

~~Method of manufacturing a plain bearing for a movable functional part, device for carrying out this method and bearing part of the plain bearing~~

Process for the production of a sliding bearing for a movable piece, device for execution of this process and bearing element for the sliding bearing.

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The invention relates to a method of manufacturing a plain bearing for a movable functional part as described in the opening section of Claim 1, a device for carrying out this method as described in the opening section of Claim 10, and a bearing part of a plain bearing as described in the opening section of Claim 24.

5 The invention relates to a method of manufacturing a plain bearing for a movable functional part whose manufacture starts with a bearing part formed integrally at a metal bearing plate by a synthetic-resin (injection-) moulding technique and comprising a bearing bridge which is passed through a hole of the metal bearing plate and retaining pieces which bear on the two plate surfaces laterally of the hole. The plain
10 bearing is provided in particular for forming rotational or slidable parts with plain bearing quality on metal plates in drive gear trains of tape reproduction devices, the parts being moulded at the metal plates by the outsert moulding technique.

15 Such a method of manufacturing a bearing of a movable functional part is known from EP 392 600 A2. The bearing plate in that case is a base plate which is provided with a plurality of retaining, supporting and functional parts, the parts provided by injection or moulding each gripping the plate by means of a bridge extending through a plate hole and retaining pieces provided on either side of the plate surfaces. Such parts are either fixed or have a limited rotation capability; they exhibit no bearing properties.

20 EP 392 600 A2 describes how the movable bearing part comprising the bridge and the retaining pieces provided on either side of the plate surfaces can be so changed by a subsequent deformation operation that the bearing is made into a plain bearing. Slides, wheel bearings for slides and gearwheels, for example, can be formed in this manner directly at the metal plate.

25 Reference is made in this connection to US-PS 32 14 504, which discloses how synthetic-resin injection-moulded spindle ends are made capable of rotation by a flexing operation in the manufacture of a spindle for a fishing rod.

DE-AS 14 72 403 discloses a method of manufacturing a mitre gear drive from synthetic-resin gears according to which the mitre gear bearings are formed in that the gear spindles are injected through a hole in a retaining plate and a wide overlap of the spindle hole, through which injection took place, is effected at the mitre gear side, while the overlap at the other side of the retaining plate is only small. The mitre gear wheels are brought into mutual engagement in that the retaining plate is crimped over. The crimping operation at the same time achieves a locking of the mitre gear wheels against dropping out. It is not described in what manner the injected parts obtain bearing properties.

It is an object of the invention to cause the deformation process to run in such a controlled manner that the synthetic resin is not adversely affected as to its structure during a deformation process and the external geometry above and below the bearing plate is not changed.

According to the invention, this object is achieved in that the bearing part is changed in a deformation process following the (injection-) moulding process by means of a force which is applied to the inner, central region of the bearing bridge and from there acts on the bearing part with deforming effect such that the bearing bridge is lengthened through stretching.

This process is a deformation process involving a change in the molecular structure in the form of orientation processes with molecular alignment. Preferred molecular orientations are created thereby at the loaded and sliding locations which lead to a better sliding quality and a higher bearing capacity. The orientation is load-resistant.

Through the use of those parameters of the synthetic resin at which it is particularly capable of flow, the envisaged flow is promoted and the structure of the synthetic resin is maintained in spite of a locally limited change in shape. In addition, a return to the original shape can be avoided through the use of the flow capability of the synthetic resin.

According to an embodiment of the invention, the force acting from the interior of the bearing bridge applies itself radially to the bridge material in the direction of the hole wall surface in the metal bearing plate, thus pressing away the bridge material towards the hole walls. In a further embodiment of the invention, the force acting from the interior of the bearing bridge applies itself axially to the bridge

material, thus deforming the bearing bridge along the hole wall surface in the metal bearing plate through stretching. In either case, the retaining pieces will be lifted off the plate surfaces.

According to a further embodiment of the invention, the synthetic resin is forced away from the interior of the bearing bridge by means of mandrels which are introduced into through passages or recesses of the bearing bridge from one of the or from both bearing plate surfaces. The flaring mandrels accordingly press away the synthetic resin in a displacement process towards the hole walls during this. According to a further embodiment of the invention, it is in that case ensured, that the synthetic resin during the displacement towards the hole walls flows towards these walls and is partly diverted there towards the plate surfaces.

To guarantee a sufficient flow capability of the synthetic resin it is important that the displacement process should not take place too fast, so as to afford the synthetic resin time to flow. According to a further embodiment of the invention, therefore, the displacement velocity lies below 0.1 m/sec. Higher velocities are also possible when PP (polypropylene) and HDPE (polythene) are used.

The flow capability of the synthetic resin and its flow velocity also depend directly on the temperature of the synthetic resin during the displacement process. According to a further embodiment of the invention, the temperature of the synthetic resin is set above the operational temperature and below the melting range or softening range during the displacement process.

According to a further embodiment of the invention, the molecular orientation created during the treatment is stabilized by a fixation, *i.e.* cooling down while the deformation pressure is maintained, and by tempering, *i.e.* storage at a certain temperature without load. This stabilization also remains in the case of subsequent renewed heat treatments. The necessary flow of the synthetic resin can already be achieved by a thermofixation during 10 minutes.

