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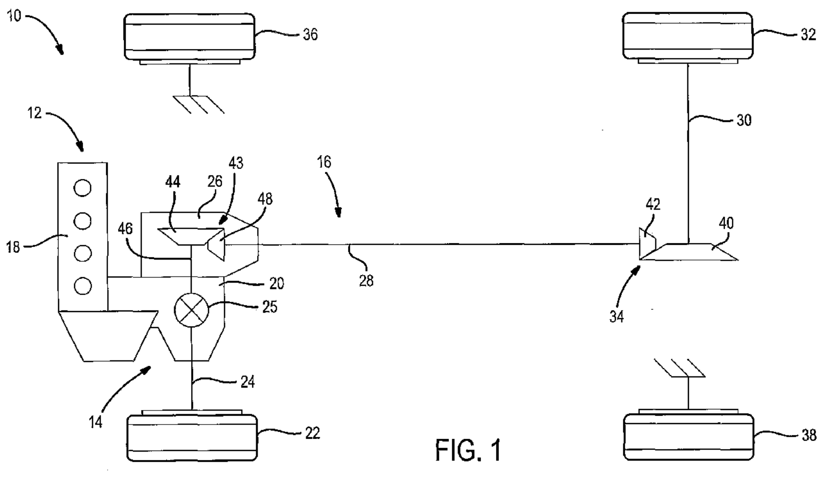

FIG. 1

(57) Abstract: A diagonal drive system for a motor vehicle includes a power source, a front driveline connected to only one front driven wheel on one side of the vehicle, and a rear driveline connected to only one rear driven wheel on the opposite side of the vehicle. A power transfer device is driven by the power source and has a first output driving the front driveline and a second output driving the rear driveline.

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DIAGONAL DRIVE SYSTEM FOR MOTOR VEHICLE

BACKGROUND

[0001] The present disclosure relates to drivetrains for motor vehicles. More particularly, a simplified vehicle diagonal drive system is provided for improving vehicle traction at a relatively low system cost.

[0002] Many vehicle manufacturers have developed four-wheel drive (4WD) and all-wheel drive (AWD) systems to improve the vehicle's traction and stability relative to a standard two-wheel drive vehicle. Most of these systems include a front differential gear assembly and a rear differential gear assembly, each driven by the vehicle powertrain for supply drive torque to the front and rear wheels. While many of these 4WD/AWD systems have accomplished the goal of improving vehicle traction, such systems are oftentimes relatively heavy, and costly to manufacture.

SUMMARY

[0003] The present disclosure relates to a diagonal drive system for a motor vehicle including a power source, a front driveline adapted to transfer torque to only one front wheel on one side of the vehicle, and a rear driveline adapted to transfer torque to only one rear wheel on the opposite side of the vehicle. A power transfer unit is driven by the power source and has a first output driving the front driveline and a second output driving the rear driveline.

[0004] Additionally, a diagonal drive system for a motor vehicle having a power source includes a front driveline adapted to transfer torque from the power source to only one front wheel on one side of the vehicle, and a rear driveline adapted to transfer torque from the power source to only one rear wheel on the opposite side of the vehicle. The diagonal drive system includes a power transfer unit having a first clutch selectively operable to drivingly interconnect the power source and the front driveline and a second clutch selectively operable to drivingly interconnect the power source and the rear driveline.

[0005] A drive system for a motor vehicle includes a driven front wheel, a non-driven front wheel, a driven rear wheel and a non-driven rear wheel. The driven front and rear wheels are positioned diagonally opposite one another across the vehicle. A power transmission device is operable to transfer drive torque to each of the driven front and rear wheels.

[0006] Further areas of applicability will become apparent from the description provided herein. It should be understood that the description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

[0007] The drawings described herein are for illustration purposes only and are not intended to limit the scope of the present disclosure in any way.

[0008] Figure 1 is a schematic depicting a drivetrain for a motor vehicle having a diagonal drive system according to the teachings of the present disclosure;

[0009] Figure 2 is a schematic depicting another diagonal drive system equipped with a viscous coupling;

[0010] Figure 3 is a schematic depicting another diagonal drive system equipped with a gerotor coupling;

[0011] Figure 4 is an exploded perspective view of a differential, friction clutch and gerotor assembly;

[0012] Figure 5 is a schematic depicting a diagonal drive system having a hydraulically-actuated wet clutch;

[0013] Figure 6 is a schematic depicting a diagonal drive system longitudinally oriented with a transfer case having a double off-set center differential;

[0014] Figure 7 is a schematic of another diagonal drive system having a longitudinal arrangement with a transfer case having a single off-set center differential;

[0015] Figure 8 is a schematic depicting another diagonal drive system having a double off-set torque vectoring device; and

[0016] Figure 9 is a schematic of another diagonal drive system equipped with a single off-set torque vectoring device.

DETAILED DESCRIPTION

[0017] The following description is merely exemplary in nature and is not intended to limit the present disclosure, application, or uses. It should be understood that throughout the drawings, corresponding reference numerals indicate like or corresponding parts and features.

[0018] With reference to Figure 1, a schematic layout for a vehicular drivetrain 10 is shown to include a powertrain 12 driving a first or primary driveline 14 and a second or secondary driveline 16. In the arrangement shown, primary driveline 14 is the front driveline and secondary driveline 16 is the rear driveline. Powertrain 12 includes a transversely-mounted engine 18 and a transaxle 20 arranged to provide motive power to a singular front driven wheel 22 associated with front driveline 14. Front driveline 14 further includes an axleshaft 24 connecting front driven wheel 22 to a differential assembly 25 associated with transaxle 20. Rear driveline 16 includes a power take-off unit (PTU) 26 driven by transaxle 20, a propshaft 28 driven by PTU 26, an axleshaft 30 connected to a rear driven wheel 32, and a right-angle gear drive unit 34 operable to transfer drive torque from propshaft 28 to axleshaft 30. The vehicle also includes a front non-driven wheel 36 that is aligned with front driven wheel 22. Likewise, a rear non-driven wheel 38 is aligned for rotation with rear driven wheel 32.

[0019] Front driven wheel 22 is located at an opposite corner of the vehicle from rear driven wheel 32. Figure 1 shows front driven wheel 22 located at a left front corner while rear driven wheel 32 is located at the right rear corner. This arrangement is merely exemplary. As such, the front driven wheel may be alternately located on the right side of the vehicle while the rear driven wheel is located on the left side of the vehicle without departing from the scope of the present disclosure. In either arrangement, the front and rear driven wheels are located on opposite sides of the vehicle to establish a "diagonal" drive system that is operable to improve vehicle traction without the cost and weight associated with presently known 4WD and AWD systems.

[0020] Figure 1 represents a simple, economically-produced drivetrain 10 having transaxle 20 equipped with an open differential assembly 25. As shown, a first output of differential assembly 25 drives axleshaft 24 while a second output drives a transfer shaft 46 associated with PTU 26. The diagonal arrangement of the driven wheels increases the probability that at least one of front driven wheel 22 and rear driven wheel 32 will be positioned on a surface capable of sustaining tractive effort. The arrangement depicted in Figure 1 may be characterized as a low cost, low weight vehicle drive system because a singular front axleshaft 24 is driven at the front end of the vehicle while a singular rear axleshaft 30 is driven at the rear end of the vehicle. Furthermore, rear driven wheel 32 receives torque from right angle gear drive unit 34 without the need for a rear axle differential. In particular, right-angle gear drive unit 34 includes a ring gear 40 that is fixed for rotation with rear axleshaft 30 and a pinion gear 42 that is driven by propshaft 28 and meshed with ring gear 40. Similarly, PTU 26 may include a simple right-angle gear drive unit 43 having a ring gear 44 fixed for rotation with transfer shaft 46 and pinion gear 48 that is fixed for rotation with propshaft 28 and meshed with ring gear 44.

