place. In Japan, Nippon Telephone and Telegraph has embarked on a massive $240 billion capital improvement program to build an integrated 10 billion-bit-per-second fiberoptic network for multipurpose uses, including data transmission, cable television and voice communication.

Gore expects his bill to pass the Senate by the end of the year. In the House, Edward J. Markey, a Massachusetts Democrat, began holding hearings on 4 October on similar legislation. —IRWIN GOODWIN

KILBY AND NOYCE WIN DRAPER PRIZE FOR DEVELOPING MICROCHIPS

In a state that once celebrated cowboys, sharpshooters and oil wildcatters, the newest legendary figures may be physicists and engineers. It isn't only the Superconducting Super Collider that could bring this about. Texas has its own brand of scientific and technological achievers—among them Jack S. Kilby and Robert N. Noyce. They are the first recipients of the Charles Stark Draper Prize, conceived by the National Academy of Engineering as the profession's equivalent of the Nobel Prize (PHYSICS TODAY, November 1988, page 51).

Though both were born in small Midwestern towns, they now make their homes in the Lone Star State. Kilby is a 6-foot-6 electrical engineer who worked for Texas Instruments in Dallas and is now chief technical officer of the Houston Area Research Center. Noyce, who earned a PhD in condensed matter physics at MIT in 1953, worked briefly at Shockley Semiconductors, then cofounded Fairchild Semiconductor and later Intel Corp. Noyce now is the chief executive of Sematech, the semiconductor consortium formed in Austin, Texas, last year by 14 companies to revitalize the industry (PHYSICS TODAY, September 1988, page 50).

They were awarded the Draper Prize for their separate inventions of the monolithic integrated circuit, better known universally as the semiconductor microchip. That Kilby and Noyce each got half of the $350 000 prize money is somewhat ironic. They were fierce contenders for the patent rights to the invention.

Their rivalry began in the mid-1950s, when dozens of electronic companies were attempting to commercialize the transistor, developed by William Shockley, Walter Brattain and John Bardeen at Bell Labs in 1952. As Kilby tells it, he sought to make resistors, capacitors and diodes out of the same material as transistors, namely germanium, which was then easier to work with than silicon. He placed the components on a single substrate. The trouble with Kilby's invention was that it was cumbersome and costly to produce in large quantities. Workers had to solder the circuits by hand with tiny gold wires.

Four months after Kilby built his germanium IC, Noyce found a way to join the circuits by printing the circuit board using lithography. They filed for patents at about the same time. Thus began protracted litigation between Texas Instruments and Fairchild. In 1961 the US Patent Office granted Noyce's patent. It later reversed itself and awarded the patent to Kilby. But in 1969 it once again decided for Noyce. The case was finally closed a year later when the US Supreme Court denied Kilby's request for an appeal of the decision.

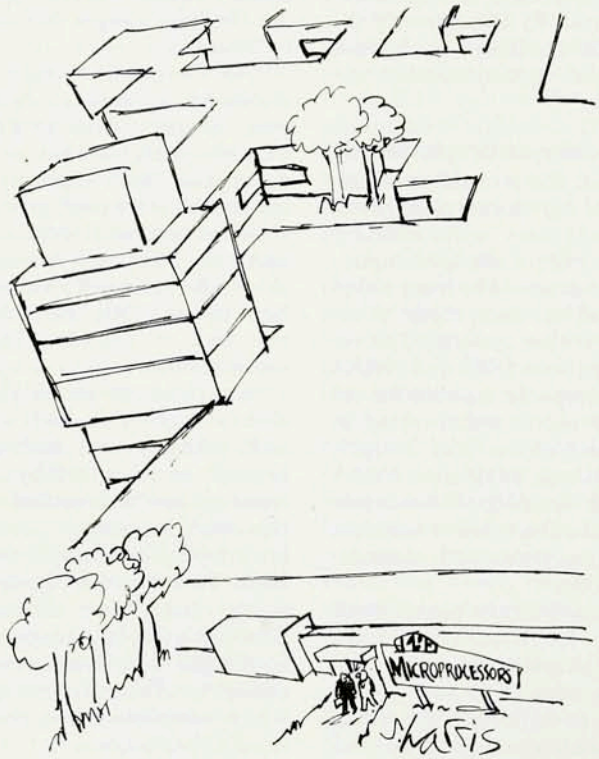
That was the legal brawl. After a summit conference in 1966 the companies agreed to license each other and other firms, enabling everyone to make chips. Kilby says any disagreements he had with Noyce over patent rights have been long forgotten and they are now friends.

Astonishing forecast

Two years before the licensing agreement, Gordon Moore, Fairchild's director of research, who later became Intel's chairman, made the astonishing prediction that the number of individual circuits on a chip would double each year. Now known as Moore's law, the prediction has come true. The most densely packed ICs now contain more than 1 million.

While the companies had developed ICs without any government R&D funding, 95% of the initial sales were to the Defense Department and NASA. Chips were soon used widely in commercial products, beginning with the pocket calculator, on which Kilby received the original patent, and then became integral to most everything, from automobiles to wristwatches. "Very few things have changed the world as dramatically as the IC," said Robert N. White, president of the Academy of Engineering, in announcing the Draper Prize on 3 October. "Its development was the single most important event that helped usher in the information age." World sales of chips last year exceeded $42 billion, with Japan accounting for about 46% of the total and the US, which once had a virtual monopoly on the manufacture of ICs, now producing about 40%.

—IRWIN GOODWIN ■



"THE SMALLER WE MAKE 'EM, THE BIGGER WE GET."