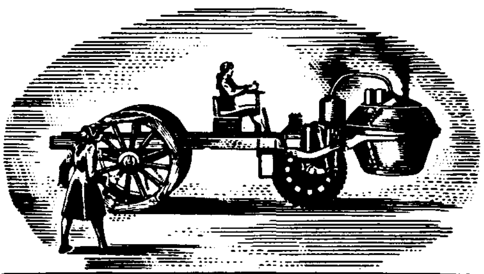
The Story of DIFFERENTIALS
PAST···PRESENT···FUTURE

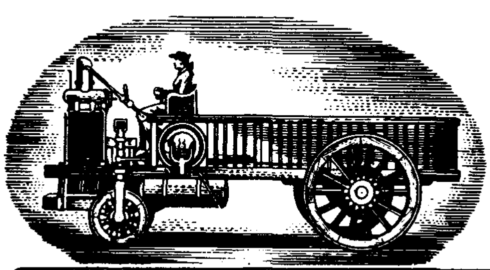
PAST

Many of the earliest mechanically driven vehicles were of the tri-wheel type, with steam power applied to a single front wheel which, also served as a steering means. The two rear wheels were free to rotate, on their axle hubs, as required when making turns. These designs, however, were soon discarded for horseless carriages of the four wheel type which not



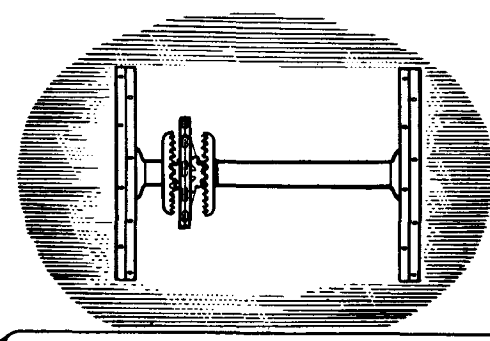
THREE WHEEL VEHICLE

only increased stability, and improved appearance but provided as well a much better distribution of weight. The early four wheel carriage had power transmitted to one rear wheel by chain and sprocket while the other rear wheel remained free to rotate independently on turns. The first known practical



EARLY FOUR WHEEL VEHICLE

installation of the bevel gear type differential was made by Onesiphore Pecquer, European inventor in the year 1827 A.D. The invention of the differential permitted the four wheel vehicle to be driven by two powered rear wheels—yet one wheel could rotate faster or slower than the other as required when turning corners or travelling over rough roads. However, when one driving wheel slipped or lost traction the other receiving little or no driving torque allowed the vehicle to stall. ***This condition is still true with present day automotive vehicles which are not equipped with NoSPIN full locking type differentials.***

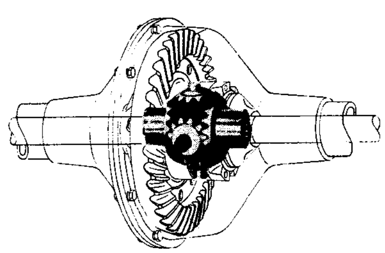


EARLY TYPE

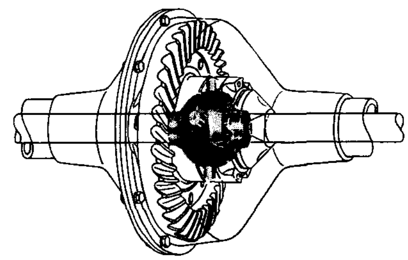
PRESENT

The engineering and development of power transmission units for driving axles of modern motor vehicles follows the same general design and operating characteristics used by their predecessors of over a century ago. The present day bevel gear differential remains the same except in size, material specifications and number of components.

For over thirty years automotive engineers and inventors have tried to overcome the principal disadvantage of the conventional differential—that of one free spinning wheel permitting the vehicle to stall. Many theories and designs for locking differentials have been devised—hundreds of thousands of dollars have been risked in financing such differential developments—yet the NoSPIN Differential is, we believe, the only full automatic locking differential on the market today which has successfully overcome the disadvantages of the conventional bevel gear type.



CONVENTIONAL Differential



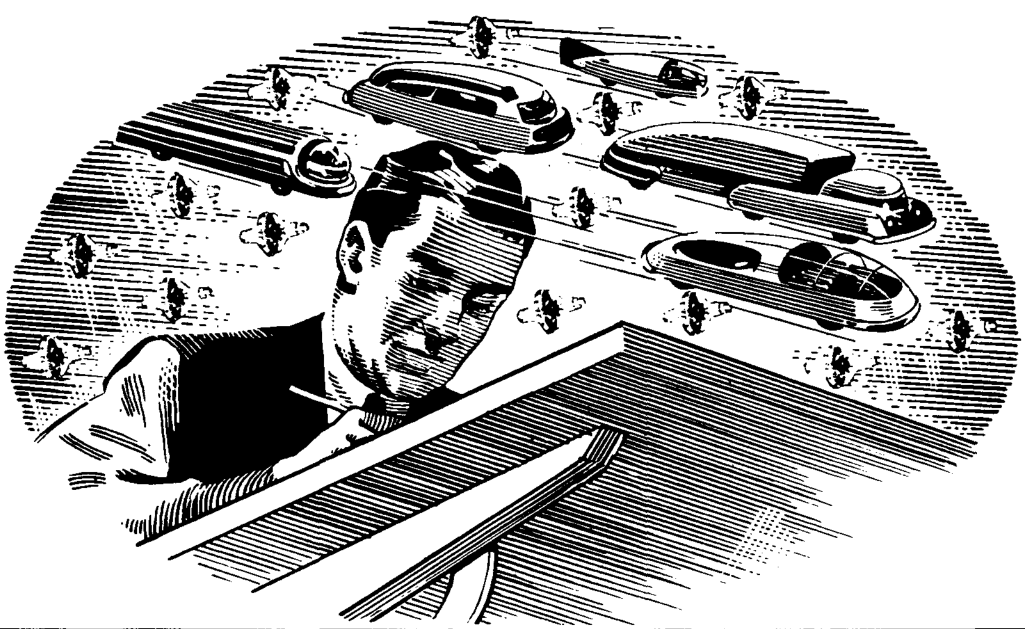
NoSPIN Differential

The NoSPIN Differential with its compact design, automatic locking feature, interchangeability and increased life factor has for many years, rendered outstanding full traction benefits and operating economies to motor vehicle operators in numerous vocations.