The moment of the deformation may be chosen so as to suit the circumstances, *i.e.* with the product still in the injection-moulding tool, immediately after removal from the mould, after renewed heating, or after removal from the mould and after cooling down of the product.

In a further embodiment of the invention, the deformation of the synthetic resin is carried out by means of a mandrel which rotates and/or vibrates in the

inner, central bridge region, while the deformation process is enhanced by a hot-air treatment during the rotary or vibratory movement of the mandrel.

Devices suitable for carrying out the method according to the invention are characterized in that at least one mandrel is provided by means of which the force to
5 be applied to the inner, central region of the bearing bridge is transmitted.

A first advantageous embodiment of the device is characterized by a slightly tapering mandrel which can be moved through a passage in the inner, central region of the bearing bridge for the partial displacement of the synthetic resin material present between the mandrel and the hole walls. Such a slightly tapering mandrel,
10 whose taper according to a further embodiment of the invention is 3° to 7° relative to the mandrel centreline, displaces the synthetic resin material between itself and the hole walls and further towards the plate surfaces while partly aligning the molecular structure.

A second advantageous embodiment of the device for carrying out the
15 method is characterized by mandrels which can be moved from both plate surfaces each against a recess in the central bridge region for displacing the synthetic resin material present between the mandrels and the hole walls. Such a two-sided mandrel application improves the linear displacement effect of the mandrel(s) relative to the hole walls.

A further evening-out of the displacement directed towards the hole walls
20 can be achieved with the use of mandrels introduced into openings of the bridge in a third embodiment of the device with a slotted bush which is provided, in the case of a round passage, between the wall of the passage and the hole walls during the widening and displacement process, whereby the mandrels press with tapering mandrel tips against the bush with widening effect, thus lengthening the bearing bridge. According to
25 a further modification of this embodiment, the wall of the passage has a bulging shape towards the centre with a smaller passage diameter. In the case of a radial bearing design, the bush widens radially and optimizes the radial displacement effect in the direction of the hole walls as well as the lengthening of the bearing bridge.

A fourth embodiment of the device for carrying out the method according
30 to the invention is characterized in that the passage in the bearing bridge can be widened by means of at least one mandrel arranged eccentrically relative to the longitudinal axis of the passage through an eccentric motion of the mandrel, whereby the synthetic resin material present between the mandrel and the hole walls is partly

displaced. The mandrel moving eccentrically about the central opening axis widens the opening in a kind of flexing movement.

A fifth embodiment of the device for carrying out the method according to the invention is characterized in that the passage in the bearing bridge has an elliptical profile perpendicularly to its longitudinal axis, in that the mandrel(s) has (have) a correspondingly shaped elliptical profile, and in that the material of the bearing bridge can be lengthened between the mandrel(s) and the hole walls by partial displacement of the synthetic resin material through a rotating or reciprocating movement of the mandrel(s). With the elliptical profile of the opening and the elliptical cross-section of the mandrel, a similar widening effect is obtained as in the fourth embodiment, again approximating a flexing process, which alternately loads and relieves the synthetic resin material between the opening and the hole walls.

According to an advantageous modification of the fourth and fifth embodiment, the mandrel has a bulging shape whose major diameter is situated approximately in the centre of the bearing bridge or central region of the bearing plate. The lengthening effect on the bearing bridge is improved by this.

A sixth embodiment of the device for carrying out the method according to the invention is characterized in that an insert mandrel is already introduced into the central region of the bearing bridge during the manufacture of the bearing part by the (injection-)moulding technique, which mandrel has a constriction at least in the hole region, and in that the bearing bridge is widened through pulling-out of the insert mandrel, so that the passage initially filled by the insert mandrel is widened by a partial displacement of the synthetic resin material. The subsequent provision of a mandrel is redundant in this case because the mandrel carrying out the widening operation is surrounded with synthetic resin in the passage during the injection-moulding process itself and causes the widening of the passage when being pulled out. This represents a considerable simplification in the equipment.

According to a seventh embodiment of the invention, a recess enters the bearing bridge from one of the plate surfaces only, a support disc covering the full cross-sectional area of the bearing bridge is present in the region of the other plate surface, and a mandrel is insertable into the recess of the bearing bridge whereby the bearing bridge can be stretched in longitudinal direction. Loosening of the retaining pieces in this case is achieved through lengthening of the bridge only. In addition, a

greater clearance between the hole walls and the bearing bridge can be set during this lengthening process.

It is particularly favourable when in this seventh embodiment the bottom of the recess is provided approximately at the level of the second plate surface reached by the mandrel upon its insertion. The bearing bridge is stretched over its entire length in this manner.

An eighth embodiment of the invention is so arranged that a mandrel can be moved against the passage in the bearing part, which mandrel in the direction towards its free end shows a transition from a portion of greater diameter than the opening *via* a constricted portion into a portion of smaller diameter, and that the portion of smaller diameter can be introduced into a recess of a hold-down by means of which the bearing part can be supported against the application direction of the mandrel for the displacement of the synthetic resin material in the direction of the hole walls. As a result, the mandrel cannot slip away sideways and carries out a very even displacement in the direction of the hole walls.

A further modification of the eighth embodiment of the invention is characterized in that the inner diameter of the hold-down and the outer diameter of the mandrel portion of smaller diameter are so attuned to one another that the mandrel portion is guided in the hold-down during the deformation process.

