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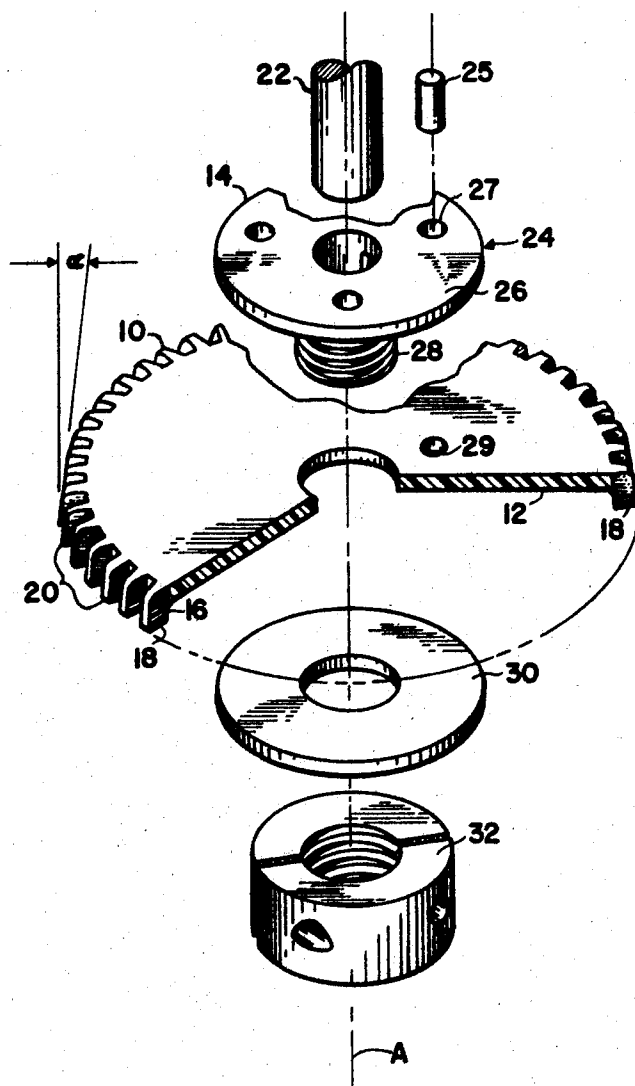
3,472,092

