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(71)(72) Applicant and Inventor: HARDING, Mark [AU/GB]; 7 Whitecroft Road, Meldreth, Nr. Royston, Hertfordshire SG8 6ND (GB).

(74) Agent: AJELLO, Michael, John; 207 Moss Lane, Bramhall, Stockport, Cheshire SK7 1BA (GB).

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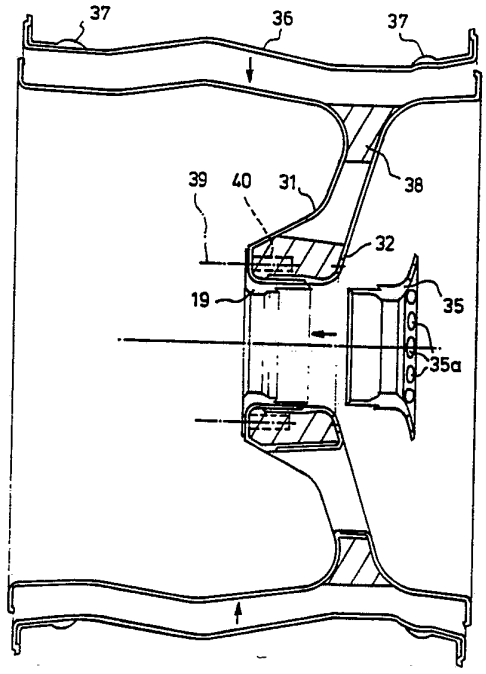

(57) Abstract

A method of fabricating a vehicle wheel particularly, though not exclusively, for racing cars, comprising the steps of forming from a profiled pattern at least two mould parts of a carbon fibre material, representing inner and outer profiles of the wheel to be produced; moulding onto said mould parts the inner and outer wheel profiles (31, 32) and combining same in a jigging mould with a structural central core (38), the completed wheel being surrounded by a rim wrap (36) of carbon fibre material having tyre bead seats adjacent the inner and outer extremities of the wheel. The completed wheel has considerable structural stability but its weight is minimised to enhance performance.

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A VEHICLE WHEEL AND A METHOD OF FABRICATING SAME

THIS INVENTION concerns a novel form of vehicle wheel, and a method of fabricating same particularly, though not exclusively, for racing vehicles. Conventionally, such wheels are produced either from steel or an alloy, and it is an object of the present invention to provide a wheel which is lighter in weight and has greater strength than most conventionally manufactured wheels. The consequent reduction in unsprung weight of the vehicle improves its racing performance.

According to the present invention a method of fabricating a vehicle wheel comprises the steps of providing a pattern consisting of one or more parts whose surface configuration resembles the wheel to be produced; producing from said pattern surface, by a moulding process, at least two mould parts representing inner and outer profiles of the wheel to be produced; moulding to said mould parts inner and outer wheel profiles respectively; and combining said wheel profiles to form the finished wheel.

Preferably, said pattern is provided in two or more parts; each said mould part is provided in two or more sections which are attached together prior to moulding the wheel profiles; at least one adaptor ring is placed in contact with at least one of said mould parts to form a hub profile; and a core of structural material is formed to opposed surfaces of the two wheel profiles and sandwiched

between the latter in the completed wheel.

Furthermore, the completed wheel is preferably surrounded by a moulded rim wrap in which tyre bead profiles are incorporated.

Also, according to the invention, there is provided a vehicle wheel produced by the aforesaid method.

The invention will now be described, by way of example only, with reference to the accompanying drawings in which:-

Fig. 1 is a schematic cross-sectional view of a pattern formed as a first part of the fabricating method according to the invention;

Figs. 2a and 2b illustrate tools or moulds produced from said pattern;

Fig. 3 is an exploded view of a multi-part pattern;

Fig. 4 is an exploded view of multi-part tools or moulds fabricated therefrom;

Figs. 5a and 5b illustrate said multi-part tools or moulds assembled to form inner and outer mould profiles respectively;

Fig. 6 is an enlarged view of the assembly of a hub sleeve or adaptor for the inner profile of Fig. 5a;

Fig. 7 is an enlarged view of an assembly means to provide a wheel centre profile to accept a hub sleeve or adaptor for an outer wheel profile;.

Fig. 8 is a cross-sectional view of a tool or mould assembled in readiness for moulding an inner wheel profile;

Fig. 9 is a similar view of a tool or mould assembled in readiness for moulding of an outer wheel profile;

Fig. 10 is an exploded view showing inner and outer wheel profiles produced by and lying between inner and outer moulds, to illustrate removal of the wheel profiles from their moulds;

Fig. 11 is an exploded view of inner and outer wheel profiles with a structural core therebetween;

Fig. 12 is a cross-sectional view of a wheel in its final stages of production whereat a rim wrap is provided.

Fig. 13 is a schematic cross sectioned view of part of a central hub region according to an alternative embodiment;

Fig. 14 is a front view of the arrangement illustrated in Fig. 13;

and Fig. 15 is a view taken on line A-A of Fig. 14.

The fabrication process will now be described with reference to the drawings. As illustrated in Fig. 1, a pattern 10 is made initially from a suitable material such as hardwood which is machined or turned out of solid or multiple layers of the wood to form the shape illustrated. In this example, a one-piece pattern is provided having vent holes 11 machined at various spaced positions around the axis.

In the first stage the working surface of the pattern 10 is prepared with a release agent and, optimally, a gel coat is laid over the surface and allowed to become partially dry.

A layer of pre-impregnated glass fibre or carbon fibre is then laid up or draped over the surface of the pattern and this is followed by three layers of pre-impregnated carbon fibre. Finally, a release film and a cloth bleed layer are applied and the whole assembly is placed in a sealed bag whereupon a vacuum forming technique is applied at a pressure of, for example, one bar and the assembly is allowed to part-cure.

