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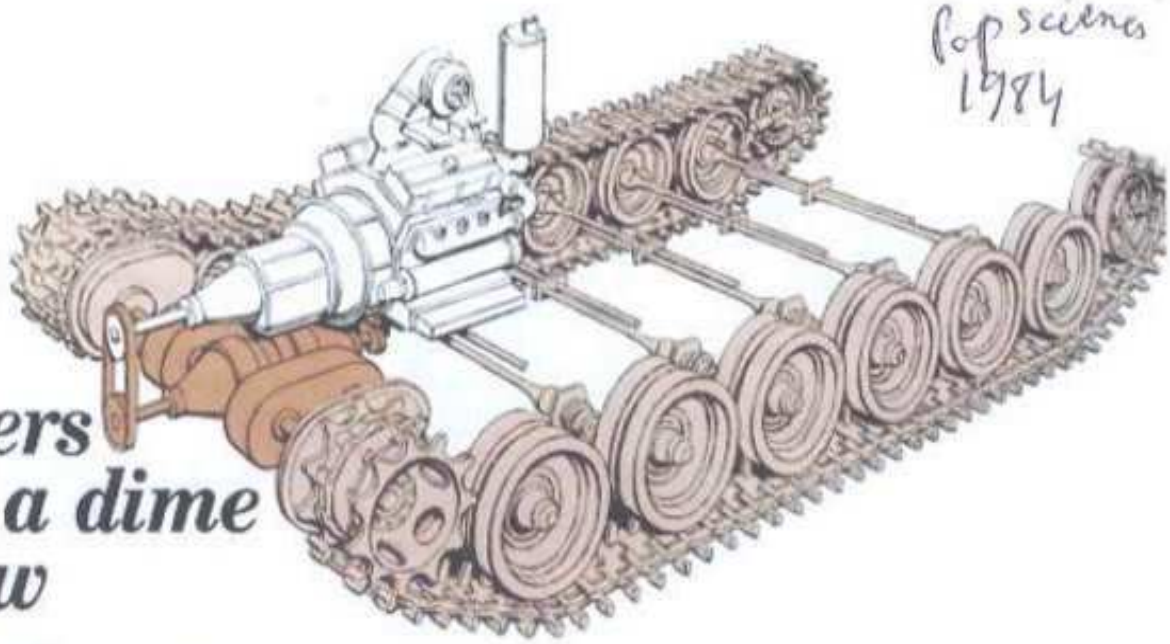

Tanks and dozers turn on a dime with new all-gear steering

Today's clumsy tracked vehicles are steered by costly, power-hungry transmissions. But a new system promises low-cost, maneuverable steering. The Marines plan to use it.

By MICHAEL BARGO JR.
Illustrations by Ray Pioch

Vernon Gleasman has been thinking about bulldozer steering for 50 years. "Back in the '30s my brother Claude used a Caterpillar bulldozer to haul logs out of New York's Adirondack Mountains," he recalls. "During the winter the bulldozer had to pull a convoy of loaded sleds up and down the steep snow-packed roads."

Like all Caterpillars, the bulldozer had a clutch and brake on each track for steering. To turn, the driver disengaged the clutch on one track, removing power from the sprocket, while engaging the other clutch. This jerked the dozer in the direction of the unpowered track—and cut power and traction.

Turning the bulldozer on those slick Adirondack roads meant that the driver had to contend with the enormous weight of the loaded sleds as they tried to push or pull his half-powered vehicle down the hill. "There were several close calls before the driver mastered clutch-and-brake steering," Gleasman remembers.

Gleasman, inventor of the revolutionary Torsen differential [PS, Feb. '84], thought there must be a better way to steer tracked vehicles. He filed the problem away in the back of his mind and thought about it for decades. But work on the new differential took priority. With his sons James and Keith, Gleasman devoted full time to it through the 1970s.

"Now that the differential has achieved worldwide acceptance," says Gleasman, "we have the time to devote to the steering gear. We've had the basic idea for quite a few years."

The idea—the Gleasman steer drive—is beautifully simple. The new system uses off-the-shelf parts, including standard differentials, in an all-gear device that gives full power to the tracks when turning. An integral part of the drive train, the Gleasman drive is the first purely mechanical system designed for tracked vehicles like bulldozers and tanks to combine steering and driving in one system.

The steer-drive outclasses conventional tracked-vehicle steering systems in several ways: It is cheaper, simpler, and more reliable, and it provides greater maneuverability. A study group charged with finding a better steering system for the new amphibious vehicles of the Marine Corps recommended the Gleasman as the only suitable one.

Antiquated steering

There have been few improvements in tracked-vehicle steering since 1904, when the Caterpillar Tractor Co. installed clutch-and-brake steering on the first tracked vehicles. The very nature of tracks creates a problem. Wheeled vehicles with front and rear axles need only move the front wheels to turn. But the only way to turn a tracked vehicle is to vary track speed. Doing this by clutch and brake cuts maneuverability and traction, as Vernon Gleasman discovered back in the '30s.

Modern army tanks turn at high speeds by using separate automatic transmissions to vary the speeds of the tracks. But the principle is still the same. And this type of steering gear is too costly, complicated, and heavy for amphibious vehicles. The transmissions cost from $50,000 to $140,000 per tank and wear out more quickly than do clutches. Also, automatic transmissions can't power bulldozers or move heavy loads. (A Caterpillar D10 bulldozer weighs 95 tons; tanks move only their own weight.)

Steering can also be done hydrostatically, but this takes an enormous amount of power. "It would require hoses to carry pressures of 10,000 psi," says Keith Gleasman. "If one broke, the force could cut a man in half. It would also require about a barrelful of fluid for the system. This alone would weigh more than our entire steering mechanism."

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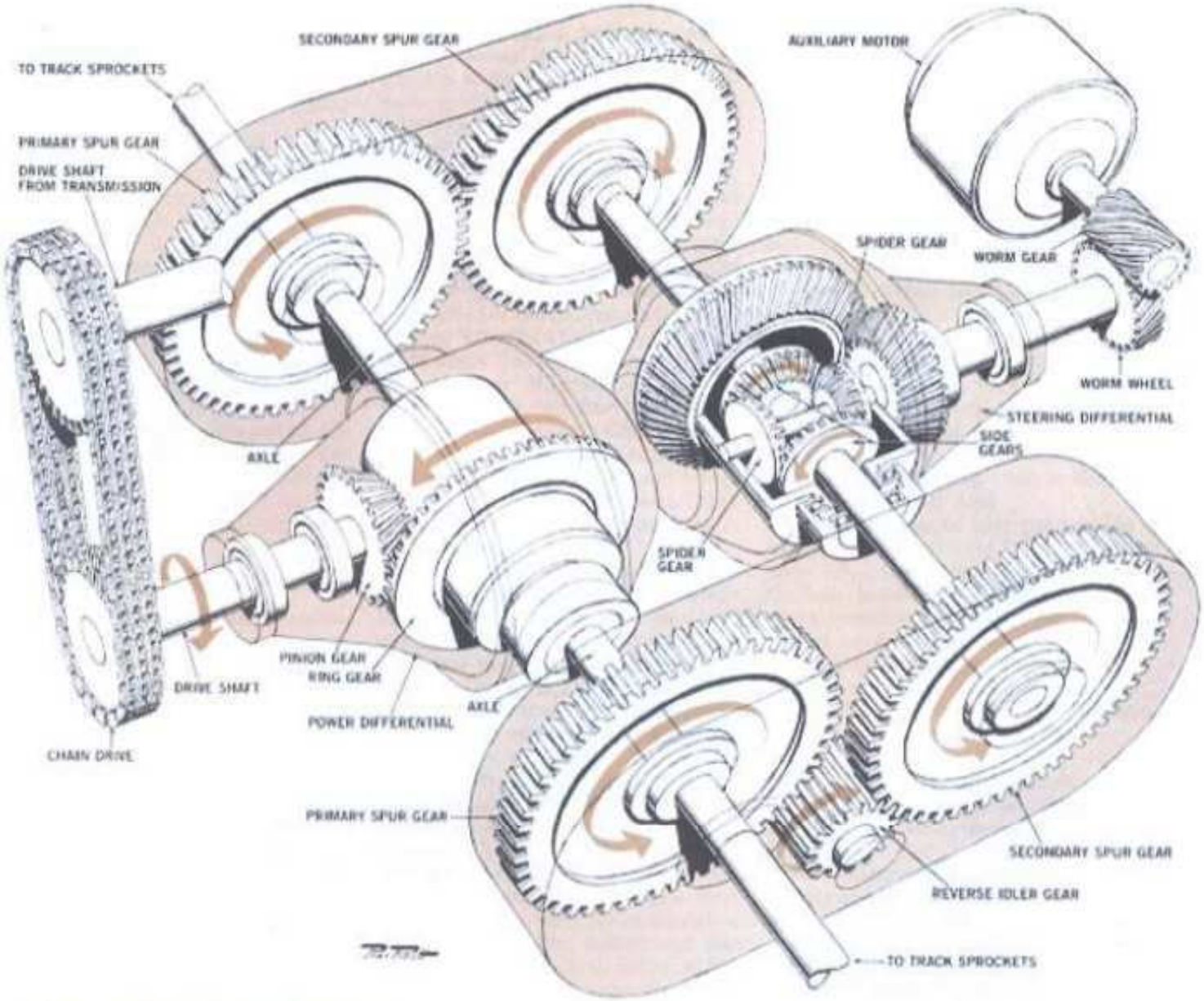

How the steer-drive system works

Gleasman's simple steer drive (shown at upper left mounted on the Marines' new LVTP7) uses two standard bevel-gear differentials with interior spider gears. The power differential mounts between the axle shafts and transmits power from the drive shaft to the track sprockets via the primary spur gears. But this differential can't steer the vehicle; it simply provides power to move it in a straight line. It can only differentiate when the steering differential allows it.

The steering differential mounts on a shaft parallel to the first. The input shaft to this secondary differential has a worm wheel that's turned by a worm gear powered by an auxiliary motor. The off-the-shelf motor is controlled by a rheostat mounted on the steering wheel.

When the vehicle travels in a straight line as shown, the steering wheel is held steady, and the worm gear doesn't move. Because it is controlled by the worm wheel, which can't turn a worm gear, the steering-differential housing is locked. This effectively locks the power differential, because of the action of the interlocking spur gears.

Although the second shaft is not connected to the sprockets, the two spur gears rigidly attached to the shaft mesh with an identical set of spur gears connected to the primary shaft. Because the steering-differential housing is kept fixed, the two spur gears run at the same speed. Since these secondary spur gears mesh solidly with the primary gears that run the sprockets, those gears must also move at equal speed. The power differential, though mechanically free to move, is effectively locked as the vehicle moves in a straight line using full engine power.

An idler gear mounted between the right-hand set of spur gears reverses the rotation of the secondary spur gear. This is necessary because the axle shafts must be able to turn in different directions. If these shafts couldn't spin in opposite directions, the two spur gears would bind when turning.

To make a turn, the speeds of the two driving sprockets must be varied so the tracks can move at different speeds. Here's where the steering differential begins to operate. The motor and worm gear act on this secondary differential just as the drive shaft in a car does. The more the driver turns the steering wheel, the more the worm gear turns the worm wheel—and rotates the housing of the steering differential.

As the housing rotates, the spider gears inside turn and walk along the side gears mounted on the axle ends inside the housing. As with conventional differentials, the rotating spiders force one side gear to move forward in one direction and the other to move equally in the opposite direction.

But because the axle shafts are already moving in opposite directions, thanks to the idler gear, this turning action merely slows down one side gear and speeds up the other. The differential action is transmitted via the spur gears to the front axles. Because the front differential is free to move, it divides the power between the sprockets, allowing the two tracks to move at different speeds and turn the vehicle.

...s amphibious vehicles the ...e Corps commissioned SEACO ...stems Engineering and Analysis ...o.), an independent research firm in Alexandria, Va., to find a steering gear that is:

- Commercially available, to avoid the enormous expense of custom-developed technology.
- Small enough to fit inside existing vehicles while allowing space for a crew and military gear.
- Simple, durable, and reliable enough to withstand field use.
- Light enough to be transportable on C-130 aircraft and retain the balance needed for seaworthiness when moving through water.

The SEACO group surveyed all the available types of steering gear. The only one to meet the low-weight, maneuverability, space, and cost requirements of the Marine Corps was the Gleasman system.

Beautiful simplicity

The durability, ease of maintenance, and low cost of the Gleasman steer-drive system arise from its basic simplicity. It uses two ordinary bevel-gear differentials, the kind that can be found on any truck. This off-the-shelf quality makes it less expensive than either the turbomatic transmission or clutch-and-brake-type steering gear. Its cost is one-tenth to one-fifteenth that of standard steering gear.

Unlike these other types, it has few parts (see diagram). And it does not lose torque or horsepower. The two drive sprockets are locked in at all times, keeping the engine's power on both tracks, even when turning.

According to Colin Drummond, project engineer at SEACO, the second differential acts as a feedback device, feeding power from the side losing traction to that gaining it. This prevents spin-out on ice or slick surfaces, both when traveling in a straight line and when turning.

Unlike the conventional clutch type, the Gleasman steer drive also offers true pivot steering. With conventional steering, one track is braked for tight turns, and the vehicle pivots on the center of the unmoving track. But because the Gleasman drive propels as well as steers, a tracked vehicle can pivot about its center axis.

"With our steer-drive system," Gleasman says, "the Marines' LVTP7 [amphibious landing vehicle] can turn about its axis twice, a 720-degree spin, in seven seconds, with no more horsepower than it is currently using. That's impossible with other types of steering gear."

The new drive is also regenerative: When one track slows down while turning, the other track instantaneously speeds up, using the power from the other side. All other attempts at regenerative steering required that right and left tracks be driven independently, by using two different transmissions, for example.

How did the Gleasmans develop this revolutionary system?

"One morning you just wake up and it's there," Vernon Gleasman says. His key insight: using a worm gear to vary power supplied to the two tracks when turning and to lock the differential during straight-line motion (see diagram). It is this locking action of the worm gear that enables the steer drive to work. This configuration, however, defies conventional mechanical-engineering concepts.

"According to engineering books," says Gleasman, "the locking action was understood to be 90 percent friction and 10 percent mechanical. The design as I use it is 90 percent mechanical and 10 percent friction. This enables me to use an auxiliary motor to control the secondary differential and steer a tracked vehicle."

The engineering community was at first as skeptical as it had been of Gleasman's Torsen differential. "The steer drive has a unique simplicity that solves a significant number of problems associated with traditional steering mechanisms," says SEACO's Drummond. "Most people are surprised that such a simple device can perform all of the functions it claims to perform. But it does.

"You'll get people who put it aside because it's so simple," Drummond adds. "But the closer you look at it, the more beautiful it becomes. It's getting engineers to overcome the 'not invented here' syndrome."

The Gleasman steer drive's applications extend beyond its planned use in the Marines' amphibious vehicles. The system can be retrofitted to virtually any tracked vehicle. Notes Drummond, "It has a lot of applications in the real world. It's made of conventional components, so there's a lot of flexibility."

For bulldozers, this means that the power-wasting clutch-and-brake method can finally be discarded. With the new steer-drive system, tracked loaders will be able to scoop up a load, turn, and dump it into a truck with one easy motion, as the driver uses an ordinary steering wheel. Now, after scooping up a load, tracked loaders must back up, turn, and drive forward because they need full power to handle a scoopful of material.

The steer-drive system can also be used in vehicles like end loaders, with articulated joints. These are driven by a planetary gear in the hub. Gleasman explains how it's done: "You just drop the two differentials, and index one planetary element forward and one backward to effect a turn—and it still maintains a positive drive."

The steer-drive system may soon be designed into a number of tracked vehicles, according to Jim Gleasman, who handles patent-license negotiations for the steer-drive system. He has had a number of meetings with several U.S. companies and trade representatives of foreign companies. Although unable to reveal specific plans, he reports, cheerily, "Most people I've met with have expressed a sincere interest in the system."

The first vehicle to use the Gleasman steering gear will be the 26-ton LVTP7, the advanced amphibious landing vehicle of the Marine Corps. The new drive will provide power to both tracks at all times, for better maneuverability.