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(54) BRAKE DISKS AND PROCESSES FOR PRODUCING BRAKE DISKS

(71) We, HONDA GIKEN KOGYO KABUSHIKI KAISHA, residing at 6-27-8, Jingumae, Shibuya-ku, Tokyo, Japan, a Corporation of Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to brake disks to be used for vehicles such as autobicycles.

Disk brakes are high in stability at high speeds and under high loads, and are used as a braking system not only for automobiles but also for autobicycles. In the case of a disk brake for an autobicycle, the brake disk will be exposed, unlike the case an automobile, and therefore the brake disk should have good corrosion resistance and a favourable appearance. Therefore stainless steel is used as a material for brake disks. The performance of such brake discs depends upon the coefficient of friction of the surface of the material, that is, the hardness and smoothness of the surface. If the hardness is too high, excessive slippage will be likely to occur. If the hardness is low, excessive friction and wear will occur. Brake squeak will be likely to occur with excessive hardness. Therefore, when stainless steel is used as a material for brake disks, the brake performance, the brake wear and the brake squeak are taken into consideration.

The performance of the brake disk is influenced by its hardness. Therefore, in general, the stainless steel is first heated to 1050 to 1150°C and quenched to obtain a material having a hardness of about 50 to 53 HRC (Rockwell hardness on scale C). Then, it is annealed at about 650°C to reduce the hardness to 30 to 40 HRC, to obtain a brake disk of a required hardness. Particularly, that surface of the brake disk which in use contacts the brake pads has a hardness of about 32 to 36 HRC, taking the brake performance and machining into condsideration.

Thus, the known process comprises heating a material to be perfectly in an austenitic range, keeping it heated, then quenching it to obtain a martensitic structure, and further annealing it to decompose the martensitic structure to a carbide-sorbite structure.

In the above conventional means of obtaining brake disks, as the stainless steel is quenched and then annealed, there is the disadvantage that, not only is an additional heat treating step required, but also that, even if a press-quenching means is used for quenching to increase the precision, strain will be generated in the annealing step thereby reducing the precision of the annual disk portion, which is a brake pad contacting surface. Further, in a disk in which an annular disk portion and wheel hub portion are integrally formed, strain will be generated in the disk as a whole. Therefore, mechanical work such as cutting will be required, and the production of brake disks will be troublesome and complicated, a mechanical working apparatus will be required, and personnel required for the work will have to be secured. Accordingly, the cost of the brake disk is high. Further, as cutting work is required, it is initially necessary for the material to be thicker than would be the case if such cutting were not required. This is disadvantageous. Further, the annealing temperature range of 650 to 750°C is so narrow that the above mentioned required hardness is difficult to obtain, due to the difficulty of temperature control.

In addition to the above, when the above mentioned integral brake disk is press-shaped, a resilient returning action or springing back of the press-shaped material will occur in the bent portion. Therefore parallelism of the annular disk portion forming the pad contacting surface will be difficult to obtain. The above mentioned cutting work will be required for its correction. However, it is difficult to perfectly correct the surface of the annual disk portion and, if the parallelism of the annular disk portion is not maintained at high precision, uneven contact between it and the brake pad will result. As a result, uneven wear will occur on the annular disk portion and on the brake pads, and the braking efficiency will be reduced.

According to the present invention, there is provided a brake disk at least those portions thereof which in use contact the brake pads being made of a martensitic stainless steel containing at least 10% of chromium and having a surface hardness suitable for a brake.

The present invention also provides a process for producing a brake disk, comprising heating a martensitic stainless steel plate containing at least 10% of chromium to an imperfectly quenching temperature such that a hardness required for a brake disk is obtained and press-quenching said heated steel plate to obtain a brake disk of a predetermined shape.

