Aug. 20, 1968 F. D. KNOBLOCK 3,397,593

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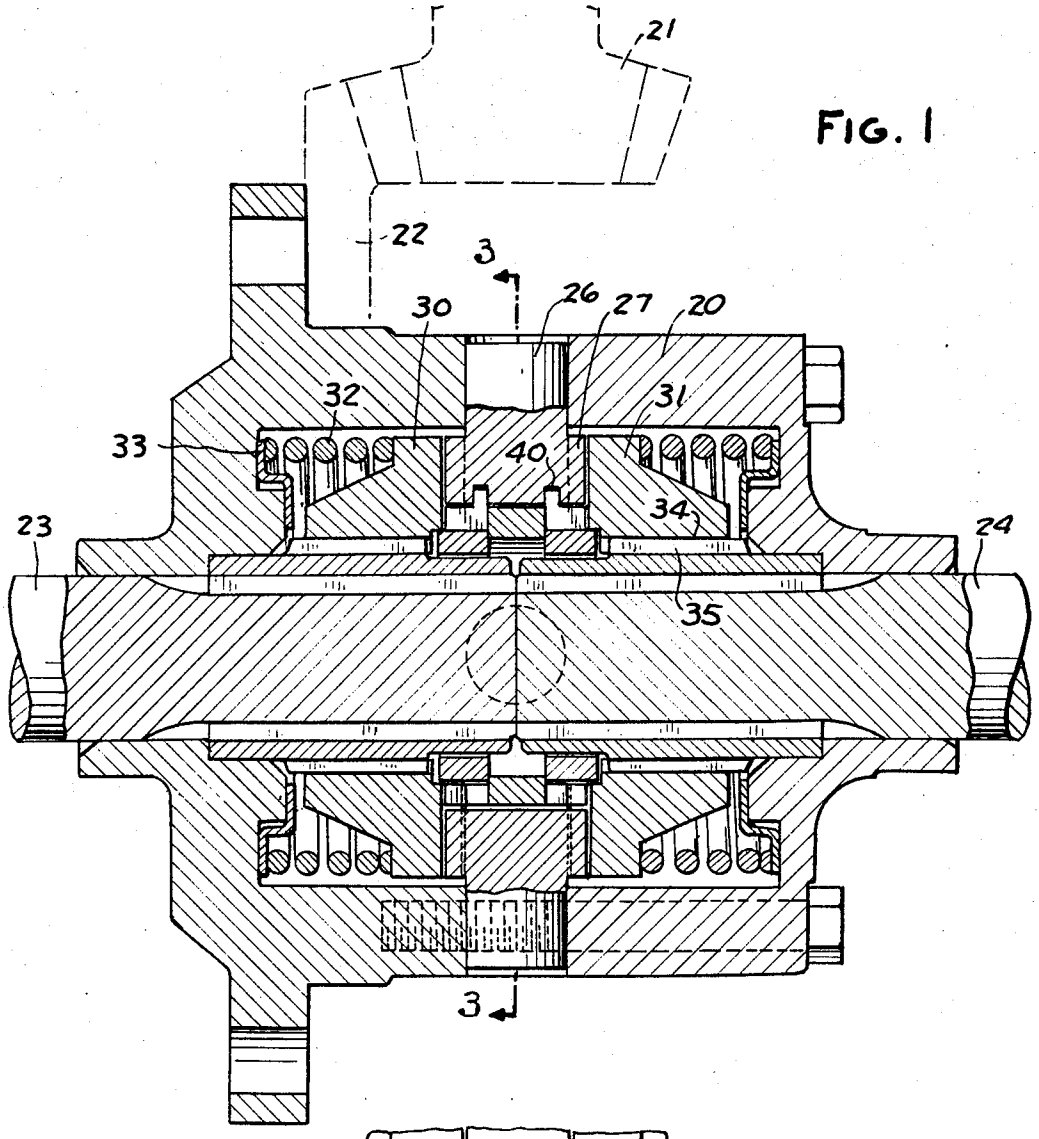


