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(54) Method for manufacturing a pulley for motor vehicle applications

(57) The invention relates to a method for manufacturing a pulley (1) for motor vehicle applications starting from a plane disk (21), which has a central axis (A) and defines a reference plane (P) orthogonal to said axis (A); the method comprises the steps of: bending an annular peripheral portion (51) of the disk (21) in a direction transverse to the reference plane (P) so as to define a rim (59) in relief; deforming, in a first axial direction (S), a central portion (52) of the disk (21) so as to generate a first cup-shaped portion (53); deforming, in a second axial direction (T) opposite to the first direction (S), a central portion of the first cup-shaped portion (53) so as to generate a second cup-shaped portion (86) axially projecting from the opposite side of the reference plane (P) with respect to the rim (59); reducing the axial height of the second cup-shaped portion (86) with respect to the reference plane (P) so as to increase the thickness thereof; and carrying out a coining operation on a surface (13) of the second cup-shaped portion (86) that is parallel to the reference plane (P) and faces the opposite side of the reference plane (P) itself to generate a plurality of radial impressions (15).

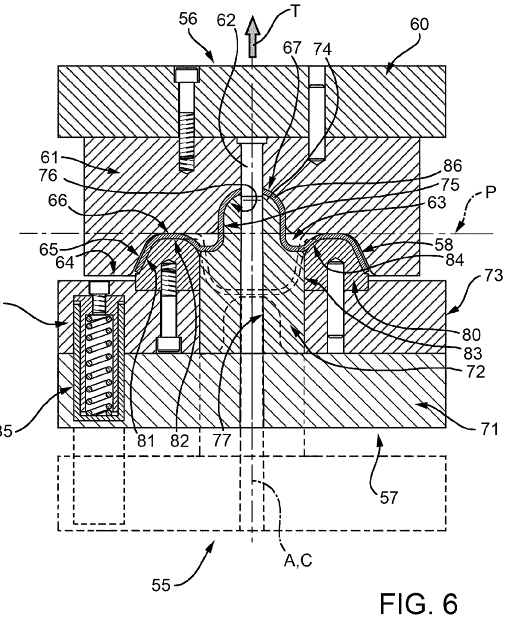

FIG. 6

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Description

[0001] The present invention relates to a method for manufacturing a pulley made of metal material for motor vehicle applications.

[0002] Known to the art are pulleys of the type specified above formed, in a single piece, by a hub, a cylindrical rim extending around the hub, and a disk-shaped annular portion for connection between the rim and the hub, which usually has a plane conformation.

[0003] In particular, the hub comprises a central portion shaped like a cylindrical cup having a disk-shaped bottom, which extends parallel to the annular portion.

[0004] The central portion of the hub further comprises a cylindrical side wall, which extends through the annular portion and has an axial end edge opposite to the bottom and projecting with respect to the annular portion from the opposite side of the bottom itself. The end edge is connected to the annular portion via a bridge element, which is also annular and has, in cross section, a U-shaped profile. The bridge element is moreover provided with a plurality of through holes, which are spaced at equal angular distances apart about the axis of the pulley and are designed to enable connection of the pulley itself to the engine shaft.

[0005] The bottom of the central portion of the hub is delimited, on the side opposite to the one facing the inside of the central portion itself, by a surface bearing a plurality of impressions that are provided by coining and that resemble the petals of a daisy evenly distributed about the axis of the pulley.

[0006] The aforesaid impressions are designed to couple with complementary projections made on a flange of a corresponding shaft, which may in turn be coupled to the hub for imparting motion on the latter or receiving motion therefrom.

[0007] The bottom of the central portion of the hub is moreover provided with an axial through hole, around which the aforesaid impressions extend.

[0008] The rim projects in cantilever fashion from the annular portion on the opposite side of the bottom and is delimited by a surface facing the hub and by an opposite surface provided with a plurality of annular grooves for coupling with a corresponding cogged belt.

[0009] On account of the need to provide on the bottom of the hub the impressions for connection of the pulley to the engine shaft, it is necessary for said bottom to have a thickness not less than a given threshold value; otherwise, it would not be possible to carry out the aforesaid coining operation. The other areas of the pulley may, instead, present thicknesses well below that of the bottom.

[0010] All this inevitably entails, with the known machining methods, considerable amounts of waste material, with consequent relatively high costs of production of the aforesaid pulleys.

[0011] The aim of the present invention is hence to provide a method that will enable manufacture of a pulley of the type described above at reduced costs and minimizing waste of material.

[0012] The above aim is achieved by the present invention in so far as it relates to a method for manufacturing a pulley for motor vehicle applications, as defined in Claim 1.

[0013] For a better understanding of the present invention a preferred embodiment is now described, purely by way of nonlimiting example and with reference to the attached drawings, wherein:

- Figure 1 is a perspective view of a pulley for motor vehicle applications obtained according to the method forming the subject of the present invention;
- Figure 2 is a perspective view of the starting product used in the method according to the present invention;
- Figures 3 and 4 are axial sectional views, with parts removed for reasons of clarity, of a first die, in two different operating conditions, for carrying out a part of the method forming the subject of the present invention;
- Figure 5 is a perspective view of a first semifinished product that may be obtained using the die of Figures 3 and 4 in the course of the method forming the subject of the present invention;
- Figure 6 is an axial sectional view, with parts removed for reasons of clarity, of a second die for carrying out another part of the method forming the subject of the present invention;
- Figure 7 is a perspective view of a second semifinished product that may be obtained using the die of Figure 6 in the course of the method forming the subject of the present invention;
- Figure 8 is an axial sectional view, with parts removed for reasons of clarity, of a third die for carrying out a further part of the method forming the subject of the present invention;
- Figure 9 is a perspective view of a third semifinished product that may be obtained using the die of Figure 8 in the course of the method forming the subject of the present invention;
- Figure 10 is an axial sectional view, with parts removed for reasons of clarity, of a fourth die for carrying out a further part of the method forming the subject of the present invention;
- Figure 11 is a perspective view of a fourth semifinished product that may be obtained using the die of Figure 10 in the course of the method forming the subject of the present invention;
- Figure 12 is an axial sectional view, with parts removed for reasons of clarity, of a fifth die for carrying out a further part of the method forming the subject of the present invention; and
- Figure 13 is an axial sectional view, at an enlarged scale and with parts removed for reasons of clarity, of a portion of the final pulley being processed in the die of Figure 12.

[0014] In Figure 1 designated as a whole by 1 is a pulley obtained according to the method forming the subject of the present invention.

[0015] The pulley 1 has an axis A and comprises, in a single piece, a hub 2, a cylindrical rim 3 extending around the hub 2, and an annular disk-shaped portion 4 for connection between the rim 3 and the hub 2. The annular portion 4 has a plane conformation and defines a reference plane P of the pulley 1, orthogonal to the axis A.

[0016] The hub 2 comprises a central portion 5 shaped like a cylindrical cup having a disk-shaped bottom 6, extending parallel to the annular portion 4 and to the reference plane P at a pre-set distance therefrom.

[0017] The central portion 5 of the hub 2 further comprises a cylindrical side wall 7 with axis A, which extends through the annular portion 4 and the reference plane P and has an axial end edge 8 opposite to the bottom 6 and projecting with respect to the annular portion 4 from the opposite side of the bottom 6 itself. The end edge 8 is connected to the annular portion 4 via a bridge element 10, which is also annular and has, in cross section, a U-shaped profile; the bridge element 10 is moreover provided with a plurality of through holes 11, which are spaced at equal angular distances apart about the axis A.