For a better understanding of the invention, reference will now be made, by way of example, to the accompanying drawings in which:

Figure 1 is a sectional view of a quenching press for producing an integral brake disk according to the invention;

Figure 2 is a section of the same press, showing the press-quenching state;

Figure 3 is a sectional view of a integral brake disk obtained by use the press shown in Figures 1 and 2;

Figure 4 is a magnified sectional view of the brake disk shown in Figure 3;

Figure 5 is a plan view of a portion of the brake disk shown in Figures 3 and 4;

Figure 6 is a sectional view showing a modification of the brake disk shown in Figures 3 to 5;

Figure 7 is a sectional view of another quenching press for use in the invention;

Figure 8 is a sectional view of a brake disk obtained by use of the press shown in Figure 7;

Figure 9 is a phase diagram of a stainless steel containing 12% of Cr; and

Figure 10 is a diagram showing the relationship between quenching temperature and HRC (Rockwell hardness on the scale C) of a stainless steel containing 12% Cr and 0.3% C.

The material to be used for a brake disk in the embodiments described with reference to the drawings is a stainless steel containing at least 10% Cr and having a predetermined surface precision and thickness precision. The Cr content is at least 10% because, if it were to be less than 10%, the brake disk would have neither a sufficient corrosion resistance nor a desirable appearance.

This material is heated and held at a temperature in a temperature range determined by the hardness required for a brake disk and above the transformation point A_1 such as shown in Figure 9 and shaping and punching steps such as edging, stamping and punching are carried out while it is held and pressed in a press. While the material is continued to be held and pressed, it is quenched to be of a predetermined hardness. Thus, the material is quenched at a temperature lower than the conventional quenching temperature, e.g. at a temperature above the transformation point A_1 and in the $\alpha + \gamma$ (ferrite + austenite) zone or the $\alpha + \gamma + Cm$ (ferrite + austenite + cementite) zone as shown by the shaded area in the phase diagram shown in Figure 9, whereby a mixed structure of martensite + ferrite + cementite or ferrite + martensite is obtained. Therefore, particularly such predetermined hardness as is mentioned above is obtained by controlling the hardness to be proper at HRC of 30 to 45 proper for a brake disk with the amount of the austenite at the time of heating it, that is, with the heating temperature without later annealing it.

The above quenching is generally called an imperfect quenching. A martensitic stainless steel plate material containing at least 10% Cr is edged, stamped and punched with a press and is simultaneously imperfectly quenched as in this kind of material as mentioned above or imperfectly quenched by press-quenching to obtain a product of HRC of 30 to 45 optimum for brake disks.

In the above, the material is press-shaped and quenched or the shaped product is only quenched to directly obtain a predetermined hardness as of a brake disk and therefore no subsequent annealing step is required. No strain will be thereby generated and the precision of the product will be maintained under a preset condition.

Fig. 10 shows relations between the quenching temperature and hardness in a stainless steel of 12% Cr — 0.3% C. As evident in this graph, the higher the quenching temperature, the higher the hardness. As shown in the graph, as this stainless steel of 12% Cr — 0.3% C is quenched generally at 920 to 980°C., the quenched hardness will be HRC of 46 to 56 which is not desirable for a brake disk. Therefore, as mentioned above, it must be annealed to be of a hardness adapted to a brake disk to control the hardness.

Therefore, the quenching should be effected at a termperature above the transformation point A_1 in the above mentioned phase diagram and in particular at a temperature dependent upon the required hardness, because, if the material is quenched at a temperature of 850 to 910°C., i.e. lower than the ordinary quenching temperature, a hardness in a range of HRC of 30 to 45 will be obtained and the hardness will be able to be controlled by one step of only quenching in the above mentioned integral type disk or the like. As a result, in the process for producing brake disks, the heat-treating step may be one, a desired hardness can be obtained in this one step, the producing steps can be greatly simplified and a brake disk having an optimum surface hardness and a brake feeling characteristic required for a brake disk, high in the wear-resistance and anticorrosion and favorable in the appearance is obtained.

Further, when the material is imperfectly quenched as held and pressed with a press, a brake disk high in the parallelism and flatness will be obtained and, with only a subsequent grinding work, the above mentioned brake disk will be obtained.

The above explained brake disk and a process for producing the same shall be explained in detail in the following.

First of all, an example of the process for producing brake disks according to the present invention will now be explained.

Figs. 1 to 3 show the production of an integral brake disk.

