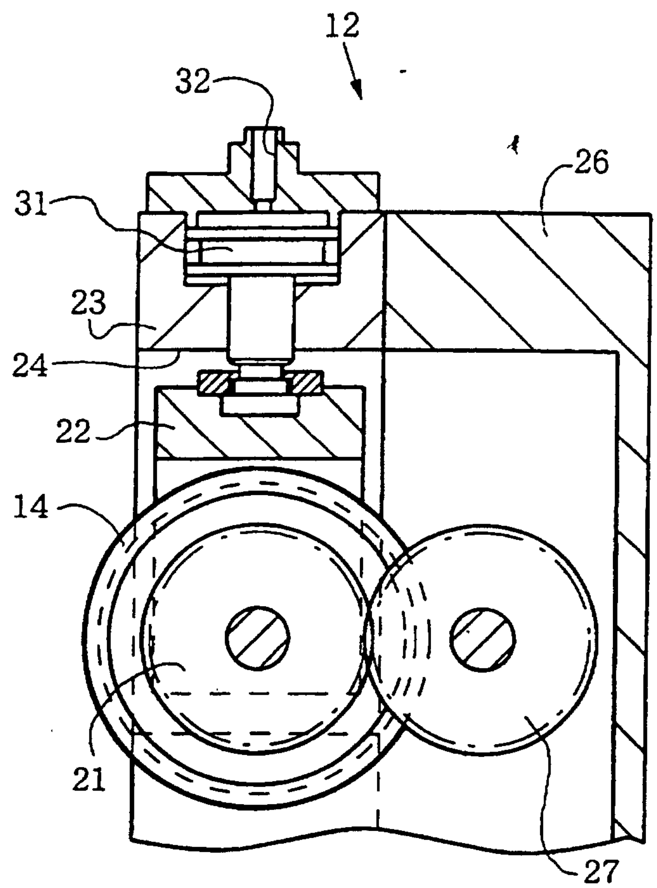


Fig.8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/02613

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] B21B13/10 B21B31/20 B21B1/16

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[7] B21B13/10 B21B31/20 B21B1/16

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

Jitsuyo Shinan Koho	1926-1996	Toroku Jitsuyo Shinan Koho	1994-2000
Kokai Jitsuyo Shinan Koho	1971-2000	Jitsuyo Shinan Toroku Koho	1996-2000

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DIALOG(WPI/L) taper

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP, 903186, A (Plant Engineering Yoshida Kinen Co.,Ltd.), 24 March, 1999 (24.03.99) & JP, 11090510, A & US, 5953948, A	1-9
A	EP, 904862, A (Sumitomo Heavy Industries Ltd.), 31 March, 1999 (31.03.99) & JP, 11104706, A & JP, 11104707, A & US, 6016679, A & CN, 1212910, A	1-9
A	JP, 9122702, A (Kawasaki Steel Corporation), 13 May, 1997 (13.05.97) (Family: none)	1-9
A	JP, 7009056, A (Kagushiki Kaisha Morita and Company), 13 January, 1995 (13.01.95) (Family: none)	1-9
A	JP, 4111901, A (Mitsubishi Heavy Industries, Ltd.), 13 April, 1992 (13.04.92) (Family: none)	1-9
A	JP, 48084763, A (Motohira Awano), 10 November, 1973 (10.11.73) (Family: none)	1-9

☐ 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
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 June, 2000 (19.06.00)	27 June, 2000 (27.06.00)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)