[0021] Figure 2 depicts another vehicular drivetrain 100 that is generally similar to drivetrain 10. As such, similar elements will retain their previously introduced reference numerals including a prime suffix. Drivetrain 100 includes transversely-oriented engine 18' providing power to transaxle 20'. Transaxle 20' differs from transaxle 20 in that a torque coupling 104 is associated with differential assembly 25' while transaxle 20 only included and open differential assembly 25.

[0022] Differential assembly 25' and torque coupling 104 cooperate with each other to limit the relative rotation between axleshaft 24' and transfer shaft 46'. Accordingly to a first non-limiting example, torque coupling 104 is a viscous coupling having a housing 108 driven by differential assembly 25'. A plurality of outer plates 110 are fixed for rotation with housing 108. A plurality of inner plates 112 are fixed for rotation with transfer shaft 46' and are interleaved with outer plates 110. A viscous fluid fills housing 108 and is positioned in communication with outer plates 110 as well as with inner plates 112.

[0023] Upon rotation of axleshaft 24' at a speed different than transfer shaft 46', inner plates 112 and outer plates 110 are forced to shear the viscous fluid located within housing 108. The energy required to shear the fluid increases as the difference in rotational speed between axleshaft 24' and transfer shaft 46' increases. Accordingly, viscous coupling 104 functions to limit the speed differential or "slip" between axleshaft 24' and transfer shaft 46'. In this manner, if one of driven wheels 22' and 32' loses traction, all of the power will not be provided to the slipping wheel.

[0024] Figures 3 and 4 relate to another vehicular drivetrain identified by reference numeral 200. Drivetrain 200 is generally similar to drivetrain 100. Accordingly, like elements will retain their previously introduced reference numerals including a double prime suffix. Drivetrain 200 differs from drivetrain 100 by including a transaxle 20" having a differential assembly 25" now associated with a hydraulic coupling 206. Hydraulic coupling is disclosed in a non-limiting version as a gerotor-type coupling 206 having a wet clutch 208 and a fluid pump 210. Gerotor coupling 206 may be passively or actively-actuated. The actively-actuated version includes an actuator 212 operable to releaseably couple one of the pump members of fluid pump 210 to a rotary component within coupling 206 or, in the alternative, actuator 212 functions to regulate operation of fluid pump 210. Because actuator 212 is associated only with the actively-controlled gerotor coupling, the element is shown in hidden line representation.

[0025] Differential assembly 25" includes a housing carrier 216 supported for rotation within transaxle 20" and which is driven by the output of transaxle 20". A differential gear assembly 218 is positioned within housing 216 and includes first and second side gears 220, 222 in meshed engagement with first and second pinion gears 224, 226. Pinion gears 224 and 226 are supported for rotation on a pinion shaft 228 that is fixed to housing 216. According to the arrangement shown, first side gear 220 is coupled to transfer shaft 46" while second side gear 222 is coupled to axleshaft 24".

[0026] Wet clutch 208 includes a plurality of outer clutch plates 230 fixed for rotation with and axial movement relative to housing 216. A plurality of inner clutch plates 232 are interleaved with outer clutch plates 230. Inner clutch plates 212 are fixed for rotation with and axial movement relative to a hub 234 that is in splined engagement with first side gear 220.

[0027] Pump 210 includes a pump housing 240, an outer rotor 242, an inner rotor 244 and an eccentric ring 246. Relative rotation between inner rotor 244 and outer rotor 242 causes fluid to be pumped from pump 210 and into communication with an axially moveable piston 250. Piston 250 is translatable to exert a compressive force on interleaved clutch plates 230, 232 of wet clutch 208 and transfer drive torque between first side gear 220 and housing 216 as a function of the fluid pressure generated by pump 210. A cover 252 is fixed to housing 216 to enclose differential gear assembly 218, wet clutch 208 and pump 210 within housing 216.

[0028] As a passively-actuated gerotor coupling, pump 210 is actuated based solely on the relative rotation between first side gear 220 and differential housing 216. As the relative rotational speed differential increases so does the hydraulic pressure discharged from pump 210. As the output from pump 210 increases, the pressure applied to piston 250 and wet clutch 208 also increases to vary the torque transferred across wet clutch 208. If gerotor coupling 206 is actively controlled, actuator 212 may sbe electively operate to drivingly interconnect one of the pump components to first side gear 220, housing 216 or another rotatable member. Actuator 212 may receive control signals from a controller 256 (See Figure

3) that may be in communication with a variety of vehicle sensors, an antilock braking system and/or a vehicle stability system.

[0029] Figure 5 shows another vehicular drivetrain identified at reference numeral 300. Drivetrain 300 is generally similar to drivetrain 200. As such, only the major differences between the drivetrains will be described in detail. Like elements will again retain their previously introduced reference numerals including a triple prime suffix. Drivetrain 300 includes a transaxle 20''' including a differential assembly 25''' coupled to a wet clutch 306. An actuator 308 is in communication with a controller 310 to selectively actuate wet clutch 306. Actuator 308 may include an electric motor 312 providing output torque to a pump 314. Pressurized fluid provided by pump 314 is applied to an axially moveable piston 316 that is operable to apply a compressive force to wet clutch 306. The torque transferred across wet clutch 306 is controlled by varying the pressure of the fluid applied to piston 316 through selective actuation and de-actuation of electric motor 312.

[0030] It should be appreciated that the hydraulic actuation system previously described may be replaced by a power-operated mechanical drive system including actuators (electric motors, EM coils, etc.) arranged to drive any number of components such as gears, power screws, ball ramp mechanisms for controlling clutch engagement without departing from the scope of the present disclosure. Controller 310 may receive signals from a variety of sensors 318 providing data regarding the current state of vehicle operation such as vehicle speed, wheel speed, vehicle acceleration in any number of directions including pitch, roll and yaw. Controller 310 provides signals to actuator 308 to vary the torque transferred across wet clutch 306.

[0031] Figure 6 relates to another diagonal drive system for a vehicular drivetrain 400. Drivetrain 400 includes a longitudinally-oriented engine 402 providing torque to a transmission 404. An input member of a power transfer unit, such as transfer case 406, receives drive torque from the output of transmission 404 for distribution to a first driveline 408 and a second driveline 410. First driveline 408 includes a front propshaft 412 driven by a first output member of transfer case 406. A right-angle gear assembly 414 transfers torque from front propshaft 412 to a front axleshaft 416. A front driven wheel 418 is driven by front axleshaft 416. Figure 6 depicts right-angle gear assembly 414 as including a first bevel gear 420 fixed for rotation with front propshaft 412 and which is meshed with a second bevel gear 422 fixed for rotation with front axleshaft 416.

[0032] Second driveline 410 includes a rear propshaft assembly 430. Propshaft assembly 430 may include a first shaft segment 432 and a second shaft segment 434 drivingly interconnected with one another. Use of a segmented propshaft may facilitate an offset arrangement between second shaft segment 434 and front propshaft 412 if so desired. Alternatively, rear propshaft assembly 430 may include a singular shaft portion longitudinally-extending rearward from and driven by a second output member of transfer case 406. Second driveline 410 also includes a right-angle gear assembly 436 including a first bevel gear 438 fixed for rotation with propshaft assembly 430 as well as a second bevel gear 440 in meshed engagement with first bevel gear 438. A rear axleshaft 442 transfers torque from second bevel gear 440 to a rear driven wheel 444. Front driven wheel 418 is diagonally positioned relative to rear driven wheel 444. A non-driven front wheel 446 is rotatably supported on a stub shaft 448. Similarly, a rear non-driven wheel 450 is rotatably supported on a stub shaft 452.