A press is provided with cooling water passages 21 and 51 respectively in an upper die 20 and lower die 50. Said upper die 20 and lower die 50 are ring-shaped. The upper die 20 is movable. Stamping portions 22 and 52 are symmetrically formed with one as a concave portion and the other as a convex portion in the intermediate parts of the opposed stamping surfaces of the respective dies 20 and 50. The lower surface of the peripheral side portion of the upper die 20 is formed of a ring-shaped flat surface 23. A movable receiving block 54 having the upper surface as a flat surface 53 is opposed to the above mentioned surface 23 of the lower die 50, is vertically movably fitted in a ring-shaped cavity 55 formed in the peripheral portion of the lower die 50 and is supported on the lower surface by stays 56 which are connected to a plurality of cushion units and which pass vertically through the die. The above mentioned cooling water passages 51 are provided in this block 54. The outer peripheral end edge of this receiving block 54 and the outer peripheral end edge of the surface 23 of the above mentioned upper die 20 are such as to fit each other. A fixed ring-shaped edge-cutting member 57 is provided on the outer periphery of the block 54.

Inside the block 54 of the lower die 50 is a tapered surface 58. The central portion enclosed with this tapered surface 58 is a flat central surface 59.

A downwardly opening circular cavity 25 is provided in the central portion of the upper die 20. A punch device 30 consisting of a punch 31 for punching and shaping a hole for inserting an axle and punches 32 for shaping holes for fitting a hub is fixed and provided in the central portion in this cavity 25. A slidable ring-shaped movable pushing block 33 for stamping, provided with cooling water passage 21 in it, is fitted on the outer peripheral portion of the above mentioned punches 31 and 32 within the cavity 25. The upper surface of this block 33 contacts rods 34 of oil pressure cylinders or the like provided vertically through the cavity 25 and outer portion of the upper die 20. A concentric step portion 35 of a diameter larger than of the central surface 59 of the lower die is made on the lower surface of the block 33 and a stepped portion 36 is made on the end edge of a tapered concave stamping portion 22 provided in the boundary portion of the opening end edge of circular cavity 25 with the flat surface 23.

On the other hand, receiving holes 60 and 61 for receiving the above mentioned punches 31 and 32 are made in the central portion of the lower die 50.

The production of integral type brake disks with the above mentioned press will now be explained. The above mentioned martensitic stainless steel plate material W containing more than 10% Cr is heated to be at the above mentioned imperfectly quenching temperature and is put as heated between the upper and lower dies 20 and 50. The upper die 20 is lowered to hold the central portion of the material W with the lower surface of the block 33 of the upper die and the central surface 59 of the lower die 50 and to hold the outer peripheral portion of the material W with the opposed flat surfaces 23 and 53 of the pheripheral portions of the upper and lower dies 20 and 50. With the fall of the upper die 20, this portion only will be pressed down by the stepped portion 35 on the inside diameter side of the lower surface of the block 33 more than the other portions to form a stepped portion. The upper die 20 will fall while the peripheral portion of the material W is strongly held and pressed by the flat surfaces 23 and 53. With the fall of the upper die 20, while holding the peripheral portion of the material W the receiving block 54 of the lower die 50 will fall against the pressure of the stays 56 and the outer peripheral portion of the material W will be cut off by the edge cutting member 57 provided in the outer peripheral portion to determine the dimension of the outside diameter of the material W.

Further, with the fall of the upper die, the material W as held and pressed in the peripheral portion and central portion will be stamped in the intermediate portion, will be plastically deformed and pressed by the stepped portion 36 on the outside diameter side in the boundary portion of the outer peripheral portion with the truncated conical portion to be stamped, will be perfectly held by the above mentioned stepped portion 35 and this stepped portion 36 in the outer peripheral portion and central portion and will be stamped only in the intermediate portion without slipping.

Together with the above mentioned fall of the upper die 20, the punches 31 and 32 will also fall to punch and shape an axle inserting hole and hub fitting holes in the central portion of the material.

