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

(11) Publication number : **0 509 734 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number : **92303284.1**

(51) Int. Cl.^{5} : **B21H 5/02**

(22) Date of filing : **13.04.92**

(30) Priority : **15.04.91 JP 110951/91**

(43) Date of publication of application :
21.10.92 Bulletin 92/43

(84) Designated Contracting States :
FR GB IT

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(54) Method and apparatus forming a helical spline gear with a stopper on a rotary shaft.

(57) In a method of forming a helical spline gear with a stopper on a shaft material, the large diameter portion of the shaft material is clamped between a pair of rolling tools each having on the outer cylindrical wall a plurality of helical teeth, and merging teeth which merge with every other helical teeth, and the rolling tools are driven to roll the shaft material under pressure, so that a plurality of helical grooves, and ahead of the helical grooves, communicating grooves communicated with every other helical grooves, and stopper portions remaining between the communicating grooves are formed on the large diameter portion in one rolling operation. With this method, the number of manufacturing steps can be reduced ; that is, the rotary shaft can be formed readily and quickly.

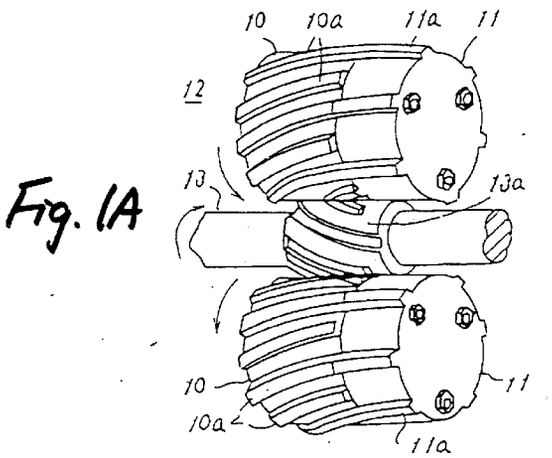

Fig. 1A

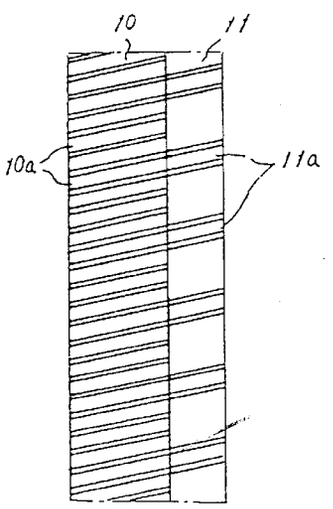

Fig. 1B

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BACKGROUND OF THE INVENTION

This invention relates to a method and apparatus for forming a helical spline gear with a stopper on a rotary shaft, on which an object to be driven is mounted through the helical splines so as to transmit torque, produce axial thrust, position the object, and prevent the latter from being coming off.

As disclosed by Japanese Utility Patent Application (OPI) No. 53727/1980 (the term "OPI" as used herein means an "unexamined published application"), a helical spline gear with a stopper is formed on the output shaft of a starter motor. The output shaft of the starter motor is spline-coupled to the sleeve of the clutch outer of the overrunning clutch so that the sleeve is prevented from coming off axially outwardly and held in place by the stopper.

An example of a conventional method of forming a helical spline gear with a stopper on a rotary shaft of this type will be described with reference to FIG. 4. A steel rod or the like is formed by cold forging into a shaft 1 to be processed (hereinafter referred to as "a shaft material", when applicable) having a large diameter portion 1a, a small diameter portion 1b, and a stopper portion 2 as shown in FIG. 4A. A plurality of grooves 2a (three grooves in the case of FIG. 4) are formed in the stopper portion 2 at equal angular intervals in a circumferential direction. Next, helical grooves 3a, the number of which is twice the number of grooves 2a (six helical grooves in the case of FIG. 4) are formed in the large diameter portion 1a in such a manner that half of the helical grooves (three helical grooves in the case of FIG. 4) are communicated with the stopper grooves 2a, respectively. More specifically, the large diameter portion 1a of the shaft material 1 is set in place and clamped with a pair of component rolling tools with helical teeth at equal angular intervals in a circumferential direction. Under this condition, the pair of rolling tools are driven in the same directions so that the shaft material 1 is rotated under pressure. As a result, a rotary shaft 4 is formed which has a helical spline gear 3 with helical grooves 3a the number of which is twice that of the stopper grooves (six helical grooves 3a in the case of FIG. 4). Every other helical grooves 3a, i.e., half of the helical grooves are communicated with the stopper grooves 2a, and the remaining helical grooves are extended to the stopper portion 2.