[0018] The bottom 6 of the central portion 5 of the hub 2 is delimited by a surface (not visible in Figure 1) facing the inside of the side wall 7, and by an opposite surface 13, bearing a plurality of impressions 15 provided by coining, that resemble the petals of a daisy and are evenly distributed about the axis A.

[0019] The impressions 15 enable coupling with projections of a complementary shape made on a flange of a corresponding shaft (in itself known and not illustrated), which is to couple with the hub 2 for imparting motion on the latter or receiving motion therefrom.

[0020] Preferably, a petal-shaped portion of the surface 13 of the bottom 6 may be excluded from the coining operation in such a way that, in use, it may function as angular reference key in order to set the engine that drives the aforementioned shaft in phase.

[0021] The bottom 6 of the central portion 5 of the hub 2 is moreover provided with an axial through hole 16, around which the impressions 15 extend.

[0022] The rim 3 projects in cantilever fashion from the annular portion 4 on the opposite side of the bottom 6 and is delimited by a surface (not visible in Figure 1), facing the hub 2, and by an opposite surface 18, provided with a plurality of annular grooves 20 for coupling with a corresponding cogged belt (in itself known and not illustrated).

[0023] The pulley 1 is obtained with the method forming the subject of the present invention starting from a plane disk 21 made of metal material (Figure 2), for example obtained by blanking from a plane plate or sheet metal. For convenience of description, it is assumed that the disk 21 defines the aforementioned reference plane P of the future pulley 1.

[0024] With reference to Figures 3 and 4, a first part of the method forming the subject of the invention is carried out using a die 25, within which the disk 21 is positioned.

[0025] In particular, the die 25 comprises a first half-die 26, appearing at the bottom in Figures 3 and 4, and a second half-die 27, facing the half-die 26 and co-operating, in use, with the latter along an axis B.

[0026] In greater detail, the half-dies 26 and 27 are available between an open configuration (not illustrated), in which they are separated from one another along the axis B by a distance sufficient to enable insertion of the disk 21 to be processed, and a closed configuration (Figure 4), in which they co-operate to deform the disk 21 itself and obtain a first semifinished product 28, illustrated in Figure 5.

[0027] More precisely, the half-die 26 comprises a base 30 axially projecting from which is a tubular matrix 31 with axis B. The matrix 31 has a cylindrical main portion 32 and a free axial end portion 33, tapered towards the half-die 27. In practice, the end portion 33 is delimited by a plane end surface 34, orthogonal to the axis A, by an inner lateral surface 35, which is shaped like a truncated cone and extends from the internal cylindrical surface of the main portion 32 towards the half-die 27 with progressively increasing diameters, and by an outer lateral surface 36, which is shaped like a truncated cone and extends from the cylindrical outer surface of the main portion 32 towards the half-die 27 with progressively decreasing diameters. The inner and outer lateral surfaces 35, 36 converge towards the half-die 27 and have different slopes with respect to the axis B. In the case in point illustrated, the outer lateral surface 36 has a conicity greater than the conicity of the inner lateral surface 35. In other words, the outer lateral surface 36 presents a greater slope with respect to the axis B than the inner lateral surface 35.

[0028] In practice, the matrix 31 of the half-die 26 has a central hole 38 having a mouth portion 39 tapered towards the base 30, and a cylindrical main portion 40 comprised between the base 30 itself and the mouth portion 39.

[0029] The half-die 27, which appears at the top in Figure 3, basically comprises a supporting wall 41, a central punch 42, which is fixedly carried in cantilever fashion by the supporting wall 41 and is designed to be inserted in the mouth portion 39 of the hole 38 of the matrix 31 in the closed configuration of the half-dies 26 and 27, and a blank holder 43, having a tubular configuration with axis B, which extends around the punch 42 and is connected to the supporting wall 41 so as to enable a relative motion along the axis B between the supporting wall 41 itself (together with the punch 42) and the blank holder 43.

[0030] In particular, the punch 42 has a cylindrical configuration with axis B and terminates axially with a shaped central protuberance 44 designed to be inserted in use in the mouth portion 39 of the hole 38 of the matrix 31. In greater detail, the protuberance 44 has a frustoconical conformation with a lateral surface 45 having the same slope as the inner lateral surface 35 of the end portion

33 of the matrix 31. The protuberance 44 has, moreover, diameters slightly smaller than the corresponding diameters of the inner lateral surface 35 of the end portion 33 of the matrix 31 so that it may be inserted in the hole 38 of the matrix 31 itself with a given gap defining the thickness of the metal sheet of the resulting semifinished product 28.

[0031] The protuberance 44 is moreover delimited, in the direction of the half-die 26, by a plane end surface 68 radiused to the lateral surface 45 by a rounded edge.

[0032] The blank holder 43 is delimited by a cylindrical outer lateral surface 46 with axis B and by an inner lateral surface 47 having a cylindrical main portion 48 with axis B that co-operates with the punch 42 and a free axial end portion 49 that is shaped like a truncated cone with diameters progressively increasing towards the half-die 26. In particular, the end portion 49 of the inner lateral surface 47 of the blank holder 43 has the same slope with respect to the axis B as the outer lateral surface 36 of the end portion 33 of the matrix 31.

[0033] The blank holder 43 is elastically connected to the supporting wall 41 by means of one or more spring actuators 50 designed to enable relative axial translation between the blank holder 43 itself and the ensemble formed by the supporting wall 41 and the punch 42.

[0034] In particular, the half-die 27 is normally set in a first operating configuration (Figure 3), in which the blank holder 43 is held by the actuators 50 at a non-zero preset axial distance from the supporting wall 41. The half-die 27 is moreover available, against the action of the actuators 50, in a second operating configuration (Figure 4), in which the blank holder 43 and the supporting wall 41 axially bear upon one another.

[0035] The disk 21 is positioned, with its own axis A aligned with the axis B, between the two half-dies 26 and 27 set in the open configuration. During the movement of relative approach between the two half-dies 26 and 27, the blank holder 43 comes into contact with an annular peripheral portion 51 of the disk 21 and deforms it, bending it towards the base 30 in a direction transverse to the reference plane P until said peripheral portion 51 remains pinched between the outer lateral surface 36 of the end portion 33 of the matrix 31 and the end portion 49 of the inner lateral surface 47 of the blank holder 43. The bent peripheral portion 51 of the disk 21 defines a rim in relief of the disk 21 itself.

[0036] As the relative axial motion between the two half-dies 26 and 27 proceeds, the spring actuators 50 are compressed, and the supporting wall 41 and the punch 42 slide axially with respect to the blank holder 43 determining insertion of the punch 42 into the hole 38 of the matrix 31 with consequent deformation, in an axial direction S, of a disk-shaped central portion 52 of the disk 21 so as to generate a first cup-shaped portion 53 projecting from the same part of the rim 59 with respect to the reference plane P.

[0037] The semifinished product 28 obtained in this step is hence formed by the cup-shaped portion 53 with frustoconical annular side wall 69, by the rim 59, which also has a frustoconical conformation but with a slope opposite to that of the side wall of the cup-shaped portion 53, and by an intermediate annular portion 54, which connects together the cup-shaped portion 53 and the rim 59 and extends along the reference plane P. The cup-shaped portion 53 (Figure 5) has a plane bottom 70 connected to the side wall 69 by a rounded edge.

[0038] With reference to Figure 6, a second part of the method forming the subject of the invention is carried out with a die 55, inside which the semifinished product 28 is positioned.

[0039] In particular, the die 55 comprises a first half-die 56, appearing at the top in Figure 6, and a second half-die 57, which faces the half-die 56 and co-operates, in use, with the latter along an axis C.