[0033] Transfer case 406 includes a differential gear assembly 460 providing torque from the input member to a front output shaft 462 and a rear output shaft 464. Front output shaft 462 and rear output shaft 464 are each offset from a longitudinal rotary axis along which engine 402 and transmission 404 extend. Differential gear assembly 460 is schematically illustrated but understood to have an input component and first and second output components driving front output shaft 462 and rear output shaft 464, respectively. A transfer assembly (not shown) is used to transfer drive torque from the driven input member of transfer case 406 to the input component of differential gear assembly 460 and may include a chain and sprocket arrangement or a geared arrangement. Drivetrain 400 may be referred to as a "diagonal" drive system having a longitudinal layout with a double off-set center differential since front output shaft 462 and rear output shaft 464 are coaxially aligned with one another. Front output shaft 462 is drivingly coupled to front propshaft 412 by a universal joint 466. In similar fashion, rear output shaft 464 is drivingly coupled to rear propshaft assembly 430 by another universal joint 468. Figure 6 is shown to represent differential gear assembly 460 as an open differential. However, it should be appreciated that any one of the various torque biasing devices previously described may be used in concert with differential gear assembly 460. In particular, it is contemplated that any one of a viscous coupling, a gerotor coupling, a mechanical or hydraulic wet clutch or any other limited slip controlling device may be integrally formed with or coupled to differential gear assembly 460.

[0034] Figure 7 relates to another diagonal drive system for a vehicular drivetrain identified at reference numeral 500. Drivetrain 500 is substantially similar to drivetrain 400. Accordingly, like elements will retain the previously introduced reference numerals of Figure 6 including a prime suffix. Drivetrain 500 differs from drivetrain 400 by including a single off-set transfer case 502 in lieu of the double off-set transfer case previously described. Transfer case 502 includes an input shaft 504 aligned with the longitudinal rotary axis defined by engine 402' and transmission 404'. Transfer case 502 also includes a differential gear assembly 506 having an input component driven by input shaft 504 and first and second output components. Transfer case 502 also includes a first output shaft 508 and a second output shaft 510. First output shaft 508 extends along an axis that is offset from and parallel to the rotary axis about which input shaft 504 rotates. Second output shaft 510 and input shaft 504 rotate about the common rotary axis. A power transfer mechanism 512 transfers torque from input shaft 504 or the first output component of differential 506 to first output shaft 508. Power transfer mechanism 512 may include a first sprocket 514 fixed for rotation with input shaft 504 or the first output component, a second sprocket 516 fixed for rotation with first output shaft 508 and a flexible member 518, such as a chain, drivingly interconnecting first sprocket 514 and second sprocket 516.

[0035] Driveline 500 is illustrated as including an open differential gear assembly 506. However, it should be appreciated that transfer case 502 may be equipped with any one of the previously described torque biasing devices including a viscous coupling, a gerotor coupling, a mechanical or hydraulic wet clutch or any other limited slip controlling device. The biasing device may be passively actuated or actively actuated depending on the level of system complexity and control desired.

[0036] Figure 8 depicts another diagonal drive system identified as vehicular drivetrain 600. Drivetrain 600 is similar to drivetrain 400. Substantially similar elements will be identified with like numerals including a double prime suffix. Drivetrain 600 includes a center torque vectoring device 602 in lieu of transfer case

406. Center torque vectoring device 602 includes an input shaft 604 in receipt of torque from engine 402" and transmission 404". A power transfer device 606 transfers torque to a first intermediate shaft 608 and a second intermediate shaft 610. A first clutch 612 selectively drivingly interconnects first intermediate shaft 608 with a first output shaft 614. In similar fashion, a second clutch 616 selectively drivingly interconnects second intermediate shaft 610 with a second output shaft 618.

[0037] Center torque vectoring device 602 is operable to selectively vary the magnitude of torque provided to front driveline 408" and rear driveline 410". To achieve this goal, a controller 620 may independently control actuation of first clutch 612 relative to second clutch 616 such that different torque magnitudes are transferred across each clutch. It is contemplated that a torque vectoring operation may occur to improve vehicle handling in a variety of situations. For example, during a left-hand turn when the vehicle is traveling in the forward direction, front driven wheel 418" will be positioned on the outside of the turn while driven rear wheel 444" is on the inside of the turn. Torque vectoring may be achieved by actuating first clutch 612 to transfer a greater amount of torque to front driven wheel 418" than the torque transferred across second clutch 616 to rear driven wheel 444". During other modes of operation, first clutch 612 and second clutch 616 may transfer the same amount of torque. Depending on the vehicle operating conditions, one of first clutch 612 and second clutch 616 may be placed in an open condition such that drive torque is transferred to only one of the driven wheels.

[0038] Figure 9 shows another diagonal drive system identified as vehicular drivetrain 700. Drivetrain 700 is a longitudinal arrangement with a single off-set center torque vectoring device 702. Torque vectoring device 702 includes an input shaft 704, a first output shaft 708 and a second output shaft 710. Torque vectoring device 702 also includes a power transfer mechanism 712 having a first sprocket 714 rotatably supported on input shaft 704, a second sprocket 716 fixed for rotation with first output shaft 708 and a flexible power transfer member 718 drivingly interconnecting first sprocket 714 and second sprocket 716.

[0039] A first clutch 720 selectively drivingly interconnects input shaft 704 with first sprocket 714 to provide drive torque to primary driveline 408'''. A second clutch 722 is selectively operable to transfer torque from input shaft 704 to second output shaft 710. As mentioned with reference to drivetrain 600, first clutch 720 and second clutch 722 are independently controlled to provide the same or different magnitudes of torque to primary driveline 408''' and secondary driveline 410'''. In the single offset longitudinal layout depicted in Figure 9, input shaft 704 is concentrically aligned with second output shaft 710 and propshaft 430'''.

[0040] It should be appreciated that each of the diagonal drive systems previously described may function in coordination with a brake traction control system. The brake traction control system may selectively apply a wheel brake (not shown) associated with wheels 22, 32, 36 and 38. It is contemplated that the diagonal drive systems equipped with an open center differential without a biasing device may benefit from coordinated actuation with the brake traction control system. Selective actuation of one or more of the wheel brakes of the vehicle may provide additional traction control during certain driving conditions.

[0041] Furthermore, the foregoing discussion discloses and describes merely exemplary embodiments of the present disclosure. One skilled in the art will readily recognize from such discussion, and from the accompanying drawings and claims, that various changes, modifications and variations may be made therein without departing from the spirit and scope of the disclosure as defined in the following claims.

CLAIMS

What is claimed is:

1. A drive system for a motor vehicle, comprising:

a power source;

a front driveline drivingly connected to only one front driven wheel on one side of the vehicle;

a rear driveline drivingly connected to only one rear driven wheel on an opposite side of the vehicle; and

a power transfer device having an input driven by said power source, a first output driving said front driveline and a second output driving said rear driveline.

2. The drive system of claim 1 wherein said power transfer device includes a differential assembly having said first output driving a front axleshaft for driving said front driven wheel.

3. The drive system of claim 2 wherein said rear driveline includes a first gearset driven by said second output of said differential assembly, a shaft driven by said first gearset, a second gearset driven by said shaft and a rear axleshaft connected between said second gearset and said rear driven wheel.

4. The drive system of claim 3 wherein said front driven wheel and said rear driven wheel are continuously drivingly interconnected.

5. The drive system of claim 3 wherein said power transfer device further includes a torque coupling operable for connecting slip between said first and second outputs of said differential assembly.

