

PATENT SPECIFICATION

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- (21) Application No. 20220/77 (22) Filed 13 May 1977 (19)
(31) Convention Application No. 52/010 963
(32) Filed 2 Feb. 1977 in
(33) Japan (JP)
(44) Complete Specification published 11 Feb. 1981
(51) INT. CL.⁸ F16H 55/14 55/06 55/08
(52) Index at acceptance
F2Q 7H1 7H5C 7H5D



(54) IMPROVEMENTS RELATING TO GEARS

(71) I, MIKIHARU IMAZAIKE, a citizen of Japan, of 22, Tanabe Nishino-cho 8-chome, Higashi Sumiyoshi-ku, Osaka, Japan, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to gears and, more particularly, to improvements in teeth of gears generally made of plastics for use in such precision devices as timepieces, acoustic devices and the like.

Such plastic gears have been fabricated heretofore by means of injection moulding and, therefore, it has been unavoidable that such strains as eccentricities and the like have been caused to occur due to contractions at the time of the moulding, whereby contact noise has been unavoidably generated due to dimensional inaccuracy.

In mutual meshing of opposing gears, it is necessary that respective components of velocity in the direction of a common normal on the two opposing tooth surfaces at the portions of contact of the meshing gears are always equal to each other. In this case, deeming such gears respectively to be a rigid body, the two opposing surfaces keep in contact with each other while rotating at a predetermined angular velocity and without mutually caving in, or separating from each other. In other words, the gears are designed so that there will be no relative movement in the direction of the common normal between the two opposing surfaces at the moment of contact, but any existing relative movement will only be mutual sliding along a tangential plane at the contacting portions of the opposing surfaces. If the gears involve any eccentricity, pitch error or the like, their opposing tooth surfaces do not contact each other at their predetermined positions, whereby such problems as an interference of teeth, timing lag of contact and the like are caused to occur. When contact timing lag occurs, the number of contacting sets of gear teeth is varied resulting in load fluctuations at the contacting portions and, when the interference of teeth occurs too, similar load

fluctuations are caused, extreme ones of which will result in unfavorable vibratory motions or noise. The present invention has been suggested to successfully remove such problems as described by providing a means that allows the gear teeth to perform an elastic deformation when they contact with those of an opposing gear, according to which, even when the interference of teeth occurs, the tooth configuration deforms in response to any load increments at the contacting portion of each tooth so as to erase the interference and, in the event of an occurrence of the variation in the number of contacting sets, the deformation acts also to erase such variation responsive to the fluctuations in the load at the contacting portions, thereby any extreme load fluctuations can be effectively eliminated and contact noise is not generated.

The present invention provides a gear comprising a boss having a hole defining an axis of rotation for the gear, a disk-shaped body mounted on the boss and extending therearound, and a plurality of teeth each separated by an inter-tooth space which enables meshing engagement with a co-operating gear, either each of said teeth of the first mentioned gear having an aperture therethrough or a recess therein, the boundary of said aperture or recess being of a similar shape to the outer profile of said tooth, or the disk-shaped body being provided with a plurality of slits each of uniform width and each extending radially inwardly from the respective inter-tooth space, or both; the apertures, recesses or slits being provided to enable said teeth to yield resiliently during said meshing engagement.

The invention can be embodied to provide a gear which, in a gear set, does not make any contact noise when the teeth mesh. Such a gear can be easy to fabricate and is suitable for use in small precision devices such as timepieces.

Embodiments of the invention will now be described with reference to the accompanying drawings, in which:—

Figure 1A is a fragmentary perspective

view of a gear in an embodiment according to the present invention;

Fig. 1B is a fragmentary perspective view showing a modification of the embodiment shown in Fig. 1A;

Fig. 1C is a fragmentary sectioned view showing a further modification of the embodiment of Fig. 1A;

Fig. 2 is an explanatory view for contacting state of gear tooth in the embodiment of Fig. 1A with an opposing tooth of another gear;

Fig. 3A is a fragmentary perspective view showing another embodiment of the present invention;

Fig. 3B is a fragmentary perspective view showing a modification of the embodiment of Fig. 3A;

Fig. 3C is a fragmentary sectioned view of another modification of the embodiment of Fig. 3A; and

Figs. 4 and 5 show further various embodiments of the present invention respectively in the similar view to Fig. 1A or 3A.

While the present invention shall now be referred to with reference to the preferred embodiments shown in the drawings, it should be understood that the intention is not to limit the invention only to those embodiments but to rather include all other possible modifications, alterations and equivalent arrangements within the scope of appended claims.

Referring now to Fig. 1A showing an embodiment in the form of a spur gear, there is provided in the center of disk-shaped body 1 a boss 2 and an axial hole 3 is formed in the boss for inserting therein a shaft (now shown). On the peripheral edge of the body 1, a plurality of teeth 4 are formed at a predetermined pitch, of which outer surfaces 5 are made in a well-known tooth configuration. Inside the teeth 4, on the other hand, an aperture 6 is formed. Preferably, the shape of this aperture 6 is made to be substantially similar to the outer tooth configuration of the teeth 4 and bottom surface 7 of the respective apertures 6 is disposed substantially on the identical circumference to bottom edges 8 of the teeth 4. Thus, in the present embodiment, a thickness 9 of the respective teeth 4 defined by the outer surface 5 and aperture 6 similar to each other is uniform over all positions along the outer periphery of each tooth.