In the case of a starter motor, the sleeve of the clutch outer of the over-running clutch has helical teeth in the inner cylindrical wall which are equal in number to the stopper grooves 2a, and are movably engaged with the stopper grooves 2a, respectively. The helical teeth of the sleeve of the clutch outer are engaged with the stopper grooves 2a of the rotary shaft, and then moved past the stopper grooves 2a so that they are disengaged from the latter 2a. Under this condition, the clutch outer is turned as much as one pitch of the helical grooves 3a, and engaged with the respective helical grooves 3a, and then pulled back until the outer end of the helical teeth strikes against the stopper portion 2. Thus, the clutch outer is prevented from coming off the,shaft axially outwardly, and is held in place.

Another example of the conventional method of forming a helical spline gear with a stopper on a rotary shaft will be described with reference to FIG. 5.

First, a steel rod or the like is formed into a shaft material 5 by cold forging to be processed which, as shown in FIG. 5A, has a large diameter portion 5a and a small diameter portion 5b. Thereafter, as shown in FIG. 5B, an annular groove 5c is formed by machining in the large diameter portion 5a at one side, thus forming a stopper protrusion 6. The large diameter portion 5a with the stopper protrusion 6 is clamped with a pair of component rolling tools having a plurality of helical teeth. Under this condition, the pair of rolling tools are driven in the same directions so that the shaft material 5 is rotated under pressure. As a result, as shown in FIG. 5C, helical splines 7 with a plurality of helical grooves 7a (six helical grooves in the case of FIG. 5) are formed at equal angular intervals on the large diameter portion 5a. Then, as shown in FIG. 5D, communicating grooves 8a are cut in the stopper protrusion 6 in such a manner that they are communicated with every other helical groove 7a. The remaining portions of the stopper protrusion 6 form stopper portions 8. Thus, a rotary shaft 9 has been formed which has the helical splines 7 and the stopper portions 8.

The above-described conventional method of forming a helical spline gear with a stopper on a rotary shaft as shown in FIG. 4 suffers from a difficulty that, in the component rolling process, it is difficult to accurately position the teeth of the rolling tools and the grooves 2a of the shaft material 1 to be processed relative to each other.

The conventional method shown in FIG. 5 is also disadvantageous in that a relatively large number of manufacturing steps are required to form the helical splines 7 and the stopper portions 8, and it is rather troublesome to form the stopper grooves 8a in such a manner that they are communicated with every other helical grooves 7a.

On the other hand, in the case of an epicyle reduction gear type starter motor, the output shaft has a flange which serves as an epicyclic gear arm, the method described with reference to FIG. 4 is not practical. That is, the flange of the output shaft obstructs the cold forging operation shown in FIG. 4B.

SUMMARY OF THE INVENTION

Accordingly, an object of this invention is to eliminate the above-described difficulties accompanying a conventional method of forming a helical spline gear with a stopper on a rotary shaft. More specifically, an

object of the invention is to provide a method of forming a helical spline gear with a stopper on a rotary shaft which can be practiced without a positioning operation, and in which, when compared with the conventional method, the number of manufacturing steps is reduced; that is, the rotary shaft can be formed readily and quickly. Another object of the invention is to provide an apparatus adapted to be used in the method.

A method of forming a helical spline gear with a stopper on a shaft material which has been preliminarily processed, according to the present invention, comprises the steps of: providing a pair of component rolling tools, each having a plurality of helical teeth formed thereon at equal intervals, and a plurality of merging teeth formed thereon so that each merging tooth is merged with every other helical tooth; clamping the shaft material between the pair of component rolling tools; and driving the pair of component rolling tools to roll the shaft material under pressure to form a plurality of helical grooves, communicating grooves communicated with every other helical grooves, and stopper portions remaining between the communicating grooves on the shaft material.