6. The drive system of claim 5 wherein said torque coupling is a viscous coupling.

7. The drive system of claim 5 wherein said torque coupling is a hydraulically-actuated unit having a friction clutch disposed between said first and second outputs of said differential and a fluid pump for actuating said friction clutch.

8. The drive system of claim 7 wherein said fluid pump is operable to generate a fluid pressure used to actuate said friction clutch as a function of a speed differential between said first and second outputs of said differential assembly.

9. The drive system of claim 7 wherein said fluid pump is driven by an electric motor.

10. The drive system of claim 1 wherein said power transfer device is a transfer case having an input shaft driven by said power source, a first output shaft driving said front driveline, a second output shaft driving said rear driveline, and a differential assembly having an input driven by said input shaft, a first output driving said first output shaft and a second output driving said second output shaft.

11. The drive system of claim 10 wherein said first and second output shafts are aligned to rotate about a common rotary axis.

12. The drive system of claim 10 wherein said input shaft and said second output shaft are aligned to rotate about a common rotary axis.

13. The drive system of claim 10 wherein said front driveline includes a front axleshaft driving said front driven wheel, a front propshaft driven by said first output shaft, and a gearset for transferring drive torque from said front propshaft to said front axleshaft.

14. The drive system of claim 13 wherein said rear driveline includes a rear axleshaft driving said rear driven wheel, a rear propshaft driven by said second propshaft, and a second gearset for transferring drive torque from said rear propshaft to said rear axleshaft.

15. The drive system of claim 1 wherein said power transfer device includes an input shaft driven by said power source, a first output shaft driving said front driveline, a second output shaft driving said rear driveline, a first clutch operable for selectively transferring drive torque from said input shaft to said first output shaft, and a second clutch operable for selectively transferring drive torque from said input shaft to said second output shaft.

16. The drive system of claim 15 further including a control system for controlling independent actuation of said first and second clutches.

17. A drive system for a motor vehicle, comprising:

a power source;

a driven front wheel;

a non-driven front wheel;

a driven rear wheel;

a non-driven rear wheel, said driven front wheel and said driven rear wheel being positioned diagonally opposite one another across the vehicle; and

a power transfer device operable to transfer drive torque to each of said driven front and rear wheels.

18. The drive system of claim 17 wherein said driven front and rear wheels are continuously drivingly connected to each other.

19. The drive system of claim 17 wherein said power transfer device is a differential.

20. The drive system of claim 19 wherein said power transfer device includes a slip limiting device coupled to said differential.