FUTURE

Countless users, both military and civilian, have proved the operational value of the NoSPIN Differential. The requirements of automotive manufacturers, engendered by public demand, for new and improved transportation units will be our guide in engineering the ultimate in traction equipment.

Detroit Automotive Products engineers are constantly seeking ways to improve the NoSPIN Differential and adopt it to the industry's future requirements for better automotive traction. This Company will bring to the public's attention the advantages of such new construction only when it is obvious that such units will contribute further to the satisfactory operation of tomorrow's vehicular transportation.



RESEARCH

HOW THE STANDARD-TYPE NoSPIN Differential OPERATES

NOMENCLATURE

Hereunder is provided a typical exploded view of a Standard-type NoSPIN Differential, indicating the various parts that make up the complete assembly.

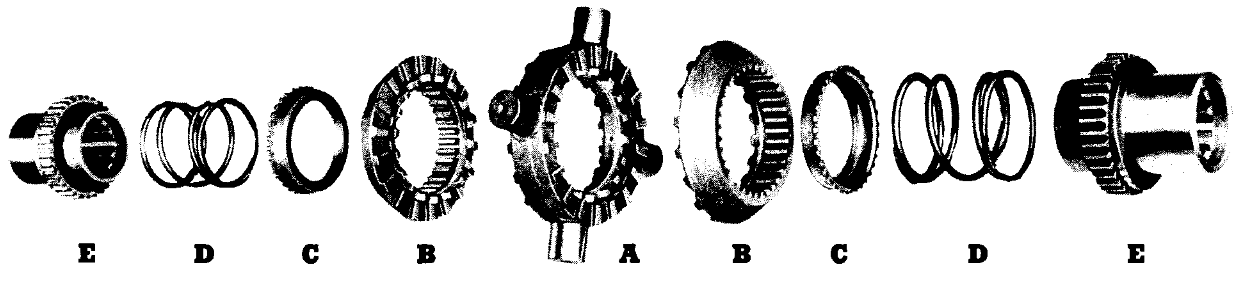


FIGURE 1

(A) SPIDER AND CENTER CAM ASSEMBLY

This assembly consists of the Spider, Center Cam and Spider Snap Ring. The Spider has four trunnions projecting radially from a Center Ring on each side of which is located fixed driving clutch teeth. These teeth vary in number depending on the size and model of Differential. The internal diameter of the Spider is uniform except for the keys which limit the rotation of the Center Cam. The Center Cam is mounted inside the Spider. This cam is held in position with a centrally mounted Snap Ring which permits the Center Cam to be rotated a predetermined distance within the Spider but prevents lateral movement.

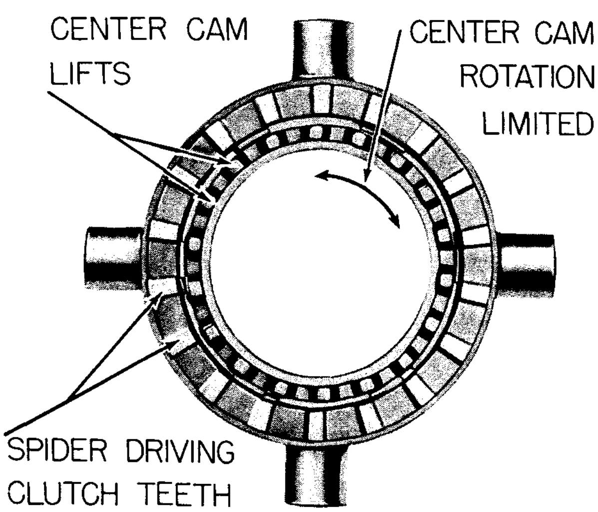


FIGURE 2

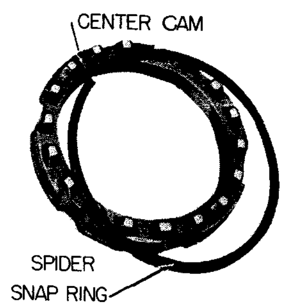


FIGURE 3

The Center Cam is symmetric having the same number of cam lifts on each side as there are clutch teeth on the Spider. These lifts or "cams" have uniform contours with rounded surfaces that provide anti-friction ramps for disengaging the Driven Clutch Members. External key slots engage with the Spider keys.

(B) DRIVEN CLUTCH MEMBERS

Two identical Driven Clutch Members are located on either side of the Spider and Center Cam assembly. Each has a set of clutch teeth to match the clutch teeth on the Spider through which driving torque is transmitted. Radially inward from the driven clutch teeth and rigidly attached thereto are cams which mesh with the cams of the Center Cam Member. The internal diameter of each Driven Clutch Member has splines which engage the external splines of the Splined Side Members.

(C) SPRING RETAINERS
(D) SPRINGS

Spring Retainers (**C**) are inserted into the outer ends of Driven Clutch Member (**B**). The bowl side of these retainers is mounted first through the outer side of the Driven Clutch Members. The flanged portion of the Spring Retainers pass through the internal splines to rest on the mating flanges of the Driven Clutch Members. The Springs (**D**) are mounted in Spring Retainers (**C**) after assembly and thrust against their inner cupped ends.