FIG. 1

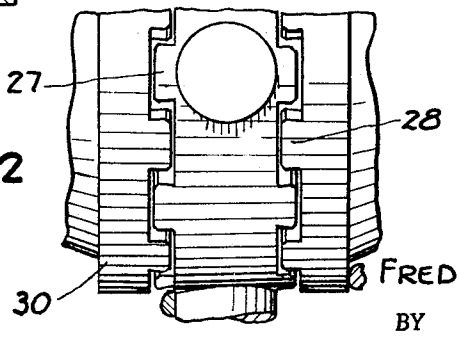


FIG. 2

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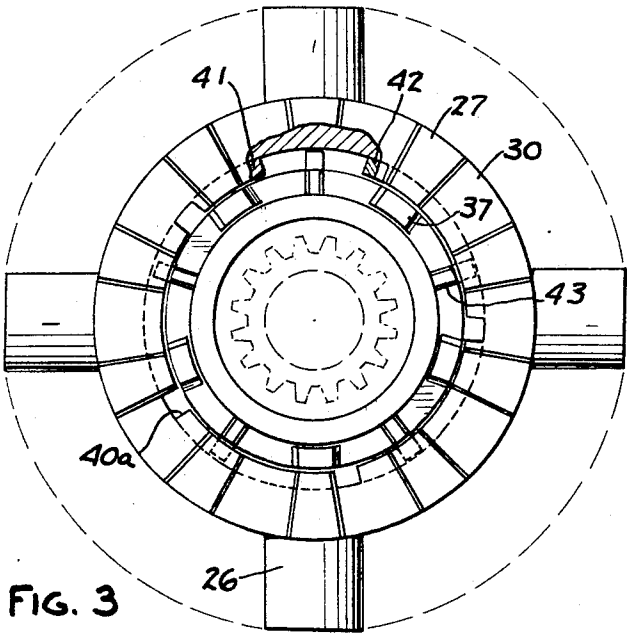