21. The drive system of claim 17 wherein said power transfer device is a torque vectoring device.

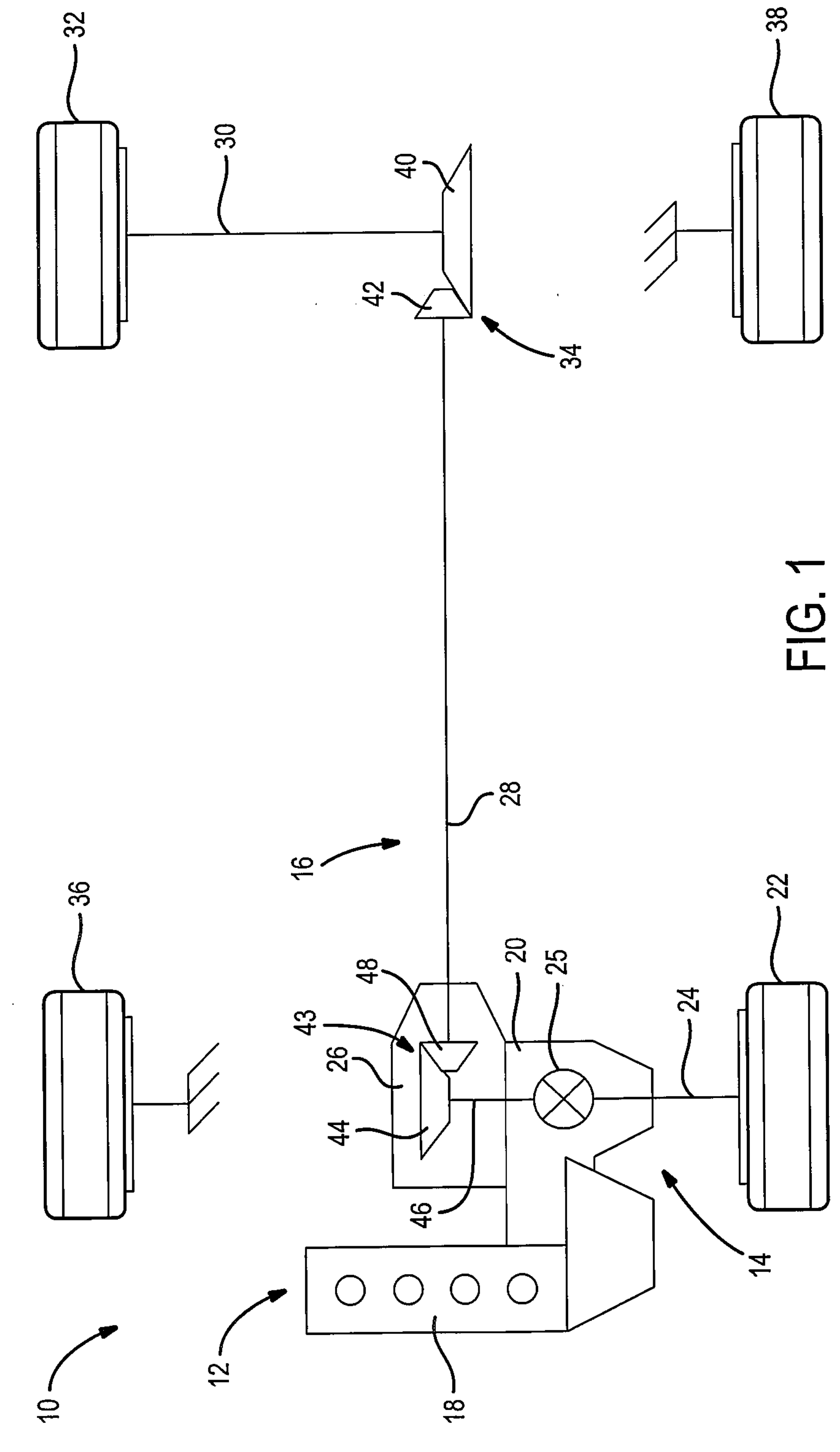

FIG. 1

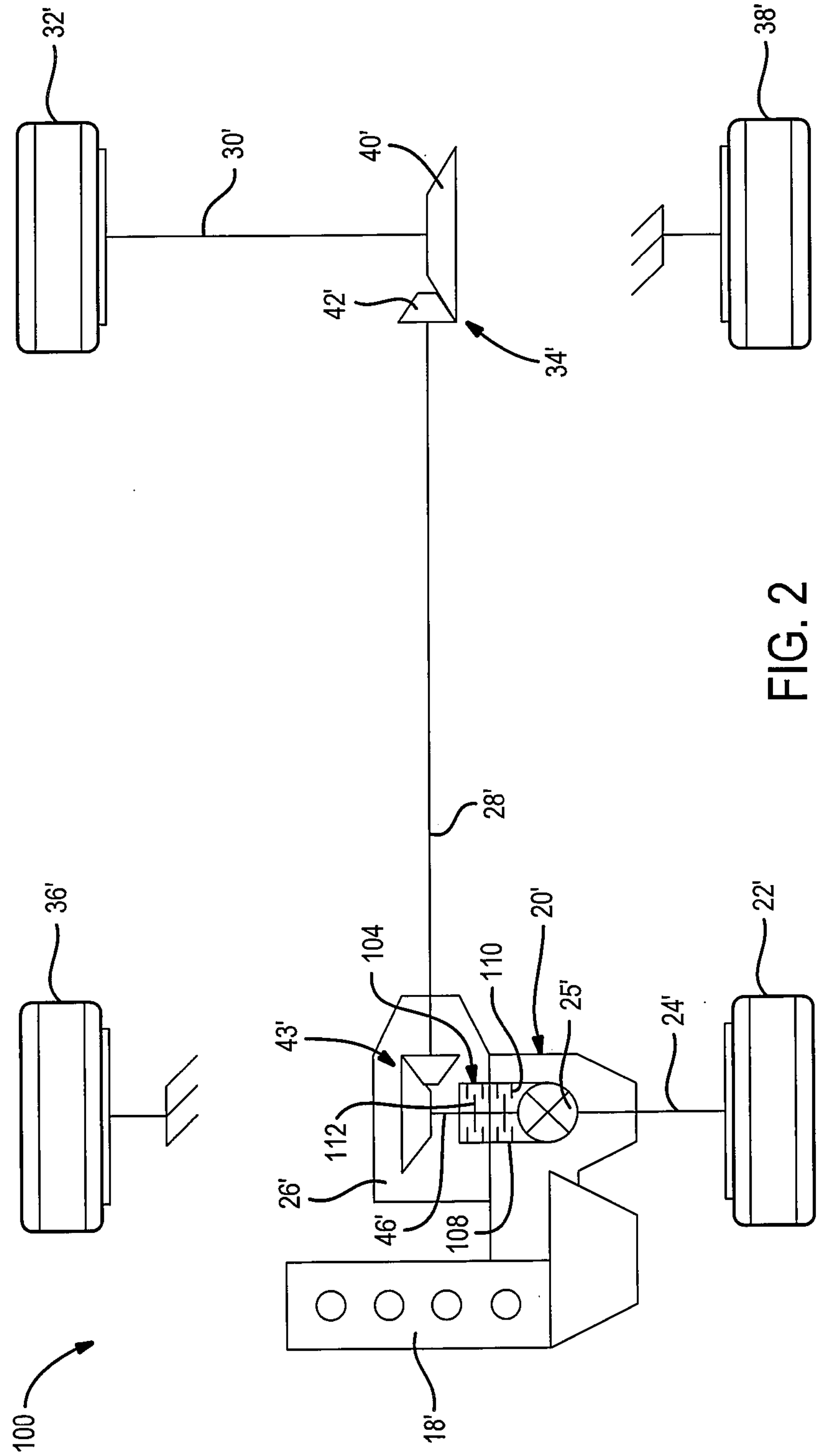

FIG. 2

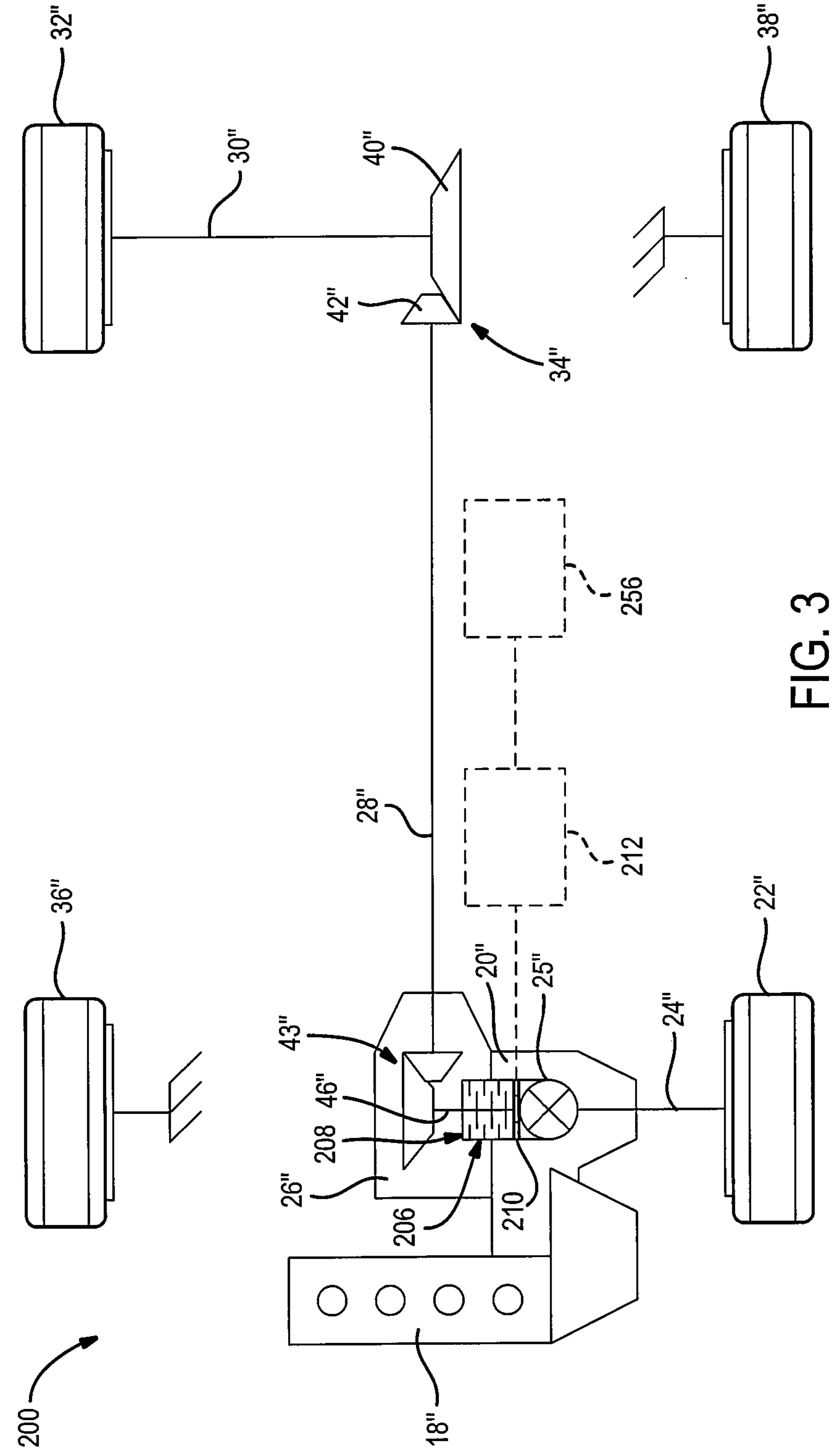
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FIG. 3