An apparatus for forming a helical spline gear with a stopper on a shaft material, according to the present invention, comprises a pair of rolling tools adapted to clamp the shaft material therebetween and roll the shaft material under pressure, each of said rolling tools having a plurality of helical teeth formed thereon at equal intervals, and a plurality of merging teeth formed thereon so that each merging tooth is merged with every other helical tooth.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1A is a perspective view showing a pair of component rolling tools employed in one example of a method of forming a helical spline gear with a stopper on a rotary shaft according to this invention;

FIG. 1B is an unfolding diagram showing the helical teeth of rolling rollers shown in FIG. 1A;

FIG. 2A and 2B are front views of essential portions of a rotary shaft, for a description of the method according to the invention, showing the manufacturing steps in order;

FIG. 3 is a front view of essential portions of a rotary shaft for a description of another example of the method of the invention;

Figs. 4A and 4B are front views of essential portions of a rotary shaft for a description of an example of a conventional method of forming a helical spline gear with a stopper on a rotary shaft, showing the manufacturing steps in order; and

Figs. 5A through 5D are front views of a rotary shaft for a description of another example of the conventional method, showing the manufacturing steps in order.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The FIG. 1A shows component rolling tools used in an example of a method of forming a helical spline gear with a stopper on a rotary shaft, which constitutes a first embodiment of this invention.

In FIG. 1, reference numeral 10 designates a first rolling roller for forming helical splines. A plurality of helical teeth 10a (six helical teeth in the case of FIG. 1) are formed in the cylindrical wall at equal angular intervals in a circumferential direction. Further in FIG. 1, reference numeral 11 designates a second rolling roller for forming a stopper portions and communicating grooves therebetween. Merging teeth 11a are formed on the cylindrical wall which merge with every other helical tooth 10a. FIG. 1B is an unfolding diagram showing the helical teeth 10a of the first rolling roller 10 and the merging teeth 11a of the second rolling roller 11.

The first and second rolling rollers 10 and 11 are axially combined, for instance, with bolts, thus forming a rolling tool 12. A pair of the rolling tools 12 thus formed are employed. In the above-described embodiment, the first and second rolling rollers 10 and 11 are formed separately. However, those rollers may be formed as one unit, i.e. a single integral unit.

The method using the pair of rolling tools 12 thus formed will be described with reference to FIG. 2A and 2B. First, as shown in FIG. 2A, a large diameter portion 13a and a small diameter portion 13b are formed on a shaft material 13 by cold forging which is to be processed. If it is difficult to form those portions 13a and 13b by cold forging because a flange is provided at one end, then the portions may be formed by machining.

As shown in FIG. 1A, the large diameter portion 13a of the shaft material 13 is clamped between the pair of rolling tools 12, and the rolling tools 12 are rotated in the same direction, i.e. counterclockwise in Fig. 1A, to roll the shaft 13. The distance between the pair of rolling tools 12 is decreased with a force of depression applied thereto so that a helical spline gear with a stopper is formed on the shaft.

That is, helical splines 14 with a plurality of helical grooves 14a (six helical grooves in the case of FIG. 2) therebetween, communicating grooves 15a which are communicated with every other helical groove 14a, and stopper portions 15 remaining between the communicating grooves 15a are formed as shown in FIG. 2B. Thus, an aimed rotary shaft 16 having the helical splines 14 and the stopper portions 15 has been formed.

In the case where it is not suitable to employ the above-described method because burrs are formed at

the corners which are formed by the insides of the stopper portions 15 and by the ends of the helical grooves 14a during cold forging, the shaft material should be processed as follows: That is, in manufacture of a rotary shaft 18, as shown in FIG. 3, the large diameter portion is machined to form an annular groove 17 along the inside of the stopper portions 15.

In the above-described embodiments, the pair of rolling tools are employed which have the helical teeth 10a and the merging teeth 11a; however, the invention is not limited thereto or thereby. That is, other rolling tools may be employed which can roll the shaft material to form the helical spline gear with the stopper on it in one rolling operation. For instance, a component rolling tool in the form of a rack may be employed which has a plurality of helical teeth, and merging teeth which merge with every helical tooth. In this case, too, with the large diameter portion of a shaft material clamped between a pair of the rolling tools thus formed, the latter are driven to turn the shaft under pressure, to form a helical spline gear with a stopper on it.