[0040] In greater detail, the half-dies 56 and 57 are available between an open configuration (not illustrated), in which they are separated from one another along the axis C by a distance sufficient to enable insertion of the semifinished product 28, and a closed configuration (Figure 6), in which they co-operate to deform the semifinished product 28 itself and obtain a second semifinished product 58, illustrated in Figure 7.

[0041] More precisely, the half-die 56 comprises a supporting wall 60 axially projecting from which is a matrix 61 with axis C. The matrix 61 is constituted by a substantially cylindrical body provided with a central dinking die 62 and has, on the opposite side of the supporting wall 60, a shaped cavity 63, which is designed to define in use the shape of the semifinished product 58 and projecting from which is a cutting end portion of the dinking die 62 itself.

[0042] Proceeding along the axis C starting from a plane end surface 64 of the matrix 61 opposite to the supporting wall 60, the cavity 63 has diameters progressively decreasing down to a minimum value in the area from which the dinking die 62 projects. In particular, proceeding along the axis C from the end surface 64 to the dinking die 62, the cavity 63 is delimited by a first surface 65 shaped like a truncated cone tapered towards the supporting wall 60, by a second, plane annular, surface 66, which is orthogonal to the axis C and originates from the radially innermost edge of the surface 65, and by a third, rounded, surface 67, which defines the bottom of the cavity 63 itself and which connects the radially innermost edge of the surface 66 to the area from which the dinking die 62 projects.

[0043] The half-die 57, which appears at the bottom in Figure 6, basically comprises a centrally perforated supporting wall 71, a central punch 72, which is fixedly carried in cantilever fashion by the supporting wall 71 and is designed to be inserted into the cavity 63 of the matrix 61 in the closed configuration of the half-dies 56 and 57, and a blank holder 73 having a tubular configuration with axis C, which extends around the punch 72 and is connected to the supporting wall 71 so as to enable a relative motion along the axis C between the supporting wall 71 itself (together with the punch 72) and the blank holder 73.

[0044] In particular, the punch 72 has a cylindrical configuration with axis C and terminates axially with a central protuberance 74 delimited laterally by a cylindrical surface 75 and at the top by an end surface 76 that is substantially dome-shaped.

[0045] The protuberance 74 has a conformation complementary to that of the surface 67 defining the bottom of the cavity 63 so that it may be inserted in the corresponding stretch of the cavity 63 itself when the half-dies 56 and 57 are reaching the closed configuration.

[0046] The punch 72 is moreover provided at the centre with a through hole 77, which communicates with the central hole of the supporting wall 71 and is designed to be engaged, in the closed configuration of the half-dies 56, 57, by the dinking die 62 for carrying out blanking to obtain a central hole 78 in the semifinished product 58 being machined.

[0047] The blank holder 73 comprises a cylindrical tubular block 79, axially fixed on which in cantilever fashion is an annular forming element 80 set around the punch 72 and in contact with the latter.

[0048] In particular, the forming element 80 is delimited by a frustoconical outer lateral surface 81, having a shape complementary to that of the surface 65 of the cavity 63 of the matrix 61, by a plane annular end surface 82, parallel to the surface 66 of the cavity 63 itself, and by a cylindrical inner lateral surface 83, which co-operates by axial sliding with the lateral surface of the punch 72 and is radiused to the radially innermost edge of the end surface 82 by means of a chamfer 84.

[0049] The blank holder 73 is elastically connected to the supporting wall 71 by means of one or more spring actuators 85 designed to enable a relative axial translation between the blank holder 73 itself and the ensemble formed by the supporting wall 71 and the punch 72.

[0050] In particular, the half-die 57 is normally set in a first operating configuration (dashed line in Figure 6), in which the blank holder 73 is held by the actuators 85 at a non-zero pre-set axial distance from the supporting wall 71. The half-die 57 is moreover available, against the action of the actuators 85, in a second operating configuration, in which the blank holder 73 and the supporting wall 71 axially bear upon one another.

[0051] The semifinished product 28 is positioned, with its own axis A aligned with the axis C, between the two half-dies 56 and 57 set in the open configuration. During the movement of relative approach between the two half-dies 56 and 57, the forming element 80 of the blank holder 73 comes into contact, with its own outer lateral surface 81 and with its own end surface 82, with the rim 59 and the annular portion 54 of the semifinished product 28, pressing them against the surfaces 65 and 66 of the cavity 63 and of the matrix 61, respectively.

[0052] As the relative axial motion between the two half-dies 56 and 57 proceeds, the spring actuators 85 are compressed, and the supporting wall 71 and the punch 72 slide axially with respect to the blank holder 73 determining insertion of the punch 72 in the stretch of the cavity 63 delimited by the surface 67. In this way, a central disk-shaped portion of the cup-shaped portion 53 is deformed in an axial direction T, opposite to the direction S so as to generate a further cup-shaped portion 86 axially projecting from the opposite side of the reference plane P with respect to the rim 59.

[0053] The cup-shaped portion 86 hence remains pinched between the protuberance 74 and the stretch of the cavity 63 delimited by the surface 67, thus assuming the conformation of the surfaces with which it co-operates, i.e., assuming a substantially dome-shaped conformation.

[0054] During the axial thrust produced by the punch 72 in the direction T on the semifinished product 28, the latter comes into contact, at its own central area, with the dinking die 62, which produces the hole 78. the blanked part is then expelled through the hole 77 of the punch 72 and the corresponding hole of the supporting wall 71.

[0055] The semifinished product 58 (Figure 7) obtained in the die 55 is thus formed by the cup-shaped portion 86, by the rim 59, by the intermediate annular portion 54, which extends along the reference plane P, and by a further annular portion 87, which has a cross section approximately shaped like a U with rounded edges and which connects the radially innermost edge of the annular portion 54 with the axial end edge of the cup-shaped portion 86.

[0056] It is to be noted that, during the moulding operation carried out in the die 55, the cup-shaped portion 53 is transformed into the cup-shaped portion 86 and into the annular portion 87 of connection of the cup-shaped portion 86 itself with the annular portion 54. Consequently, in this operation, a major part of the material constituting the semifinished product 28 is displaced towards the centre of the semifinished product 28 itself. In this step, there is also obtained a reduction of the axial height of the initial cup-shaped portion 53 with respect to the reference plane P, which remains basically defined by the annular portion 87.

[0057] With reference to Figure 8, the next step of the method forming the subject of the invention is carried out using a die 90, positioned inside which is the semifinished product 58.

[0058] In particular, the die 90 comprises a first half-die 91, appearing at the bottom in Figure 8, and a second half-die 92, which faces the half-die 91 and co-operates, in use, with the latter along an axis D.

[0059] In greater detail, the half-dies 91 and 92 are available between an open configuration (not illustrated), in which they are separated from one another along the axis D by a distance sufficient to enable insertion of the semifinished product 58, and a closed configuration (Figure 8), in which they co-operate to deform the semifinished product 58 itself and obtain a further semifinished product 93, illustrated in Figure 9.

[0060] More precisely, the half-die 91 comprises a supporting wall 94 axially projecting from which is a matrix

95 with axis D. The matrix 95 is constituted by a number of parts fixed together, for example by means of screws, and joined to the supporting wall 94, also in this case by means of screws.

[0061] As may be noted from a comparison between Figures 6 and 8, the matrix 95 has a conformation very similar to that of the ensemble constituted by the punch 72 and the blank holder 73 of the half-die 57 set in the second operating configuration. In particular, the matrix 95 basically comprises a central core 96 having a conformation similar to that of the punch 72 but without any central hole, and an outer tubular body 97, which extends around the core 96 and has a conformation similar to that of the blank holder 73.