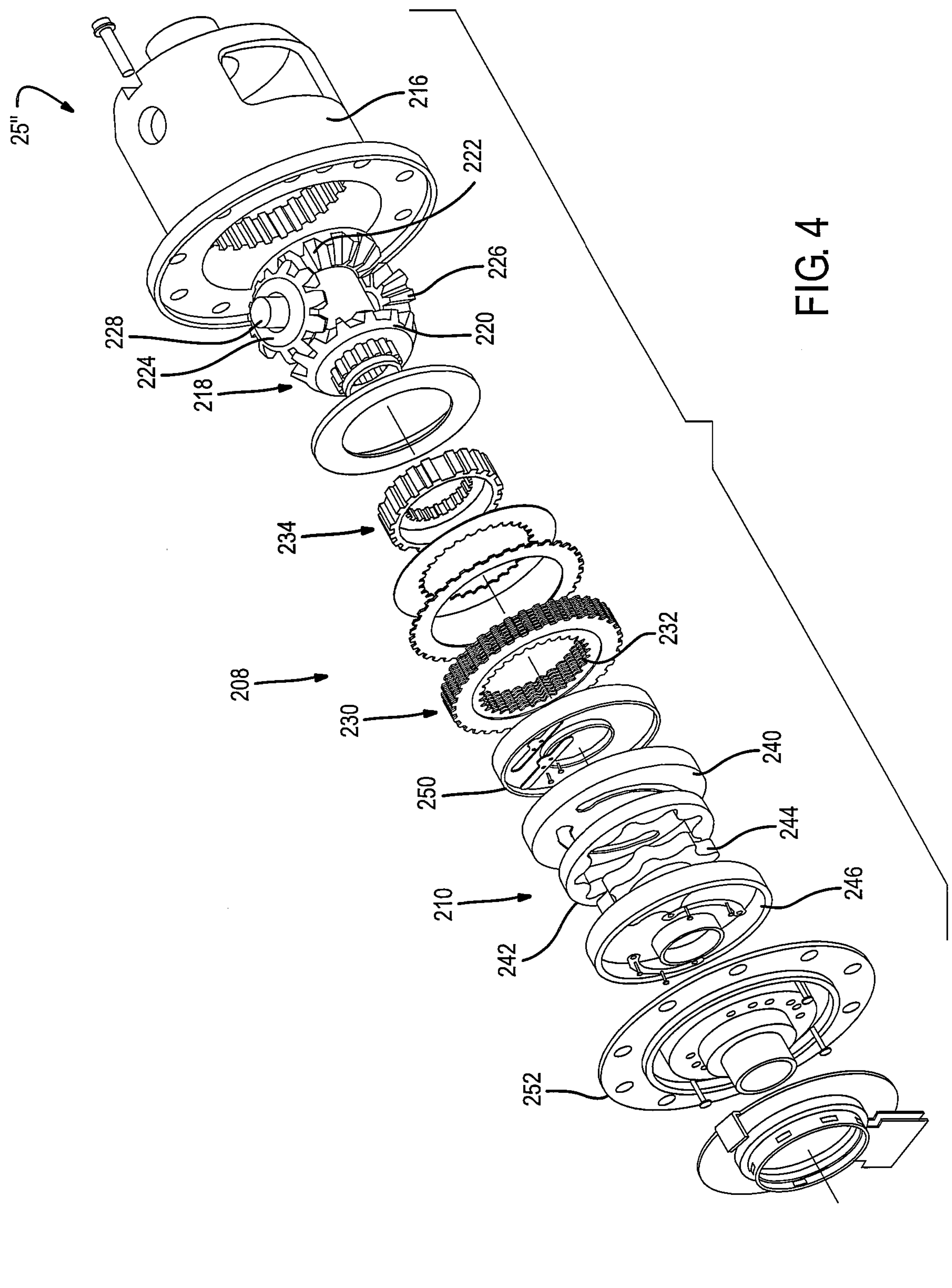
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FIG. 4

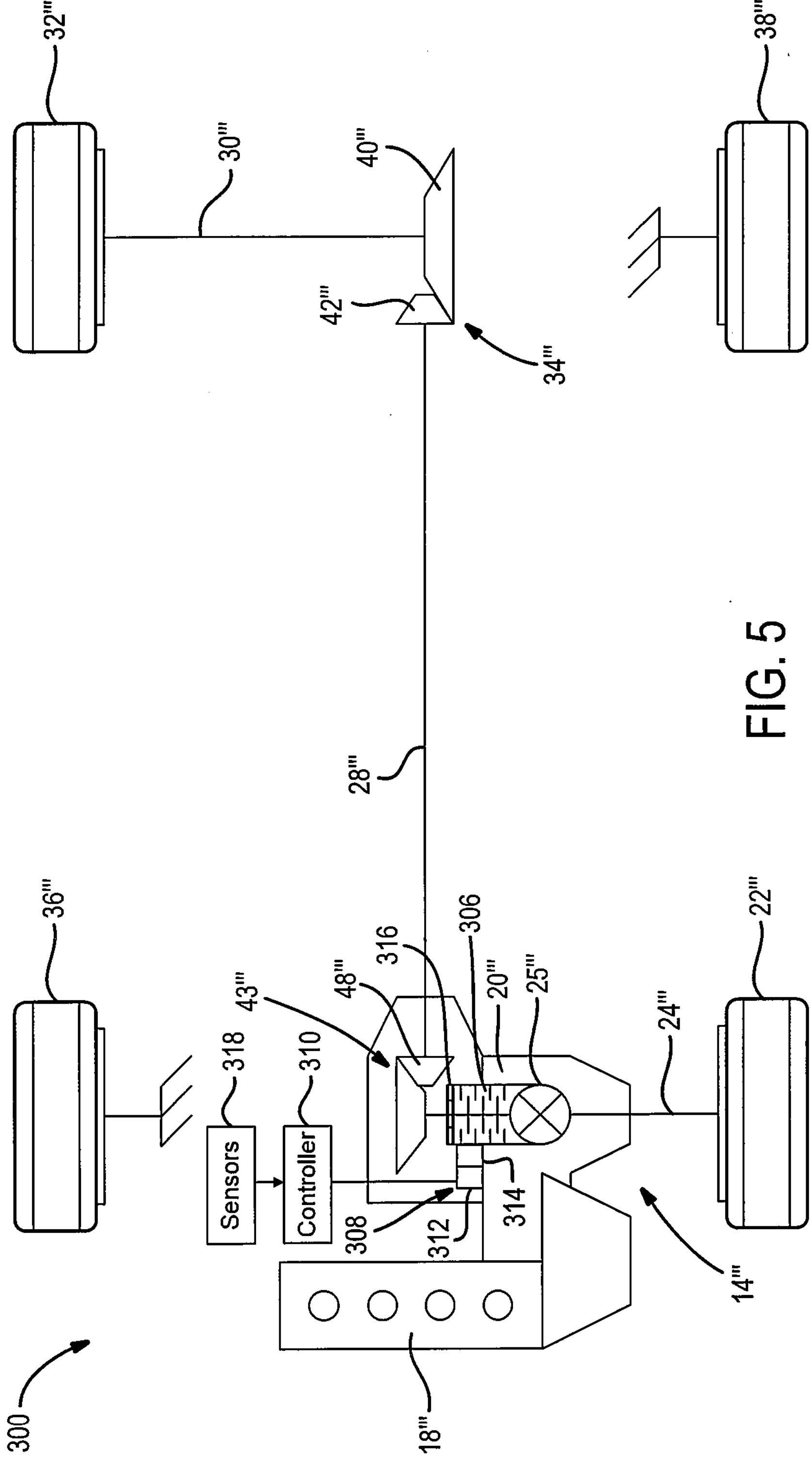
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FIG. 5