(E) SPLINED SIDE MEMBERS

These two Splined Side Members are splined internally to receive the truck axle shafts. The inner hubs of the Splined Side Members are inserted in the outer ends of the Springs (**D**). The external splines of the Splined Side Members engage the internal splines of Driven Clutch Members (**B**) on each side of the completed assembly.

CONSTRUCTION

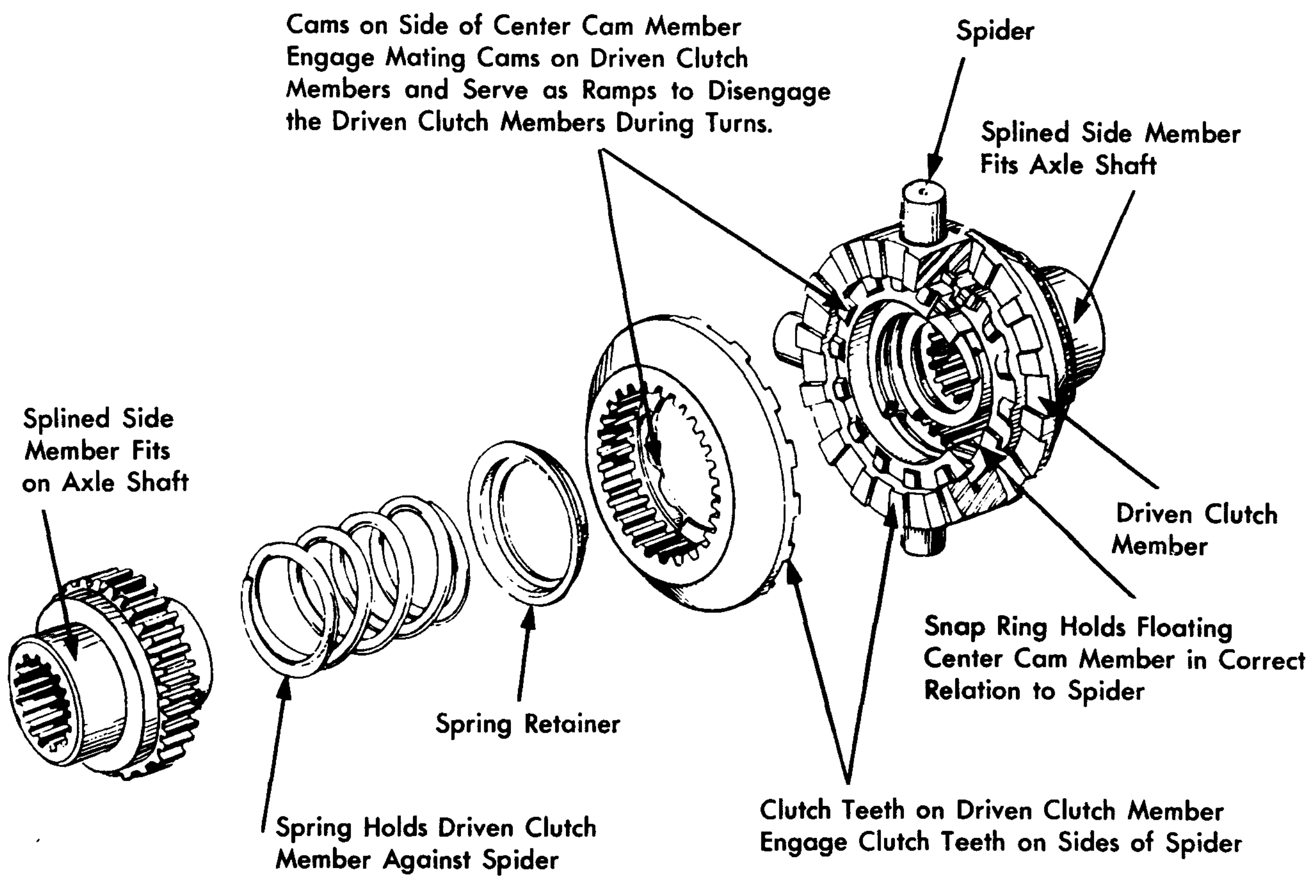


FIGURE 4

OPERATION

STRAIGHT FORWARD DRIVING

When a vehicle is being driven in a straight forward direction the clutch teeth, on both sides of the Spider assembly, are fully engaged with the clutch teeth on each Driven Clutch Member. Likewise the fixed cams of the Driven Clutch Members are fully meshed with the cam surfaces of the floating Center Cam ring mounted on the inside diameter of the Spider, as described previously.

Engagement of the driving and driven clutch teeth is assured by the pressure of the two Springs which force the Driven Clutch Members inwardly against the Spider and also by the positive locking action developed by the mating undercuts on the driving faces of the clutch teeth.

In this condition both clutches remain fully engaged so that the assembly operates as a solid unit and each rear wheel is driven forward at ring gear speed. (See Figure 5.)

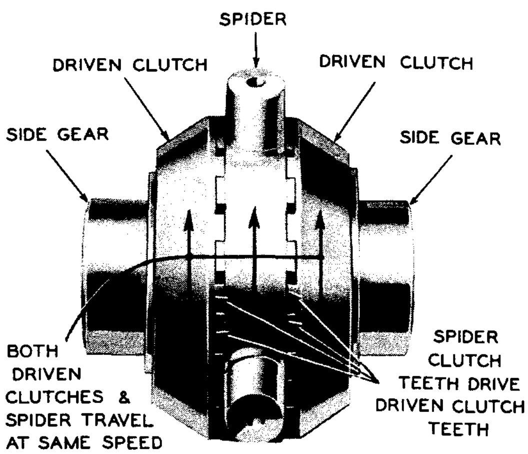


FIGURE 5

STRAIGHT REARWARD DRIVING

When driving a vehicle in a straight rearward direction both Driven Clutch Members are held in full engagement with the Spider and Center Cam as described for Straight Forward Driving. However, in this case the Spider rotates in the reverse direction, and shifts the driving force to the opposite set of driving faces on the mating clutch teeth. Again we have the assembly operating as a unit with each wheel being forced to rotate at ring gear speed.