[0062] In detail, the core 96 is constituted by a substantially cylindrical body with axis D and terminates axially with a central protuberance 98, which is similar to the protuberance 74 but has an axial height smaller than that of the latter. In this case, the protuberance 98 is delimited by a substantially dome-shaped surface 99 and projects from a plane annular end surface 100 of the core 96.

[0063] The outer body 97, in a way similar to the blank holder 73, comprises a cylindrical tubular block 101, axially fixed on which in cantilever fashion is an annular forming element 102 arranged around the core 96 and in contact with the latter.

[0064] In particular, the forming element 102 is delimited by a frustoconical outer lateral surface 103, by a plane annular end surface 104, which is orthogonal to the axis A, and by a cylindrical inner lateral surface 105, which co-operates with the lateral surface of the core 96 and is radiused to the radially innermost edge of the end surface 104 by means of a stretch 106 having a cross section shaped substantially like an L so as to generate a sort of step between the surfaces 104 and 105 themselves.

[0065] The half-die 92, appearing at the top in Figure 8, basically comprises a supporting wall 107, a central punch 108 with axis D, which is fixedly carried in cantilever fashion by the supporting wall 107 and is designed to co-operate with the semifinished product 58 on the opposite side of the matrix 95 in the closed configuration of the half-dies 91 and 92, and a blank holder 109 having a tubular configuration with axis D, which extends around the punch 108 and is connected to the supporting wall 107 so as to enable a relative motion along the axis D between the supporting wall 107 itself (together with the punch 108) and the blank holder 109.

[0066] In particular, the punch 108 is constituted by an approximately cylindrical body having, on the opposite side of the supporting wall 107, a shaped surface 110 having a shape complementary to that of the surfaces 99, 100 of the core 96 of the matrix 95 and to that of the stretch 106 and of part of the end surface 104 of the forming element 102.

[0067] The blank holder 109 has a cylindrical external configuration and co-operates by sliding with the punch 108 along an internal surface 111 thereof. The blank holder 109 moreover has, on the opposite side of the supporting wall 107, a shaped surface 112 having a shape complementary to that of the outer lateral surface 103 and to the remaining part of the end surface 104 of the forming element 102, which does not co-operate with the punch 108.

[0068] The blank holder 109 is elastically connected to the supporting wall 107 by means of one or more spring actuators 115 designed to enable a relative axial translation between the blank holder 109 itself and the ensemble formed by the supporting wall 107 and the punch 108.

[0069] In particular, the half-die 92 is normally set in a first operating configuration (not illustrated), in which the blank holder 109 is held by the actuators 115 at a non-zero pre-set axial distance from the supporting wall 107. The half-die 92 is moreover available, against the action of the actuators 115, in a second operating configuration (Figure 8), in which the blank holder 109 and the supporting wall 107 axially bear upon one another.

[0070] The semifinished product 58 is positioned, with its own axis A aligned with the axis D, between the two half-dies 91 and 92 set in the open configuration. During the movement of relative approach between the two half-dies 91 and 92, the blank holder 109 comes into contact, with its own shaped surface 112, with the rim 59 and the annular portion 54 of the semifinished product 58, which remain consequently pinched between the blank holder 109 itself and the outer lateral surface 103 and end surface 104 of the forming element 102 of the matrix 95.

[0071] As the relative axial motion between the two half-dies 91 and 92 proceeds, the spring actuators 115 are compressed and the supporting wall 107 and the punch 108 slide axially with respect to the blank holder 109, determining the axial thrust of the punch 108 in the direction S on the cup-shaped portion 86, the axial height of which is reduced. In practice, the cup-shaped portion 86 is pressed by the shaped surface 110 of the punch 108 on the protuberance 98 of the core 96 of the matrix 95 so as to reproduce the shape. At the same time, the shaped surface 110 of the punch 108 acts on the annular portion 87 of the semifinished product 58 pressing it against the step-shaped stretch 106 of the forming element 102, against the part of the end surface 104 of the forming element 102 itself adjacent to the aforesaid stretch 106 and against the end surface 100 of the core 96 of the matrix 95. As a result of this action, the annular portion 87 maintains the U-shaped profile but has edges that are more "squared".

[0072] During the moulding operation carried out in the die 90, the axial height of the cup-shaped portion 86 with respect to the reference plane P is reduced with simultaneous increase of its thickness as compared to the remaining part of the semifinished product 93 thus obtained.

[0073] Consequently, the semifinished product 93 maintains the same structure as the semifinished product 58, but differs from the latter basically in that it presents a cup-shaped portion 86 having a smaller axial height with respect to the reference plane P and an increased thickness with respect to the remaining part of the semifinished product 93 itself. Said cup-shaped portion 86 still has a dome-shaped conformation. Moreover, as highlighted above, the annular portion 87 maintains the U-shaped profile but has edges that are more "squared".

[0074] With reference to Figure 10, the next step of the method forming the subject of the invention is carried out using a die 120, positioned inside which is the semifinished product 93.

[0075] In particular, the die 120 comprises a first half-die 121, appearing at the bottom in Figure 10, and a second half-die 122, which faces the half-die 121 and co-operates, in use, with the latter along an axis E.

[0076] The half-dies 121, 122 have the same structure as the half-dies 91, 92, respectively, and will be described in what follows only as regards what differs from the latter. Parts that are the same as or equivalent to parts already described will be designated by the same reference numbers.

[0077] In detail, the half-die 121 differs from the half-die 91 basically in that the protuberance 98 of the core 96 of the matrix 95 is delimited by a cylindrical surface 123 with axis E, axially projecting in cantilever fashion from the plane annular end surface 100 of the core 96 itself.

[0078] In an altogether equivalent way, the half-die 122 differs from the half-die 92 basically in that the punch 108 is delimited, on the opposite side of the supporting wall 107, by a shaped surface 124 having, on the protuberance 99 of the matrix 95, a shape complementary to that of the surface 123; i.e., it is shaped like a cylindrical cup.

[0079] Operation of the die 120 is identical to that of the die 90 and is not repeated here. In this case, during descent of the punch 108 in the axial direction S and with respect to the blank holder 109, the cup-shaped portion 86 of the semifinished product 93 is pressed by the shaped surface 124 of the punch 108 itself on the protuberance 98 of the core 96 of the matrix 95 so as to reproduce the shape. In this way, the cup-shaped portion 86 assumes a cylindrical conformation with plane bottom so as to define the cup-shaped central portion 5 of the hub 2 of the pulley 1. The annular portion 87 defines, instead, the bridge element 10 of the pulley 1, and the annular portion 54 defines the similar annular portion 4 of the pulley 1 itself.

[0080] At the end of the operation carried out with the die 120 a semifinished product 125 is consequently obtained (Figure 11), which differs from the final pulley 1 in that the rim 59 has a frustoconical and non-cylindrical conformation and is without annular grooves, and in that the hub 2 is without the impressions 15 along the bottom 6.

[0081] In a next step (not illustrated), the rim 59 is bent further to assume a cylindrical conformation. Moreover, on the radially outermost surface 18 of the rim 3 thus obtained the annular grooves 20 are provided by means of a rolling operation, in itself known and not illustrated.

[0082] At this point, the pulley 1 is subjected to a coining operation with a die 130 (Figure 12) to obtain the impressions 15 on the surface 13 of the bottom 6, i.e., on the surface of the cup-shaped portion 86 that is parallel to the reference plane P and faces the opposite side of the reference plane P itself.

[0083] In particular, the die 130 comprises a first half-die 131, appearing at the bottom in Figure 12, and a second half-die 132, facing the half-die 131 and co-operating, in use, with the latter along an axis F.