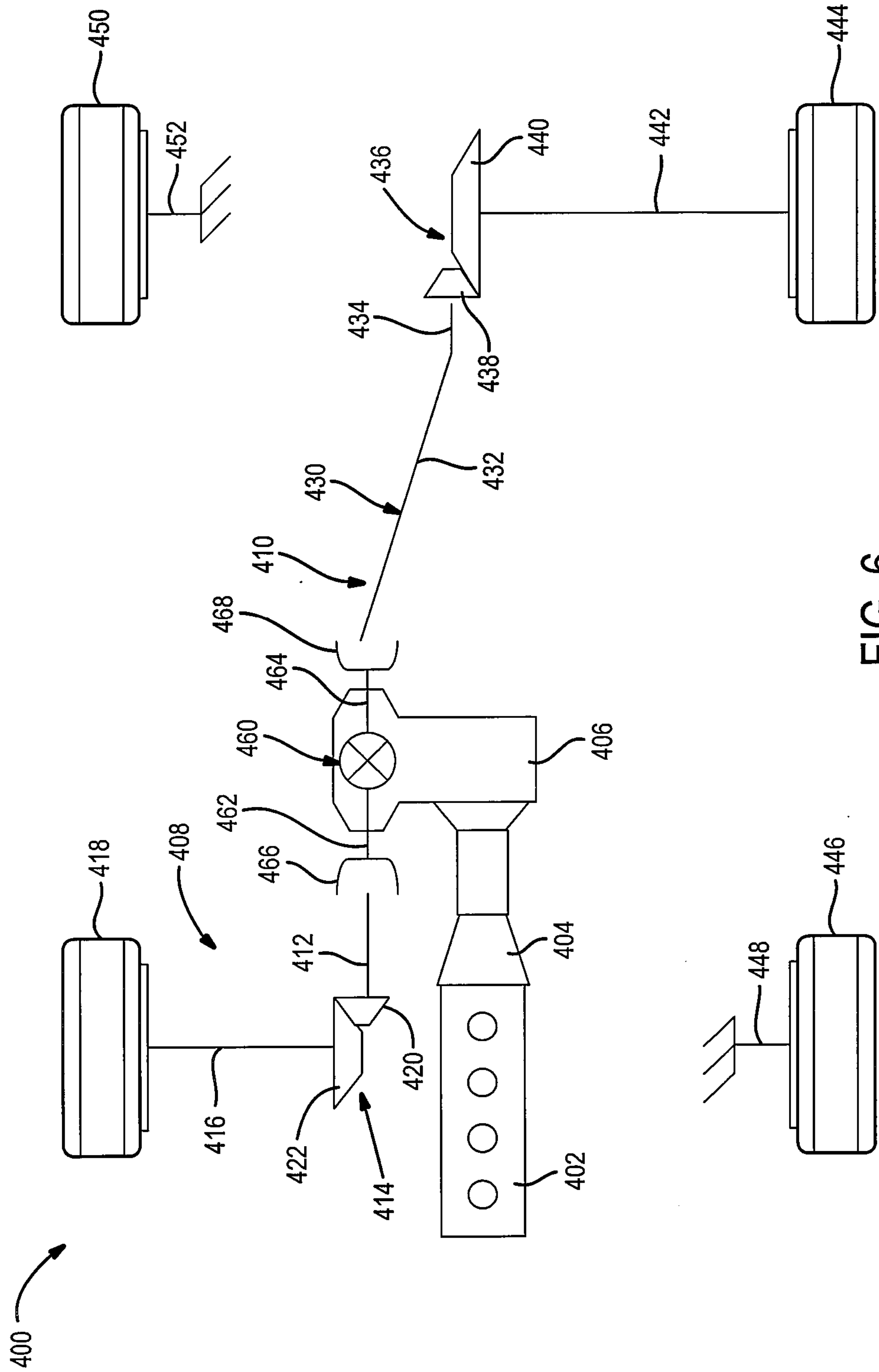
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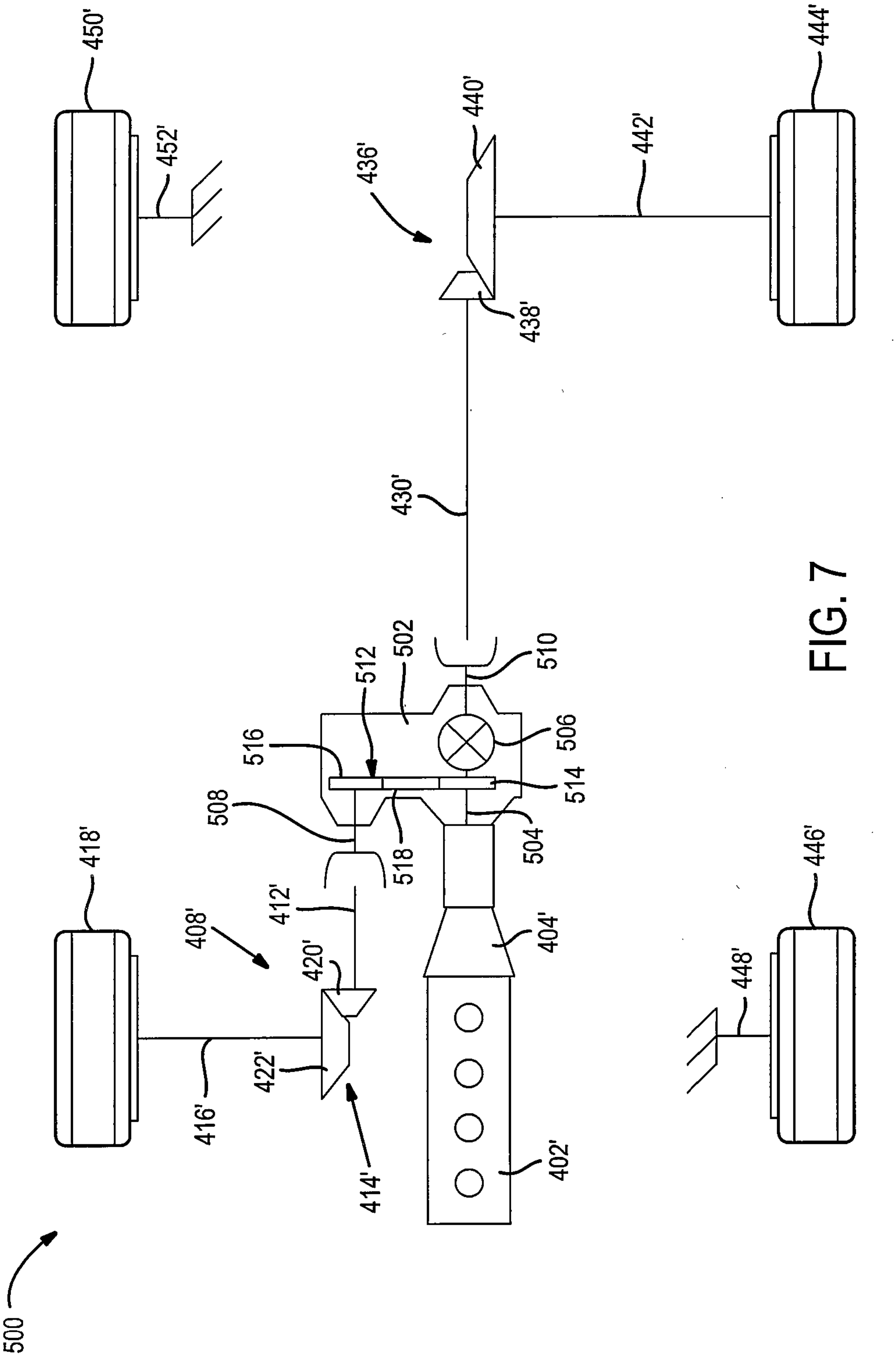
FIG. 6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402'
500