FIG. 3

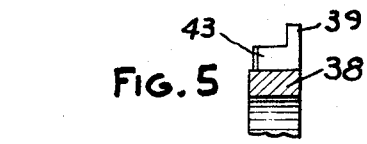


FIG. 5

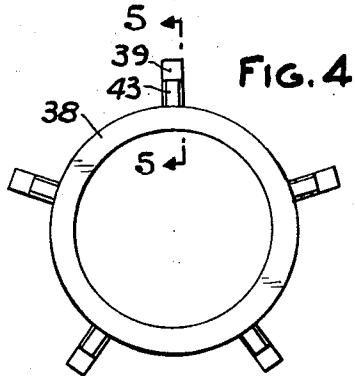


FIG. 4

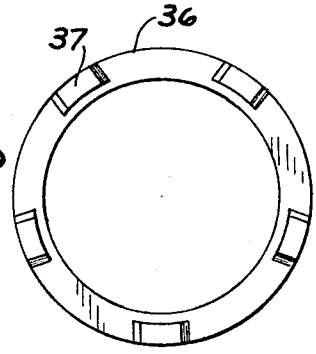


FIG. 6

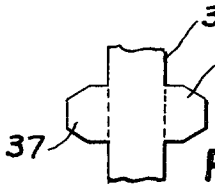


FIG. 7

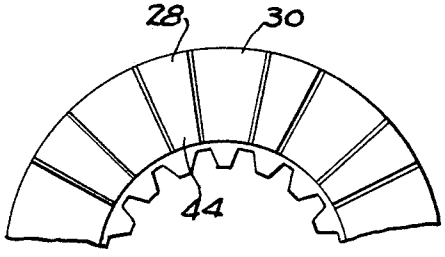


FIG. 8

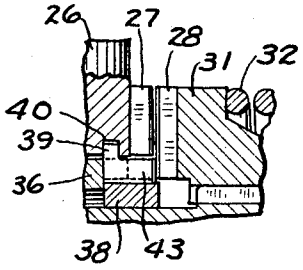


FIG. 9

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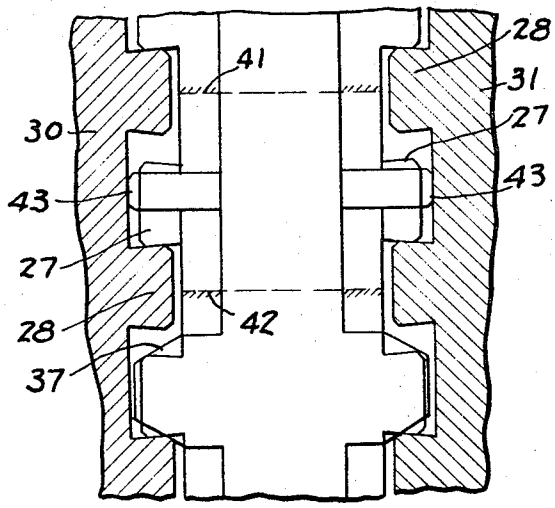


FIG. 10

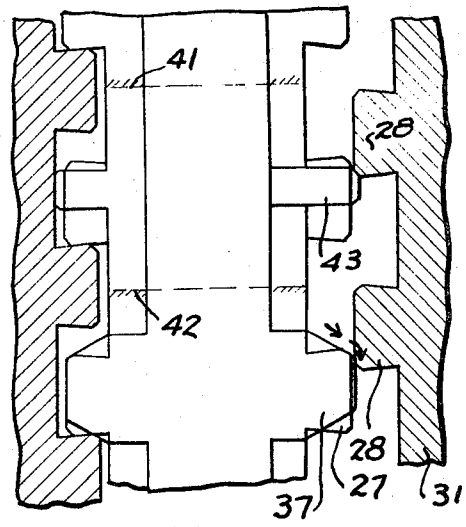


FIG. 11

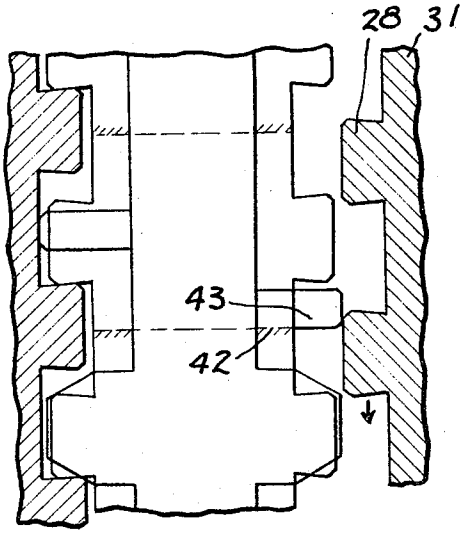


FIG. 12

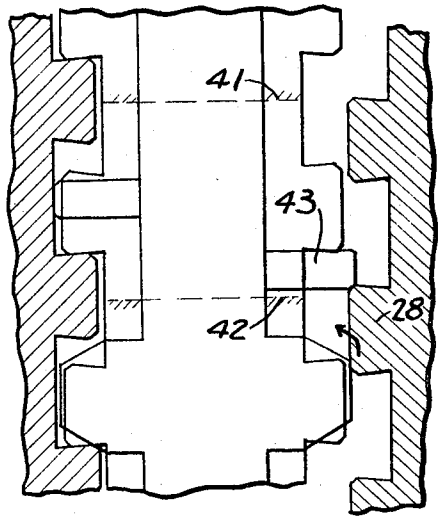


FIG. 13

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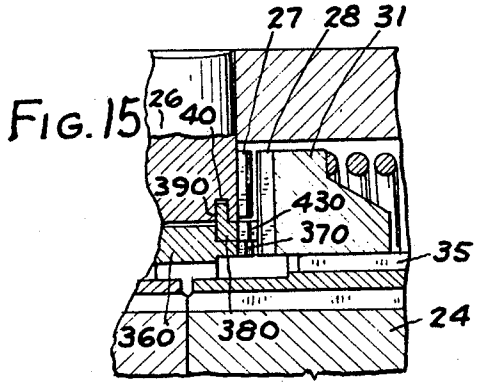