[0084] In greater detail, the half-dies 131 and 132 are available between an open configuration (not illustrated), in which they are separated from one another along the axis F by a distance sufficient to enable insertion of the pulley 1, and a closed configuration (Figure 12), in which they co-operate to obtain the impressions 15 on the surface 13 of the bottom of the central portion 5 or of the cup-shaped portion 86.

[0085] More precisely, the half-die 131 comprises a supporting wall 134 and a matrix 135, which is fixed to the supporting wall 134 by means of screws (not illustrated) and axially projects in cantilever fashion from the supporting wall 134 itself.

[0086] The matrix 135 has a cylindrical configuration and has a shaped end surface 136 facing the half-die 132 and having a shape complementary to that of the pulley 1 on the side opposite to that of the surface 13. In this way, the pulley 1 may be fitted on the end surface 136 of the matrix 135.

[0087] As may be seen in Figure 12, the matrix 135 is moreover provided with a plurality of through holes 137, which are spaced at equal angular distances apart about the axis F and communicate with a through opening 138 of the supporting wall 134. The function of the holes 137 will be clarified in what follows.

[0088] The half-die 132, appearing at the top in Figure 12, basically comprises a supporting wall 139, a central coining tool 140 with axis F, which is fixedly carried in cantilever fashion by the supporting wall 139 and is designed to co-operate with the surface 13 of the bottom 6 of the pulley 1, and a blank holder 141 having a tubular configuration with axis F, which extends around the coining tool 140 and is connected to the supporting wall 139 so as to enable a relative motion along the axis F between the supporting wall 139 itself (together with the coining tool 140) and the blank holder 141.

[0089] In particular, the coining tool 140 terminates, towards the matrix 135, with a cylindrical body 142 delimited by a shaped end surface 143, which is designed to co-operate with the surface 13 of the bottom 6 of the pulley 1 and is provided with a plurality of moulds 144 (Figure 13) having substantially the shape of petals of a daisy evenly distributed about the axis F.

[0090] The coining tool 140 is moreover provided with a plurality of dinking dies 148 extending around the cylindrical body 142, which project towards the half-die 131 and are spaced at equal angular distances apart about the axis F.

[0091] In the closed configuration of the half-dies 131, 132, the dinking dies 148 are designed to engage the respective holes 137 of the matrix 135.

[0092] The blank holder 141 has a cylindrical external configuration and co-operates by sliding with the coining tool 140 along an inner surface thereof. The blank holder 141 moreover has, on the opposite side of the supporting wall 139, a shaped surface 145 having a shape complementary to that of the bridge element 10 and of the annular portion 4 of the pulley 1 on the side of the surface 13.

[0093] The blank holder 141 is elastically connected to the supporting wall 139 by means of one or more spring actuators 146, which are designed to enable a relative axial translation between the blank holder 141 itself and the ensemble formed by the supporting wall 139 and the coining tool 140.

[0094] In particular, the half-die 132 is normally arranged in a first operating configuration (not illustrated), in which the blank holder 141 is held by the actuators 146 at a non-zero pre-set axial distance from the supporting wall 139. The half-die 132 is moreover available, against the action of the actuators 146, in a second operating configuration (Figure 12), in which the blank holder 141 and the supporting wall 139 axially bear upon one another.

[0095] The blank holder 141 is moreover provided with a plurality of through holes, which are spaced at equal angular distances apart about the axis F and are slidably engaged by the respective dinking dies 148 of the coining tool 140 in such a way that the cutting end portions of the dinking dies 148 themselves will come out of the shaped surface 145 in the second operating configuration of the half-die 132.

[0096] The pulley 1 is positioned, with its own axis A sharing the axis F, between the two half-dies 131 and 132 arranged in the open configuration. During the movement of relative approach between the two half-dies 131 and 132, the blank holder 141 comes into contact, with its own shaped surface 145, with the bridge element 10 and the annular portion 4 of the pulley 1, which remain consequently pinched between the blank holder 141 itself and the matrix 135.

[0097] As the relative axial motion between the two half-dies 131 and 132 proceeds, the spring actuators 146 are compressed, and the supporting wall 139 and the coining tool 140 slide axially with respect to the blank holder 141.

[0098] This determines in the first place exit of the cutting end portions of the dinking dies 148 from the shaped surface 145 of the blank holder 141 with consequent creation of the holes 11 on the pulley 1. The blanked part is then expelled through the opening 138 of the supporting wall 134.

[0099] Moreover, the moulds 144 of the coining tool 140 are brought into contact with the surface 13 of the bottom 6 of the pulley 1. The bottom 6 remains consequently pressed between the matrix 135 and the coining tool 140 in such a way that the moulds 144 of the coining tool 140 themselves will produce the impressions 15 on the surface 13.

[0100] From an examination of the characteristics of the method forming the subject of the present invention, the advantages that it affords are evident.

[0101] In particular, the method described enables the pulley 1 to be obtained starting from a relatively thin disk 21. In fact, the various operations carried out on the disk 21 (creation of the cup-shaped portions 28 and 86) enable displacement of material from the periphery of the disk 21 itself towards the central area, where it will then be necessary to have a certain thickness of the sheet metal to be able to obtain the impressions 15 by coining.

[0102] Since the disks 21 are blanked from a sheet metal, the smaller the thickness of the starting disk, the smaller the amount of material that will have to be rejected between one disk and the adjacent ones.

[0103] Moreover, the method described requires a relatively short cycle time and makes it possible to produce the pulley 1 by plastic deformation, hence without generation of swarf.

[0104] Finally, it is clear that modifications and variations may be made to the method described and illustrated herein, without thereby departing from the scope defined by the claims.

Claims

1. A method for manufacturing a pulley (1) for motor vehicle applications starting from a plane disk (21), which has a central axis (A) and defines a reference plane (P) orthogonal to said axis (A), said method being **characterized in that** it comprises the steps of:

   a) bending by means of moulding a peripheral annular portion (51) of said disk (21) in a direction transverse to said reference plane (P) so as to define a rim (59) in relief of the disk (21) itself;
   b) deforming, in a first axial direction (S) and by means of at least one moulding operation, a central disk-shaped portion (52) of said disk (21) so as to generate a first cup-shaped portion (53) projecting from the same part of said rim (59) with respect to said reference plane (P);
   c) deforming, in a second axial direction (T) opposite to said first direction (S) and by means of at least one moulding operation, a central disk-shaped portion of said first cup-shaped portion (53) so as to generate a second cup-shaped portion (86) axially projecting from the opposite side of said reference plane (P) with respect to said rim (59);
   d) reducing, by means of one or more moulding operations, the axial height of said second cup-shaped portion (86) with respect to said refer-

ence plane (P) so as to increase the thickness thereof with respect to the remaining part of the semifinished product (93, 125) thus obtained; and

e) carrying out a coining operation on a surface (13) of said second cup-shaped portion (86) that is parallel to said reference plane (P) and faces the opposite side of the reference plane (P) itself to generate a plurality of radial impressions (15) extending around said axis (A).

2. The method according to Claim 1, wherein said first cup-shaped portion (53) generated in said step b) has an annular side wall (69) and a plane bottom (70) connected to said side wall (69) by a rounded edge.

3. The method according to Claim 1 or Claim 2, wherein said second cup-shaped portion (86) generated in said step c) has a dome-shaped conformation.

4. The method according to Claim 3, wherein, during said step d), the bottom (6) of said second cup-shaped portion (86) is rendered plane.

5. The method according to any one of the preceding claims, comprising the further step of creating by blanking an axial through hole (78) in said second cup-shaped portion (86).