Subsequently, further layers of pre-impregnated carbon fibre are applied and the process is repeated to the required thickness and the material is then fully cured.

Mould parts are thus formed and removed from the pattern, one on each side and representing the inner and outer wheel profile moulds 12 and 13 respectively. Figs. 2a and 2b illustrate the moulds produced, and these are provided with vent hole surfaces 14 and 15 in a similar manner.

Referring now to Figs. 3 to 5b, the process described previously may be carried out to produce mould sections 16 from separate pattern parts 17, the sections 16 then being bolted or otherwise attached together as illustrated at 18 in Figs. 5a and 5b to form the moulds. Instead of the bolted flanges 18, the mould parts may have mating stepped recesses formed by incorporating blanking plates or other protrusions on the pattern parts.

In the next stage of the process, an alloy carbon fibre hub sleeve 19, or a removable adaptor of similar shape is placed on one of the mould profiles, in this example the inner profile 12 and this is carried out as illustrated in Fig. 6 where a machined alloy peg 20 is placed in the centre line receptor 21 of the mould (see Fig. 2a), and this is followed by a concentric sleeve 22 which has an outwardly tapering flange 23on its inner end. The hub sleeve 19, is concentrically placed over the sleeve 22 and peg 20 as illustrated.

Similarly, in the outer wheel profile mould 13 a similar alloy peg 24 is placed in the mould receptor 25 (see Fig. 2b) and this is followed by a concentric sleeve 26 which has an outer end flange 27.

As stated, Figs. 8 and 9 illustrate respectively completed moulds for inner and outer wheel profiles. In the case of Fig. 8 there can be seen the hub sleeve 19 or adaptor mounted on its peg 20 and sleeve 22 against the outer surface of the mould 12 and there can also be seen removable lugs 28 which will provide a moulding surface for the vent holes in the finished wheel. These lugs include outer sleeves 29 which are subsequently removable for a purpose to be described.

In those parts of the mould wall which are parallel to the axis of the mould there is located an additional ring 30 which is in two or more annular sections to provide a "hollowed" shape for the wheel in the region which will be adjacent the brake disc and calliper in use. This is to enable the wall of the finished wheel to be located as far away as possible from the heat-generating brake mechanism.

The inner and outer wheel profiles are then fabricated by laying up or draping several layers of carbon fibre over each of the mould surfaces. After several successive layers have been applied a release film and bleed layer cloth can be applied and the whole assembly for each profile is placed in a vacuum bag, formed and part-cured in an oven in much the same manner as was adopted when fabricating the mould parts. This procedure may be repeated several times, if necessary, as layers of carbon fibre material are built up to produce the wheel profiles. Once fully cured the laminated wheel profiles are removed from their respective moulds, and all additional mould parts, such as ring 30, are removed, leaving inner and outer

wheel profiles 31 and 32 as illustrated in Fig. 10. The inner wheel profile 31 has been formed with the hub sleeve 19 in situ, whilst the outer wheel profile 32 has been formed with a receptor collar 33 to receive the corresponding central region of the inner profile 31.

It can also be seen from Fig. 10 that, after removal of sleeves 29 fabricated vent hole tubes 34 on the inner profile 31, may receive corresponding smaller diameter tubes 35 on outer profile 32.

In an alternative arrangement the inner and outer wheel profiles 31 and 32 may be produced each with its own internal core of a honeycombed aramid fibre paper or alloy to enhance the structural characteristics and performance of the finished wheel. This can be done by bonding the honeycombed material to one surface of half of the layers of carbon fibre material once they are fully cured. The honeycombed core may be held in place by any appropriate method such as a vacuum bag and placed in an oven and cured. The remaining layers of carbon fibre would then be applied directly over the honeycombed core and the process repeated until the required thickness is achieved. To ensure adequate bonding of the carbon fibre to the honeycombed material, a glue film would be applied before the additional carbon fibre layers. Thus, a thin profile of honeycombed material is sandwiched between carbon fibre to increase structural integrity commensurate with minimal weight.

Referring now to Fig. 11, there are illustrated the inner and outer wheel profiles 31 and 32 respectively and a structural core element 38 which is to be sandwiched between them. This core

element is produced from a structural foam or honeycombed aramid fibre paper or an alloy and may be formed according to the following method steps. The inner and outer wheel profiles 31 and 32 are placed together to define a cavity therebetween. A closing rim (not shown) is placed around the circumference of the cavity and two apertures are pierced in the closing rim to permit the injection of an expanding resin which is then allowed to set. Subsequently, by separating the inner and outer profiles 31 and 32 the expanded resin core shape is available to serve as a buck for producing the final core element 38 from materials referred to previously. Once this is machined to shape, it is placed in between the inner and outer profiles 31 and 32 which are then brought together, and the entire assembly is bonded to form a single structure, as shown in Fig. 12.

An outer profile hub sleeve or adaptor 35 is bonded to the outer surface of the outer profile 32 in the hub region and to the complementary surfaces of the inner hub sleeve or adaptor 19. Sleeve 35 defines a ring of apertures 35a around its peripheral region to minimise its weight. Apertures to accept a series of drive pegs (not shown) which extend outwardly from the upright assembly of the vehicle hub are provided in the hub sleeve 19, and as illustrated by the dotted lines 39, the pegs are accommodated in blind apertures 40 provided in the wheel structure.

Finally, the wheel is completed by applying successive layers of pre-impregnated carbon fibre as a rim wrap 36 around the peripheral surface of the assembly. This is shown for the purposes of

illustration in Fig. 12 as being spaced radially therefrom. The rim wrap 36 is applied by successive vacuum forming steps as described previously in relation to other parts of the assembly.

In the inner and outer axial regions of the rim wrap 36 additional material is laid up and machined to provide tyre bead seats as illustrated at 37.