As was described above, in the method of the invention, the large diameter portion of the shaft material is clamped between one pair of rolling tools each having on the outer cylindrical wall a plurality of helical teeth, and merging teeth provided ahead of the helical teeth in such a manner that the merging teeth merge with every other helical teeth, and the rolling tools are driven to roll the shaft material under pressure, to form on the large diameter portion a plurality of helical grooves, and ahead of the helical grooves communicating grooves communicated with every other helical grooves, and stopper portions remaining between the communicating grooves. That is, according to the invention, a helical spline gear with a stopper can be formed on the shaft in one rolling operation readily and quickly.

Claims

1. A method of forming a helical spline gear with a stopper on a shaft material which has been preliminarily processed, said method comprising the steps of:
   (a) providing a pair of component rolling tools, each having a plurality of helical teeth formed thereon at equal intervals, and a plurality of merging teeth formed thereon so that each merging tooth is merged with every other helical tooth;
   (b) clamping said shaft material between said pair of component rolling tools; and
   (c) driving said pair of component rolling tools to roll said shaft material under pressure to form a plurality of helical grooves, communicating grooves communicated with every other helical grooves, and stopper portions remaining between said communicating grooves on said shaft material.

2. The method according to claim 1, wherein said step (a) includes the steps of:
   providing a first rolling roller having a first predetermined length and the plurality of said helical teeth formed at first equal angular intervals in a circumference direction thereof;
   providing a second rolling roller having a second predetermined length and the plurality of said merging teeth formed at second equal angular intervals in a circumference direction thereof; and
   combining said first and second rolling roller with each other so that each merging teeth of said second rolling roller is merged with every other helical tooth of said first rolling roller, thereby forming each component rolling tool.

3. The method according to claim 2, wherein said step (c) includes rotating the pair of said component rolling tools in the same direction and depressing the pair of said component rolling tools against said shaft material.

4. The method according to claim 1, further comprising the step of
   (d) forming an annular groove on said shaft material along the inside of the stopper portions.

5. The method according to claim 1, wherein each of said pair of component rolling tools is in the form of rack, said tools mutually movable relative to each other to roll said shaft material under pressure.

6. An apparatus for forming a helical spline gear with a stopper on a shaft material, comprising:
   a pair of rolling tools adapted to clamp said shaft material therebetween and roll said shaft material under pressure, each of said rolling tools having a plurality of helical teeth formed thereon at equal intervals, and a plurality of merging teeth formed thereon so that each merging tooth is merged with every other helical tooth.

7. The apparatus according to claim 6, wherein each of said tools including a first rolling roller having a first predetermined length and said helical teeth formed at equal angular intervals in a circumferential direction, and a second rolling roller having a second predetermined length and said merging teeth which are merged with every other helical tooth.

8. The apparatus according to claim 7, wherein said first and second rolling rollers are positioned in place and combined with each other so that each merging tooth is merged with every other helical teeth.

9. The apparatus according to claim 7, wherein said first and second rolling rollers are formed as a single integral unit so that each merging tooth is merged with every other helical teeth.

10. The apparatus according to claim 6, wherein each of said pair of component rolling tools is in the form of rack, said tools mutually movable relative to each other to roll said shaft material under pressure.