The thus edged, stamped and punched material W as held is quenched by feeding cooling water through the cooling water passages 21 and 51 so as to be of a predetermined hardness to obtain a shaped product. This is shown in Fig. 2. Then the shaped product is mechanically worked such as by grinding on both surfaces of the annular disk portion and is painted on the hub fitting surface to obtain such brake disk as is shown in Fig. 3.

Fig. 3 shows a sectioned side view of the above obtained brake disk B. Fig. 4 shows a magnified view of the same for the convenience of the explanation.

B_1 of the outer peripheral portion is an annular disk portion. B_4 is a truncated conical portion. B_6 is a hub fitting portion in the central portion parallel with the above mentioned disk portion B_1. An axle inserting hole B_9 and hub fitting holes B_{10} are formed in this hub fitting portion B_6. B_5 are holes for weight reduction and decoration which are formed in the portion B_4 in the embodiment in Figs. 4 and 5, by the use of further punches in the above mentioned press. As this brake disk B is press-shaped and quenched as mentioned above as continuously held and pressed in the respective steps, the parallelism and flatness over the entire peripheries of both front and rear surfaces B_2 and B_3 of the annular disk portion B_1 can be set and maintained at a very high precision. Further, as no annealing is carried out, the initially set parallelism and flatness can be obtained without requiring any special mechanical work. Further, as both front and rear surfaces B_7 and B_8 of the hub fitting portion B_6 in the central portion are shaped and quenched also as held and pressed, the parallelism with the annular disk portion B_6 can be maintained nearly perfectly. In the case of stamping the portion B_4 in the above, the boundary portions of the annular disk portion B_1 and hub fitting portion B_6 with the stepped portions 36 and 35 will be held in the stepped portions 36 and 35 of the upper die 20, the material will not slip and the axle inserting hole B_9 and hub fitting hole B_{10} will be able to be prevented from being deformed.

The stepped portions formed in the brake disk B in the above will be explained in the following.

Fig. 4 is magnified to definitely show the stepped portions formed in the brake disk B.

In the boundary portions of both surfaces of the portion B_4 with both front and rear surfaces B_2 and B_3 which are pad sliding surfaces of the annular disk portion B_1 of the brake disk B and the boundary portions of both front and rear surfaces B_7 and B_8 of the hub fitting portion B_6 with both surfaces of the portion B_4, slight stepped portions B_{11}, B_{12} and B_{13}, B_{14} are respectively formed in the axle fitting direction in the direction vertical to these surfaces B_2, B_3 and B_7, B_8. These stepped portions B_{11}, B_{12} and B_{13}, B_{14} are formed over the entire peripheries of the annular boundary portions and are shaped in the shaping step in the above mentioned press. The stepped portions B_{11}, B_{12} and B_{13}, B_{14} are formed in the same direction vertical to the flat surfaces, B_2, B_3 and B_7, B_8 on both front and rear surfaces of the above mentioned boundary portions. The heights of the stepped portions are different depending on the kind and thickness of the material but are slight. That is to say, the heights of the stepped portions B_{11}, B_{12} and B_{13}, B_{14} form such steps as cause a plastic deformation verical to the surface portion of the material structure in those portions, deform the structure over the deformation elastically recovering limit in the portions, maintain a sufficient continuity in the central portion of the structure and maintain a sufficient strength as of a brake disk without impairing the strength of the product.

When the above mentioned stepped portions B_{11}, B_{12} and B_{13}, B_{14} are formed, an effective plastic deformation will be produced in the structure of the surface portion of each of those portions of the brake disk B. Therefore, in the hub fitting portion B_6 and annular disk portion B_1 connected above and below the truncated conical portion B_4 and parallel with each other, even if the brake disk is integrally press-shaped, the springing back usually generated in each boundary portion with the portion B_4 which is a stamped portion will be absorbed by the above mentioned step shaping and, at the time of separating the upper and lower dies 20 and 50, no springing back will occur. Therefore, the parallelism and flatness of the front and rear pad sliding surfaces B_2 and B_3 of the annular disk portion B_1 and of the front and rear surfaces B_7 and B_8 of the hub fitting portion B_6 will be maintained at a high precision.

