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(R) Planetary Gears - Terminology

RATIONALE

This revision adds clarifications and updates relevant to both historical and recent vehicle planetary geartrain practice.

1. SCOPE

Figures 1 through 6 illustrate in simplified form some of the more common planetary gears, gearsets, and geartrain arrangements in order to establish applicable terminology. Figures 7 and 8 provide additional examples that use elements of those gear arrangements.

2. REFERENCES

2.1 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

Benford, H. and Leising, M., "The Lever Analogy: A New Tool in Transmission Analysis," SAE Technical Paper 810102, 1981, https://doi.org/10.4271/810102.

"Design Practices: Passenger Car Automatic Transmissions, Chapter 3," (Warrendale, SAE International, 2012), https://doi.org/10.4271/AE-29.

2.1.2 Other Publications

Dudley, D.W. (Ed.). (1962). *Gear Handbook*. McGraw-Hill Book Company, Inc.

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3. DEFINITIONS

3.1 SUN, PLANET, CARRIER, RING, PINION, AND WHEEL

In a planetary assembly, suns are the externally toothed gears interposed centrally between the other gears. Planet gears are the externally toothed gears that are supported by a carrier that is coaxial to the planetary assembly's central axis. The planets act as intermediary, or “idler,” gears between the other gears. Ring, or annulus, gears are the internally toothed gears that are coaxial to the planetary's central axis that surround and mesh with the planets. The suns, carriers, and ring gears can serve to transmit mechanical power into and out of planetary assemblies. The planets themselves as idler gears serve to transfer mechanical power between the other gears and the carrier, but only within the planetary assembly itself.

It should be noted that, while planet gears are those that regardless of size relative to the central sun gear are interposed between the sun and other coaxial gears, the specific name “pinion” should only be used for the smaller of two gears in a meshing pair. This follows general practice where the smaller of two meshing gears is called the “pinion” and the larger the “wheel” or sometimes just the “gear.”

For graphical example, in Figure 7, the “LP” long planet could be larger than Sun 1 or Sun 2. In Figure 8 each “P” planet could be larger than the “S” sun. In those and other such cases, it would be improper to call those particular planets “pinions.” In automotive and other planetary practice there are planetary assemblies where the planets are larger than the mating sun gear, providing for even greater relative torque multiplication from the sun to the carrier and ring gear.

It should also be noted that internally toothed planetary ring gears are inherently larger than any planet gears they surround and mesh with. In non-planetary externally toothed gears, “ring” is often another name given to the larger of two gears in a meshing pair, similar to the “wheel” or “gear” nomenclature above, mating with the smaller pinion.

3.2 GEARSET

A specific set of directly intermeshed gears. In a planetary assembly this can refer to either the sun and planet, the planet and ring, or the full planetary assembly.

3.3 GEARTRAIN

An assembly of one or more gearsets and/or planetary assemblies as a full transmission system with one or more overall gear ratios depending on input, output, and reaction and/or grounding arrangements.

3.4 EPICYCLIC

An epicyclic path of motion is a curve traced by a point on a circle that rolls on the outside of another circle. Planetary gears are referred to as epicyclic gearsets as a point on the pitch, or rolling, radius of the involute profile of one planetary gear when it rolls in mesh with its mating involute profile gear follows an epicyclic curve.

3.5 COMPOUND PLANETARY ARRANGEMENTS

A compound planetary arrangement is, specifically, when two or more subsets of otherwise individual gearsets in two or more axial planes are combined in one fixed assembly via shared planets reaching across the axial space between them. Figures 3 through 7 provide examples of this.

3.6 SOLAR, STAR, AND PLANETARY EPICYCLIC GEARSET ARRANGEMENTS

A solar planetary arrangement is when the sun is fixed or held to ground and the ring and carrier rotate with respect to it. A star planetary arrangement is when the carrier is fixed or held to ground and the sun and ring rotate with respect to it. A planetary arrangement, specifically referred to as such, is when the ring is fixed or held to ground and the sun and carrier. rotate with respect to it.

As long as there are relative speeds between any of these elements in any of these arrangements, the planets will rotate with respect to the carrier. If the relative speeds are fixed between any two of the sun, carrier, or ring, all three as well as the planets will be fixed with respect to each other and have no relative speed between them.

3.7 GEAR RATIO

Gear ratio is the numerical ratio of input to output speed between two of the elements of the planetary assembly, and conversely the ratio of the ideal, lossless output torque to the input torque between those same components. Ideal torque multiplication or division ratios between elements is independent of their speeds relative to ground or each other. Speed multiplication or division ratios for a full assembly may be quoted with respect to each element or relative to ground.