As fabricating material of this gear, preferably such plastics material as polyacetal, polyimide or the like is employed. As the apertures 6 are formed inside the teeth 4, in addition to mechanical characteristics of the plastic material employed, the teeth 4 are properly formed for providing an elastic deformation upon receiving an external force acting on the tooth surface, and the degree of this elastic deformation can be

made variable by means of proper selections of the tooth configuration, tooth thickness or dimensions of the aperture, fabricating material employed and the like.

As shown in Fig. 1B, it is possible to provide a slit 10 in the top part of each tooth 4 substantially in alignment with the center line thereof so that a larger elasticity or deformability will be provided as required. Further, the aperture 6 may be closed, as shown in Fig. 1C, by means of a film part 11 formed integral with the tooth 4 with the plastics material. In the illustrated case, the film part 11 is provided on one side surface of the tooth 4 as an example, but the film may be provided in the middle position of the aperture 6 if desired. With this modification, the elasticity of the teeth 4 may be somewhat restrained by the film part 11 so that a controlled deformability will be attained.

Referring next to Fig. 2 showing a contacting state of the gear tooth 4 in the embodiment of Fig. 1A with an opposing tooth 12 of another gear, the both gear teeth 4 and 12 contact with each other at a point 13 on their outer surfaces. When the force applied to the point 13 fluctuates due to a pitch fluctuation or the like of the teeth on either side of the gears, the tooth configuration of the tooth 4 having the aperture 6 will deform as shown by double-dotted chain lines depending on the amount of such fluctuation, which deformation acts to erase the fluctuation. Due to this action, any extreme fluctuations in the load on the respective teeth is cancelled so that a remarkably quiet contacting movement can be well performed. It should be readily appreciated that the gear according to the present invention may be employed either on the driving side, or on the driven side of a gear set, and even on both sides.

Fig. 3A shows another embodiment of the present invention in which the similar gear tooth configuration to that of Fig. 1A is employed in a crown gear. In the drawing, a disk-shaped body 22 is formed around an axial boss 21, a plurality of gear teeth 23 respectively projecting out of circumferential edge in parallel to the axial direction of the boss 21 and body 22 are provided at an equal pitch, and an aperture 24 is formed in each of the teeth 23. In the present instance, the shape of the aperture 24 is made to be similar to the outer surface configuration of the teeth 23 and the aperture 24 is opened on the side opposite to the teeth 23 as the most preferable structure, as in the case of the embodiment of Fig. 1A. It will be appreciated that, with this arrangement, the same operation and effects at those of the arrangement of Fig. 1A can be established.

As shown in Fig. 3B, the respective teeth 23 of the embodiment of Fig. 3A may be provided with a slit 25 at their top part so

that the slit 25 will be in alignment with projecting axis of each tooth 23. Alternatively, the aperture 24 may be closed by a thin film part 26, as shown in Fig. 3C, preferably formed on the side facing the boss 21 of the respective 23 and integrally therewith.

With reference to Fig. 4, a yet another embodiment of the present invention is referred to, in which a spur gear is formed by providing around an axial boss 71 a disk-shaped body 72 and a plurality of gear teeth 73 so as to extend radially from the circumferentially edge of the body. In the present embodiment, radial slits 74 are made in the disk-shaped body 72 so that the respective teeth 73 will be divided by the slits 74 from each other substantially at the center of their bottom parts. With such provision of the slits 74, the respective teeth 73 are provided with an elasticity because of their long extending base parts defined by the respective slits 74. It will be understood that the degree of such elasticity will be dependent on the length and width of the slits 74 which may be selectively determined separately or jointly in accordance with required elasticity.

The embodiment of Fig. 4 can be also applied to the crown gear as shown in Fig. 5. In this case, a disk-shaped body 28 formed around an axial boss 81 is provided with a plurality of gear teeth 83 respectively projecting in parallel directions to the axial line of the axial boss 81, respective base parts of which teeth connected to the body 82 are divided by a plurality of slits 84 radially extending in the body to pass substantially the center of the respective bottom parts of the teeth 83. Dimensions of the respective slits 84 will be also properly selected to provide to the teeth a desired degree of the elastic deformability, as in the case of Fig. 4.

It will be appreciated that, while the present invention has been described only with reference to the illustrated embodiments, the respective types of the means for yielding the elastic deformation of the gear teeth may be properly used as selectively combined with one another in certain ways such as, for example, combinations of the means of Fig. 1A with those of Fig. 4; or the means of Fig. 1B with those of Fig. 4; or the means of Fig. 3B with those of Fig. 5.