ANTIBACKLASH GEAR

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4 Sheets-Sheet 1

FIG. 1



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4 Sheets-Sheet 2

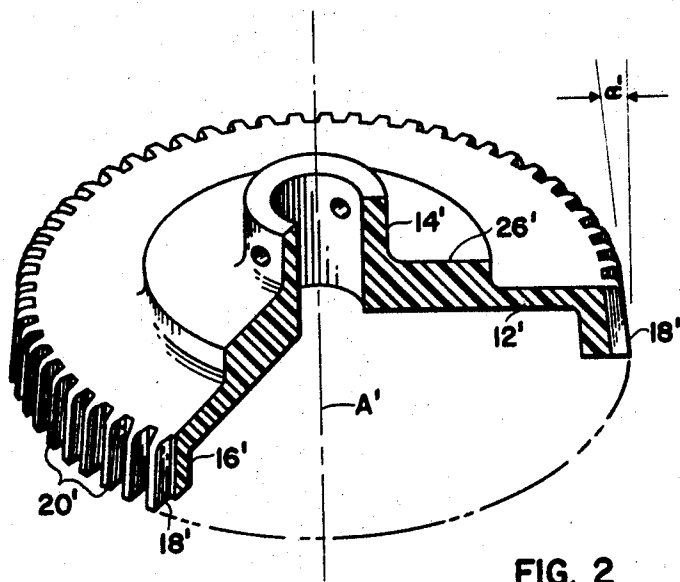


FIG. 2

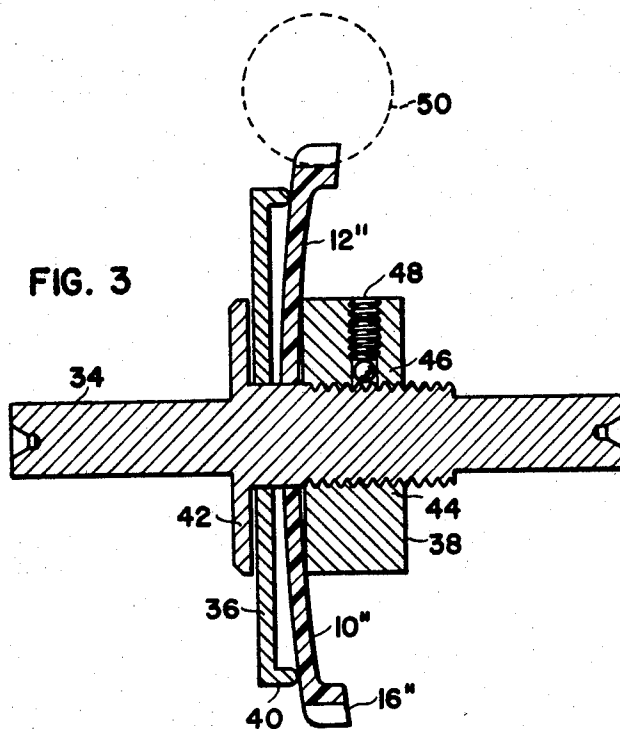


FIG. 3

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4 Sheets-Sheet 3

FIG. 4

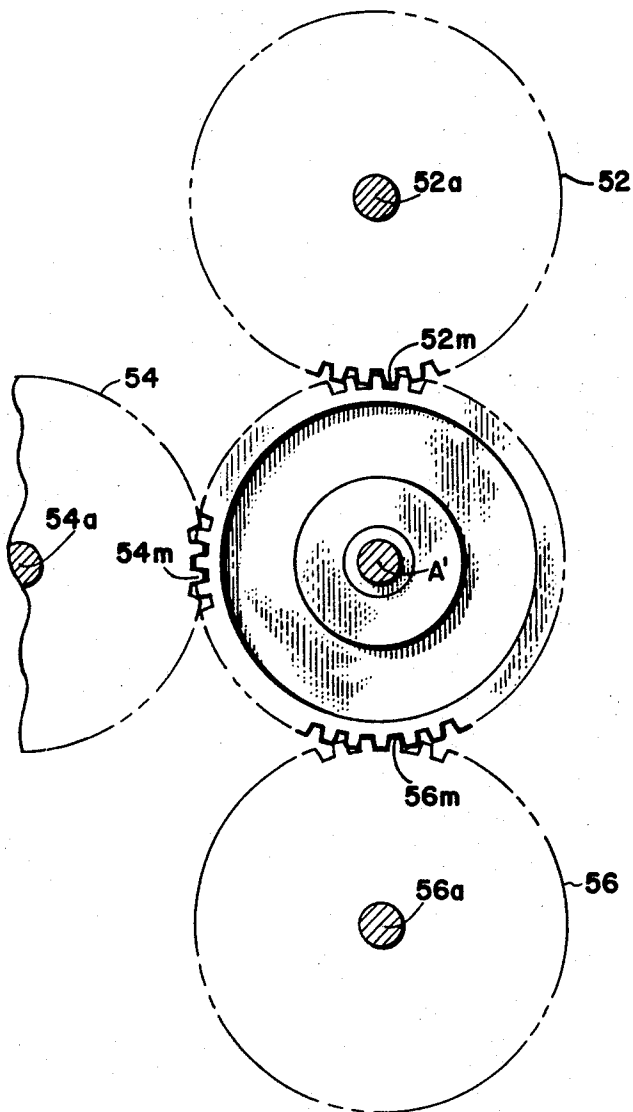
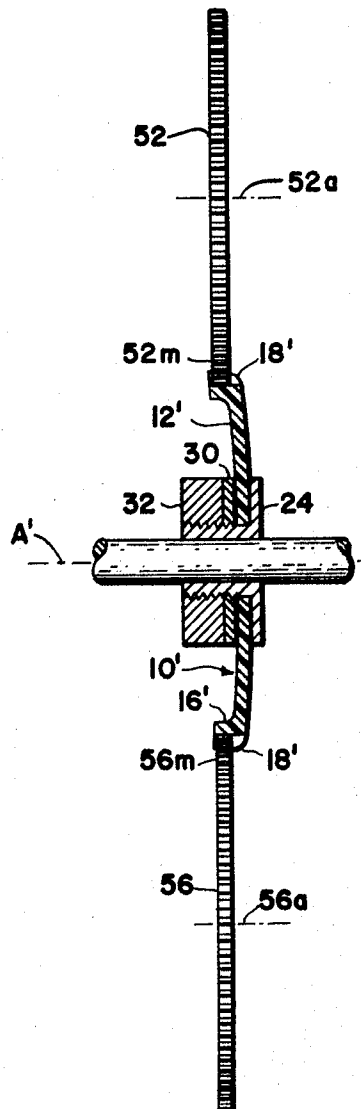