3.8 SPEED REDUCER

When the numerical gear ratio is greater than 1, as for input speeds greater than output speeds, the system may be referred to as a speed reducer, similar to the terminology used in industrial machinery, particularly as driven by electric motors or turbines. The downstream speed division ratio is then the inverse of the downstream ideal torque multiplication ratio, particularly when relative to a grounded carrier.

4. PLANETARY GEARSET ARRANGEMENT EXAMPLES

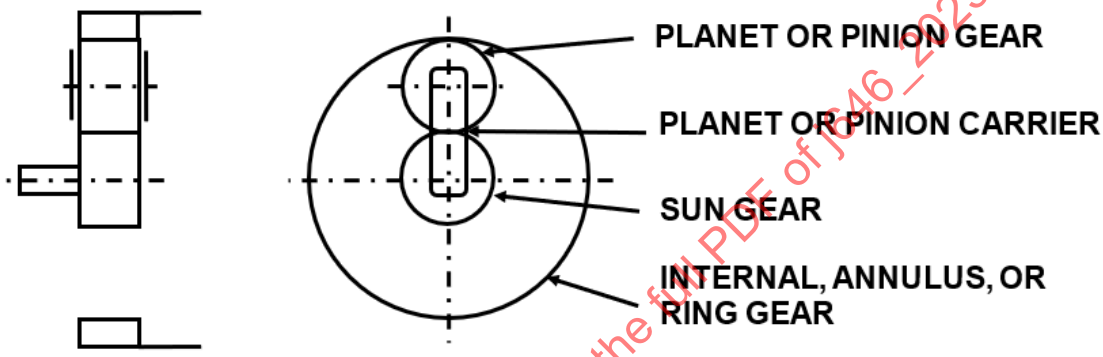

Figure 1 - Simple planetary arrangement

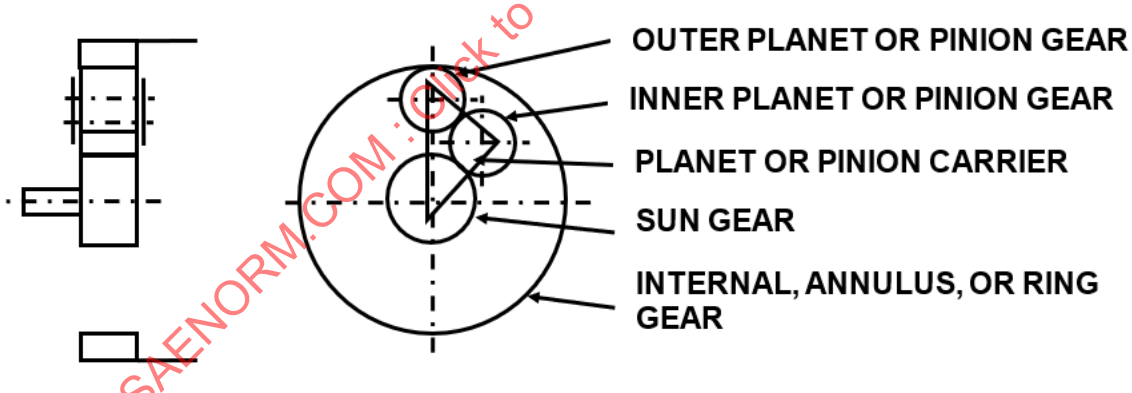

Figure 2 - Dual planetary arrangement

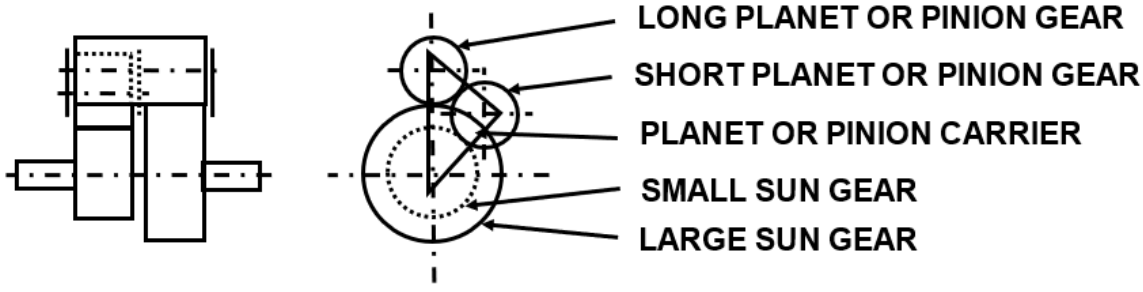

Figure 3 - Compound external planetary arrangement, dual sun, dual planet