6. The method according to any one of the preceding claims, wherein, during said step c), a reduction of the axial height of said first cup-shaped portion (53) with respect to said reference plane (P) is obtained.

7. The method according to any one of the preceding claims, wherein the rim (59) obtained in said step a) has a frustoconical conformation.

8. The method according to Claim 7, comprising the further step of bending said rim (59) obtained in said step a) so as to cause it to assume a cylindrical conformation.

9. The method according to any one of the preceding claims, wherein said impressions (15) have a conformation resembling the petals of a daisy.

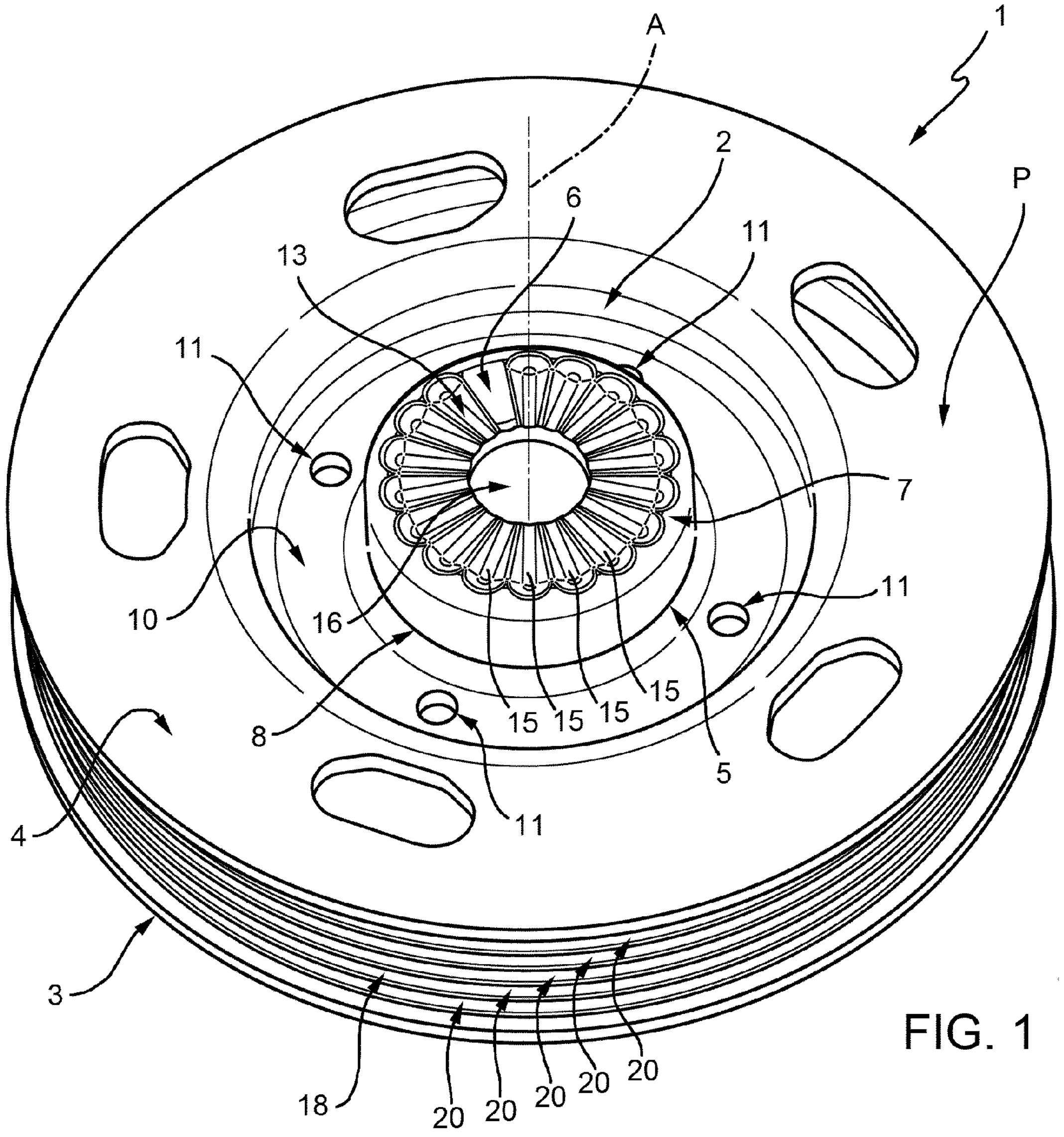
A
1
2
P
6
11
13
11
7
10
16
11
8
15
15
15
15
5
4
11
3
18
20
20
20
20
20