RIGHT HAND TURNS—FORWARD DIRECTION—POWER APPLIED

When making a turn, differential action is required in order to permit the outside wheel to travel a greater distance, and faster, than the inside wheel.

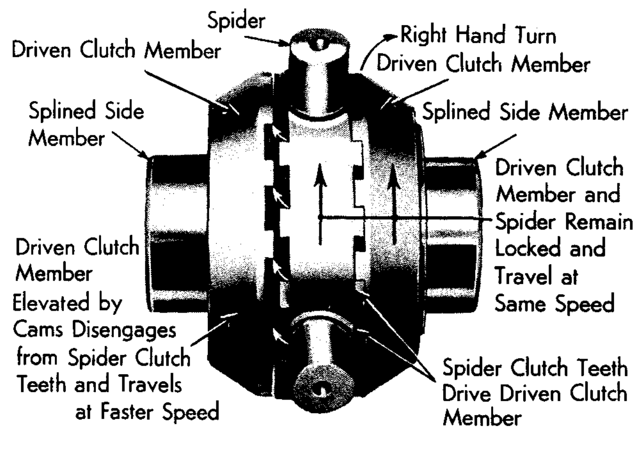


FIGURE 6

A conventional bevel gear type differential permits the outside wheel to turn faster than ring gear speed while the inside wheel turns slower than ring gear speed. The NoSPIN Differential allows either wheel to turn faster than the ring gear speed but does not permit either wheel to turn slower than the ring gear speed when power is applied.

When negotiating a right hand turn, in a forward direction, the right hand Driven Clutch Member remains fully engaged with the Spider clutch teeth and the corresponding cams. (See Figure 6.)

The driving clutch teeth of the Spider transmit the driving force to the Driven Clutch Member which, in turn, drives the right hand (inside) wheel constantly at ring gear speed thus propelling the vehicle. The left hand (outside) wheel covers a greater arc than the right hand (inside) wheel and, driven by the traction of the road, must turn faster than ring gear speed. Likewise, the left hand Driven Clutch Member must turn faster than the Spider. In other words, it permits differences in wheel speeds or differential action. Figure No. 7 illustrates how this is accomplished.

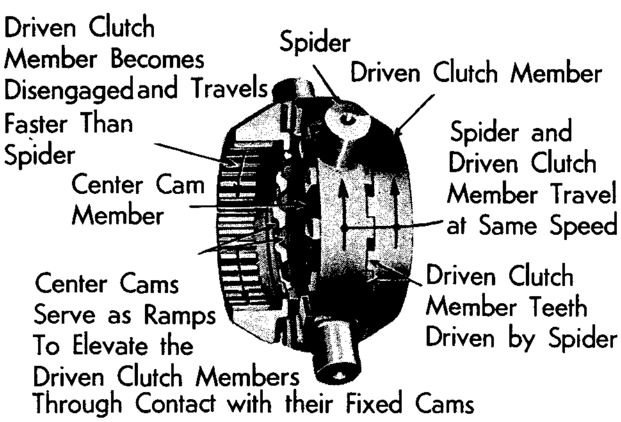


FIGURE 7

The right hand row of cams on the Center Cam Member are meshed securely with the cams on the right hand Driven Clutch Member. With the Center Cam thus locked in this position so that it cannot rotate with respect to the Spider, its cams on the left hand side serve as ramps upon which the mating cams on the left hand Driven Clutch Member can rise enabling that Driven Clutch Member to disengage from the Spider. The ramps on the Center Cam are high enough to permit the clutch teeth on the Driven Clutch Member to clear the teeth on the Spider and when the crest of the ramp is passed the teeth of the Driven Clutch Member are forced back by spring pressure into full engagement with the clutch teeth of the spider.

This engagement and disengagement or indexing operation continues throughout the turn with a rapidity that is in direct relation to the speed of the overrunning wheel.

As the vehicle completes the turn and is again driven in a straight forward direction, differential action no longer being required, both Driven Clutch Members become fully engaged with the clutch teeth of the Spider then the operation, as described in "Straight Forward Driving" is resumed.

RIGHT HAND TURNS—FORWARD DIRECTION—BRAKING CONDITION

In this situation the vehicle is moving forward but the direction of torque of the ring gear is reversed because the vehicle is being slowed down by braking action. This reversal of torque is produced by the action of road traction driving the wheels against the torque of the motor. In this condition when a right hand turn is negotiated, the left hand (outside) wheels rotate at ring gear speed since the left hand driven clutch member remains fully engaged while the right hand (inside) wheels rotate slower than ring gear speed.

The symmetrical design of the differential makes it possible to function in the manner described above which is in effect directly opposite to that described as Right Hand Turns—Forward Direction—Power Applied.

It should be noted that if a turn is negotiated in such a manner that power is first applied and then braking action is encountered before the turn is completed, the Differential is designed to function without interruption and will automatically take care of such reversal of torque.

