

# DIESEL PROGRESS

## NORTH AMERICAN

Dedicated To Engine Drive Systems Professionals

QUENTIN CURRIE

JUNE 1981



**SPECIAL EMPHASIS:**  
Technical Dynamics Of  
The Small Diesel Markets

Also: New Technologies Meet On A Hillside

# New Technologies Meet On A Hillside

By Mike Osenga



When we first began hearing reports about a new farm tractor from Knudson Tractor, the phrase "state-of-the-art" kept popping up.

Use of the phrase is not unusual. It is bandied about with regularity in industrial circles as almost everyone feels their particular product or service represents the latest specific technology has to offer.

Webster calls state-of-the-art "the level of development reached at any particular time, usually as a result of modern methods." All of which means that everything, or nothing, could lay claim to the title.

However, the more we heard about this four-wheel drive (and steer) tractor, the more the phrase seemed to fit. Electronic controls were used in two different functions. Microprocessors controlled the transmission. The transmission itself is new. The engine was spec'ed to meet the latest needs of agriculture, namely fuel economy. The axles were unique, custom units involving commercial technology from the construction market.

So while other pieces of mobile equipment may be moving along faster in one or two specific areas, it seems that this new ag tractor finds a lot of the latest technologies in a number of areas coming together in this one application.

And the application itself is different. The tractor is aimed at the hillside farming market. Basically concentrated in the Pacific Northwest, Northern Idaho, Southeastern Idaho and parts of California, it represents a geographically narrow market. However, the areas in California alone represent over 500,000 acres, so while it may be a regional application, it is by no means insignificant.

The application itself, with the possibility of working on grades up to 45%, required special design considerations throughout. The main feature is automatic leveling of the tractor, keeping the operator on an even keel on side slopes up to 28%. This, Knudson tells us, means more operator comfort, better weight distribution for increased traction, increased time in the field, leading to better overall productivity — the goal of any new design.

The tractor, which rolled off the assembly line for the first time last October and opened to rave reviews at January's Ag Expo show in Spokane, is actually a second generation. However, things have changed since the original models were sold from 1974 through 1977. Knudson Tractor is now a division of Allmand Bros., Inc. which purchased patent and manufacturing rights in 1979. Manufacturing has been moved from North Dakota, to Allmand's headquarters in Holdrege, Neb. Several key engineering people, familiar with the tractor also made the move and were instrumental in its redesign.

The story starts with a Cummins NTA-855-C "Big Cam" diesel engine which delivers a maximum 360 hp (268 kW) at its governed speed, 2100 rpm. The six-cylinder, 855 cu. in. (14 L) engine delivers a maximum torque of 1075 ft. lbs. (1458 Nm) at 1450 rpm.

"We used an earlier version of the 855," explained Knudson's Bud Ward. "The engine can run at lower rpm with the 'constant power' concept. By having that constant power, the torque curve is higher with more power at a lower rpm, meaning less fuel."

The engine is located forward over the front axle putting 60% of the static weight on that axle, which when the vehicle operates under load yields about a 50/50 split of the weight over the axles. Following this idea one step further, the drawbar is connected to the frame immediately behind the front axle furthering the even distribution of weight. This, Ward said, prevents the tractor from becoming "tail heavy" under load, which could lead to unstable results on the side of a hill.

Accessories in the engine compartment include a Perfex radiator, Donaldson silencer and an Engineaire pre-cleaner.

Two hydraulic pumps provide oil for auxiliary functions. A 28 gpm engine-mounted pump gives power for the front axle steering brakes and four remote outlets for implement power. The second pump, a 12 gpm model, also engine-mounted, provides oil for the self-leveling mechanism and the rear axle steering.

From the engine a Twin Disc drive shaft runs to the transmission. The transmission itself is a Twin Disc model 1402-122. A new model transmission, the unit is part of the Power Commander series, with full power shifting through hydraulically actuated multiple disc wet clutches. The 12-speed transmission allows gear shifting without using the clutch. The clutch is used to shift in either direction. Shifting simply involves moving a lever on the control panel.