FIG. 5



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4 Sheets-Sheet 4

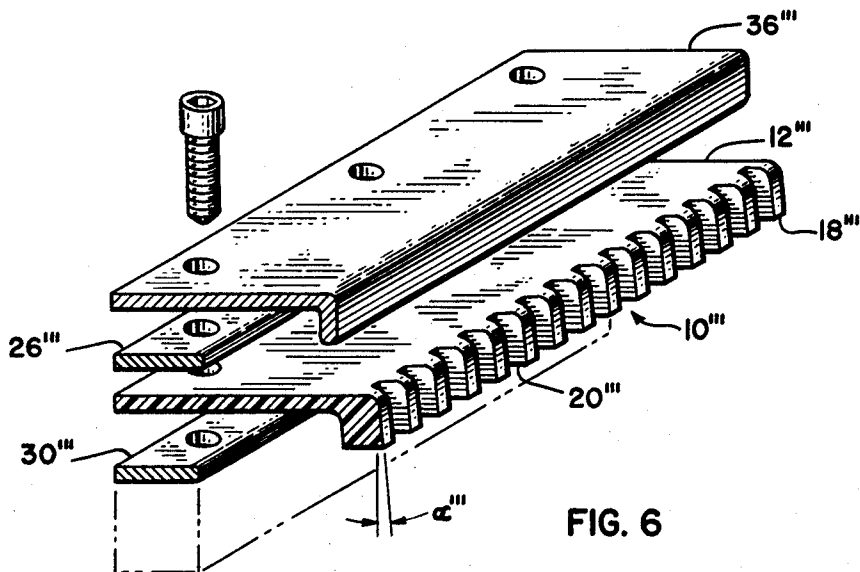


FIG. 6

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1

3,472,092

ANTIBACKLASH GEAR

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6 Claims

ABSTRACT OF THE DISCLOSURE

An antibacklash gear and method of making same wherein said gear has a resilient rim joined to a resilient web, which rim and web are deflected and stressed during meshing with another gear and impart a spring action to the teeth in mesh, urging them into tighter meshing engagement for minimizing backlash.

BACKGROUND OF THE INVENTION

The present invention relates to gearing and, more particularly, to a gearing system which employs a gear of novel formation for eliminating or minimizing backlash, and to a method of fabricating such a gear.

Various solutions have been proposed in efforts to minimize or eliminate lost motion in gearing to solve the problem of backlash. For example, Hotine in Patent No. 2,764,034 utilizes gears having skewed teeth which are undercut and individually deformable, Hetzel in Patent No. 2,845,809 and Michaelec in Patent No. 3,174,356 employ spring-loaded gears, Visser in Patent No. 3,122,938 makes use of a deformable flexible web interconnecting a rigid hub and a rigid rim having rigid teeth, and McDougal in Patent No. 3,213,704 features a frusto-conical or dished gear of thin resilient sheet material having flat involute teeth around its periphery which are distorted and flexed radially by pressure of engagement with the teeth of another gear. Although each of these arrangements has made its contribution to the advance of the gearing art, there is still the reliance upon such things, for example, as skewed teeth and torsional loading, with their detrimental effect upon the torque-transmitting capability and wear life of the gearing system, and limitations in the application of the arrangements to thin material or to configurations which do not lend themselves to fabrication by conventional gear cutting techniques.