LEFT HAND TURNS—FORWARD DIRECTION—POWER APPLIED

In making a left hand turn with the vehicle driven in a forward direction the left hand wheel is on the inside of the turn and the power is applied to it so that it must rotate at ring gear speed. The right hand wheel travels through the greater arc, being on the outside of the turn. Its Driven Clutch Member becomes disengaged from the Spider clutch teeth permitting it to be rotated by ground traction faster

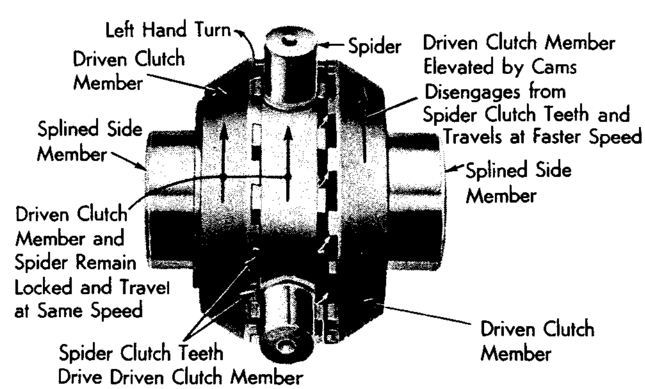


FIGURE 8

than the ring gear. (See Figures 8 and 9.)

The operation of the Driven Clutch Member, on

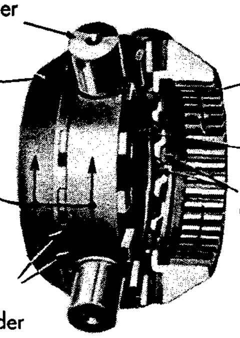


FIGURE 9

the right side of the assembly in the foregoing instance, is illustrated above.

RIGHT AND LEFT HAND TURNS— REARWARD DIRECTION— POWER APPLIED

The operation of the NoSPIN Differential when required to make turns while travelling in a rearward direction is identical to that when making turns in a forward direction. When moving rearward in a turn under power, the inside wheel is driven at ring gear speed while the outside wheel is driven by the ground faster than ring gear speed. When the rearward turn is nearing completion and the vehicle is slowing down because of application of the brakes the outside wheel is driven by the ground at ring gear speed, as its Driven Clutch Member is fully engaged, and acts to "brake" against the motor torque. The inside wheel is driven by the ground through the smaller arc of travel and since its Driven Clutch Member is disengaged it will rotate slower than ring gear speed.

Figure 10 shows the operation of the Differential when a right hand turn in a rearward direction is being negotiated.

ROUGH, UNEVEN OR CHOPPY ROAD CONDITIONS

When a vehicle is travelling at moderate speed over a rough road it will be found that constant differentiation will be required of the NoSPIN Differential. In other words the NoSPIN Differential will go through its complete unlocking and locking cycle in rapid succession as required by such road conditions. Should one driving wheel, however, encounter soft and slippery road conditions both driving wheels will remain locked and revolve at ring gear speed thus preventing wheel spin and undue scuffing of the tire.

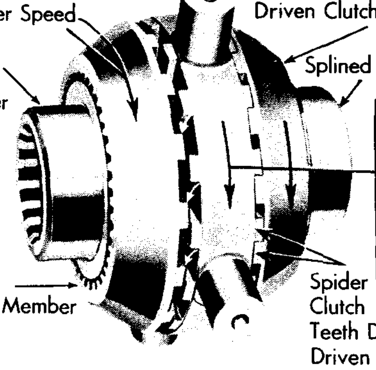


FIGURE 10

When a vehicle equipped with a conventional differential is travelling over the above described road conditions there is intermittent speeding ahead of one wheel over the other. This action occurs as the wheel leaves the ground when encountering choppy road conditions. When this spinning wheel regains contact with the ground there is a severe shock load imposed on the entire power transmission components due to the sudden slowing down of this spinning wheel to ring gear speed.

In the case of similar road conditions when a vehicle equipped with a NoSPIN Differential in the driving axle there is no spinning ahead of the wheel or wheels that are off the ground. So, tire scuffing due to the spinning wheel exceeding ring gear speed is eliminated. When one wheel, in this case, is off the ground and regains contact with the road its speed is identical to the speed of the other driving wheel and consequently no sudden shock is imposed on the propulsion members of the vehicle. Thus the uncontrollable flywheel action of a free spinning wheel, as permitted by the conventional differential, is eliminated. (See Comparative Traction Diagram, Page 11.)

ONE WHEEL ON ICE—OTHER WHEEL ON DRY GROUND

The wheel on ice is assumed to have no traction— the other wheel still has its full rim pull to propel the vehicle and will pull up to the limit of its tractional resistance at the ground. Here both wheels rotate at ring gear speed whether the vehicle is moving in a straight or curved path.

With a conventional differential the vehicle would be stalled since the wheel on ice would spin freely while the wheel on dry ground would not rotate.

SILENT-TYPE NoSPIN Differential

General Information and Brief Description of Its Construction and Operation

GENERAL INFORMATION

The requirement for a full automatic locking two-way overrunning clutch or differential, for use in transfer and drop cases of multi-axle vehicles as well as driving axles of all types of commercial vehicles and passenger cars, has been evident to users of automotive vehicles for a great many years.