Thus, a brake disk which is very high in the parallelism, flatness, various performances as of the above mentioned brake disk and precision can be obtained by providing the stepped portions together with the above mentioned material, hot press-shaping and imperfect quenching as held and pressed.

Fig. 6 shows a modification of the above mentioned stepped portion.

As evident in the drawing, at the time of integrally shaping the disk, a cavity B_{20} is made in the form of a ring over the entire periphery of the boundary surface on the opposed surface side to the surface on the axle fitting side of the ring-shaped boundary portion of the portion B_4 with the annular disk portion B_1. This cavity 20 is made to have a small width in the direction of the portion B_4, the bottom portion 21 of the cavity is inclined to be parallel with the portion B_4, the peripheral surface B_{22} on the annular disk portion side of the cavity B_{20} is formed to be vertical to the sliding surface B_2 and the peripheral surface B_{23} on the portion B_4 side is formed to be parallel with the above mentioned peripheral surface B_{22}.

On the surface opposed to the above mentioned cavity B_{20} of the annular disk portion B_1 and portion B_4, a recessed stepped portion B_{24} is formed to be recessed to the axle fitting side vertically to the pad sliding surface B_3 of said surface as slightly deflected in the direction of the inside diameter from the inner peripheral surface B_{22} of the above mentioned cavity B_{20}. The peripheral edge B_{25} on the outer peripheral side of this recessed stepped portion B_{24} is formed to be vertical to the surface B_3 and the top surface B_{26} is formed to be parallel with the surface B_3 in the direction of the inside diameter and is connected with the surface in the same inclined direction of the portion B_4. The above mentioned cavity B_{20} and recessed stepped portion B_{24} are integrally shaped at the time of the above mentioned shaping and can be easily worked by modifying the dies. These cavity B_{20} and recessed stepped portion B_{24} are provided so as not to impair the strength of the part forming them. The above mentioned stepped portions B_{13} and B_{14} are provided between the portion B_4 and hub fitting portion B_6.

In the above mentioned embodiment in Fig. 6, as the brake disk is integrally formed by providing the cavity B_{20} and recessed stepped portion B_{24} on both front and rear surfaces between the annular disk portion B_1 and portion B_4, a sufficient plastic deformation will be given to the surface of the material structure and the springing back produced in the integral brake disk will be able to be eliminated more than in the above mentioned embodiment.

Figs. 1 to 6 show embodiments of integral brake disks. In the embodiment in Figs. 1 and 2, the edge of the material is simultaneously cut off but a material cut to be of a predetermined dimension of the outside diameter may be used. Further, the material may be shaped to be of the shape of a brake disk in advance, heated as mentioned above, punched with a press and quenched. The brake disk and process for producing the same according to the present invention include the one obtained by such process as in the above and the process.

In the above, cooling water passages are provided in the dies for quenching. However, such system as spraying cooling water from outside can be also adopted.

An integral disk and process for producing the same are explained in the above. The present invention includes also a brake disk made by shaping a hub fitting portion and disk portion separately and securing them through rivets or the like and a process for producing the same in such manner as shown in Figs. 7 and 8.

Fig. 7 shows a quenching press for it wherein the upper die 120 is a movable die provided with cooling water passages 121 in the peripheral portion, a die surface 123 formed to be flat on the peripheral side and a punch 131 for shaping an axle inserting hole and punches 132 for shaping hub fitting member riveting holes movably provided in a cavity 125 formed to open downward in the central portion. The lower die 150 is provided as a fixed die provided with opposed cooling water passages 151 in the same manner as is mentioned above, a recessed die surface 153 for receiving a disk material W as fitted as half immersed on the die surface and holes 160 and 161 for receiving the above mentioned punches 131 and 132 in the central portion.