Referring now to Figs. 13 to 15, in an alternative arrangement the central region of the wheel may comprise a hub section 41 which, like most other parts of the structure, may be pre-moulded from carbon fibre, a number of radially extending reinforcing spokes 42, and, interposed between the spokes 42, a number of vent hole assemblies 43. Once again, the spokes 42 and assemblies 43 may be produced by laying up and curing carbon fibre material.

As can be seen from Fig. 15, each spoke assembly 42 comprises an inner core 44 of honeycombed aramid fibre paper or alloy having laid up on each side thereof a carbon fibre skin 45. The honeycombed core 44 is of the kind having considerable compressive strength in one direction, transverse to the radius of the wheel.

Each spoke 42 is thus formed with an I-shaped cross section the flanges of which can abut or overlap the opposing faces of the adjacent vent hole assemblies 43.

In production of the wheel the hub and spoke section 41, 42 is assembled in a jigging mould with vent hole assemblies 43.

These components are bonded together with a high strength adhesive and are adapted to receive the inner and outer wheel profiles in a form generally similar to those illustrated in Fig. 11 but with the omission of vent hole parts 34 and 35 and hub parts 19 and 33. Thus, the fabrication system described in relation to Figs. 13 to 15 is a substitute for the vent hole and core assembly of the previous embodiment and may be considered a preferable manufacturing technique. It will be appreciated that the number of radial spokes 42 and of the vent hole assemblies 43 may be selected according to user requirements and to ensure minimum weight commensurate with adequate structural ability. Again, the wheel is completed with a rim wrap and tyre bead seats laid up upon its periphery, and the hub will receive an adaptor or sleeve similar to that illustrated at 35 in Fig. 12 but with a plain annular insert to be received within the hub section 41.

It will be appreciated that a wheel made in accordance with the invention as described above, is light in weight but structurally sound. The patterns and tools which are variable in configuration to some extent are however substantially standard, whilst the hub sleeves or adaptors 19 and 35 may be provided to suit the particular axle assembly of the end user.

A wheel produced in accordance with the invention substantially avoids the use of cast or spun alloy components and consists of an integrated structure from composite materials which may be used in any combination to provide optimum weight and

performance characteristics. These materials make up substantially the entire wheel and may be adapted also for the hub sleeves which incorporate the main load-bearing faces of the wheel in its hub region.

CLAIMS

1. A method of fabricating a vehicle wheel, comprising the steps of providing a pattern consisting of one or more parts whose surface configuration resembles the wheel to be produced; producing from said pattern surface, by a moulding process, at least two mould parts representing inner and outer profiles of the wheel to be produced; moulding to said mould parts inner and outer wheel profiles respectively; and combining said wheel profiles to form the finished wheel.

2. A method according to Claim 1, wherein, from said pattern in two or more parts, each said mould part is produced in two or more sections which are attached together prior to moulding the wheel profiles; at least one adaptor ring is placed in contact with at least one of said mould parts to form a hub profile; and a core of structural material is formed to opposed surfaces of the two wheel profiles and sandwiched between and bonded to the latter to produce the completed wheel.

3. A method according to Claim 1 or Claim 2, wherein the wheel is surrounded by a moulded rim wrap incorporating tyre bead profiles.

4. A method according to Claim 1, wherein said moulding process includes the steps of laying over the surface of the pattern a gel coat; subsequently laying thereon a layer of impregnated glass fibre; and subsequently three or more layers of pre-impregnated

carbon fibre, the whole assembly being then vacuum formed and allowed to cure.

5. A method according to Claim 1, including, on at least one of said mould parts, a removable plug which when the wheel profiles are moulded provides a formed vent hole for the wheel.

6. A method according to Claim 1, wherein said mould parts have mating stepped recesses formed by incorporating blanking plates or other protrusions on the pattern parts.

7. A method according to Claim 1, wherein, in said moulding process, a bracing member is placed externally against each mould part during initial curing thereof to prevent distortion during the production of the mould part.

8. A method according to Claim 1, wherein, in said moulding process, said inner and outer wheel profiles are moulded to said mould parts by laying up several layers of carbon fibre over each mould surface and forming same thereto by vacuum bagging.

9. A method according to Claim 2, wherein the structural core is formed between the inner and outer wheel profiles by initially placing therebetween an expanded resin core shape and subsequently producing therefrom a core element of structural foam which is placed between the inner and outer profiles and bonded thereto.

10. A method according to Claim 1, wherein a hub sleeve or adaptor is placed centrally within the wheel and defines a ring of apertures around the peripheral region of the hub sleeve or adaptor, adapted when the wheel is in use, to receive a series of drive pegs extending outwardly from a vehicle hub, blind apertures being provided in the wheel structure behind the ring of apertures in the hub sleeve or adaptor.

11. A method according to Claim 1, wherein the inner and outer wheel profiles are initially formed without inter-engaging vent hole assemblies and combined in the final assembly with separate preformed vent hole assemblies and reinforcing spokes, all components being bonded together with the inner and outer wheel profiles in the final combination of the parts to form the finished wheel.

12. A method according to Claim 11, wherein each said reinforcing spoke is formed by a radial strip of honeycombed aramid fibre paper or alloy, surrounded on each side by carbon fibre skins and abutting or overlapping the adjacent vent hole assemblies, the spokes and vent hole assemblies being recessed to receive the inner and outer wheel profiles in a jigging mould.

13. A vehicle wheel produced by a method according to any one of the preceding claims, wherein the inner and outer wheel profiles are made entirely or predominantly from a carbon fibre material.

14. A vehicle wheel according to Claim 13, comprising inner

and outer wheel profiles having a central hub sleeve or adaptor, a plurality of vent holes annularly distributed around the wheel, a structural or reinforcing core between the wheel profiles, the completed wheel being surrounded by a moulded rim wrap including tyre bead profiles adjacent the inner and outer extremities thereof, substantially the entire assembly being made from a carbon fibre material.