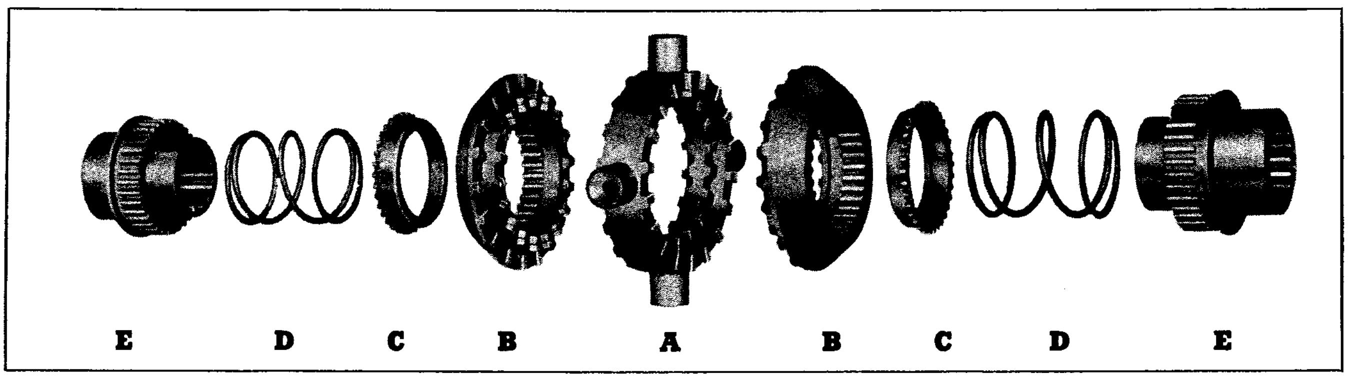
Detroit Automotive Products' engineers, in constant search for a simpler and silent means of preventing individual wheel-spin in driving axles of light weight vehicles and the elimination of trapped-torques between driving axles, have developed the silent-type NoSPIN Differential, briefly described hereunder.

The principle on which this device operates is very similar to the regular type NoSPIN Differential set forth in the forepart of this Manual. The primary difference in this device is that it may overrun continuously until this movement is completed then it automatically returns to full locked engagement, whereas with the regular NoSPIN during the overrunning cycle the clutch teeth of both the driving and driven members re-engage after each tooth, causing a slight indexing sound. Positive drive is assured by each type of mechanism when traction is lost on either side of the device. Both types then remain locked and each side **must** rotate at ring gear speed until normal overrunning is required for turns or the negotiation of uneven terrain.

CONSTRUCTION

The clutch members of the silent-type NoSPIN Differential are held out of engagement while overrunning by the automatic positioning of rotatable "hold-out" Cam Ring mounted on each Driven Clutch Member. See Figures 11, 13 and 15.

The exploded view of a typical silent-type NoSPIN Differential, together with the nomenclature of the respective components, is shown in Figure 11.



A—Spider-Center Cam Ass'y B—Driven Clutch Members and "Hold-out" Cam Rings C—Spring Retainers D—Springs E—Splined Side Members

FIGURE 11

As may be seen in Figure 12, the Spider and Center Cam Assembly of the silent type differential is quite similar to that of the regular NoSPIN except that the Center Cam has wider cam teeth to carry the two sets of cams on each Driven Clutch Member, one fixed, the other rotatable. Note the Spider has one long tooth or key on its inside diameter which engages a slot, of predetermined width, in the Center Cam. This slot limits the travel of the Center Cam to either side of the clutch teeth of the Driven Clutch Member as required to permit the unlocking and locking action of the differential assembly in either direction.

The rotatable "hold-out" Cam Ring is mounted over the outer diameter of the fixed cam ring of each driven clutch member as shown in Figure 13. The gap between the ends of the "hold-out" ring meshes with the long tooth or key of the Spider as the Driven Clutch Members and other components are brought together to complete the differential assembly shown in Figure 14.