The formation of the passages in the bearing bridges is also of essential importance for the displacement, stretching, and widening effect as well as for the orientation or internal reinforcement effect.

According to a further embodiment of the invention, a bearing part of a plain bearing formed from synthetic resin for a functional part of a bearing bridge by one of the above methods or devices is characterized in that the bearing bridge has a through passage or at least a recess in its inner, central region.

A first embodiment of this bearing part is characterized in that the bearing bridge comprises the passage with the passage wall in its inner, central region and in through direction, and in that the passage has a wall shape which bulges towards the centre of the passage with smaller diameters thereof before entry of the mandrels. This bulging wall shape towards the opening centre may be formed in various ways. A preferred modification is characterized in that the wall bulge has its smallest passage diameter approximately half-way the passage length. Another preferred modification is

characterized in that the wall bulge towards the passage centre is achieved through the formation of saddle surfaces. Given the corresponding mandrel shape, favourable conditions for axial widening are then obtained, whereby the synthetic resin material flows from the passage centre towards the hole edge.

5 Another embodiment of the bearing part of the plain bearing is characterized in that the bearing bridge comprises the passage with the passage wall in its inner, central region and in through direction, and in that the passage has a wall shape which is parallel to the hole walls before entry of the mandrels. This passage may, for example, be widened by means of the eccentric mandrel or, in a further
10 embodiment of the invention, is characterized in that a bush slotted transversely to the bearing plate is injection-moulded into the passage, which bush separates itself from the hole walls after widening of the bush. The bush drops from the opening after the widening process.

In another embodiment of the bearing part of the plain bearing, a recess
15 enters the bearing bridge from one of the plate surfaces, and a support disc covering the full cross-sectional area of the bearing bridge is present in the region of the other plate surface.

In a further development of this embodiment of the bearing part, advantageously, the recess extends from the one plate surface up to approximately the
20 level of the other plate surface. According to a further embodiment of the bearing part of the plain bearing, two recesses are present extending from the two plate surfaces into the hole.

According to a further embodiment of the invention, at least the components subjected to the deformation are made of
25 POM (polyoxymethylene/polyacetal) or
ABS (acrylonitril-butadiene-styrene (copolymer)) or
PA (polyamide) or
HDPE (polythene) or
PP (polypropylene).

30 A further embodiment of the bearing part is then characterized in that the synthetic resins are reinforced with fibres, such as glass or carbon fibres; while it may also be characterized in that the synthetic resins are provided with fillers.

The method according to the invention together with devices for carrying

out this method according to the invention is described in more detail with reference to the drawings, in which

5 Figs. 1a and 1b show the manufacture of a plain bearing, for example for a functional part, which after being injection-moulded to a metal bearing plate of a drive gear train for magnetic tape devices is given its plain bearing property, the generation of the plain bearing property being effected by means of a tapering mandrel which is passed through a passage in the central region of a synthetic resin bridge of the movable plain bearing part extending through the bearing plate,

10 Figs. 2a and 2b show the deformation of a moulded plain bearing, formed by injection at the metal bearing plate, by means of two mandrels which are axially introduced into the bridge of the plain bearing from opposite directions, a radial support disc being maintained between the walls of a hole in the metal bearing plate through which the bridge is passed; Fig. 2a showing the action of the mandrels and Fig. 2b showing the result of the mandrel action,

15 Figs. 3a and 3b show the deformation of the injection-moulded bearing part of the functional part by means of two mandrels acting in opposite directions which radially widen a bush inserted into the opening of the bridge according to Fig. 1, Fig. 3a showing the widening process and Fig. 3b the result of the widening process; Fig. 3aa showing an optionally applicable, diagonally slotted bush,

20 Figs. 4a to 4c show the widening of the bridge according to Fig. 1 by means of an eccentrically arranged mandrel, Fig. 4a showing the widening process in cross-section and Fig. 4b in plan view, while Fig. 4c shows the plain bearing formed during the widening process,

25 Figs. 5a to 5c show a modification of the embodiment of Fig. 4 in which the passage in the bridge is injection-moulded with an elliptical cross-section, and a mandrel which is elliptical in cross-section is introduced into this elliptical passage, which mandrel presses away the bridge in the elliptical passage through rotation, thus displacing the synthetic resin material; Fig. 5a showing the elliptical modification in cross-section and Fig. 5b partly in plan view with the mandrel cut away; while Fig. 5c shows the moulded part of Fig. 5a transformed into a plain bearing,

30 Figs. 6a and 6b show the conversion of the bearing part into a functional plain bearing, whereby the mandrel carrying out the displacement of synthetic resin is introduced simultaneously with the injection-moulding process of the moulded bearing

part, after which it is pulled out so as to displace the synthetic resin, the moulded bearing of Fig. 6a being converted thereby into a plain bearing according to Fig. 6b,

5 Figs. 7a and 7b show a moulded plain bearing similar to the one shown in Fig. 2a and 2b with a radial support disc which is maintained; a mandrel is introduced into a central recess of the bridge which does not extend throughout this bridge, and presses against the radial support disc owing to which the bridge becomes longer; the unfinished plain bearing of Fig. 7a is thus transformed into a plain bearing according to Fig. 7b,

10 Figs. 8a and 8b show the conversion of an unfinished plain bearing with an passage for a mandrel, where the widening of the bridge is carried out between the mandrel and a fixed countersupport; Fig. 8a shows the arrangement and Fig. 8b shows the unfinished part converted into a plain bearing.

