Mechanics/Machinery

Phase-Oriented Gear Systems

Larger mechanical advantages can be realized in smaller packages.

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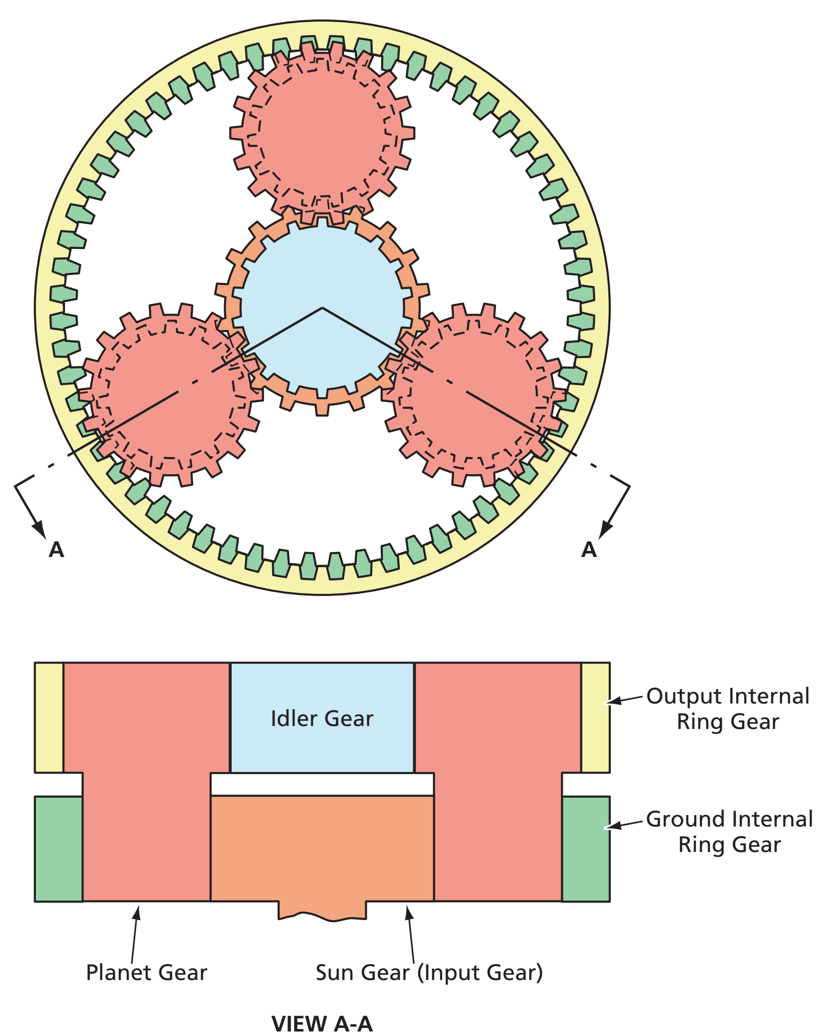
Phase-oriented gear systems are differential planetary transmissions in which each planet gear has two sets of unequal numbers of teeth indexed at prescribed relative angles (phases). The figure illustrates an application of the phase-oriented gearing concept to a relatively simple speed-reducing differential planetary transmission that includes a sun gear, an idler gear, three identical planet gears, a ground internal ring gear, and an output internal ring gear. Typically, the ground internal ring gear and output internal ring gear have different numbers of teeth, giving rise to a progressive and periodic phase shift between the corresponding pairs of teeth engaged by each successive planet gear. To accommodate this phase shift, it is necessary to introduce a compensating phase shift between the ground-gear-engaging and output-gear-engaging sections of each planet gear. This is done by individually orienting each planet gear.

Each planet gear consists of a top (output-gear-engaging) part and a bottom (ground-gear-engaging) part that are coaxially joined into a unit. Typically, the numbers of teeth in the top and bottom parts differ by one, (but could differ by more than one). Typically, the teeth on the bottom part are indexed with those on the top part such that at least one tooth on the bottom part lies at the same angular position as does one tooth on the top part; in other words, these two teeth are in phase with each other. The next tooth on the top part is slightly out of phase with the nearest corresponding tooth on the bottom part. Proceeding circumferentially around the planet gear, this phase difference increases linearly, tooth-by-tooth, until the total phase change reaches 360° upon completing one full rotation. Depending on the specific numbers of teeth, such an arrangement could offer many tooth-phasing possibilities, making it possible to include various numbers of appropriately phased (oriented) planet gears. This is advantageous because in some applications, it is desirable to increase numbers of planet gears in order to make more teeth share the total load, thereby reducing loads on individual teeth.



Different Numbers of Teeth on the upper and lower part of each planet gear are used to accommodate the phase differences occasioned by the use of different numbers of teeth on the ground and output gears.

The phase-oriented gearing concept admits of so many variations that is not possible to describe or even to merely list them within the space available for this article. In general, it can be said that the numbers of teeth and the angles can be chosen to achieve desired speed ratios and other design goals. The phase-oriented gearing concept can be implemented in conjunction with other advanced planetary-gearing concepts, including those of carrierless and gear-bearing transmission types described in several *NASA Tech Briefs* articles in recent years. Relative to prior differential planetary transmissions, phase-oriented gear systems offer advantages of simplicity, ruggedness, strength, and smoothness of operation. Moreover, for a typical speed-reducing transmission, phase-oriented gearing makes it possible to obtain unprecedentedly large mechanical advantage in a compact package — in effect, what previously would have been characterized as two-stage performance in the space previously occupied by a one-stage package.

This work was done by John M. Vranish of Goddard Space Flight Center.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center, (301) 286-7351. Refer to GSC-14790-1.