SUMMARY OF THE INVENTION

The antibacklash gear according to this invention utilizes resilient material which imparts a spring action at the gear mesh to control backlash. In one embodiment of this invention, a web of resilient material integrally connects a hub and an annular rim, the outer periphery of the latter being frusto-conical and provided with gear teeth adapted to cooperate with adjacent gears in such a manner that, when meshed, the rim and web are resiliently deformed at the point of intermeshing. Means are provided in the form of control discs, which may be either separate, washerlike discs, or which may form part of the gear hub, functioning in either case to control the stiffness of the web. The degree of angle cut into the face of the gear blank, the web thickness, the length of the unrestricted expanse of the web and the material selected contribute to the antibacklash and functioning capability of gearing according to the invention.

The principle of the invention in another embodiment thereof is incorporated into a rack type gear wherein the rim and gear teeth are formed obliquely to the plane of the web to mesh with a pinion and function in a manner analogous to that described above with respect to rotary gearing. In the rack embodiment the web control

2

members are in the form of clamp plates and/or part of the structure holding the rack, and the clamp plates may be formed integrally with the web.

In performing one method of this invention, the antibacklash gear is formed by providing a gear blank having a relatively thin web and an outer rim or edge with a frusto-conical form. In the case of the rotary gear, the web is deflected axially by a suitable means such as a flanged disclike member and, when in its deflected convex position, is cut by a suitable hobbing tool. When the flanged fixture is removed, the now hobbled gear returns to its original disclike shape with a frusto-conical gear formed on the outer periphery of the rim. The rack is cut in an analogous manner.

Another method of this invention comprises placing the flat or planar gear blank on a suitable holder, omitting the deflecting member and cutting the teeth at the angle of the rim or flange of the gear blank. This eliminates the requirement for deflecting the web. The rack may be formed in this manner also.

It is, therefore, an object of the present invention to provide antibacklash gearing which has both torque-transmitting capability and insensitivity to wear.

Another object is the provision of antibacklash gearing which controls backlash within broad limits of fabrication and assembly tolerance accumulations, wear, thermal variations, and other conditions affecting dimensions.

A further object is the provision of antibacklash gearing which is simple in form and which can be fabricated in an easy and economical manner using normal hobbing or other procedures.

A still further object is to provide a method by which an antibacklash gear of unique form is fabricated by conventional hobbing techniques.

Other objects, advantages, and features of the present invention will become more readily apparent from consideration of the following detailed description in connection with the accompanying drawings wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a perspective exploded view of one embodiment of the antibacklash gear of the present invention, partly in section and with parts broken away;

FIGURE 2 is a perspective view in partial section of another embodiment of the antibacklash gear of the present invention in which an attaching hub is integrally formed;

FIGURE 3 is a cross sectional view of a gear blank mounted in a hobbing fixture, from which blank the gear of FIGURE 1 is formed;

FIGURE 4 is a schematic elevational view of a planetary gear system employing the antibacklash gear of the present invention;

FIGURE 5 is a sectional view taken generally along line 5—5 of FIGURE 4; and

FIGURE 6 is an exploded perspective view showing the invention applied to an antibacklash rack and showing the deflection members used in cutting the gear teeth.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, wherein like reference characters designate like or corresponding parts, there is shown in FIGURE 1 an embodiment of the present invention in a gear designated by reference numeral 10 and comprising a resilient web 12, a resilient frusto-conical annular rim 16 having gear teeth 18 with edges 20 disposed at an angle α to the axis A of gear 10. Web 12 is formed integrally with one edge of the inner periphery of rim 16, either the web or the rim, or both, being deformable to dispose edges 20 of teeth 18 in a substantially cylindrical surface when meshed. Web 12 may be at-

tached to a shaft 22 by means of a partially split hub 24, suitably attached to and fixed upon the shaft, hub 24 having a flange 26 to which the gear is keyed by a pin 25, which passes through holes 27 and 29 in the flange 26 and web 12, respectively. A threaded, split sleeve 28 is engaged by a hub clamp or pressure nut 32 and contracted to lock the assembly in position on the shaft. Both the flange 26 and control disc 30 function to control the stiffness of the web 12 during the operation of the gear 10.