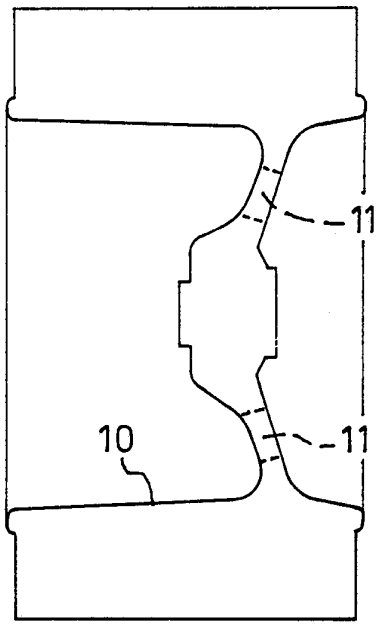


FIG.1

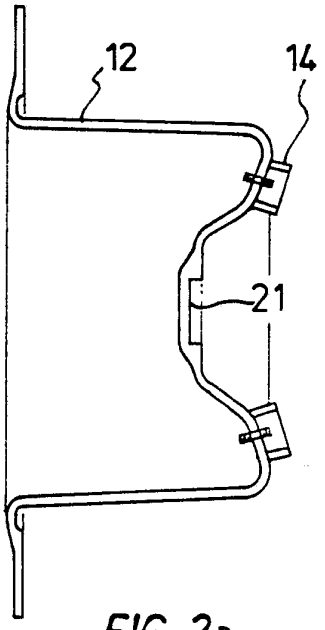


FIG. 2a

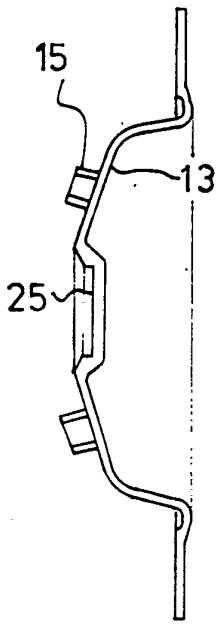


FIG. 2b

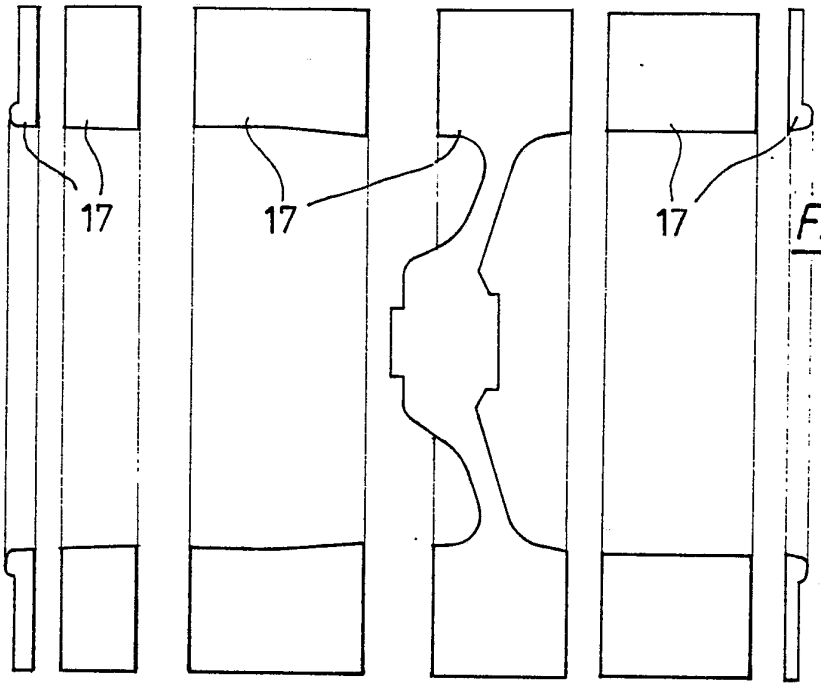


FIG.3

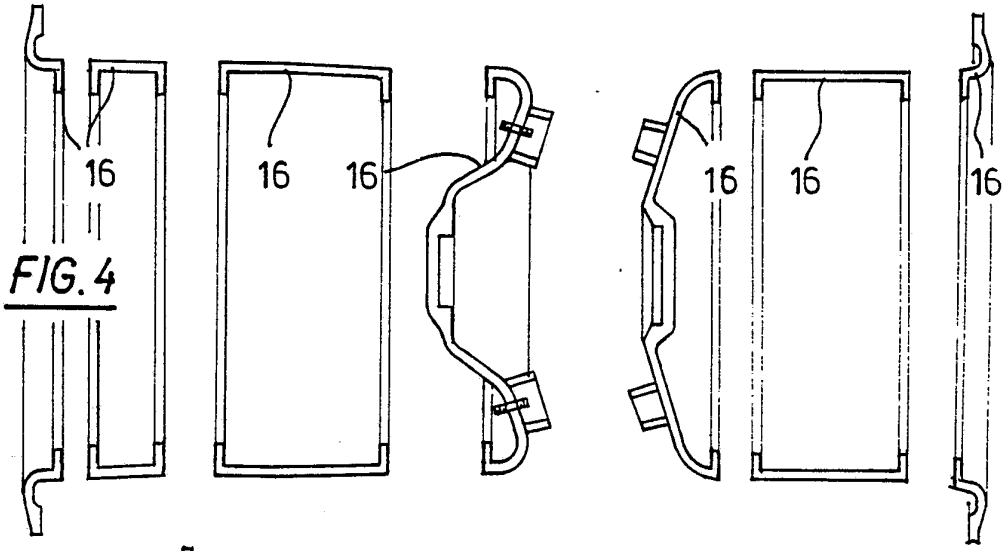


FIG.4

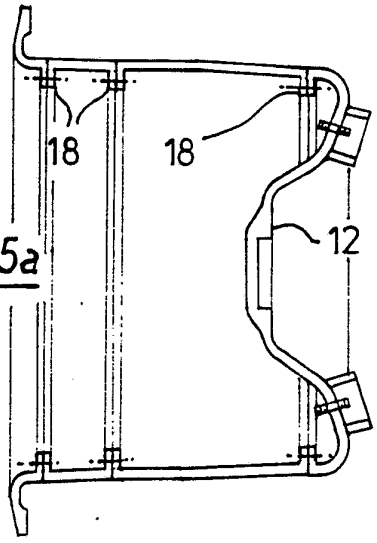


FIG 5a

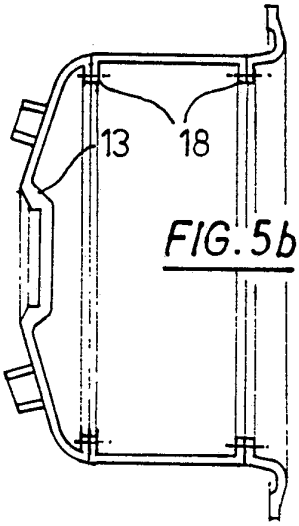


FIG.5b

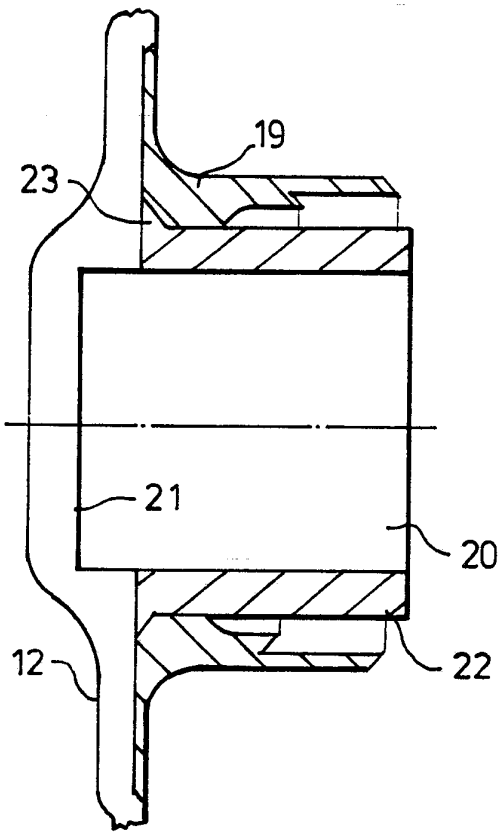


FIG.6