Fig. 1A

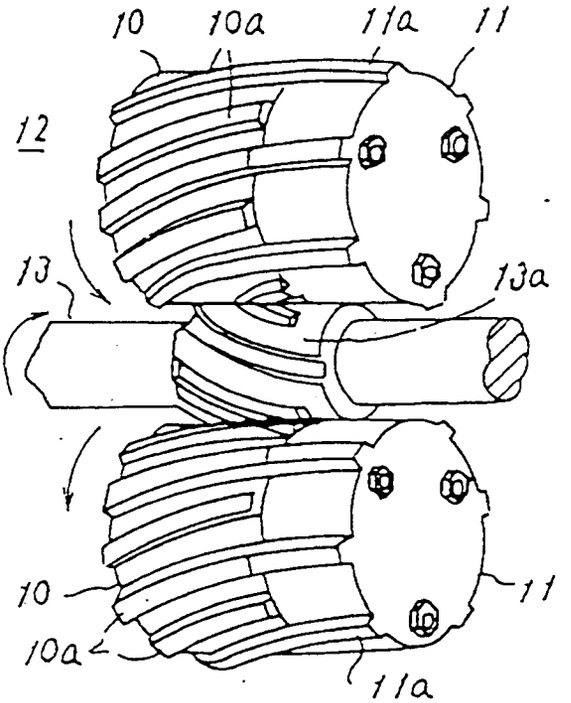


Fig. 1B

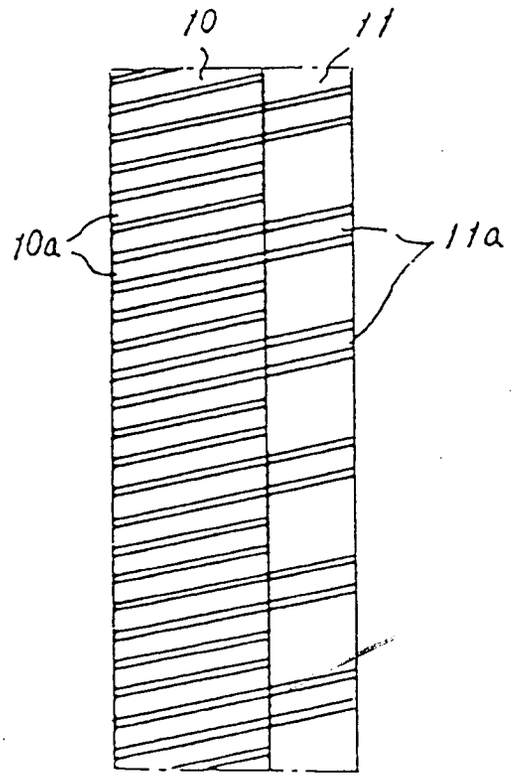


Fig. 2A

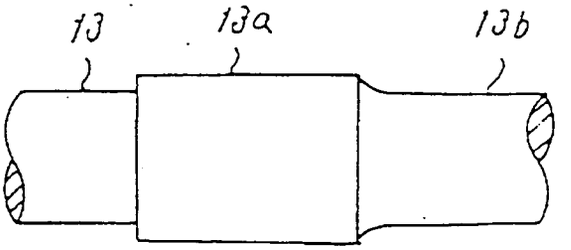


Fig. 2B

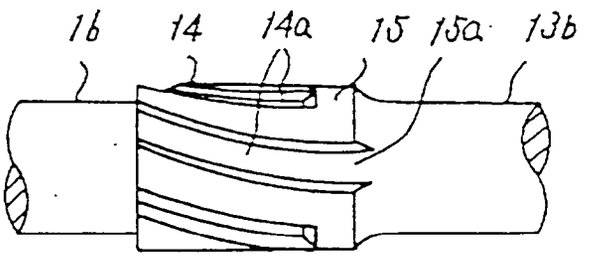


Fig. 3

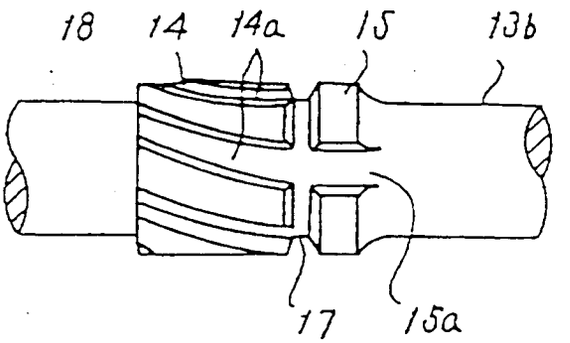


Fig. 4A

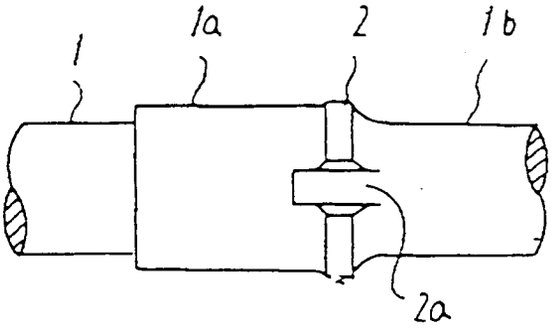


Fig. 4B

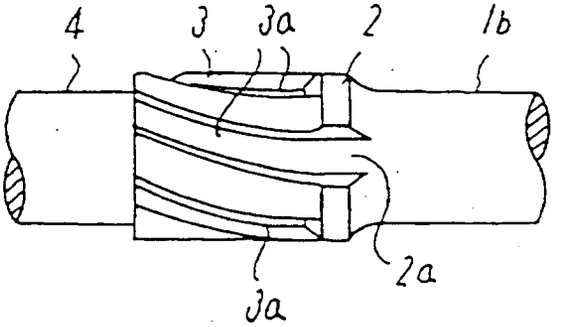


Fig.5A

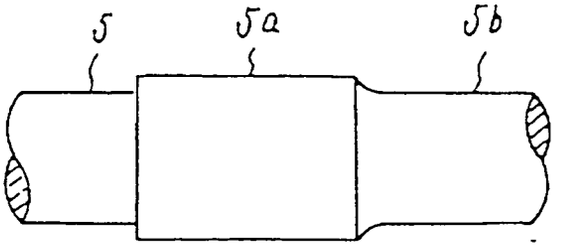


Fig.5B

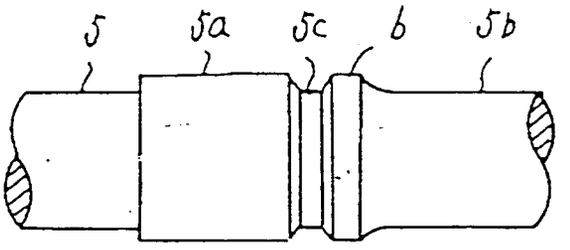


Fig.5C

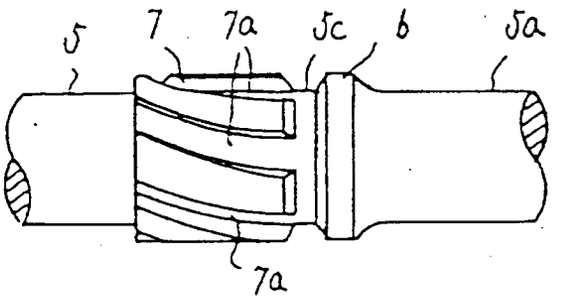
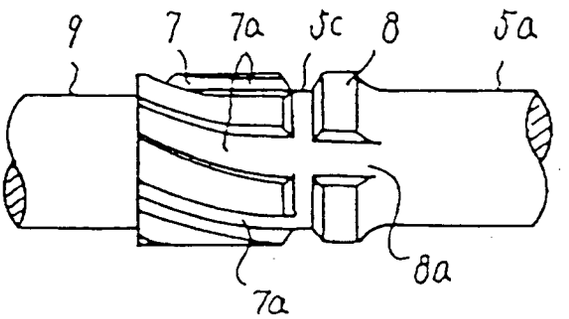


Fig.5D



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EUROPEAN SEARCH REPORT

Application Number

EP 92 30 3284

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.5)
D,Y	JP-Y-55 053 727 (...) 12 December 1980 * figures 2,5,6 *	1,4-6,10	B21H5/02
Y	US-A-3 062 077 (MCCARDELL) * column 2 - column 3; figures 1-5 *	1,4-6,10	
A	JP-A-55 010 007 (HITACHI SEISAKUSHO) 24 January 1980 * figures * & PATENT ABSTRACTS OF JAPAN vol. 4, no. 37 (M-4)(519) 27 March 1980 * abstract *	1,4,6	
A	EP-A-0 213 880 (ANDERSON-COOK) * pages 5 - 9, 13 - 16; figures 1, 2, 9 - 12 *	1-10	
A	GB-A-1 193 395 (FORD MOTOR) * page 2 - page 3; figures 1,2A,2B,6 *	1-3,6-9	
A	JP-A-59 209 449 (TOYOTA JIDOSHA) 28 November 1984 * figures 5,6 * & PATENT ABSTRACTS OF JAPAN vol. 9, no. 80 (M-370)(1803) 10 April 1985 * abstract *	1,5,6,10	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5) B21H F02N

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	13 JULY 1992	ROSENBAUM H.F.J.

CATEGORY OF CITED DOCUMENTS

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