FIG. 1

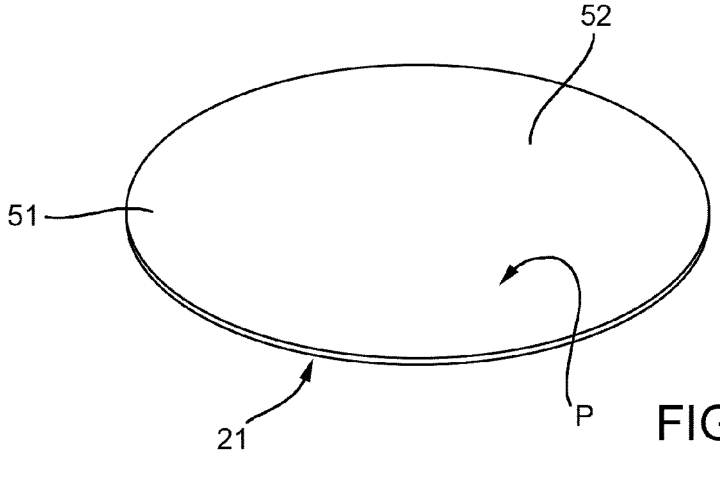
52
51
21
P

FIG. 2

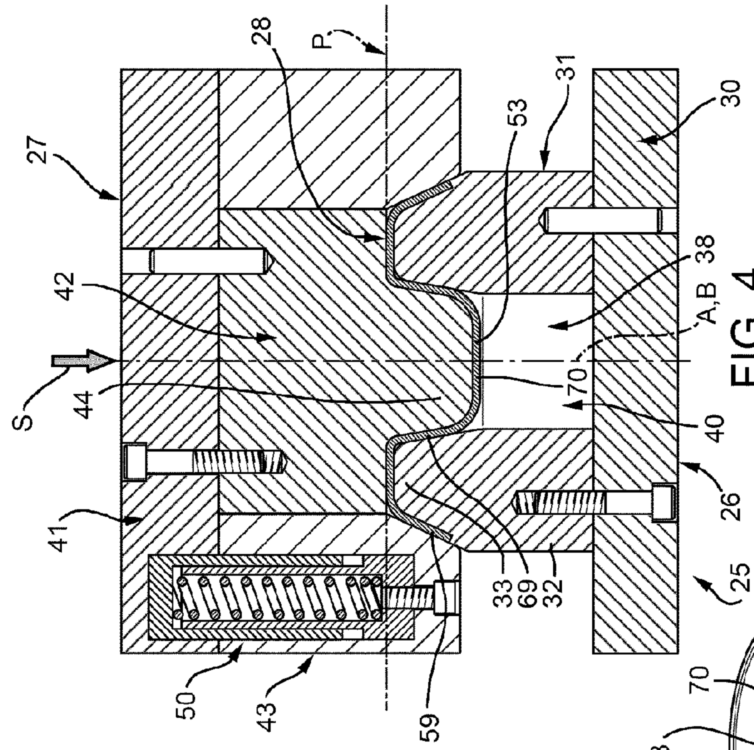

FIG. 4

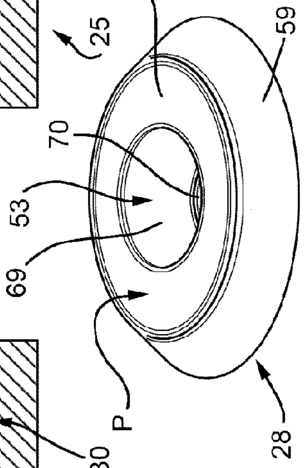

FIG. 5

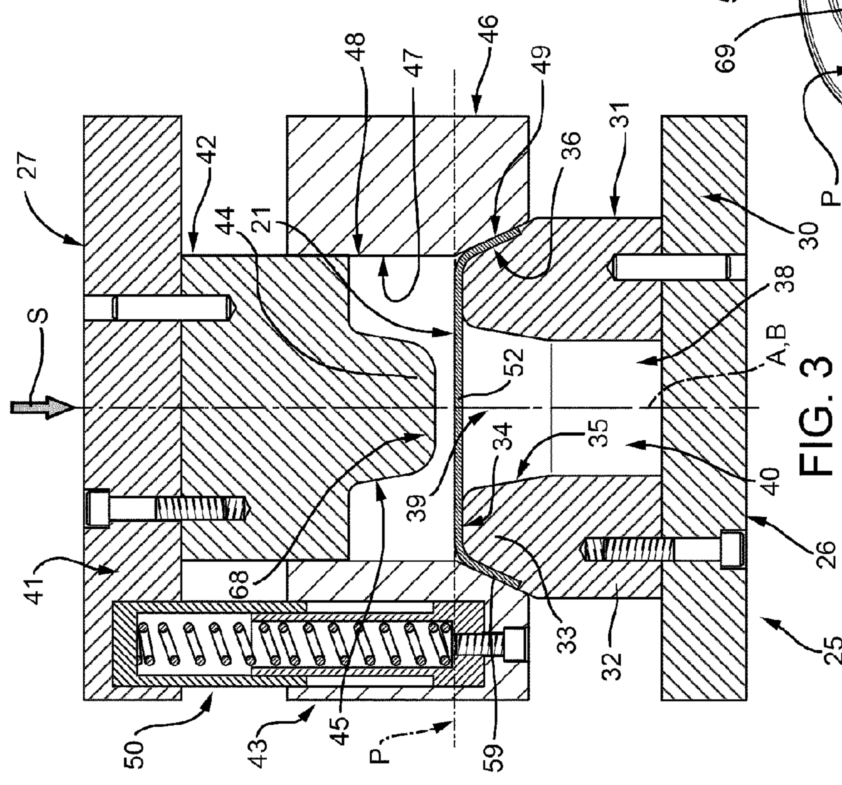

FIG. 3

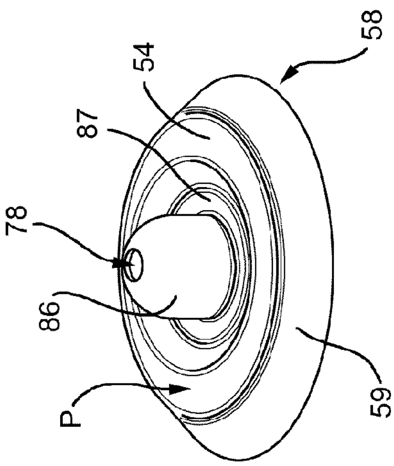
58
54
87
78
86
P
59

FIG. 7

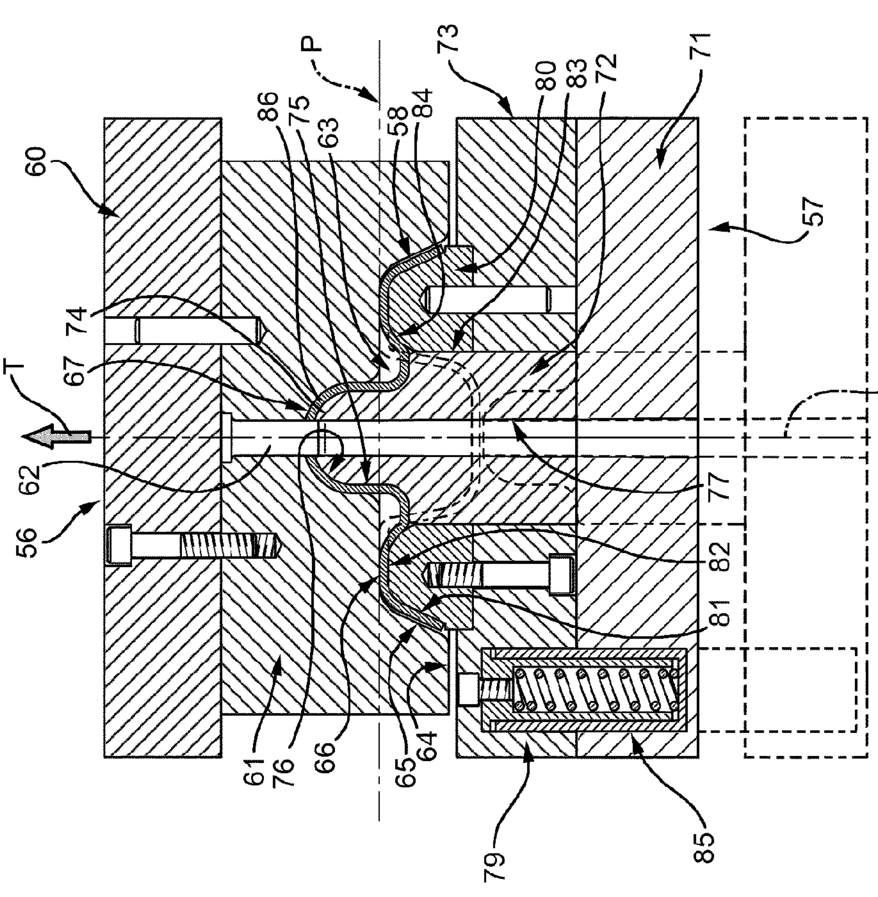
60
74
67
T
62
56
86
75
63
58
84
P
73
80
83
72
71
57
A,C
77
82
81
55
61
76
66
65
64
79
85