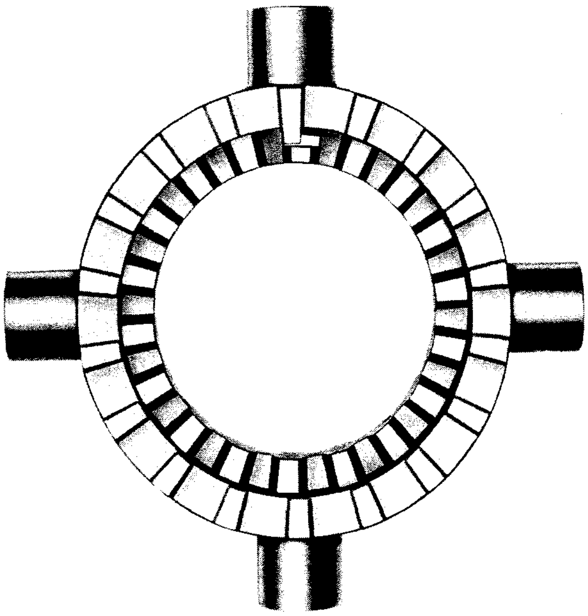


FIGURE 12

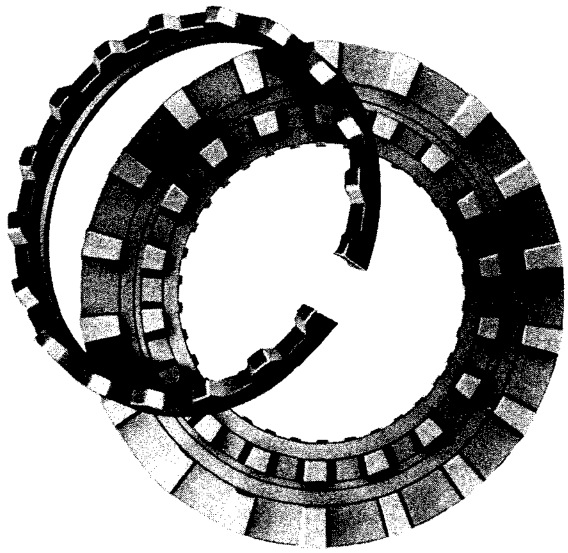


FIGURE 13

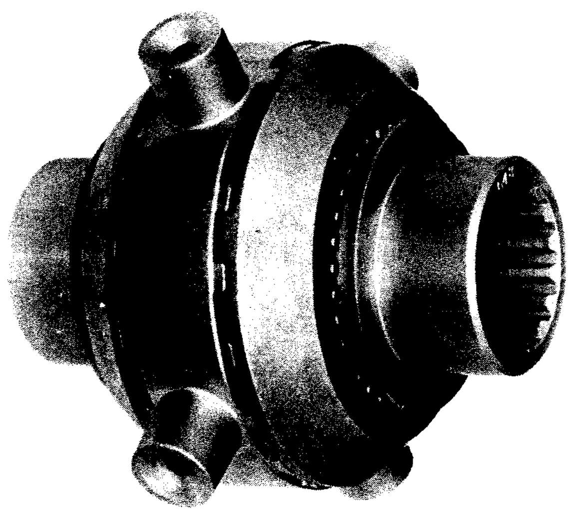


FIGURE 14

OPERATION

When driving straight forward on a level surface the clutch teeth of the Spider and Driven Clutch Members are fully engaged and similarly the two sets of cam rings of the Driven Clutch Members are fully meshed with the Center Cam. Full engagement of these driving and driven clutch teeth is assured by the pressure of the two Springs on each side of the assembly. The Springs also assure complete and rapid re-engagement of all clutch teeth as required during the NoSPINs normal cycle of operation.

When the Spider is rotated forward by the action of the ring gear the clutch teeth of the Spider now meshed with the clutch teeth of the Driven Clutch Members are held in a positive locked position by the mating undercuts on the driving faces of all clutch teeth. The assembly as a unit then rotates, each output shaft must turn at ring gear speed.

Similar conditions prevail when driving rearward. However, as the Spider starts its rotation in a reverse direction the driving torque shifts to the opposite side of all driving clutch teeth.

Consider, for the purpose of explanation, that the silent type differential is installed in the driving axle of a motor vehicle with the mechanism in a fully locked position. Now start a left-hand turn in a forward direction. As may be seen in Figure 12, the cams of the Center Cam Ring are held to the rear of the driving clutch teeth. Therefore, the right Driven Clutch Member is required to rotate faster to make the turn through the overrunning action of the right wheel, its fixed cams then are free to ride up and over the cams of the Center Cam. The left Driven Clutch Member is held in firm locked engagement with the Center Cam by the natural resistance of the slower left wheel. At this instant one end of its rotatable "hold-out" Cam Ring moves over and engages the Spider key described above. This movement sets the cams of the rotatable cam ring between the fixed cams of this Driven Clutch Member, as shown in Figure 15, thus preventing the clutch member from returning to engagement so long as it rotates faster than the Spider and Center Cam assembly is being driven. When this overrunning movement ceases and the relative speed of the Spider and overrunning Driven Clutch Member become the same there is a slight reversal of torque which causes the opposite end of the rotatable "hold-out" Cam Ring to engage the other side of the Spider key causing the rotatable "hold-out" Cam Ring to move back into phase with the fixed cams of the Driven Clutch Member, permitting these cams to return to full engagement with the cams on the Center Cam. Simultaneously the clutch teeth of the Driven Clutch Member return to full locked engagement with those of the Spider.

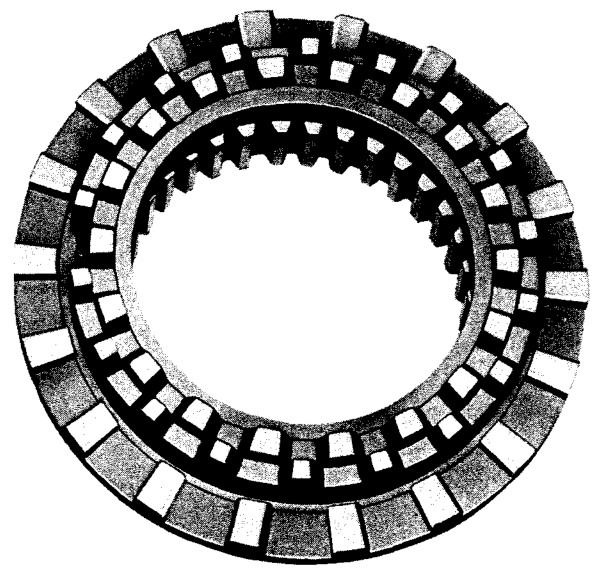


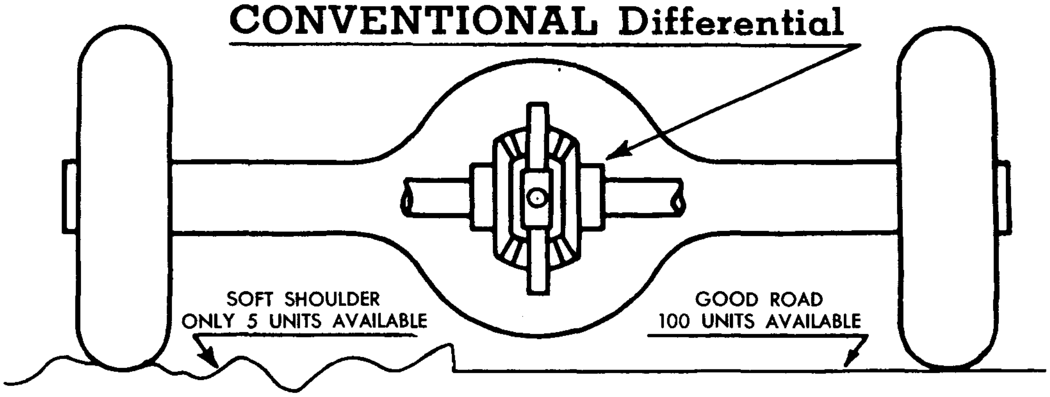
FIGURE 15

When making a turn to the right or left, forward or rearward, all types of NoSPIN Differentials permit either Driven Clutch Member to rotate faster than ring gear speed but will not allow either one to turn slower when power is applied. In other words should traction be lost on either side, then that side is forced to rotate at ring gear speed as described above and, therefore, the total traction or ground adhesion available to each wheel is combined to propel the vehicle. (See Diagram on Page 11.)