FIG. 15

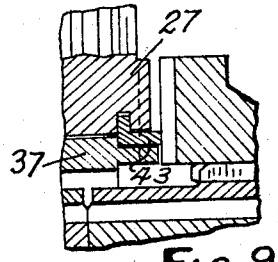


FIG. 9A

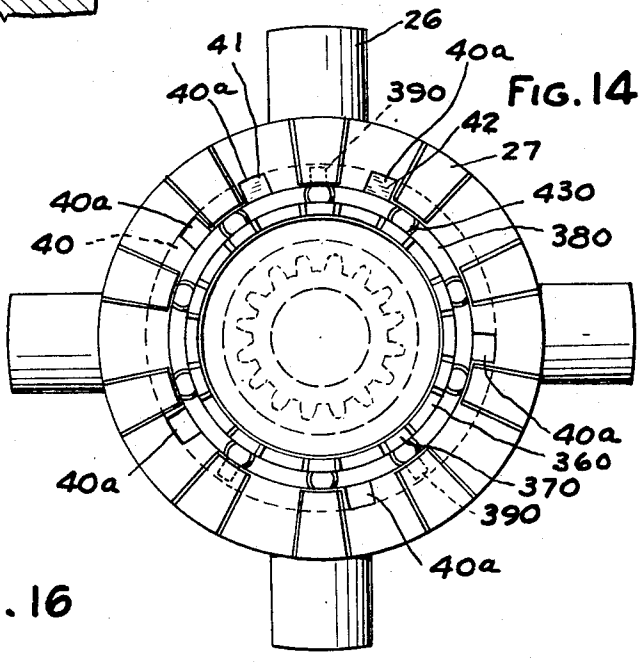


FIG. 14

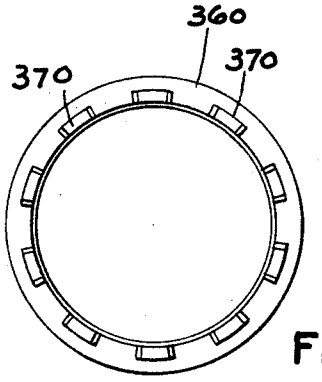


FIG. 16

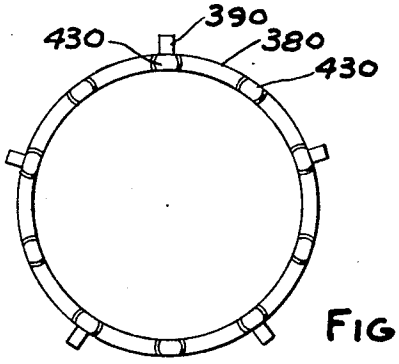


FIG. 17

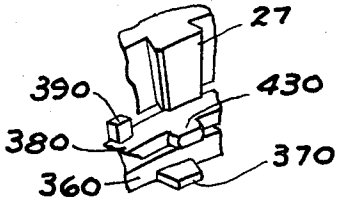


FIG. 18

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3,397,593

DIFFERENTIAL

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Continuation-in-part of application Ser. No. 468,717, July 1, 1965. This application Apr. 19, 1966, Ser. No. 543,611

17 Claims. (Cl. 74—650)

ABSTRACT OF THE DISCLOSURE

The differential disclosed herein comprises a driving member and a pair of driven members yieldingly urged together. A center cam is rotatably mounted in the driving member and has circumferentially spaced teeth aligned in one position of the center cam with at least some of the teeth of the driving member. A pair of control cams are rotatably mounted in the driving member and have circumferentially spaced teeth aligned in one position with at least some of the teeth of the driving member. Stop means are provided on the driving member for limiting the rotating movement of each control cam.

This invention is a continuation-in-part of my copending application Ser. No. 468,717, filed July 1, 1965.

This invention relates to differentials and particularly to differentials utilizing interengaging teeth between the driving and the driven members.

The objects of this invention are to provide a differential which is quiet, cheaper to manufacture, less likely to wear, and foolproof as contrasted to prior differentials of this type.

In the drawings:

FIG. 1 is a sectional view through a differential embodying the invention.

FIG. 2 is a side elevational view of a portion of the differential shown in FIG. 1, parts being broken away.

FIG. 3 is a sectional view taken along the line 3—3 in FIG. 1.

FIG. 4 is a plan view of a control cam utilized in the differential.

FIG. 5 is a fragmentary sectional view taken along the line 5—5 in FIG. 4.