From the transmission, dual outputs drive into each axle. Staying on hills without drift is an important consideration. So Knudson has designed the tractor with crab steering to hold the line without slipping. The axles are built with components from Caterpillar and Rockwell, items that found application on construction equipment.

Lloyd Molby, president of ATP, Inc., Longview, Texas, and a consultant to Knudson, oversaw the design and manufacture of the custom axles. The front axle has a no spin differential, the rear a high traction differential, with 21:1 total reduction. Both axles are cradle mounted with 20 degree oscillation in each direction on the front axle and 15 degrees for the rear.

Rockwell's R-170, heavy-duty carrier is used along with Caterpillar planetary wheel ends. The R-170 carrier is from Rockwell's heavy-duty on and off-highway axle series, while the Cat wheel ends are found on

its 980C front end loader.

Molby said the wheel ends have totally enclosed integral disc brakes and Duo-Cone metallic seals. The steering knuckle and socket are an Allmand design while the U-joint and drive shaft are from Rockwell's 92N series. A Dyneer noise pin is used with the differential.

Molby specifically mentioned that each steering wheel end has separate outside vents to allow for adequate cooling of the high levels of oil required in side hill operations. Because of the potential for severe grades the oil levels in the differential and planetary must be higher than normal, Molby said.

Electronics and microprocessors come into play with the self-leveling, selectable steering and the power shift transmission. All three were designed by Grad-Line Inc. (GLI) in Woodinville, Wash. (see *Microprocessor Controls Finding Off-Highway Niche, March 1981 DP*).