FIGURE 2 shows a form of the antibacklash gear designated in its entirety by reference numeral 10' and comprising a resilient web 12', and attaching hub 14' and a resilient annular rim 16' on which the gear teeth 18' are formed. Like the embodiment shown in FIGURE 1, the rim 16' is frusto-conical in configuration, the teeth 18' having outer edges 20' which lie in the original frusto-conical surface of the outer periphery of the rim of the gear blank, and which are disposed at an angle α' with respect to the axis A' of the gear 10'. Web 12' is formed integrally with the inner periphery of the rim 16' at one edge thereof, and like the embodiment shown in FIGURE 1, the web 12' is adapted to deflect so that the teeth when meshed, are disposed generally parallel to the axis A' and lie in a substantially cylindrical surface. In this embodiment no further description is deemed necessary, since parts or portions of the invention are given like reference numerals when they perform the same function. Thus, the flange 26', while actually an integral part of the gear structure, performs the same function, in controlling the resiliency of the web 12, as does the separate flange 26 in the embodiment of FIGURE 1.

Turning now to FIGURE 3, there is shown a gear blank 10'' from which a gear similar to gear 10 of FIGURE 1 is fabricated. Blank 10'' has a resilient web 12'' and a resilient annular rim 16'' which is ordinarily frusto-conical but for hobbing is deformed into a substantially cylindrical configuration. This deformation is accomplished by mounting blank 10'' on an arbor 34 and applying pressure to the blank through a substantially rigid deflection disc 36 and a pressure nut 38, the disc being formed with an annular flange 40 which bears against web 12'' adjacent the annular rim, the pressure nut 38 pressing the central portion of the web. As seen in FIGURE 3, disc 36 is held in place by a flange 42 on the arbor and nut 38 is threaded to the arbor, as at 44; a nylon ball 46 and set screw 48 serving to lock the nut in any desired position of adjustment.

To prepare blank 10'' for cutting gear teeth in rim 16'', nut 38 is drawn up to disc 36 until web 12'' has been bent or bowed by the annular flange 40 to dispose the outer periphery of the rim parallel to the axis A'' of the arbor 34, and the nut is locked in this position of adjustment. The blank is then properly related to gear tooth cutter, such as a hob indicated at 50, for cutting gear teeth, spur, helical, worm, bevel and other types, in the rim in a rapid and conventional manner well known in the art. It will be appreciated that after cutting of the gear teeth and removal of the resulting gear from the arbor, the web and rim will flex back and the gear will assume the shape of gear 10 in FIGURE 1.

FIGURE 4 schematically shows a gear system employing the antibacklash gear 10 of FIGURE 1 in interfering mesh with a plurality of conventional gears 52, 54 and 56. The axis of rotation A of gear 10' is so-disposed relative to the respective axes 52a, 54a, and 56a of gears 52, 54, and 56 that in the areas where the teeth of gear 10 are in meshing engagement with the teeth of the other gears the portion of rim 16 and adjacent area of web 12 are flexed and deformed by this interfering mesh so that the outer edges of the teeth in the meshing areas are disposed generally parallel and lie in a substantially cylindrical surface (FIGURE 5). The meshing areas are generally indicated by shading and are designated by reference numerals 52m, 54m, and 56m. It will be appreciated

that the outer edges of the teeth of gear 10 outside the aforementioned meshing areas are disposed in the original frustoconical surface of the outer periphery of rim 16 in its unflexed or nondeformed shape. Thus, flexing the rim and the web at the meshing areas introduces loading which urges the gear teeth 18 of gear 10 into tighter meshing engagement with the teeth of the other gears, thereby taking up any lost motion and eliminating backlash.

Turning now to FIGURE 6 of the drawings, there is disclosed a rack type gear, indicated in its entirety by 10''' and having, like the rotary gears previously described, a web 12''', integral with a flange or rim 18''', and teeth 20''' which are formed at an angle α''' from the normal to the plane of the web. Suitable control plates 26''' and 30''', shown separated from the web, may be utilized as desired in service to control the resiliency of the web in a manner similar to that described in connection with the control flange 26 and control disc 30 in the previous figures. Instead of being separate as shown, either or both of plates 26''' and 30''' may be an integral part of the web 12'''. While the rack 10''' is being hobbled, the deflection plate 36''' functions to deflect the blank in a manner similar to that described in connection with the deflection disc 36 of FIGURE 3. The deflecting plate 36''', normally omitted when the rack is in service, may be used in service to provide adjustability, with or without plate 26''' as a shim, to vary the deflection of web 12''' and thus vary the meshing characteristics. (It should be noted that, similarly, in the rotary gearing of FIGURES 1 and 3, a deflecting disc like disc 36 can be used in service to change the angle α and adjust the meshing characteristics.) This rack type gearing is suitable for use with a conventional pinion, and the antibacklash feature of the invention functions in a manner similar to that described above in connection with rotary gearing.