The outsert moulding technique, a synthetic resin injection or moulding technique, is used for forming functional parts such as gears, slides, adjustment levers, and other items at a metal bearing plate. Each bearing then consists of a hole or slot in the metal bearing plate and injection-moulded bearing parts which comprise a bearing bridge passed through the hole and retaining pieces gripping around the hole edges at the plate surfaces. The bearing parts carry functional parts such as gears, slides, levers, etc, for example, a drive gear for magnetic tape devices. Such an injection-moulded part at the hole of the bearing plate is difficult to move since, as a result of contraction, the bridge has indeed become detached from the hole edges, but the retaining pieces lie tightly against the plate surfaces. This unfinished bearing must therefore be changed in order to be converted into a plain bearing. The properties of the synthetic resin are to be taken into account in this change so that its semi-crystalline structure remains intact and the plain bearing capability is not lost again owing to undesirable subsequent regeneration.

25 The transformation of the moulded bearing part into the movable parts of a plain bearing with plain bearing properties which remain constant throughout life is achieved by means of a deformation process in which the synthetic resin bridge is so changed in the hole of the bearing plate, more in particular is lengthened, that the retaining pieces are lifted off the plate surfaces while the contraction clearance between the bearing bridge and the hole walls remains substantially intact. The essence of the process for forming the sliding properties of the movable bearing part of the plain

bearing consists in that the bridge material is deformed from its central bridge portion by pressure towards the hole walls, the deformation process taking place under time and temperature conditions under which the synthetic resin is particularly capable of flow in accordance with its properties, while a locally restricted alignment of its undisturbed molecular structure takes place. The deformation process must not proceed too quickly so that the synthetic resin has an opportunity to escape sideways under the exerted pressure. Any shearing action should be avoided. The temperature of the synthetic resin at the moment of deformation of the bridge has a clear influence on its flow capability during this. It has been found that a preferred displacement velocity lies below 0,1 m/sec when the temperature of the synthetic resin material is set above the operating temperature and below the melting range during the displacement process.

During the displacement and stretching of the synthetic resin, it should be ensured that the bearing bridge is widened in the direction of the opposing walls of the hole. The synthetic resin material then shows a preferential flow towards the hole walls. The simplest possibility for displacement towards the hole walls consists in that a through passage or recesses are provided from the outside in the bridge itself in its central region, into which passage or recesses a mandrel is introduced from one side or two mandrels are introduced from two sides. Various preferred embodiments of the device according to the invention are available for this, which will be explained in more detail below. Another displacement and stretching possibility is that the bearing bridge is lengthened in its longitudinal direction.

Since the space between the mandrel(s) and the hole walls becomes smaller all the time during the displacement towards the hole walls, the synthetic resin must also escape in the longitudinal direction of the bearing bridge. This escape in longitudinal direction of the bearing bridge leads to a lengthening of the bridge and to a lifting effect of the retaining pieces away from the plate surfaces, while the contraction clearance between the bearing bridge and the hole walls is maintained. A complete functional plain bearing is thus created from the bearing part formed by injection-moulding at the bearing plate through deformation and fixation, the bearing properties of which do not deteriorate any more because no regeneration takes place, while the material is not prone to premature ageing because a change in the chemical structure has not taken place.

Fig. 1a shows a first embodiment of a device for widening the bearing

bridge from the centre towards the hole edges of the bearing plate. The unfinished bearing 1 which is to be given sliding capability then consists of a hole 3 in the fixed bearing plate 1 with hole edges 5, and a movable bearing part which has been injection-moulded around the hole 3 and which comprises a bearing bridge 7 and retaining pieces 9. The bridge 7 extends through the hole 3 and interconnects the retaining pieces 9 which rest on the plate surfaces 11a, 11b around the hole edges 5. Because of the contraction of the synthetic resin material of the bearing parts 7, 9, the bridge 7 has become detached from the hole edges 5, while the retaining pieces 9 clearly bear on the plate surfaces 11a, 11b. A passage 15 is provided in the central region of the bridge 7 along a centreline 13 (in the case of a slide) and an axis 13 (in the case of a rotary bearing). This passage 15 has a double-cone wall shape, the smallest passage diameter with the accompanying bulge being situated approximately at half the passage length. The passage 15 accordingly is usually constricted in the centre of the bridge 7, and widens to the greatest extent at the extreme ends of the bridge 7. The divergence between the centreline or axis 13 and the conical opening walls 15a may be approximately 20° in that case.

A mandrel 17 with a tapering front 17a is used for widening the passage 15. The taper of the wall surface 17b relative to the centreline or axis 13 is approximately 5° . While the mandrel 17 is being pressed into the opening 15, the bearing part 1 is supported from the other end by a countersupport 19 which bears on a contact surface 9a of the retaining piece 9 shown in bottom position in the drawing.

When the mandrel 17 is slowly introduced into the passage 15, the synthetic resin material of the bridge 7 is displaced towards the hole edge 5, so that the synthetic resin flows towards the hole edge 5 and escapes from there along the centreline or axis 13 towards the plate surfaces 11a and 11b. The insertion velocity of the mandrel 17 is determined by the flow capability of the synthetic resin.