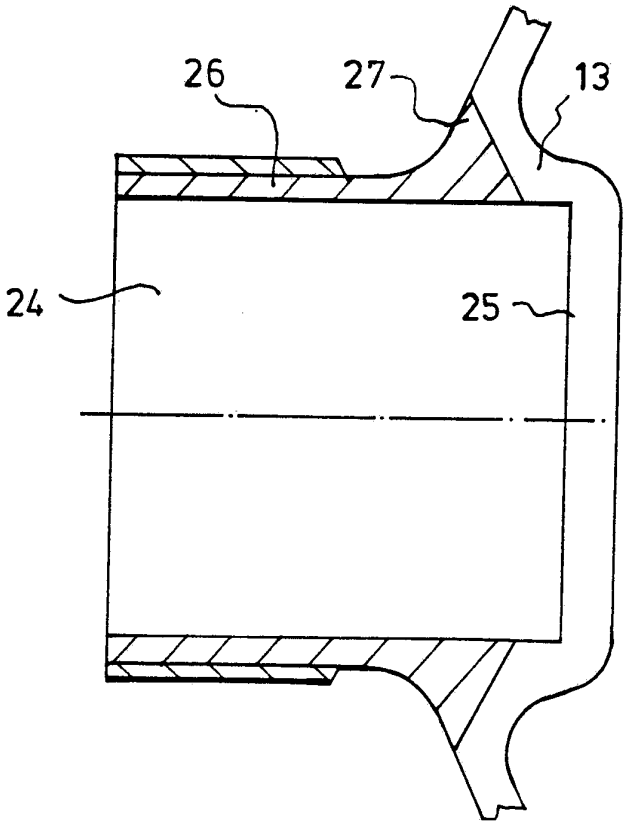


FIG.7

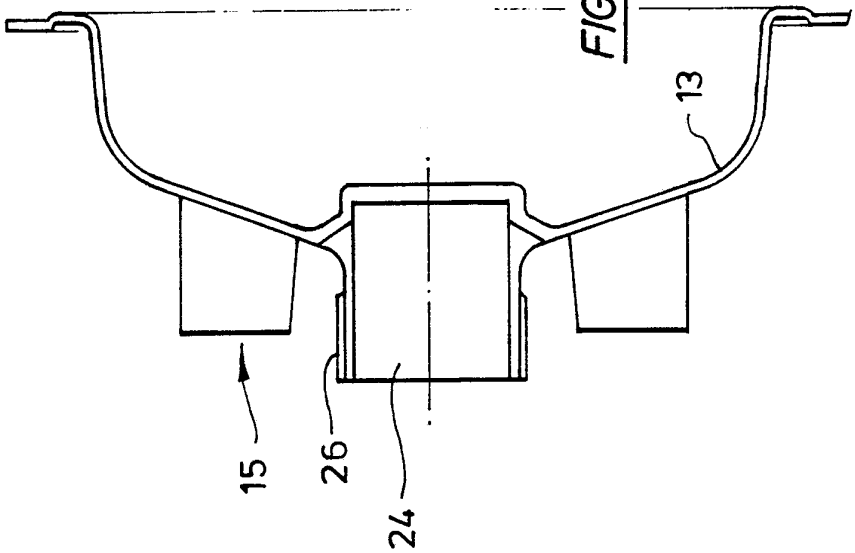


FIG.9

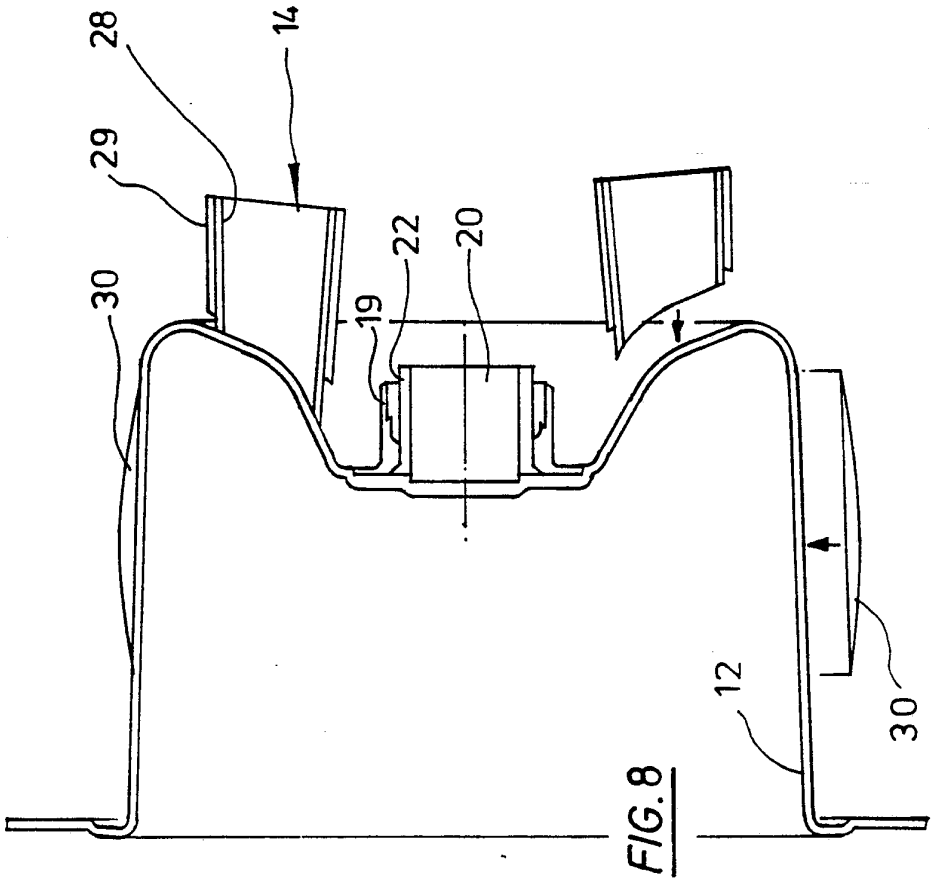


FIG.8

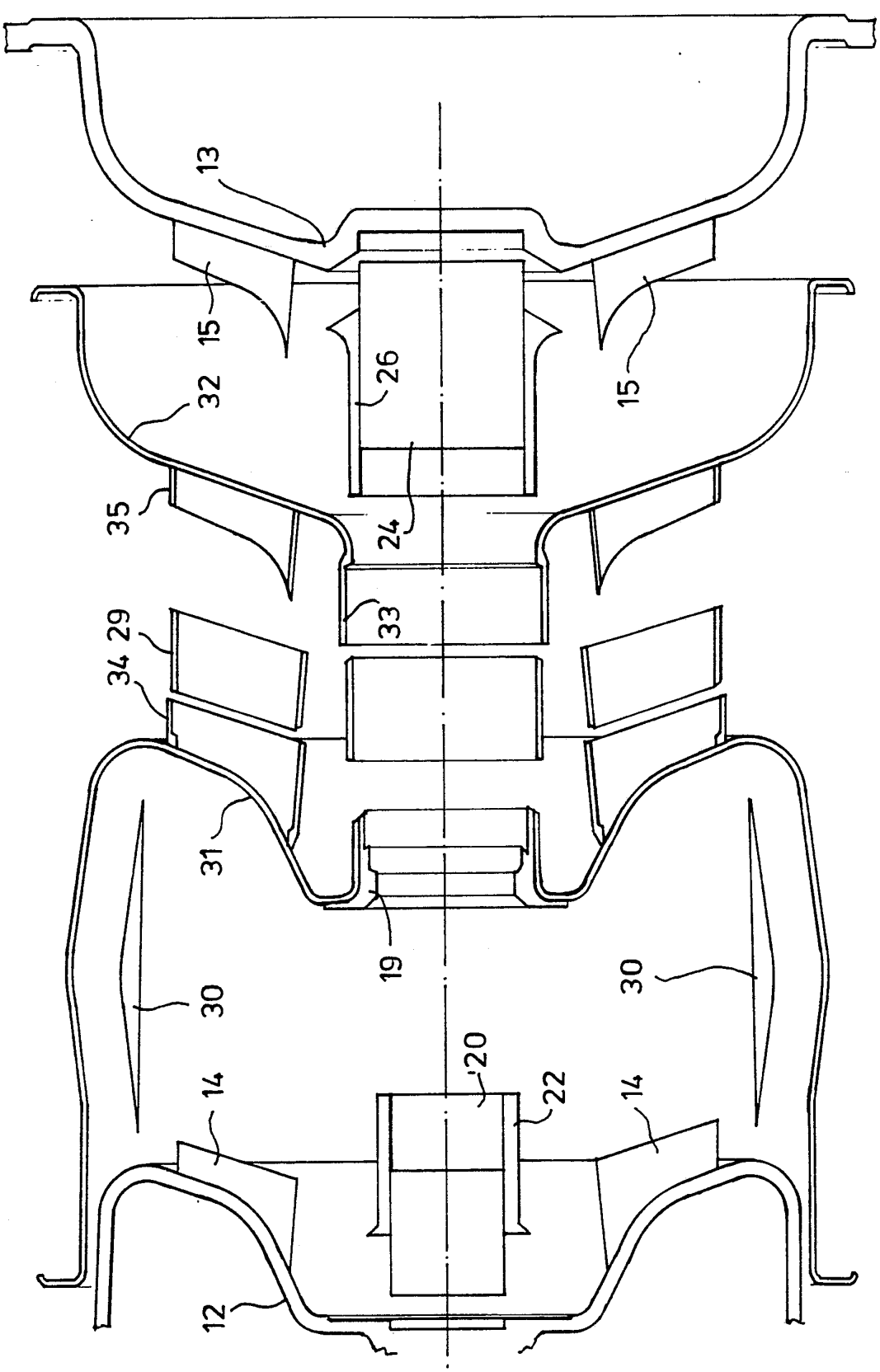


FIG.10

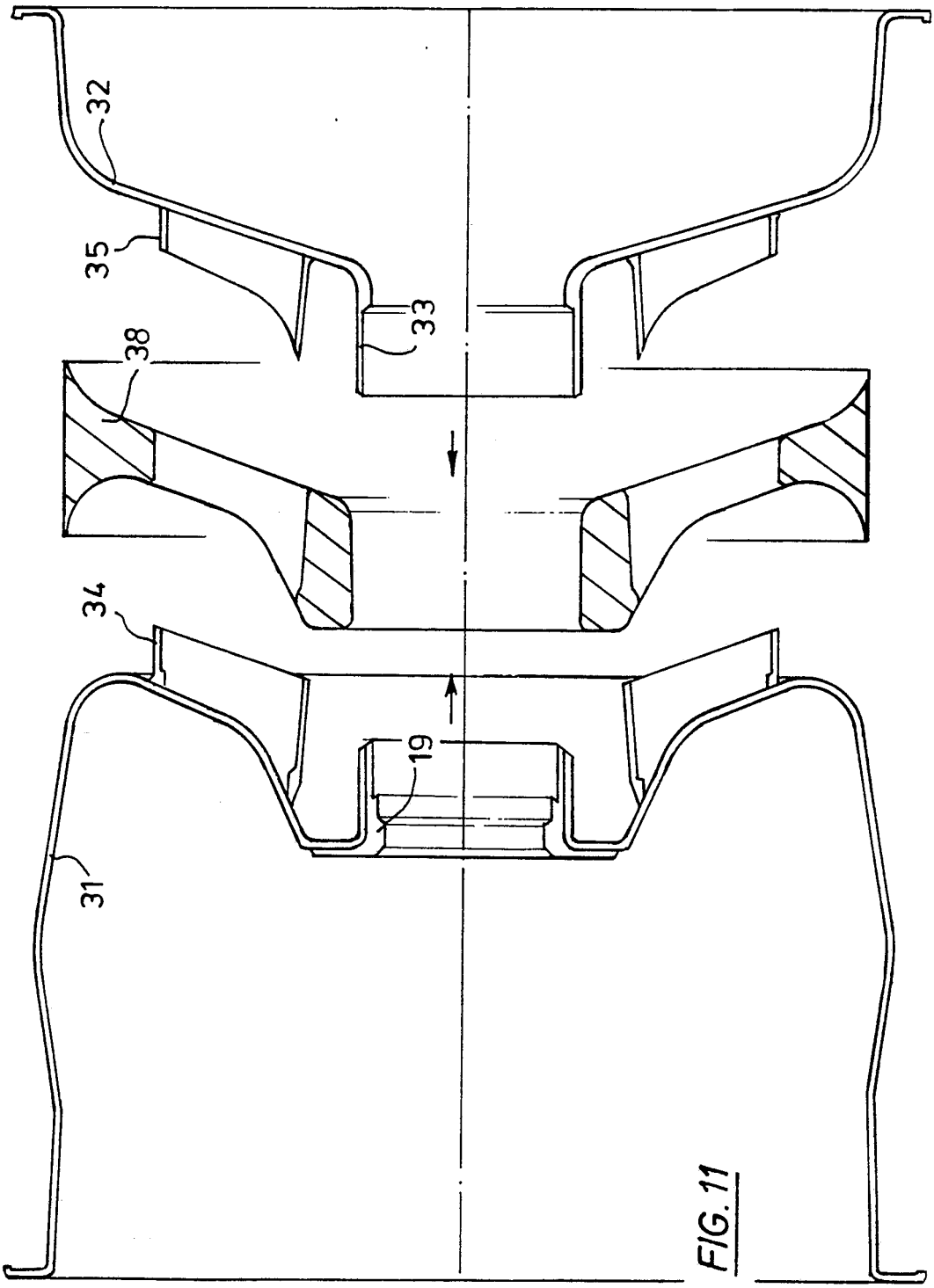


FIG. 11

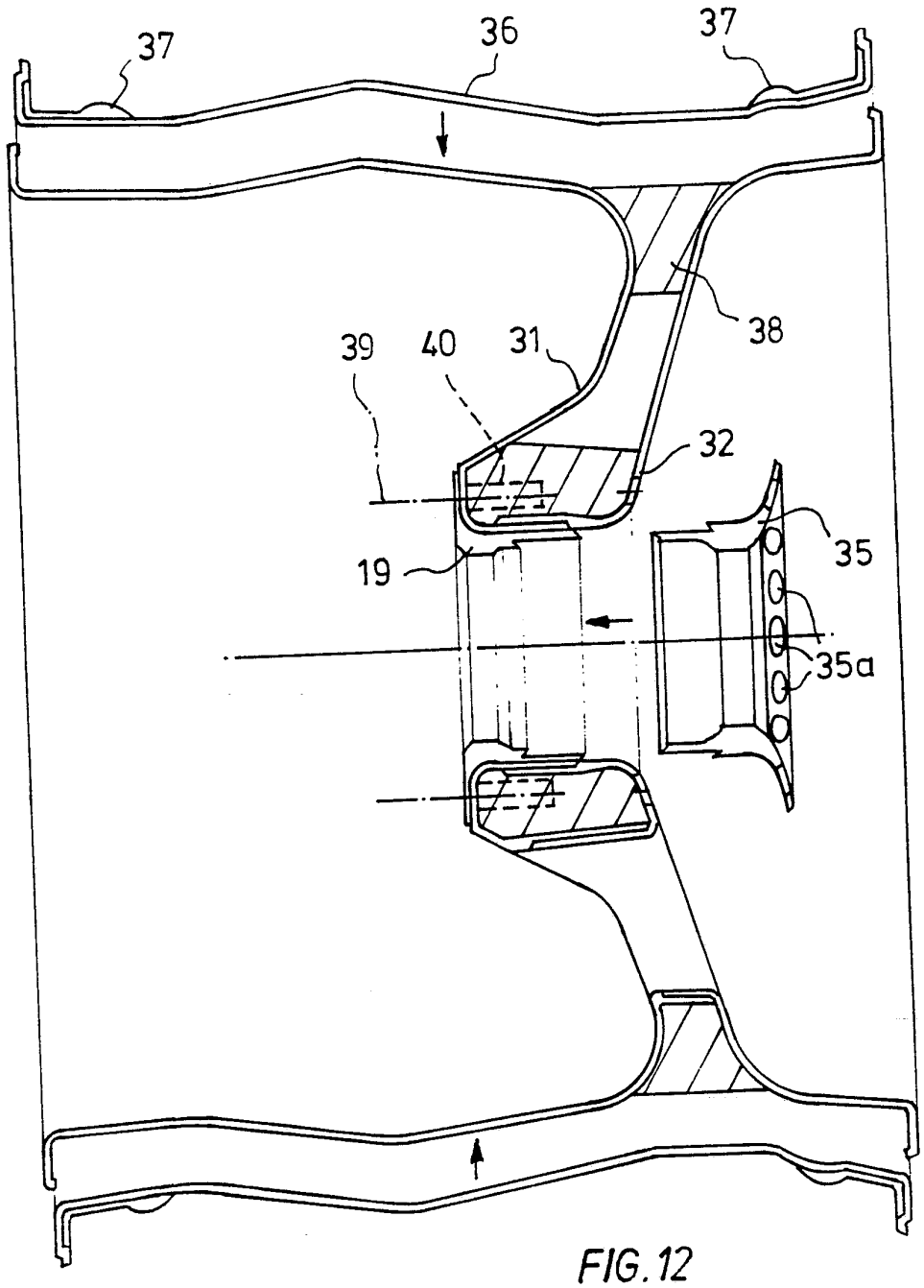


FIG. 12

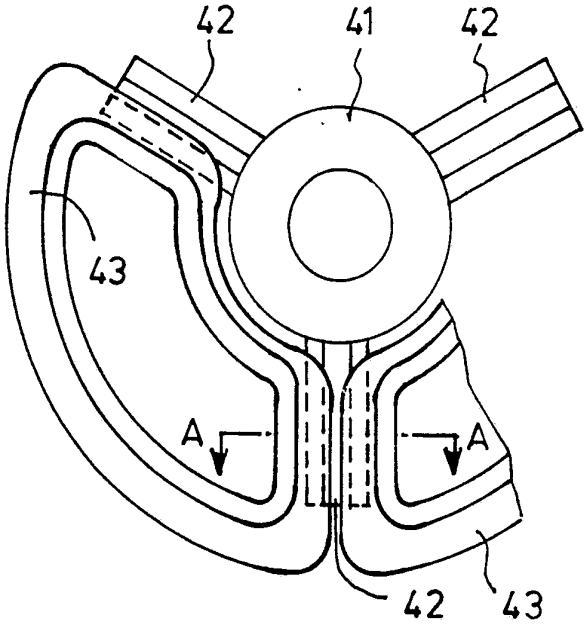
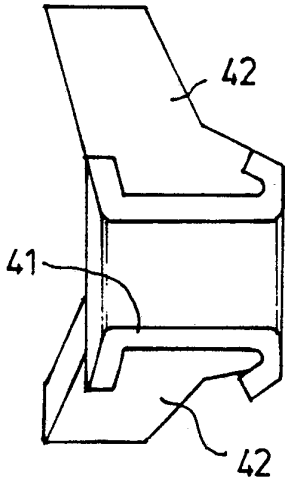


FIG. 14

FIG. 13



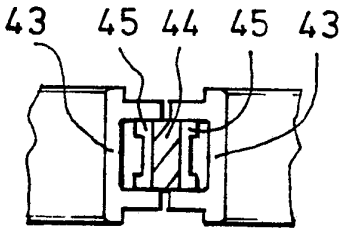


FIG. 15

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 92/01307

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 B29D31/00; B29C67/22; B29C33/40; B60B5/02

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	B29D ; B29C ; B60B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	GB,A,2 112 700 (SUMITOMO ELECTRIC IND LTD.,HONDA GIKEN KOGYO KABUSHIKI KAISHA) 27 July 1983	1,13
Y		2,3,4,8, 9,11
X	EP,A,0 065 086 (MESSERSCHMITT-BÖLKOW-BLOHM) 24 November 1982	1,13,14
Y		3
Y	US,A,4 153 657 (WILCOX) 8 May 1979	2,9
Y	GB,A,654 289 (SPERRY) 13 June 1951	4,8

-/--

° Special categories of cited documents :[10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
20 NOVEMBER 1992	18. 12. 92
International Searching Authority	**Signature of Authorized Officer**
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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category°	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
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A	FR,A,2 449 542 (MOTOR WHEEL CORP.) 19 September 1980 ---	5
A	FR,A,1 595 590 (GRÜNBERG) 15 June 1970 ---	1
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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9201307 SA 63616

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