Insights
Truck-Size Transistors
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The ascendant automotive technology today is the hybrid-electric engine. Hybrids will sweep across the auto market in the next decade or so, not only because they're cleaner and more fuel efficient but also because they can radically improve on every aspect of performance of conventional engines. And who exactly do we thank for this? The key enabling technology was invented in 1979 by an American--Frank Wheatley--and his German colleague at RCA, Hans Becke.

We owe the car as we still know it to the inventors of the internal combustion engine.

In 1863 a Belgian, Etienne Lenoir, first thought to burn an engine's fuel inside the cylinder that drove the piston that cranked the shaft, rather than in an external furnace. Then a German, Nikolaus Otto, grasped that liquid fuel could provide a lot more

power, and he went on to build the first practical two-stroke engine, and then a four-stroke in 1876. For 130 years cars have used the mechanical power produced by Otto's engine directly, to turn wheels and pump fluids. Soon all the power from that same engine (100 horsepower in a small car) will be used to generate electricity (70 kilowatts) to drive electric motors distributed throughout the vehicle. It takes remarkable technology to convert that much power from mechanical to electric on the fly, while controlling current and voltage with the fine precision that driving demands. The key device that makes this practical and affordable is the insulated gate bipolar transistor.

Wheatley and Becke invented it. In their breakthrough design of the first such high-power chip, they found a way to get silicon semiconductors to handle kilowatts of power almost as fast and precisely as microprocessors handle microwatts. Wheatley and Becke, in short, did for power in 1979 what the inventors of the integrated circuit, Jack Kilby and Robert Noyce, did for logic in 1959. Kilby and Noyce transformed digital computing. Wheatley and Becke all but created digital power.

Before Wheatley-Becke, the toughest semiconductor switches--Mosfets (metal-oxide semiconductor field effect transistors)--couldn't handle more than about 100 watts. Power Mosfets are now ubiquitous; they handle the locks on car doors, the on-off switches on videocams and countless other lightweight chores. The quite different design of the insulated gate bipolar transistor, however, is robust enough to control the propulsion of trucks, cars and industrial machines. And that's where these devices are now landing, by the millions. Annual sales now probably surpass $1 billion a year, and sales will double and redouble every few years for a long time to come.

How did Kilby and Noyce manage to beat Wheatley and Becke by 20 years? Semiconductor logic depends on atomic-scale junctions built into materials that really don't like to conduct electricity at all--hence the "semi." And atomic-scale junctions are inherently frail because they're so tiny--but tiny is what makes them so fast. The first such junction was the transistor, and for the first several decades of the transistor's existence it proved far

easier to make it smaller, to handle less power, than to make it bigger, to handle more. Happily, logic is lightweight stuff: Keeping track of a 1 or a 0 doesn't require a whole lot of current. Etching millions of microwatt gates onto a single silicon wafer is no mean feat--but building a single kilowatt gate on that same wafer is a lot harder. When you do finally manage to push the power up, however, you set the stage for a truly fundamental change in the infrastructure of the industrial economy. We are beginning to see this fundamental change in Detroit.

Looking back, you can see that James Watt's steam engine marked such a turning point in 1765 and that Otto's internal combustion engine marked another in 1876 and that Nikola Tesla's electric motor marked yet another in 1883. In our own times--exactly a quarter of a century ago--Wheatley and Becke invented the device that now unites the raw power of Otto's mechanical piston with the speed and precision of Tesla's motor.

Hans Becke died in the late 1980s. Frank Wheatley is now living in retirement in Drums, Pa. Their names belong in the pantheon of engineers who changed the world.

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