Fig. 1b shows how the bearing part 1 has changed after the introduction of the mandrel 17. The passage 15 now has straighter walls and the bridge has been so lengthened that a gap 21 has been created between the plate surface 11b and the retaining-piece surface 9b previously bearing thereon. Since the bridge 7 again has a certain radial clearance relative to the hole wall 5 owing to elastic regeneration after the deformation, a plain bearing with sliding properties according to Fig. 1b has been created from the unfinished bearing of Fig. 1a.

Fig. 2a shows a different embodiment of the bearing part 1a with a bridge 7a and retaining pieces 9. The bearing part 1a has again been injection-moulded over the hole 13 of the bearing plate 1 with hole edge 7. The bridge 7a is passed through the hole 3, and the retaining pieces 9 bear on the surfaces 11a and 11b of the bearing plate 1. Recesses 23 have been injection-moulded in the bridge 7a in the direction of the centreline or axis 13. Between the recesses 23, the bearing bridge is closed by means of a radial support disc 25. Mandrels 27 whose cross-section corresponds to the cross-section of the recesses 23 are provided for deforming the bridge 7a and thus to displace the synthetic resin material towards the hole walls. The mandrels 27 are moved towards one another, so that the synthetic resin material flows away towards the hole edges 5 and farther, perpendicular thereto, in the direction of the centreline or axis 13, while the thickness of the radial support disc 25 decreases. After the deformation process, the unfinished bearing of Fig. 2a formed by injection-moulding has been converted into an operational plain bearing according to Fig. 2b, the support disc 25 having become thinner and the surfaces 9b of the retaining pieces 9 being removed from the surfaces 11a and 11b of the bearing plate 1, whereby a gap 21 is formed.

It is important that the displacement direction of the synthetic resin is towards the hole edges 5. To improve this displacement towards the hole edges 5, a third embodiment of the device for carrying out the method is shown in Fig. 3a where a bush 29 with multiple slots is inserted into a tapering passage 7b with a bulging wall 15c having its smallest passage diameter in the centre of the passage, the slot 29a extending preferably perpendicular to the bearing plate, so in longitudinal bush direction. Alternatively, however, the slot may be provided diagonally as is shown in Fig. 3aa with slot 29aa. The mandrels 33 moved from both plate surfaces 11a, 11b in the direction of the arrows 31 against the bush ends 29b press with tapering tips 33a against the axial bush ends 29b, thus widening the bridge 7b in the direction of the hole edges 5. In this case the synthetic resin material also flows towards the hole edges 5 and simultaneously parallel to the centreline or axis 13 in both directions towards the plate surfaces 11a and 11b. As Fig. 3b shows, the result corresponds to that of the deformation operation of Fig. 1, where the surfaces 9b of the retaining pieces 9 have been lifted from the plate surfaces 11a and 11b by a lengthening of the bearing bridge 7b, thus forming the gap 21. The unfinished bearing of Fig. 3a formed by injection-

moulding has been transformed into a plain bearing according to Fig. 3b by the deformation operation with the mandrels 33 and the bush 29 of Fig. 3a.

Fig. 4a shows a fourth embodiment of a device for deforming the bearing bridge 7b. The initially stiffly movable injection-moulded unfinished bearing again comprises the plate 1 with the hole 3 around which the bearing part 1b with its bearing bridge 7b and its retaining pieces 9 has been moulded. To convert this unfinished bearing into a plain bearing, a mandrel 35 is inserted into the passage 15 having a passage wall 15c, the axis 35a of the mandrel being shifted relative to the axis 13 of the passage 15 by a difference A. The mandrel 35 has a bulging shape in the region of the bearing bridge 7b with the greatest bulge diameter approximately in the centre of the bearing plate. As a result, the mandrel 35, when rotated in the direction of an arrow 35b about the axis 13, moves eccentrically and widens out the wall portion 15c of the passage 15 preferably at half the length of the passage in the bearing plate centre by means of this free-forming process. The synthetic resin material is displaced towards the hole edges 5 during this. At the same time, as in the preceding embodiments, it also flows in an axial direction towards the plate surfaces 11a and 11b.

Fig. 4b shows the rotation movement of the mandrel 35. Fig. 4c shows the plain bearing created from the stiff unfinished bearing 4a through the eccentric rotation of the mandrel 35, whereby the surfaces 9b of the retaining pieces 9 have lifted themselves off the surfaces 11a and 11b of the bearing plate, thus creating gaps 21.

To avoid rotation of the bearing part 1b during the rotation of the mandrel 35, the bearing part 1b is provided with a projection 37 with which the bearing part 1b can be locked against rotation.

Fig. 5a shows a fifth embodiment of a device for carrying out the deformation operation on the bridge 7c of a bearing part 1c which consists of the bearing bridge 7c and the retaining pieces 9. The passage 15 in this case has an elliptical cross-section. A mandrel 41 of corresponding elliptical shape can be inserted into this passage 15 of elliptical cross-section. The mandrel 41 has a bulging shape in the region of the bearing bridge 7c with the greatest bulge diameter approximately in the centre of the bearing plate. Fig. 5a shows the arrangement in side elevation, and Fig. 5b in cross-section. The cross-section of the mandrel 41 provided in the passage 15, also of elliptical shape, is clearly discernible. The passage 15 may be widened through rotation of the mandrel 41 in the direction of the double arrow 41b, and the

shape shown in broken lines in Fig. 5b is obtained.