It is therefore seen that the basic feature of the antibacklash gearing of the present invention is the utilization of a resilient material which imparts a spring action at the gear mesh. The degree of angle cut into the gear blank face and/or the hobbing attitude of the blank, the rim thickness, the web thickness, the length of the lever arm, that is, the unrestricted expanse of the web, and the material selected all contribute to the antibacklash capability. In one case, a gear made in accordance with the invention, using an acetal resin structural plastic as the material, was run over 11,000,000 revolutions without noticeable wear, but still retained its antibacklash capability. This gear as assembled in the test gear system employed normal center-to-center distance dimensions for meshing as a standard gear and was fabricated to the standards of the American Gear Manufacturers Association.

The operation of the antibacklash gear construction of this invention should be apparent from the foregoing description. However, briefly and in summary, the antibacklash gear (or rack) is placed in interfering mesh with other gears so that the rim portion and adjacent web area of the teeth of the antibacklash gear in mesh are deformed and stressed so as to urge such teeth into tighter engagement with the teeth of the other gears to take up lost motion and eliminate backlash.

Although the antibacklash gear of the present invention has been schematically shown in FIGURE 4 as associated with three other gears, it is understood, of course, that it could be used with a greater number or with only one gear. Also, the principles of the invention permit the type of gear teeth to be varied for different applications to provide, of course, a rack, a spur gear, a bevel gear, a helical gear, a worm gear, and other types of gears as necessary.

There has thus been provided an antibacklash gear which by its inherent spring action urges the gear teeth

5

into tighter meshing engagement for taking up lost motion and eliminating backlash. Obviously, many modifications and variations of the invention are possible in the light of the above teachings. It is, therefore, to be understood that this invention is not limited to the specific embodiments illustrated and described but may be varied within the scope and spirit of the invention.

We claim:

1. An antibacklash gear comprising, in combination: a resilient connecting web; and
a resilient rim having an inner edge to which said web is connected and an outer edge defined by an inclined surface having gear teeth formed therein.
2. An antibacklash gear comprising, in combination: a resilient connecting web; and
a resilient rim having an inner periphery, to one edge of which said web is connected, and an outer periphery defined by a frusto-conical surface having gear teeth formed therein.
3. The antibacklash gear as defined in claim 2, wherein: said gear teeth are radially disposed equidistantly from a central axis and are adapted to mesh with the gear teeth of another gear having a central axis parallel to said first-named axis and spaced therefrom a distance such that said rim in the area of said meshing teeth is deformed, so that the outer edges of said first-named gear teeth completely in meshing engagement generate a substantially cylindrical surface, said deformation of said rim flexing the adjacent portion of said web into a stressed condition which urges said first-named gear teeth into tighter meshing engagement with the gear teeth of the other gear.

6

4. The antibacklash gear as defined in claim 2 wherein: said web comprises a relatively thin disclike plate having a central axis, said web being adapted to bending action.
5. An antibacklash gear according to claim 1, for linear relative motion between it and a rotary gear, in which said gear teeth when disengaged are generally disposed at the angle of the inclined surface but when in mesh are disposed generally parallel to the axis of rotation of the gear with which they mesh.
6. A method of fabricating an antibacklash gear for mesh at a pitch surface tangent to a cylinder, comprising the steps of:
preparing a gear blank having a resilient web provided with a rim extending from the web at an angle of projection inclined to the plane of the web, said rim having an outer surface disposed at said angle of projection;
deflecting said resilient web to where said outer surface is substantially perpendicular to said web when not deflected; and
cutting teeth in said outer surface.

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29—159.2; 74—411; 90—9