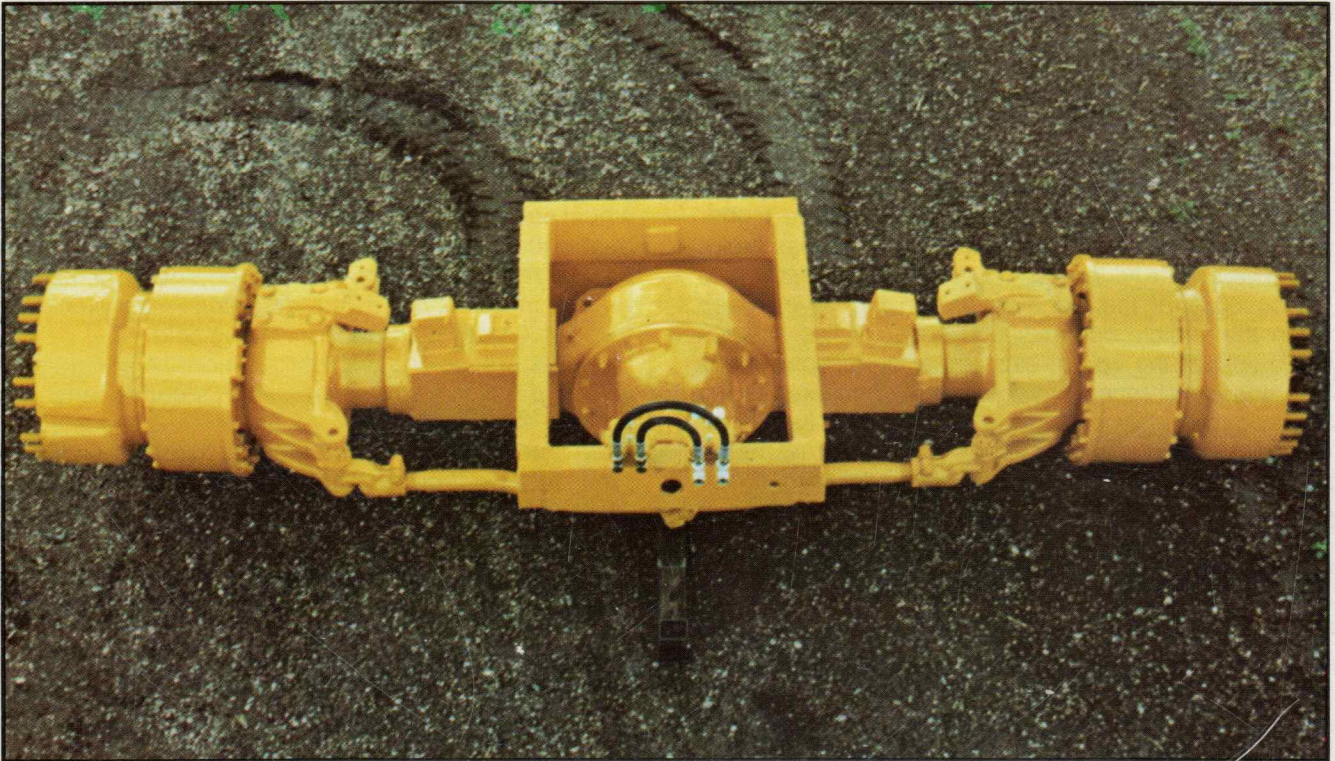


For the crucial self-leveling feature, a standard GLI model LC276 self-leveling control is used. The axle connects the leveling cylinders to the machine's frame enabling the entire tractor to pivot. The total angle for the cylinder controlled oscillating joint is 15 degrees to either side of center. The self-leveling control contains a potentiometric gravity sensor and a servo amplifier built into a single casing. The controller boasts at 0.1% slope accuracy and uses pulse width modulation techniques to achieve a proportional system response with inexpensive on/off solenoid operated valves. This leads to two major features. The operator is always level and comfortable and the vehicle center of gravity is moved to the uphill side, allowing operation on steeper hillsides.

This fall Knudson will incorporate GLI's selective steering system, providing the tractor with three different steering modes. Front wheel steering uses normal automotive-type control. Coordinated steering turns the rear wheels in the opposite direction of the front, giving the tractor a short 25.5 ft. turning radius measured outside of the dual wheels and less than nine feet measured on the inside.

As stated, the crab steering is an important feature considering the application. Implement towing creates a tendency for downhill slippage. The complete steering system contains two angle sensors and a controller with a mode selector switch. The sensor mounts in the center of the front and rear kingpins. A standard power steering unit turns the front wheels, a Grad-Line controller steers the rear.

The system senses the angle of the front wheels and serves the rear wheels to within 0.5 degrees of the correct position. The control voltage from the amplifier to the steering valves is pulse-width/pulse-amplitude modulated at a frequency of about 50 Hz to



The axles for the hillside tractor were designed and manufactured by Lloyd Molby, president of ATP in Longview, Texas. The axles use Caterpillar planetaries and Rockwell carriers for a unique custom design needed because of the tractor's special application.

compensate for static friction and hysteresis in the steering valve and reduce silting.

Controller electronics monitor sensor integrity. Should the sensor circuit fail, the electronics will automatically disable drive to the rear wheels. The drive will remain inhibited until the problem is corrected or the operator switches to another mode in which that sensor is not used.

The Twin Disc 1402-122 transmission has a Grad-Line electronic transmission controller. GLI designs the control system for the operation of power-shift transmissions without hydraulic torque converters, as discussed in our March issue.

The GLI control system consists of an electronic controller, shift lever, digital angle indicator and a transmission mounted solenoid valve body. The controller senses the position of the shift lever, clutch pedal and determines the proper range and energizes the solenoid valves to achieve the proper gear ratio.

Richard Dickson of Grad-Line told us that, "Microprocessor-based electronics ensure optimum performance by constantly monitoring self-check diagnostic routines. Should a malfunction occur, an error code is displayed intermittently with the transmission range. The transmission can still be shifted, but only manually."

In-cab instrumentation is fairly standard, featuring a Hewitt Industries pyrometer with a thermodynamic control running off a pyroalarm to prevent the engine from over fueling. Carl Murray of Knudson told us most of the instrumentation set points were selected at the "close to critical" point, allowing the farmer to get the tractor off a hillside and back to the farm for repair or maintenance, avoiding hillside shutdowns.

State-of-the-art? We think so. □

The microprocessor control for the Twin Disc transmission was manufactured by Grad-Line, Inc. The controller senses the position of the shift lever, clutch pedal and determines the proper range.



Basically a geographical market concentrated roughly in a wide area of the Northwest, the hillside tractor requires special engineering features because of its unique application.