During this widening process, the synthetic resin material is pressed towards the hole edges 5, as in all other devices, flowing in the direction of these hole edges and also carrying out a flow movement parallel to the axis 13 towards the plate surfaces 11a and 11b. The plain bearing shown in Fig. 5c is thereby created from the
5 hardly or stiffly movable unfinished bearing of Fig. 5a and 5b, after the surfaces 9b of the retaining pieces have lifted themselves off the bearing plate surfaces 11a and 11b, thus forming gaps 21.

Fig. 6a shows a sixth embodiment of the device for deformation of the
10 bearing part 1d which has been injection-moulded over the hole 3 of the bearing plate 1. The bearing part 1d comprises a bearing bridge 7d extending through the hole 3 and retaining pieces 9 which grip around the plate surfaces 11a and 11b. A mandrel 43 of the mould was enclosed in the bridge 7d during injection-moulding, the axis of the mandrel 13 coinciding with the axis of the bridge 7d. The mandrel 43 has a constricted
15 portion 43a in the region of the bridge 7d. This constricted portion 43a is a little longer than the bridge 7d in axial direction in the region of the bearing plate 1.

As is shown in Fig. 6a, the bearing part 1d is deformed in that the mandrel 43, which forms part of the mould, is pulled out. During pulling out of the mandrel, before separation of the mould, which may take place in conjunction with
20 other slides, pins, or retention devices of the mould, the mould acts as a hold-down 45 which supports the bearing plate at the side of its surface 11a. When the mandrel 43 is pulled from the bearing bridge 7d in the direction of an arrow 45 for the purpose of carrying out the deformation process, the bearing bridge 7d is widened in the direction of the hole walls 5a. Owing to the flow of material towards the hole edges 5 and
25 towards the bearing plate surfaces, the bridge increases its dimension in the direction of the axis 13, and the retaining piece surfaces 9b are lifted off the plate surfaces 11a and 11b. The stiffly movable unfinished bearing of Fig. 6a has then become a plain bearing according to Fig. 6b.

A seventh embodiment of the device for carrying out the deformation
30 process of the bearing part is shown in Fig. 7a. The bearing part 1e is injection-moulded around the hole 3 of the bearing plate 1 and consists of the bearing bridge 7e extending through the hole and the retaining pieces 9 gripping around the plate surfaces 11a and 11b. A recess 47 whose bottom 47a is provided approximately at the level of

the lower plate surface 11b extends in a direction parallel to the axis or centreline 13 in the drawing from the upper side of the bearing part 1e. A connection 49 acting as a radial support disc interconnects the retaining pieces at the lower side of the bearing part 1e of Fig. 7a and is also in connection with the bearing bridge 7e.

5 A mandrel 51 is provided which can be inserted into the depression 47. A countersupport 53 supports the lower plate surface 11b.

When the mandrel 51 is pressed against the connection 49 for carrying out the deformation process, the surfaces 9b are lifted off the plate surfaces 11a and 11b while the bearing bridge 7e is lengthened. The hardly or stiffly movable unfinished bearing of Fig. 7a is converted thereby into a plain bearing according to Fig. 7b.

10 An eighth embodiment of the device for carrying out the deformation process is described with reference to Fig. 8a. The bearing part 1f here is injection-moulded around the hole 3 of the bearing plate 1. The bearing part 1f comprises a bearing bridge 7f which extends through the hole 3 and the retaining pieces 9 which rest against the surfaces 11a and 11b of the plate 1. An passage 15, which is widened at the upper and lower end into cups 15f, extends centrally through the bearing bridge 7f. In order to be deformed, the bearing part 1f is supported from below by a countersupport 19a which enters the lower cup 15f. A mandrel 53 enters the upper cup 15f from the upper side of the bearing part 1f. Seen in the direction of its free end 53c, this mandrel first has a portion of greater diameter which corresponds approximately to the diameter of the cup 15f, then a tapering portion 53a in the form of a truncated cone, and finally a mandrel portion 53b of smaller diameter. This mandrel portion 53b of smaller diameter enters a recess 19b of the countersupport 19a. Mandrel 53 and countersupport 19a are thus mutually aligned.

25 When the mandrel 53 moves into the bearing bridge 7f in the direction of the arrow 55, the synthetic resin material of the bearing bridge 7f will flow radially towards the hole edges 5 and axially further towards the two bearing plate surfaces 11a and 11b. The bearing bridge 7f thus lengthens itself in the direction of the axis 13, and the surfaces 9b of the retaining pieces lift themselves off the bearing plate surfaces 11a and 11b. The plain bearing of Fig. 8b is thus obtained from the stiffly movable unfinished bearing of Fig. 8a.

30 After the deformation and partly also during the deformation, a thermofixation process is carried out, *i.e.* a stoving treatment while the parts are held in

- fixed position. A stoving treatment alone would lead to subsequent shrinking. By stoving treatment is meant in this case storage at a temperature substantially higher than room temperature and without fixation. Depending on the nature of the polymer, the stoving treatment usually takes place above 100° C. During fixation, the deformation
- 5 pressure is maintained during cooling-down. Owing to the deformation and the additional stoving treatment and fixation, the bearing properties become more load-resistant and the bearing becomes more heat-resistant up to the temperature of the fixation process.