FIG. 6

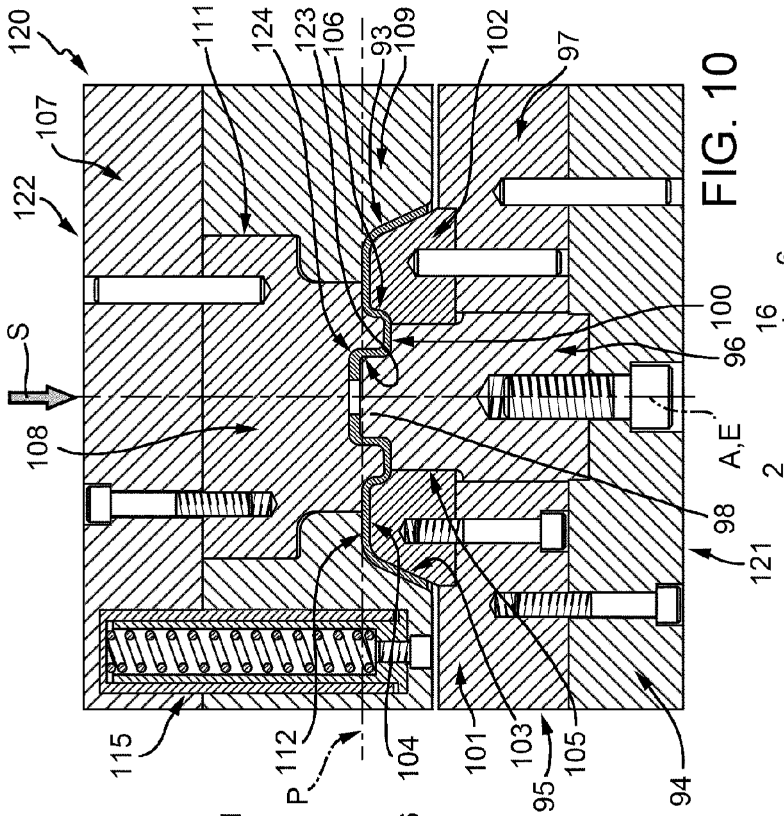

FIG. 10

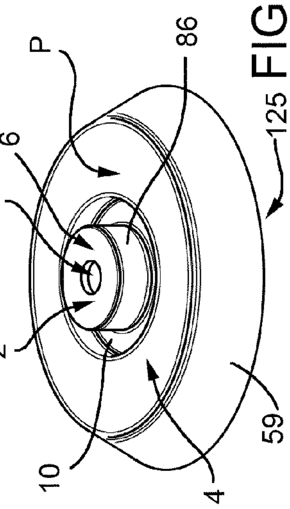

FIG. 11

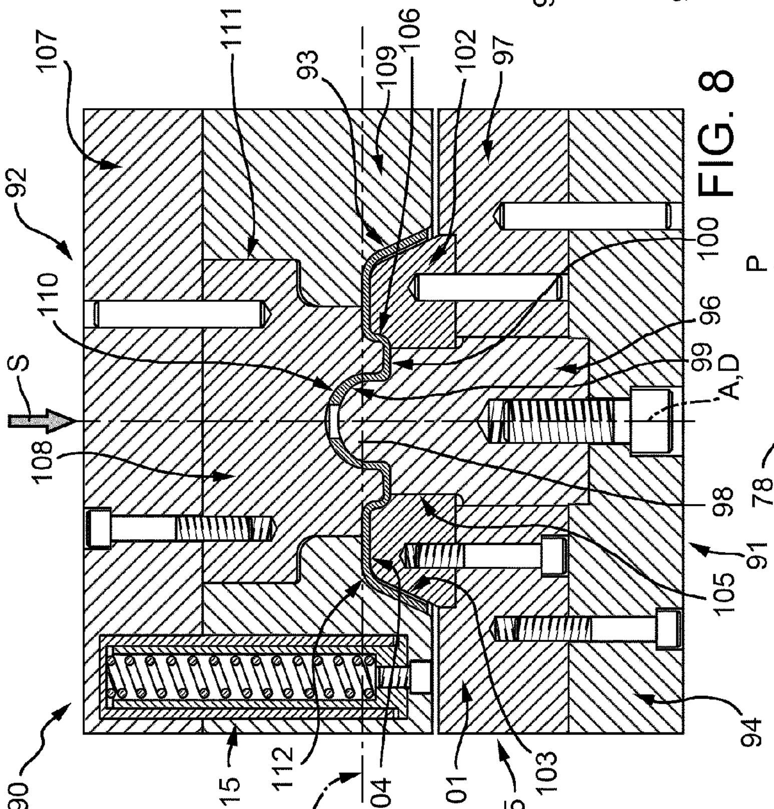

FIG. 8

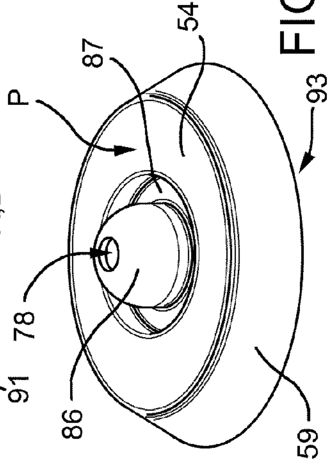

FIG. 9

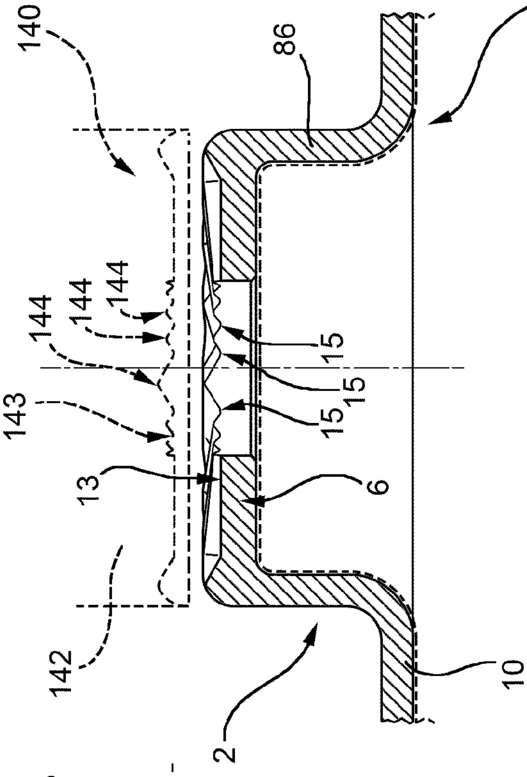
140
86
1
144
144
144
143
13
15
15
15
6
142
2
10

FIG. 13

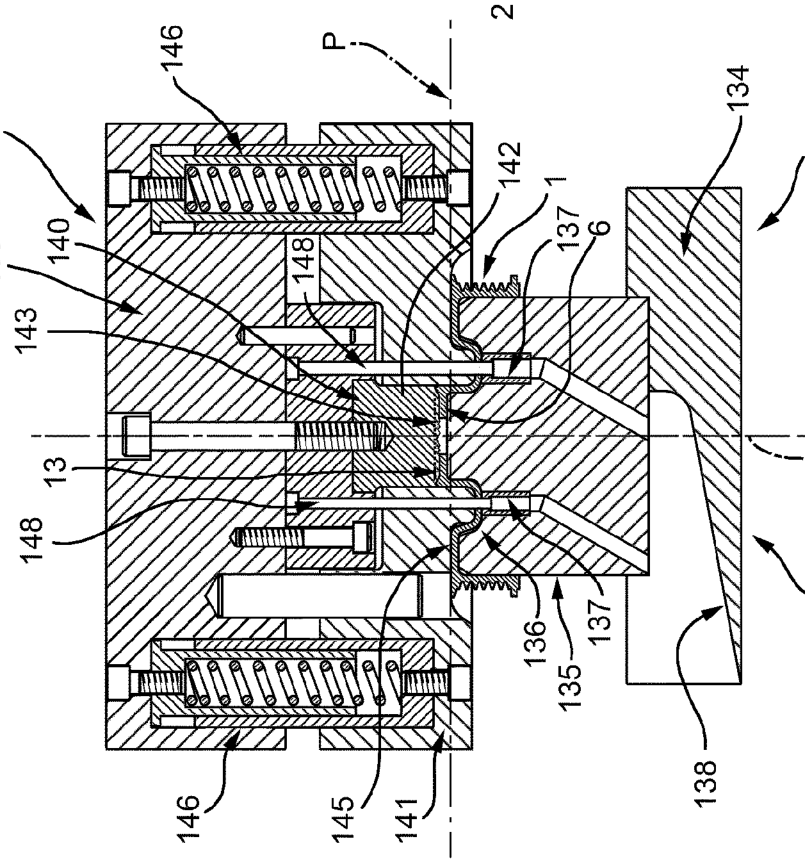
132
146
P
139
140
143
148
142
1
137
6
134
130
13
148
136
135
137
131
138
146
145
141
A,F

FIG. 12