WHAT WE CLAIM IS:—

1. A gear comprising a boss having a hole defining an axis of rotation for the gear, a

disk-shaped body mounted on the boss and extending therearound, and a plurality of teeth each separated by an inter-tooth space which enables meshing engagement with a co-operating gear, either each of said teeth of the first mentioned gear having an aperture therethrough or a recess therein, the boundary of the respective aperture or recess being of a similar shape to the outer profile of said tooth, or the disk-shaped body being provided with a plurality of slits each of uniform width and each extending radially inwardly from the respective inter-tooth space, or both; the apertures, recesses or slits being provided to enable said teeth to yield resiliently during said meshing engagement

2. A gear according to claim 1 wherein each tooth of said first gear is provided with said recess, the recess extending into said tooth and being closed by web formed integrally with said tooth.

3. A gear according to any of claims 1 or 2 wherein each tooth of said first gear is provided with a slit which extends inwardly of said tooth from its tip.

4. A gear according to any one of the preceding claims which is a spur gear.

5. A gear according to any one of the preceding claims which is a crown gear.

6. A gear substantially as herein described with reference to Fig. 1A of the accompanying drawings.

7. A gear substantially as herein described with reference to Fig. 1B of the accompanying drawings.

8. A gear substantially as herein described with reference to Fig. 1C of the accompanying drawings.

9. A gear substantially as herein described with reference to Fig. 3A of the accompanying drawings.

10. A gear substantially as herein described with reference to Fig. 3B of the accompanying drawings.

11. A gear substantially as herein described with reference to Fig. 3C of the accompanying drawings.

12. A gear substantially as herein described with reference to Fig. 4 of the accompanying drawings.

13. A gear substantially as herein described with reference to Fig. 5 of the accompanying drawings.

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that the slit 25 will be in alignment with projecting axis of each tooth 23. Alternatively, the aperture 24 may be closed by a thin film part 26, as shown in Fig. 3C, preferably formed on the side facing the boss 21 of the respective 23 and integrally therewith.

With reference to Fig. 4, a yet another embodiment of the present invention is referred to, in which a spur gear is formed by providing around an axial boss 71 a disk-shaped body 72 and a plurality of gear teeth 73 so as to extend radially from the circumferentially edge of the body. In the present embodiment, radial slits 74 are made in the disk-shaped body 72 so that the respective teeth 73 will be divided by the slits 74 from each other substantially at the center of their bottom parts. With such provision of the slits 74, the respective teeth 73 are provided with an elasticity because of their long extending base parts defined by the respective slits 74. It will be understood that the degree of such elasticity will be dependent on the length and width of the slits 74 which may be selectively determined separately or jointly in accordance with required elasticity.

The embodiment of Fig. 4 can be also applied to the crown gear as shown in Fig. 5. In this case, a disk-shaped body 28 formed around an axial boss 81 is provided with a plurality of gear teeth 83 respectively projecting in parallel directions to the axial line of the axial boss 81, respective base parts of which teeth connected to the body 82 are divided by a plurality of slits 84 radially extending in the body to pass substantially the center of the respective bottom parts of the teeth 83. Dimensions of the respective slits 84 will be also properly selected to provide to the teeth a desired degree of the elastic deformability, as in the case of Fig. 4.

It will be appreciated that, while the present invention has been described only with reference to the illustrated embodiments, the respective types of the means for yielding the elastic deformation of the gear teeth may be properly used as selectively combined with one another in certain ways such as, for example, combinations of the means of Fig. 1A with those of Fig. 4; or the means of Fig. 1B with those of Fig. 4; or the means of Fig. 3B with those of Fig. 5.

WHAT WE CLAIM IS:—

1. A gear comprising a boss having a hole defining an axis of rotation for the gear, a

disk-shaped body mounted on the boss and extending therearound, and a plurality of teeth each separated by an inter-tooth space which enables meshing engagement with a co-operating gear, either each of said teeth of the first mentioned gear having an aperture therethrough or a recess therein, the boundary of the respective aperture or recess being of a similar shape to the outer profile of said tooth, or the disk-shaped body being provided with a plurality of slits each of uniform width and each extending radially inwardly from the respective inter-tooth space, or both; the apertures, recesses or slits being provided to enable said teeth to yield resiliently during said meshing engagement

2. A gear according to claim 1 wherein each tooth of said first gear is provided with said recess, the recess extending into said tooth and being closed by web formed integrally with said tooth.

3. A gear according to any of claims 1 or 2 wherein each tooth of said first gear is provided with a slit which extends inwardly of said tooth from its tip.

4. A gear according to any one of the preceding claims which is a spur gear.

5. A gear according to any one of the preceding claims which is a crown gear.

6. A gear substantially as herein described with reference to Fig. 1A of the accompanying drawings.

7. A gear substantially as herein described with reference to Fig. 1B of the accompanying drawings.

8. A gear substantially as herein described with reference to Fig. 1C of the accompanying drawings.

9. A gear substantially as herein described with reference to Fig. 3A of the accompanying drawings.

10. A gear substantially as herein described with reference to Fig. 3B of the accompanying drawings.

11. A gear substantially as herein described with reference to Fig. 3C of the accompanying drawings.

12. A gear substantially as herein described with reference to Fig. 4 of the accompanying drawings.

13. A gear substantially as herein described with reference to Fig. 5 of the accompanying drawings.

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