FIG. 6 is a plan view of a center cam utilized in the differential.

FIG. 7 is a fragmentary view taken in the direction of the arrow in FIG. 6.

FIG. 8 is a fragmentary plan view of a driven member utilized in the differential.

FIG. 9 is a fragmentary sectional view of a portion of the differential shown in FIG. 1.

FIG. 9*a* is a fragmentary sectional view similar to FIG. 9 showing some of the parts in further section.

FIGS. 10–13 are fragmentary developed end views showing the relative positions of the parts during operation of the differential.

FIG. 14 is a sectional view similar to FIG. 3 of a modified form of the invention.

FIG. 15 is a fragmentary sectional view of a portion of the differential shown in FIG. 14.

FIG. 16 is a plan view of a center cam utilized in the differential shown in FIGS. 14 and 15.

FIG. 17 is a plan view of a control cam utilized in the differential shown in FIGS. 14 and 15.

FIG. 18 is a fragmentary perspective view showing the relative positions of the driving clutch teeth, control cam and center cam in operating condition of the differential.

Referring to FIG. 1, the differential embodying the invention comprises a separable housing **20** which is adapted to be driven by a bevel gear **21** that meshes with a ring gear **22** fixed to the housing **20**. Rotation of the

housing **20** is adapted to drive the axles **23**, **24** as presently described. A driving member **26** in the form of a spider is mounted in the housing **20** for rotation with the housing. The spider is provided with an annular series of circumferentially spaced teeth **27** on each side thereof which are adapted to engage corresponding teeth **28** on driven members **30**, **31**.

Each of the driven members **30**, **31** is yieldingly urged into position to engage the teeth **28** with the teeth **27** of the driving member **26** by a coil spring **32** which is interposed between a shoulder on the driven members **30**, **31** and a retainer **33**. Each of the driven members **30**, **31** is formed with a spline **34** that meshes with a complementary spline **35** on the shafts **23**, **24**, respectively.

In operation, when the wheel on one of the axles **23**, **24** overruns, the corresponding driven member moves axially out of engagement with the driving member.

Referring to FIGS. 6 and 7, a center cam ring **36** having circumferentially spaced teeth **37** on each side thereon is rotatably mounted within the driving member **26**. The teeth **37** are radially aligned, in one position, with alternate teeth **28** of an adjacent driven member **30**, **31**. Center cam **36** is held in position axially within driving member **26** by control cams **38** on each side of the center cam **36**. As shown in FIG. 4, each control cam **38** is formed with circumferentially spaced fingers **39** which extend into an annular groove **40** in the driving member **26** (FIGS. 1, 9) to axially retain the center cam ring **36** in position and, at the same time, axially retain the control cams **38** in position. The control cams **38** are inserted by aligning the fingers **39** of each control cam with slots **40***a* (FIGS. 3 and 4) in the driving member **26** and rotating the control cam **38** to move the fingers **39** into the groove **40**. Slots **40***a* are so located in driving member **26** that two adjacent slots **40***a* receive and retain keys **41**, **42**. These keys **41**, **42** retain the cam rings **38** in position and limit their circumferential movement for reasons presently described.

As shown in FIGS. 4 and 5, each of the control cams **38** is formed with circumferentially spaced teeth **43** along each finger **39** so that when the control cam **38** is in one position, the teeth **43** are interposed circumferentially between the adjacent teeth **37** on the center cam **36** and lie substantially in the same plane. In FIG. 3 the teeth **43** are shown aligned with alternate teeth **27** on driving member **26** while the other teeth **27** are aligned with the teeth **37** on center cam ring **36**.

As shown in FIG. 8, the teeth **28** on each driven member **30** or **31** extend radially such that the innermost portions or radial extensions **44** thereof intermesh between the cam teeth **37** and **43**. As shown in FIG. 7, the teeth **37** of the center cam **36** have inclined sides. The teeth **27**, **28** and **43** have beveled edges.