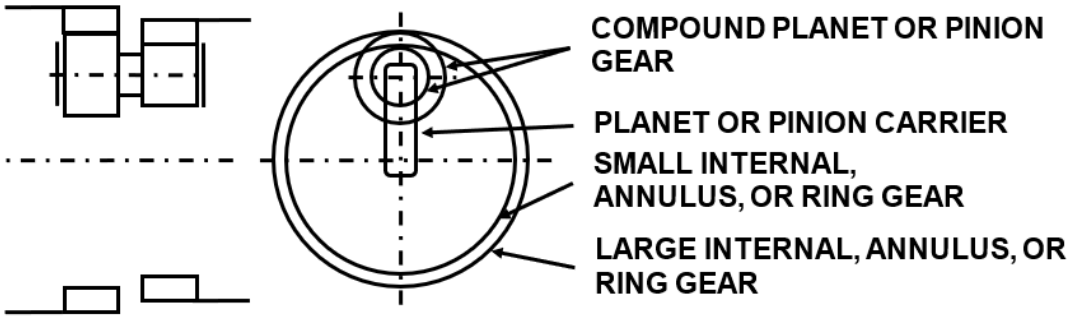

Figure 4 - Compound internal planetary arrangement, dual ring, stepped planet

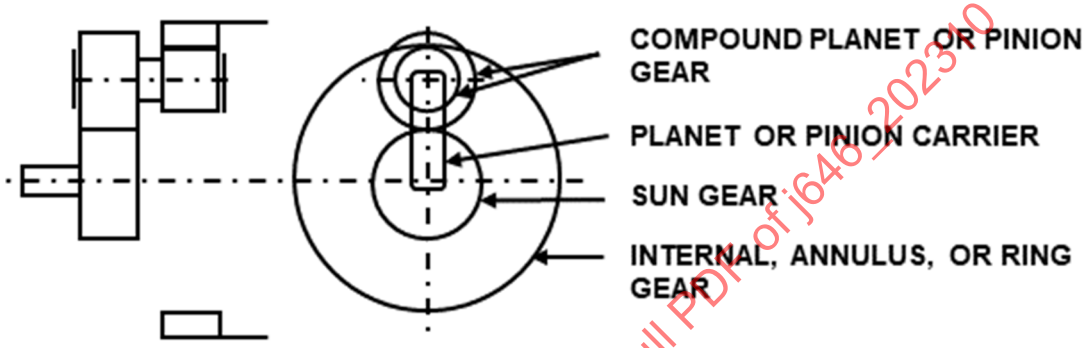

Figure 5 - Compound internal planetary arrangement, single sun, single ring, stepped planet

The above compound planetary gear arrangements may utilize additional gear elements. In particular, the compound planetary in Figure 3 may be used in combination with a ring gear in the commonly found Ravigneaux planetary arrangement in Figure 6.

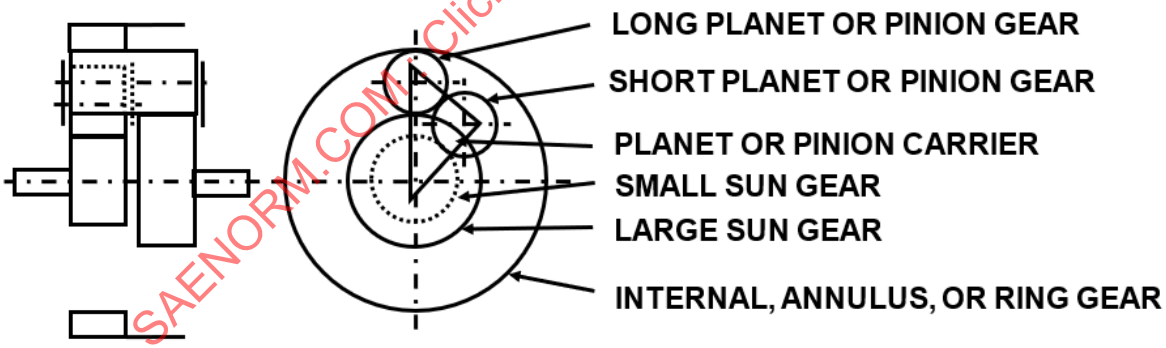

Figure 6 - Ravigneaux planetary arrangement

The Ravigneaux-type planetary arrangement may also be found utilizing two ring gears, with a long planet extending between what would individually act as two dual planet planetaries. An example is as follows: