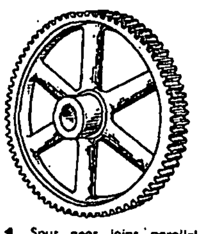
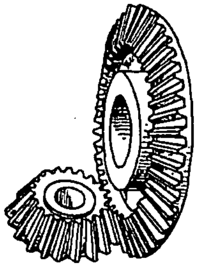
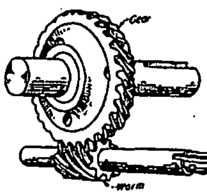


1 Spur gear joins parallel shafts; has straight teeth

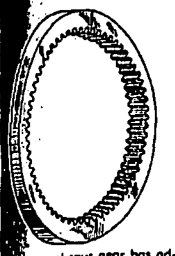


2 Bevel gear joins nonparallel shafts; straight teeth

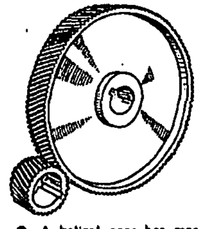


3 Worm gear connects right-angle shafts; screw teeth

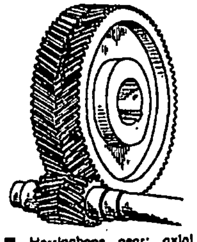
4 Spiral gear joins shafts at an angle or parallel



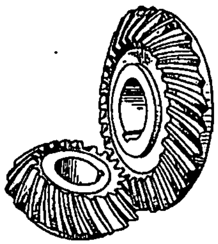
5 Internal-spur gear has advantages over the external



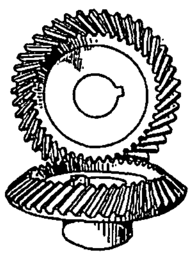
6 A helical gear has more teeth in mesh than a spur



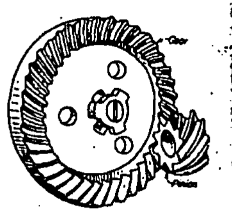
7 Herringbone gear; axial thrusts oppose each other



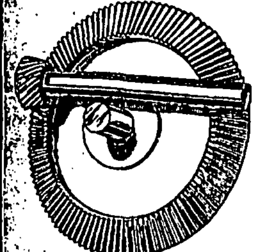
8 Spiral-bevel gear teeth have overlapping action



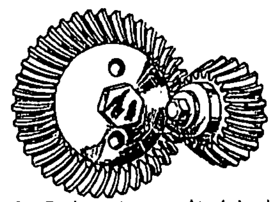
9 This skew-bevel gear design has skew teeth in both the gear and the pinion



10 Hypoid gear has curved teeth; pinion axis is offset below that of gear



11 Hypoid gear is arranged so that pinion shaft crosses the face of gear



12 Zerol gear is a curved-tooth bevel design with a zero spiral angle

Apply Right Gear to the Job to Get Longer Service

John K Rewalt, application engineer, Philadelphia Gear Works, compares characteristics of gears common in industrial applications. One gear may run smoother and at higher speed, transmit greater load, suit application better than another design

■ GEARING IS A TERM sometimes applied to any method of transmitting motion from one shaft to another. It includes pulleys and belts, sprockets and chains, rocker arms and links, and toothed wheels or gears. Many problems relating to the different methods of motion transmission are similar, but each has its separate and distinct field of usefulness. Here we will deal with toothed gearing only.

Gears may be classified with reference to the elements of their teeth, and also the relative position of their axes or shafts, as: Fig. 1—Spur gears connect parallel shafts and have straight teeth. Fig. 2—Bevel gears connect shafts whose axes meet if they are prolonged and have straight teeth. Fig. 3—Worm gears connect shafts that are not parallel. Their axes do not meet, *and they have screwlike teeth. Fig. 4*—Spiral gears connect shafts that are either parallel or at an angle, but their axes do not meet and their teeth are helical.

Under the heading of spur gears, the internal gear and pinion, Fig. 5, should be considered. It is the opposite of an external gear and its teeth point toward its center. Because of this condition, for the same tooth ratio the length of the line of tooth action is greater. Also, the teeth come into and go out of contact with less slippage.

An internal gear has several advantages when properly applied, such as in drives for truck and tractor rear axles. With its mating pinion, it operates on a closer center distance than an external gear of the same size and forms its own gear guard. It has more teeth in contact with its pinion than a corresponding-size external gear. All these advantages give longer life and greater strength. Internal gears also have helical teeth.

Racks that also fall into the spur-gear category are straight pieces with teeth that mesh with spur gears. Theoretically, if a straight rack were extended until it reached around the earth, it would actually be a spur gear. Racks may also be cut *helical* and herringbone.

Gears, other than straight-tooth spur for connecting parallel shafts, are helical, Fig. 6, and herringbone spur gears, Fig. 7. They meet demands for smooth, silent operation not attainable with straight-tooth spur gears. Helical and herringbone gears of proper design also promote long gear life and high operating efficiency. These so-called quality gears have teeth that extend helically across their face. This *obliquity* keeps the teeth of each meshing pair in engagement, until one or more of the following pairs are well engaged, which eliminates sudden load transfer, impact or shock on the teeth.

As a result of the overlapping action of spiral-bevel-gear teeth, Fig. 8, load is transferred from tooth to tooth without shocks or sudden changes in tooth pressure. With straight-tooth gears, transferring load from tooth to tooth creates noise and vibration, especially noticeable at high speeds. Because of the larger number of teeth in contact, and the consequently greater area over which the load is spread, curved-tooth spiral-bevel gears transmit greater loads than straight bevels, Fig. 2, of the same size. Spiral-bevel gears can transmit power between shafts at practically any angle and speed. They are especially desirable where smooth, quiet gears are required and for large ratios at high speeds where pinion size must be kept as small as possible. Their continuous pitch-line contact makes it practicable to obtain good performance with a smaller number of teeth in pinion than is possible with straight bevels. Spiral-bevel gears run on either ball or taper-roller bearings to provide for thrust and radial loads. Their efficiency compares favorably with accurately generated straight-tooth bevels.

Skew-bevel gears are another variety of bevel gearing, in which the tooth arrangement departs from the usual radial plan of straight-line teeth. The axes of the gears are not in a common plane. There are two designs of these unorthodox gear drives. In one the pinion has ordinary straight teeth, like Fig. 2, and the gear has oblique teeth, which are the most commonly used. The other has skew teeth in both pinion and gear, Fig. 9.

Hypoid gears, Fig. 10, have curved teeth like the spiral-bevel design, but have the *pinion axis offset* above or below the center of the gear axis like skew gears. They are stronger and run more smoothly and quietly than spiral-bevel gears, which in turn run much more smoothly and quietly than skew bevels. Hypoid gears were first used by the automotive industry in 1925. Their operating qualities, together with the fact that their pinion offset permits the design of lower automobile bodies, have proved such an advantage that today the majority of American automobiles have adopted them. Other uses are in steel and paper mills, and on locomotives and printing presses. In another design of this gear, Fig. 11, the *pinion shaft crosses* the gear face to permit placing bearing at pinion.

Zerol gears, Fig. 12, are a curved-tooth bevel design with zero-degree spiral angle. They combine the localized tooth contact of spiral-bevel gears with the low thrust loads of straight-bevel gears. Their tooth arrangement produces smooth, quiet operation even under extremely high loads. For these reasons zerol gears are replacing straight-bevel gears in many applications where thrust limitations prevent use of spiral-bevel designs.

Like straight-bevel gears, zerol gears have no inward axial thrust. With zero-degree spiral angle, thrust loads are the same as for equivalent straight-bevel gears; therefore, zerol gears can be substituted for straight-bevel gears, without changing thrust bearings. Like other bevel gears, they are designed with long and short addendum tooth proportions for smooth, quiet operation, and with large fillet radii for maximum strength.

The worm and gear is not a new mechanism; the spiral screw was studied by Archimedes (287-212 BC). It has been during the last 40 years, however, that complex engineering and research work has brought it to its present high state of efficiency and use-