Referring to FIGS. 10–13, in normal operation, for example, when a vehicle utilizing the differential is moving in a straight line, the teeth **27** of the driving member **26** are engaged with the teeth **28** on both of the driven members **30**, **31**. However, when one of the driven members **31** overruns, for example, when the vehicle is driving around a corner, the member **31** on the outside wheel (FIG. 11) moves ahead of the driving member **26** and some of the teeth **28** engage the inclined sides of the teeth **37** on the center cam **36**. As the driven member **31** further overruns the driving member **26**, the driven member **31** is cammed outwardly by the inclined sides of the teeth **37** to a position where the teeth **28** overrun the teeth **27** on the driving member.

During this movement, some of the teeth **28** have engaged the teeth **43** on the control cam and rotate the control cam **38** around until rotation is stopped by key **42**. In this position, the teeth **43** prevent re-engagement of the

teeth 28 on the driven member 31 with the teeth 27 on the driving member as shown in FIG. 12. This condition continues until the driven member 31 no longer overruns the driving member 26. Any slight change in direction of vehicle turning or any slight torque reversal will tend to move the driven member 31 rearwardly, as shown in FIG. 13, causing some of the teeth 28 to engage the teeth 43 and rotate the control cam 38 back away from stop key 42 to its original position. At the same time, the teeth 28 are thereby permitted to move down the inclined sides of the teeth 37 on the center cam 36 into engagement with the teeth 27 on the driving member 31.

A similar operation is achieved when the driven member 30 on the opposite side of the differential overruns. Also when the vehicle is decelerating, or is driving in reverse, the same sequence of events will occur in the opposite direction, with stop key 41 coming into play.

The height of the teeth 43 axially is greater than the height of the teeth 37 which, in turn, is greater than the height of the teeth 27 so that the proper clearances are provided for engagement and re-engagement and for overrunning without successive engagement and re-engagement (FIGS. 10–13).

In the form of the invention shown in FIGS. 14–18, identical reference numerals are used for identical parts. In this form of the invention, the center cam ring 360 (FIG. 16) has circumferentially spaced teeth 370 on each side thereof which have a radial thickness less than the radial width of the main body of the ring 360. The center cam ring 360 is rotatably mounted within the driving member 26 (FIGS. 14, 15). The teeth 370 are radially aligned in one position with teeth 27 of the driving member 26. Center cam 360 is held in position axially within driving member 26 by control cams 380 on each side of the center cam 360. As shown in FIG. 17, each control cam 380 is formed with circumferentially spaced fingers 390 which extend into annular groove 40 (FIG. 15) to axially retain the center cam ring 360 in position and, at the same time, axially retain the control cam 380 in position. The control cams 380 are inserted by aligning the fingers 390 of each control cam 380 with slots 40*a* (FIG. 14) in the driving member 26 and rotating the control cam 380 to move the fingers 390 into the groove 40. As in the previous design, keys 41, 42 are inserted which retain the cam ring 380 in position and limit their circumferential movement to the desired angle of rotation.

As shown in FIGS. 14, 17 and 18, each of the control cams 380 is formed with circumferentially spaced teeth 430 so that when the control cam 380, center cam 360 and the driving member 26 are in the same position, the teeth 430 are aligned with and located between the teeth 370 on the center cam 360 and the teeth 27 on the driving member 26. The height of the teeth 430 is slightly greater in an axial direction than the height of the teeth 370 which in turn are greater in height than the teeth 27. The teeth 370 of the center cam 360 have inclined sides. The teeth 430 have beveled edges. The teeth 27 extend radially outwardly from the teeth 430 and 370.

The operation of the differential shown in FIGS. 14–18 is the same as that described above in connection with the form of the invention shown in FIGS. 1–13. Specifically, when a vehicle utilizing the differential is moving in a straight line, the teeth 27 of the driving member 26 are engaged with the teeth 28 on both of the driven members 30, 31. However, when one of the driven members 31 overruns, for example, in going around a corner, the member 31 (FIG. 11) moves ahead of the driving member 26 and some of the teeth 28 engage the inclined sides of the teeth 370 on the center cam 360. As the driven member 31 further overruns the driving member 26, the driven member 31 is cammed outwardly by the inclined sides of the teeth 370 to a position where the teeth 28 overrun the teeth 27 on the driving member.

During this movement, some of the teeth 28 have engaged the teeth 430 on the control cam and carry the control cam 380 around to a position wherein the stop key 42 prevents further rotation of cam 380 (FIG. 12). In this position, the teeth 430 prevent re-engagement of the teeth 28 on the driven member 31 with the teeth 27 on the driving member 26. This condition continues until the driven member 31 no longer overruns the driving member 26. Any slight change in direction of vehicle turning or any slight torque reversal will tend to move the driven member 31 rearwardly with respect to the driving member 26, as shown in FIG. 13, causing some of the teeth 28 to engage the teeth 430 and rotate the control cam 380 away from key 42 back to its original position. At the same time, the teeth 28 are thereby permitted to move down the inclined sides of the teeth 370 on the center cam 360 into engagement with the teeth 27 on the driving member 31 as in FIG. 10.

A similar operation is achieved when the driven member 30 on the opposite side of the differential overruns. Also, if motor torque reverses and either driven member 30 or 31 underruns the driving member 26, then its control cam 430 will be rotated in the other direction until it is stopped by key 41. Then all events will follow as before but in this direction of rotation.

It can thus be seen that there has been provided a differential which is relatively quiet, is cheaper to manufacture because of a lesser number of parts, and which requires no thrust members other than the control cam.

I claim:

1. A differential comprising
a driving member,
a pair of driven members,
means yieldingly urging said driven members and said driving member together,
interengaging teeth between said driving member and said driven members,
a center cam rotatably mounted in said driving member,
said center cam having circumferentially spaced teeth aligned in one position of said center cam with at least some of the teeth of said driving member,
a pair of control cams rotatably mounted in said driving member,
each said control cam having circumferentially spaced teeth aligned in one position of said control cam with at least some of the teeth of the driving member,
means on the driving member for limiting the rotating movement of each said control cam,
whereby when one of said driven members overruns said driving member, the teeth on said driven member are moved out of engagement with the teeth on said driving member by the teeth on said center cam and said control cam is rotated circumferentially to a position which prevents re-engagement of the teeth of the overrunning driven member with the teeth of the driving member.

2. The combination set forth in claim 1 wherein the teeth on each control cam have a lesser circumferential width than the teeth on said center cam.

3. The combination set forth in claim 1 wherein the edges of said control cam teeth are beveled.

4. The combination set forth in claim 1 wherein the circumferentially spaced teeth of each said control cam are always circumferentially interposed between the teeth of the center cam.

5. The combination set forth in claim 1 wherein the height of the teeth on the control cam is greater than the height of the teeth on the center cam and the height of the teeth on the center cam being greater than the height of the teeth on the driving member.

6. The combination set forth in claim 5 wherein the teeth on each control cam have a lesser circumferential width than the teeth on said center cam.

7. The combination set forth in claim 6 wherein the edges of all said teeth are beveled.

8. The combination set forth in claim 1 wherein the circumferentially spaced teeth on the center cam are aligned

in said one position of said center cam with alternate teeth of the driving member.

9. A differential comprising
a driving member,
a pair of driven members,
means yieldingly urging said driven members toward said driving members,
interengaging teeth between said driving member and said driven members,
a center cam rotatably mounted in said driving member,
said center cam having circumferentially spaced teeth aligned in one position of said center cam with some of the teeth of said driving member,
a pair of control cams rotatably mounted in said driving member,
each said control cam having circumferentially spaced teeth interposed between the teeth of said center cam and aligned in one position of said control cam with other of the teeth of the driving member,
stop means on the driving member for limiting the angular movement of said control cam,
whereby when one of said driven members overruns said driving member, the teeth on said driven member are moved out of engagement with the teeth on said driving member by the teeth on said center cam and said control cam adjacent said overrunning driven member is rotated circumferentially to a position which prevents re-engagement of the overrunning driven member with the teeth of the driving member.