Such martensitic stainless steel plate material W containing more than 10% Cr as is mentioned above is cut to be disk-shaped of a predetermined outside diameter dimension, is heated to be at the above mentioned imperfectly quenching temperature and is then put between the die surfaces of the upper die 120 and lower die 150 as shown in Fig. 7, the upper die 120 is lowered to hold and press the peripheral portion of the material and the punches 131 and 132 are lowered in this state to punch and shape the material. While the material remains held and pressed as it is, cooling water is fed through the cooling water passages 121 and 151 to imperfectly quench the material. The quenched ring-shaped disk member B_{30} will have an axle inserting hold B_{31} formed in the central portion and holes B_{32} for riveting a hub fitting member B_{40} formed on the peripheral side of said axle inserting hole B_{31}. Aside from this annular disk member B_{30}, there is prepared a hub fitting member B_{40} provided with a flange portion B_{41}, truncated conical portion B_{42}, hub fitting portion B_{43}, axle inserting hole B_{44}, hub fitting holes B_{45} and riveting holes B_{46} made in the above mentioned flange portion B_{41}. The hub fitting member B_{40} is placed on the annular disk member B_{30} and rivets B_{50} are inserted through the holes B_{46} and B_{32} and are calked to secure both members B_{30} and B_{40} as shown in Fig. 8. The present invention is applied also to the brake disk made by thus securing separate members and the process for producing the same.

In this embodiment, the material is preset so that the outside diameter dimensions may fit and is punched, held, pressed and imperfectly quenched but may be simultaneously cut on the edge. As there is no stamping, a material cut to be of the outside diameter dimensions and having had the axle inserting hole and hub fitting member combining holes formed in advance may be heated and imperfectly press-quenched as held and pressed. The present invention includes also such embodiment.

WHAT WE CLAIM IS:—

1. A brake disk at least those portions thereof which in use contact the brake pads being made of a martensitic stainless steel containing a least 10% of chromium and having a surface hardness suitable for a brake.

2. A brake disk according to claim 1, wherein said martensitic stainless steel has a surface hardness suitable for a brake by virtue of the fact that it has been imperfectly quenched.

3. A brake disk according to claim 1 or 2, wherein said martensitic stainless steel has a surface hardness of from 30 to 45, measured as Rockwell hardness on scale C.

4. A brake disk according to any of claims 1 to 3, comprising an integral outer peripheral annular disk portion, a intermediate portion connected to the inner periphery of said annular disk portion, and a hub fitting portion connected to the inner periphery of said intermediate portion.

5. A brake disk according to claim 4, wherein said annular disk portion and said hub fitting portion are substantially parallel and flat, wherein a truncated conical portion is provided between said annular disk portion and said hub fitting portion to connect said annular disk portion and said hub fitting portion, wherein said hub fitting portion has an axle inserting hold formed therein, and wherein said hub fitting portion has a plurality of hub fitting holes formed therein.

6. A brake disk according to claim 4, wherein a truncated conical portion is provided between said annular disk portion and said hub fitting portion to connect said annular disk portion and said hub fitting portion, said truncated conical portion having holes provided therein.

7. A brake disk according to claim 4, comprising an outer pheripheral flat annular disk portion, a truncated conical portion connected to the inner periphery of said annular disk portion, a flat hub fitting portion connected to the inner peripheral portion of said truncated conical portion and parallel to said annular disk portion, and a step substantially perpendicular to the flat surface of the boundary between said annular disk portion and said truncated conical portion and the boundary between said truncated conical portion and said hub fitting portion.

8. A brake disk according to claim 4, comprising an outer peripheral flat annular disk portion, a truncated conical portion connected to the inner periphery of said annular disk portion, a flat hub fitting portion connected to the inner periphery of said truncated conical portion and parallel to said annular disk portion, a cavity provided on one surface of the boundary between said annular disk portion and said truncated conical portion, a recessed portion on the other surface of said boundary, and a stepped portion in the boundary between said truncated conical portion and said hub fitting portion.

9. A brake disk according to any of claims 1 to 3, comprising an outer peripheral annular disk portion and a separate hub fitting portion, said annular disk portion and said hub fitting portion being secured to one another.

10. A process for producing a brake disk, comprising heating a martensitic stainless steel plate containing at least 10% of chromium to an imperfectly quenching temperature such that a hardness required for a brake disk is obtained, and press-

quenching said heated steel plate to obtain a brake disk of a predetermined shape.