CLAIMS:

1. A method of manufacturing a plain bearing for a movable functional part whose manufacture starts with a bearing part (1 to 7f) formed integrally at a metal bearing plate (11) by a synthetic-resin (injection-) moulding technique and comprising a bearing bridge (7 to 7f) which is passed through a hole (3) of the metal bearing plate (11) and retaining pieces (9) which bear on the two plate surfaces (11a, 11b) laterally of the hole (3), characterized in that the bearing part (1 to 1f) is changed in a deformation process following the (injection-) moulding process by means of a force which is applied to the inner, central region (15, 23, 47) of the bearing bridge (7 to 7f) and from there acts on the bearing part (1 to 7f) with deforming effect such that the bearing bridge (7 to 7f) is lengthened through stretching.
2. A method as claimed in Claim 1, characterized in that the force acting from the interior (15, 23) of the bearing bridge (7 to 7d and 7f) applies itself radially to the bridge material in the direction of the hole wall surface (5) in the metal bearing plate (11), thus pressing away the bridge material towards the hole walls (5).
3. A method as claimed in Claim 1, characterized in that the force acting from the interior (47) of the bearing bridge (7e) applies itself axially to the bridge material, thus deforming the bearing bridge (7e) along the hole wall surface (5) in the metal bearing plate (11) through stretching.
4. A method as claimed in any one of the Claims 1 to 3, characterized in that the synthetic resin is forced away from the interior of the bearing bridge (7 to 7f) by means of mandrels (17, 27, 33, 35, 41, 43, 51, 53) which are introduced into through passages (15) or recesses (23, 47) of the bearing bridge (7 to 7f) from one of the or both bearing plate surfaces (11a, 11b).
5. A method as claimed in Claim 1 or 2, characterized in that during the radial displacement the synthetic resin first flows towards the hole walls (5) and is partly diverted there towards the plate surfaces (11a, 11b).
6. A method as claimed in any one of the Claims 1 to 5, characterized in



that the displacement velocity lies below 0.1 m/s.

7. A method as claimed in any one of the Claims 1 to 6, characterized in that the temperature of the synthetic resin is set above the operational temperature and below the melting range during the displacement process.

5 8. A method as claimed in any one of the Claims 1 to 7, characterized in that the molecular orientation created during the treatment is stabilized by fixation, *i.e.* cooling down while the deformation pressure is maintained, and by tempering, *i.e.* storage at a certain temperature without load.

9. A method as claimed in any one of the Claims 1, 2, and 4 to 8,
10 characterized in that the deformation of the synthetic resin is carried out by means of a mandrel (35, 41) which rotates and/or vibrates in the inner, central bridge region (7 to 7d and 7f), while the deformation process is enhanced by a hot-air treatment during the rotary or vibratory movement of the mandrel (35, 41).

10. A device for carrying out the method as claimed in any one of the
15 Claims 1 to 9 for manufacturing a plain bearing for a movable functional part whose manufacture starts with a bearing part (1 to 7f) formed integrally at a metal bearing plate (11) by a synthetic-resin (injection-) moulding technique and comprising a bearing bridge (7 to 7f) which is passed through a hole (3) of the metal bearing plate (11) and retaining pieces (9) which bear on the two plate surfaces (11a, 11b) laterally of the hole
20 (3), characterized in that at least one mandrel (17, 27, 33, 35, 41, 43, 51, 53) is provided by means of which the force to be applied to the inner, central region (15, 23, 47) of the bearing bridge (7 to 7f) is transmitted.

11. A device as claimed in Claim 10, characterized in that the mandrel (17)
25 has a slightly tapering shape and can be moved through a passage (15) in the inner, central region of the bearing bridge (7 to 7d and 7f) for the partial displacement of the synthetic resin material present between the mandrel (17) and the hole walls (5).

12. A device as claimed in Claim 11, characterized in that the taper of the mandrel (17) relative to the mandrel centreline (13) is 3° to 7°.

13. A device as claimed in Claims 8 to 12, characterized by a slotted bush
30 (29) which is provided, in the case of a round passage (15), between the wall of the passage (15) and the hole walls (5) during the widening and displacement process, whereby the mandrels (33) press with tapering mandrel tips (33a) against the bush (29) with widening effect, thus lengthening the bearing bridge.



14. A device as claimed in Claim 13, characterized in that the wall (15c) of the passage (15) has a convex shape towards the centre with a smaller passage diameter.

15. A device as claimed in Claim 10, characterized by mandrels (27) which can be moved from both plate surfaces (11a, 11b) each against a recess in the inner, central bridge region for displacing the synthetic resin material present between the mandrels (27) and the hole walls (5).

16. A device as claimed in Claim 10, characterized in that the passage (15) in the bearing bridge (7b) can be widened by means of at least one mandrel (35) arranged eccentrically relative to the longitudinal axis of the passage (15) through an eccentric motion of the mandrel, whereby the synthetic resin material present between the mandrel (35) and the hole walls (5) is partly displaced.

17. A device as claimed in Claim 10, characterized in that the passage in the bearing bridge (7c) has an elliptical profile perpendicularly to its longitudinal axis, in that the mandrel(s) (41) has (have) a correspondingly shaped elliptical profile, and in that the material of the bearing bridge (7c) can be lengthened between the mandrel(s) (41) and the hole walls (5) by partial displacement of the synthetic resin material through a rotating or reciprocating movement of the mandrel(s) (41).