FIG. 7

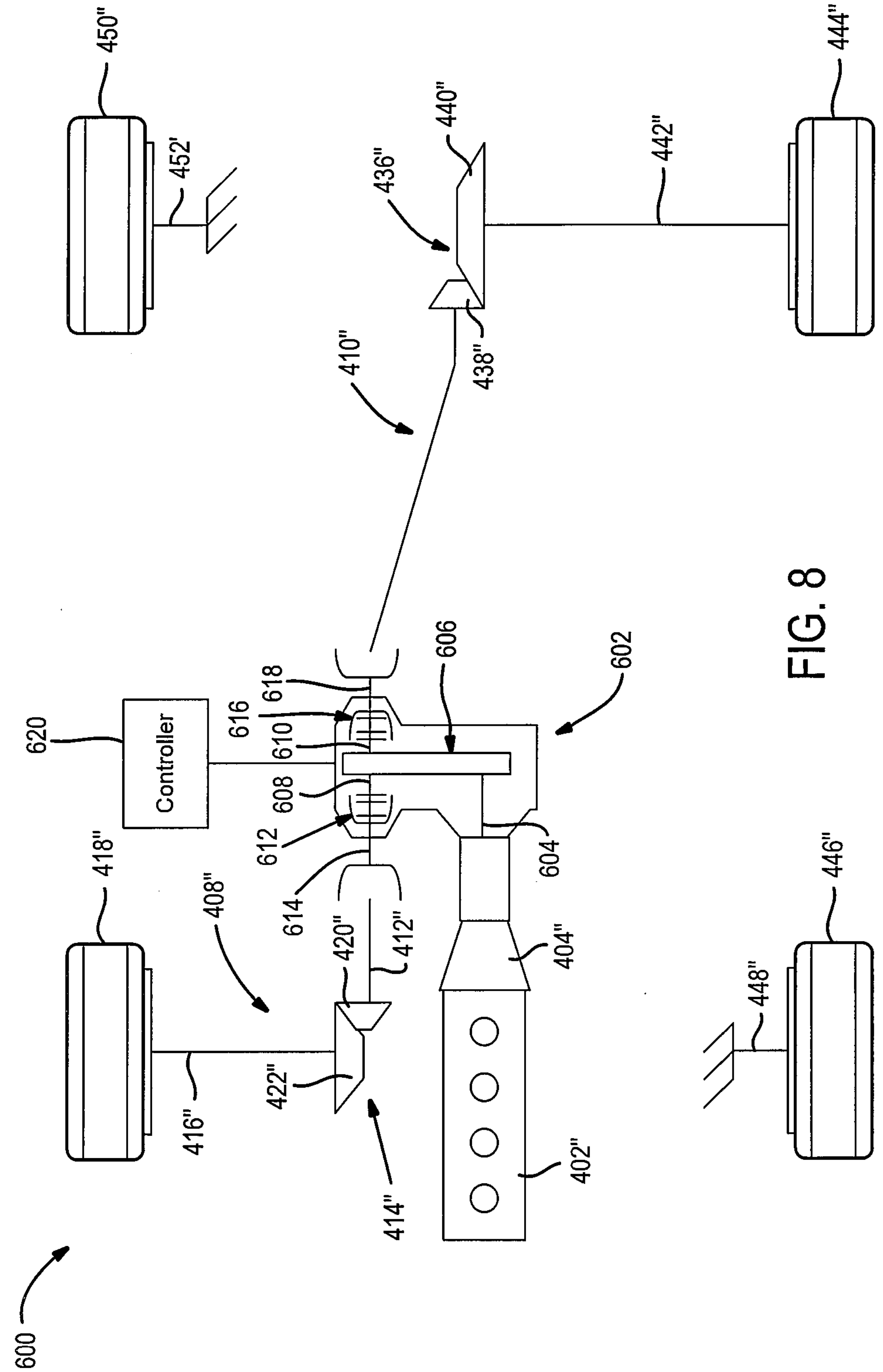
450"
452'
440"
436"
444"
442"
410"
438"
620
Controller
618
616
610
608
612
606
602
604
614
418"
408"
420"
412"
404"
422"
416"
414"
402"
446"
448"
600

FIG. 8

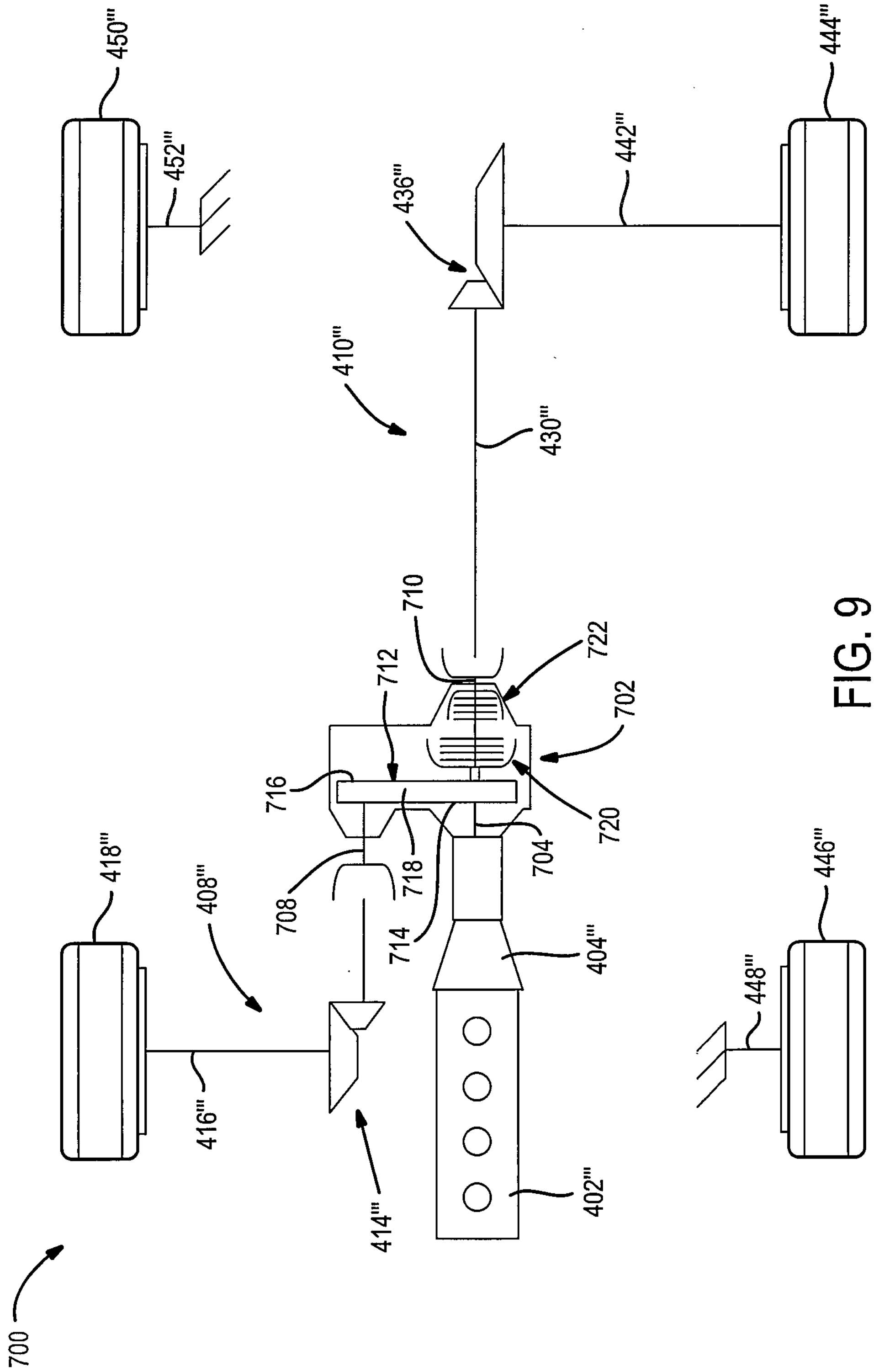
450'''
452'''
436'''
442'''
444'''
410'''
430'''
710
722
712
702
716
720
704
718
708
714
404'''
418'''
408'''
416'''
414'''
402'''
446'''
448'''
700

FIG. 9