Comparative Traction Diagram

CONDITION No. 1

CONVENTIONAL Differential

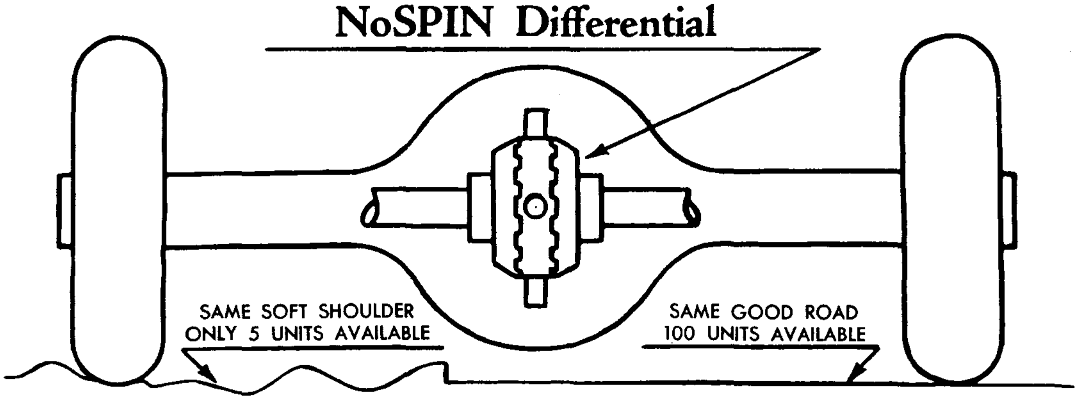


5 UNITS USED → TOTAL 10 UNITS OF TRACTION ← 5 UNITS USED

The conventional bevel gear differential can transfer to the wheel with good footing only as many units of traction as are available to the wheel with the poorer footing.

CONDITION No. 2

NoSPIN Differential



5 UNITS USED → TOTAL 105 UNITS OF TRACTION ← 100 UNITS USED

The FULL LOCKING FEATURES of the NoSPIN Differential makes possible for the first time the combination of the total units of traction available to *each* wheel to propel the vehicle.

The NoSPIN Differentials described and illustrated in this Operation Manual are patented or patents are pending in one or more of the following countries: UNITED STATES, CANADA, GREAT BRITAIN and SWEDEN

WARRANTY: NoSPIN Differentials are warranted under the same Standard Warranty form as established by The Automobile Manufacturers Association.

DETROIT AUTOMOTIVE PRODUCTS CORPORATION

8701 Grinnell Avenue Detroit 13, Michigan, U. S. A.

FACTS YOU SHOULD KNOW ABOUT YOUR NoSPIN DIFFERENTIAL

The NoSPIN Differential provides positive drive to both wheels of the axle in which it is installed and allows differential action when required. The performance of a truck equipped with the NoSPIN will be somewhat different from that of one with a standard differential. For example:

1. When turning a corner the outside wheel must rotate faster than the inside wheel, otherwise serious tire scuffing would occur. When driving around a turn, the NoSPIN clutch driving the outside wheel is automatically disengaged permitting this wheel to rotate freely until the turn is completed at which time it is reengaged.

   While the turn is being made there will be a series of clicking sounds resulting from the alternate disengagement and engagement of the differential clutch teeth on the outside clutch. These clicking sounds, which are quite audible in small trucks and pickups, are not so pronounced in larger trucks, and are normal in the Standard-type NoSPIN.

2. When driving straight ahead a continuous click may be heard if the tires are not equal in rolling radii due to unequal wear or unequal inflation. This, of course, can be corrected by matching up the tires and checking pressures periodically. If clicking continues, adjust tire pressures so that the distance from the ground to the rim is equal.

   NOTE: The above conditions apply to the Standard-type NoSPIN. In the Silent-type NoSPIN only an occasional click will be heard as the NoSPIN clutch reengages.

3. If, with either type NoSPIN, you get a pull to the right or left, particularly when accelerating check the tire pressure and rolling diameters of the rear tires. (Also, if the load is on one side of the truck you may get a pull to the right or left.)

4. In short wheelbase trucks and tractors having a very short turning circle, you may get some reaction on the steering when making a turn under power. By letting off on the throttle for an instant, you will reduce the torque to the rear wheels which will permit the truck or tractor to go into the turn.

5. An increase in the amount of backlash is also normal in both types. This is purposely built into the NoSPIN to allow the clutch teeth to disengage or reengage automatically when travelling forward or backward during the turn.

6. The amount of backlash in the NoSPIN is a fixed amount which does not increase appreciably with use. The total backlash in the entire drive system including the transmission, joints, various splines and gears will develop a noticeable increase as mileage increases, due to normal wear of these parts.

7. When alternately accelerating and decelerating during a turn you may hear an occasional snapping noise as the torque is being alternated from "driving" torque to the inside wheel to "braking" torque from the outside wheel.

8. When making a turn in loose gravel or in other conditions of poor traction with the outside clutch member momentarily disengaged, the inside wheel may receive so much torque that it will slip or scuff momentarily until power is being transmitted to both wheels. Whenever traction conditions are so poor that there is not enough traction under one wheel to drive the vehicle, the inside tire will continue to slip or scuff until the turn is completed. This condition is more noticeable in cars or lightly loaded vehicles.

AFTER THE NoSPIN INSTALLATION IS COMPLETED, ALWAYS MAKE THE "TEST FOR PROPER OPERATION AND INSTALLATION" SHOWN ON PAGES 5, 6 AND 7 OF THE INSTALLATION INSTRUCTION FOLDER.

DETROIT AUTOMOTIVE PRODUCTS CORPORATION

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