18. A device as claimed in any one of the Claims 16 or 17, characterized in that the mandrel (35, 41) has a convex shape whose major diameter is situated approximately in the centre of the bearing bridge (7b, 7c), or in the central region of the bearing plate.

19. A device as claimed in Claim 10, characterized in that an insert mandrel (43) is already introduced into the central region of the bearing bridge (7d) during the manufacture of the bearing part by the (injection-) moulding technique, which insert mandrel has a constriction (43a) at least in the hole region, and in that the bearing bridge (7d) is widened through pulling-out of the insert mandrel (43) so that the passage originally occupied by the insert mandrel (43) is widened by a partial displacement of the synthetic resin material and the bearing bridge (7d) is lengthened.

20. A device as claimed in Claim 10, characterized in that a recess (47) enters the bearing bridge (7e) from one (11a) of the plate surfaces only, in that a support disc (49) covering the full cross-sectional area of the bearing bridge (7e) is present in the region of the other plate surface (11b), and in that a mandrel (31) is insertable into the recess (47) of the bearing bridge whereby the bearing bridge (7e) can



be stretched in longitudinal direction.

21. A device as claimed in Claim 20, characterized in that the bottom of the recess (47a) is provided approximately at the level of the second plate surface (11b) reached by the mandrel (51) upon its insertion.

5 22. A device as claimed in Claim 10, characterized in that a mandrel (53) can be moved against the passage (15) in the bearing part (1f), which mandrel in the direction towards its free end (53c) shows a transition from a portion of greater diameter than the passage (15) via a tapering portion (53a) into a portion of smaller diameter, and in that the portion of smaller diameter (53b) can be introduced into a
10 recess (19b) of a hold-down (19a) by means of which the bearing part (1f) can be supported against the application direction of the mandrel (53) for the displacement of the synthetic resin material in the direction of the hole walls (5).

23. A device as claimed in Claim 22, characterized in that the inner diameter of the hold-down (19a) and the outer diameter of the mandrel portion (53b) of smaller
15 diameter are so attuned to one another that the mandrel portion (53b) is guided in the hold-down (19a) during the deformation process.

24. A bearing part (1 to 7f) of a plain bearing for a movable functional part formed by a method or a device as claimed in any one of the Claims 1 to 23, whereby the bearing part (1 to 7f) and the movable functional part are formed integrally at a
20 metal bearing plate (11) by a synthetic-resin (injection-) moulding technique, and the bearing part comprises a bearing bridge (7 to 7f) which is passed through a hole (3) of the metal bearing plate (11) and retaining pieces (9) which bear on the two plate surfaces (11a, 11b) laterally of the hole (3), characterized in that the bearing bridge (7 to 7f) has a through passage (15) or at least a recess (23, 47) in its inner, central region
25 (15, 23, 47).

25. A bearing part of a plain bearing as claimed in Claim 24, characterized in that the bearing bridge (7, 7b, 7d, 7f) comprises the passage (15) with the passage wall (15c) in its inner, central region (15) and in through direction, and in that the passage (15) has a wall shape which bulges towards the centre of the passage with
30 smaller diameters thereof before entry of the mandrels (17, 51).

26. A bearing part of a plain bearing as claimed in Claim 25, characterized in that the wall bulge has its smallest passage diameter approximately half-way the passage length.



27. A bearing part as claimed in Claim 25, characterized in that the wall bulge towards the passage centre is achieved through the formation of saddle surfaces (15f).

28. A bearing part of a plain bearing as claimed in Claim 24, characterized in that the bearing bridge (7) comprises the passage (15) with the passage wall (15c) in its inner, central region (15) and in through direction, and in that the passage (15) has a wall shape which is parallel to the hole walls (5) before entry of the mandrels (33, 35).

29. A bearing part as claimed in Claim 25 or 26, characterized in that a slotted bush (29) is injection-moulded into the passage (15), which bush separates itself from the passage walls (15c) after widening of the bush.

30. A bearing part of a plain bearing as claimed in Claim 24, characterized in that a recess (47) enters the bearing bridge (7e) from one (11a) of the plate surfaces, and in that a support disc (49) covering the full cross-sectional area of the bearing bridge is present in the region of the other plate surface (11b).

31. A bearing part of a plain bearing as claimed in Claim 30, characterized in that the recess (47) extends from the one plate surface (11a) to approximately the plane of the other plate surface (11b).

32. A bearing part of a plain bearing as claimed in Claim 24, characterized in that two recesses (15d) are present, extending from the two plate surfaces (11a, 11b) into the hole (5).

33. A bearing part of a plain bearing as claimed in Claim 24, characterized in that at least the parts subjected to the deformation are made of POM (polyoxymethylene/polyacetal), or ABS (acrylonitrile-butadiene-styrol (copolymer)), or PA (polyamide), or HDPE (polythene), or PP (polypropylene).

34. A bearing part as claimed in Claim 33, characterized in that the synthetic resins are reinforced with fibres, such as glass or carbon fibres.

35. A bearing part as claimed in Claim 33 and/or 34, characterized in that the synthetic resins are provided with fillers.