11. A process according to claim 10, including the step of press-shaping and punching the heated plate while said plate is held and pressed, and simultaneously press-quenching said plate.

12. A process according to claim 11, including the steps of holding and pressing the peripheral side portion and central portion of said heated plate, stamping the intermediate portion, shaping stepped portions in the boundaries between said intermediate portion and said peripheral portion and said central portion simultaneously with said shaping step, and simultaneously press-quenching said plate.

13. A process according to claim 11, including the steps of cutting off the edge of the heated plate, and press-shaping and punching said plate while said plate is held and pressed, and simultaneously press-quenching said plate.

14. A process according to claim 10, including the step of shaping and punching said plate in advance and quenching said plate while said plate is held and pressed.

15. A process according to claim 10, including the steps of punching and shaping said plate to be circular ring-shaped, boring said plate, heating said plate, quenching said plate while said plate is held and pressed, and securing said plate to a separately shaped hub fitting member.

16. A process according to claim 10, including the steps of punching and boring the heated plate with a press, press-quenching said plate while said plate is held and pressed to obtain a ring-shaped annular disk member, and securing said plate to a separately shaped hub fitting member.

17. A brake disk substantially as hereinbefore described with reference to, and as shown in, Figures 3, 4 and 5, or Figure 6, or Figure 8 of the accompanying drawings.

18. A process for producing a brake disk, substantially as hereinbefore described with reference to Figures 1 and 2 or Figure 7 of the accompanying drawings.