10. A differential comprising
a driving member,
a pair of driven members,
means yieldingly urging said driven members toward said driving member,
interengaging teeth between said driving member and said driven members,
a center cam rotatably mounted in said driving member,
said center cam having circumferentially spaced teeth aligned in one position of said center cam with alternate teeth of said driving member,
a pair of control cams rotatably mounted in said driving member,
each said control cam having circumferentially spaced teeth interposed between the teeth of said center cam and aligned in one position of said control cam with alternate teeth of the driving member,
stop means on said driving member for limiting the angular movement of said control cam,
said teeth on said driven members having radial inwardly directed extensions engaging between the teeth of said center cam and control cams,
the height of the teeth on the control cam being greater than the height of the teeth on the center cam and the teeth on the driving member,
the height of the teeth on the center cam being greater than the height of the teeth on the driving member,
said teeth on said center cam having inclined sides,
whereby when one of said driven members overruns said driving member, the teeth on said driven member are moved out of engagement with the teeth on said driving member by engagement with the inclined sides of the teeth on said center cam and said control cam adjacent said driven member is rotated circumferentially to a position which prevents re-engagement of the overrunning driven member with the teeth of the driving member.

11. A differential comprising
a driving member,
a pair of driven members,
means yieldingly urging said driven members and said driving member together,
interengaging teeth between said driving member and said driven members,
a center cam rotatably mounted in said driving member,
said center cam having circumferentially spaced teeth aligned in one position of said center cam with at least some of the teeth of said driving member,
a pair of control cams rotatably mounted in said driving member,
each said control cam having circumferentially spaced teeth aligned in one position of said control cam with at least some of the teeth of the driving member,
stop means on said driving member for limiting the angular movement of each said control cam,
the circumferentially spaced teeth of each said control cam being aligned in one position of said control cam with other of said teeth of the center cam,
the circumferentially spaced teeth of each control cam being radially interposed between the teeth on said driving member and the teeth on said center cam,
the height of the teeth on the control cam being greater than the height of the teeth on the center cam and the height of the teeth on the center cam being greater than the height of the teeth on the driving member,
whereby when one of said driven members overruns said driving member, the teeth on said driven member are moved out of engagement with the teeth on said driving members by the teeth on said center cam and said control cam is rotated circumferentially to a position which prevents re-engagement of the teeth of the overrunning driven member with the teeth of the driving member.

12. A differential comprising
a driving member,
a pair of driven members,
means yieldingly urging said driven members and said driving member together,
interengaging teeth between said driving member and said driven members,
a center cam rotatably mounted in said driving member,
said center cam having circumferentially spaced teeth aligned in one position of said center cam with some of the teeth of said driving member,
a pair of control cams rotatably mounted in said driving member,
each said control cam having circumferentially spaced teeth aligned in one position of said control cam with other of the teeth of the driving member,
means on the driving member for limiting the rotating movement of each said control cam,
whereby dhen one of said driven members overruns said driving member, the teeth on said driven member are moved out of engagement with the teeth on said driving member by the teeth on said center cam and said control cam is rotated circumferentially to a position which prevents re-engagement of the teeth of the overrunning driven member with the teeth of the driving member,
the circumferentially spaced teeth of each control cam being radially interposed between the teeth on said driving member and the teeth on said center cam.

13. A differential comprising
a driving member,
a pair of driven members,
means yieldingly urging said driven members and said driving member together,
interengaging teeth between said driving member and said driven members,
a center cam rotatably mounted in said driving member,
said center cam having circumferentially spaced teeth aligned in one position of said center cam with some of the teeth of said driving member,
a pair of control cams rotatably mounted in said driving member,
each said control cam having circumferentially spaced teeth aligned in one position of said control cam with other of the teeth of the driving member,

means on the driving member for limiting the rotating movement of each said control cam,

whereby when one of said driven members overruns said driving member, the teeth on said driven member are moved out of engagement with the teeth on said driving member by the teeth on said center cam and said control cam is rotated circumferentially to a position which prevents re-engagement of the teeth of the overrunning driven member with the teeth of the driving member,

said teeth on said driven members having radial extensions engaging between the teeth of said center cam and control cams.

14. The combination set forth in claim **10** wherein the teeth on each control cam have a lesser circumferential width than the teeth on said center cam.

15. The combination set forth in claim **10** wherein the edges of said control cam teeth are beveled.

16. The combination set forth in claim **11** wherein the teeth on each control cam have a lesser circumferential width than the teeth on said center cam.

17. The combination set forth in claim **11** wherein the edges of said control cam teeth are beveled.

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