19. A brake disk when produced by a process according to any of claims 10 to 16 and 18.

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FIG. 1

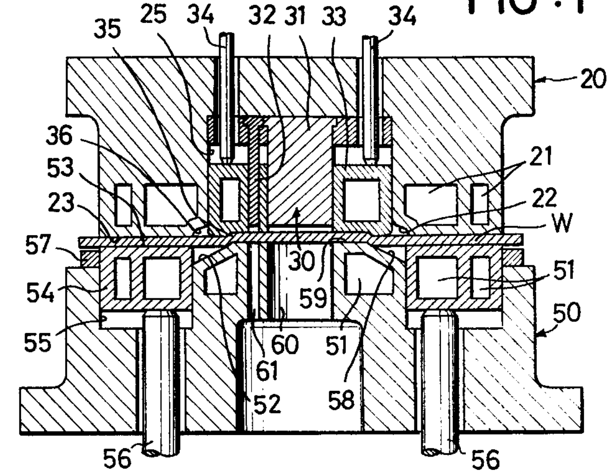

FIG. 2

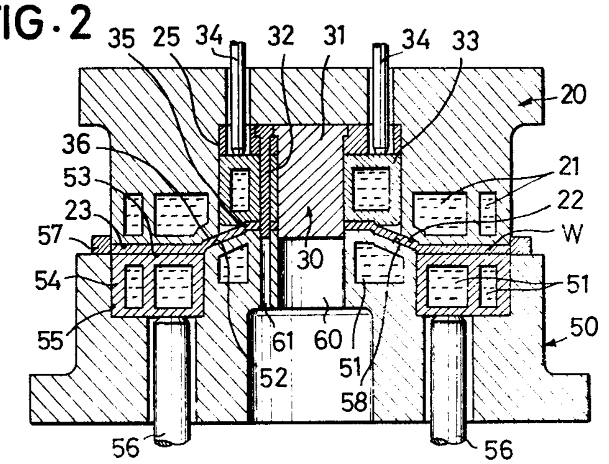

FIG. 3

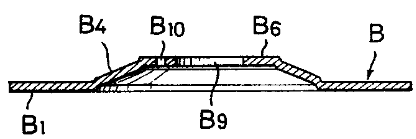

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FIG .4

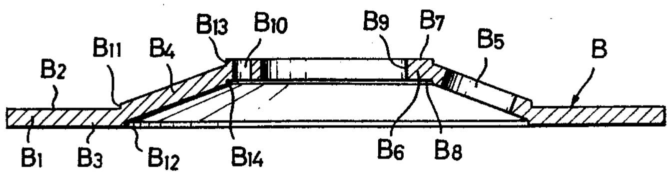

FIG . 5

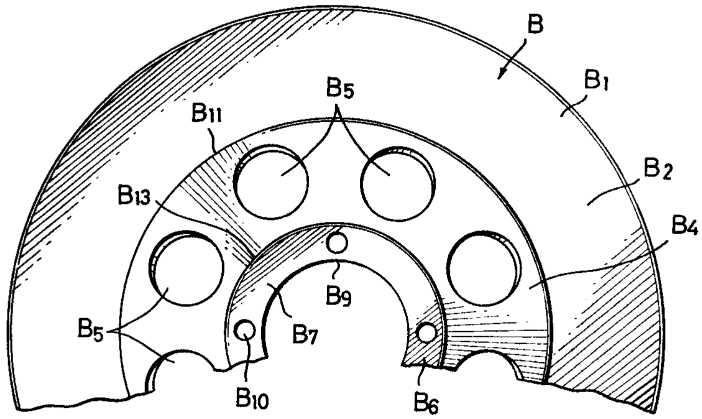

FIG . 6

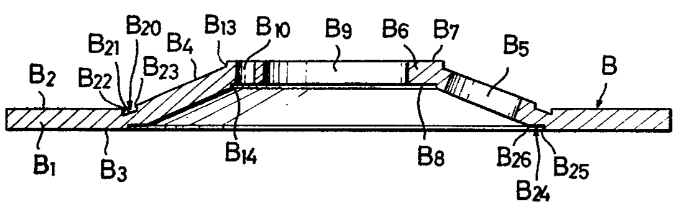

FIG. 7

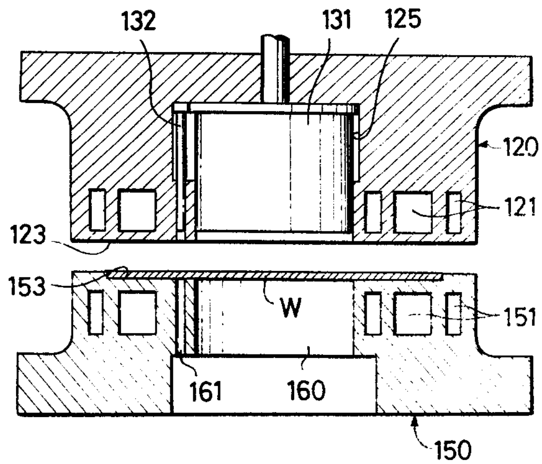
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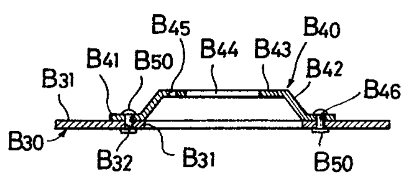
FIG. 8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Sheet 4

FIG. 10

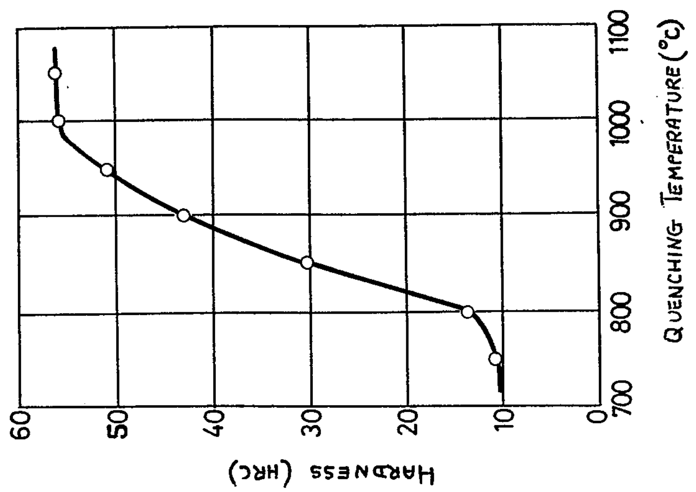

FIG. 9