F.V.E.A.A. NEWSLETTER

JANUARY 1986

MEETING NOTICE

THE NEXT MEETING WILL BE FRIDAY **JAN.** 17th, at MID AMERICA FEDERAL SAVINGS 250 E. ROOSEVELT RD. WHEATON, ILLINOIS. - TIME - 7:30 P.M.

PRESIDENT'S MESSAGE

The year 1986 will, I hope, bring reevaluation of the objectives and purpose of the FVEAA. The organization was founded after the oil embargo days of 1973 when memmories of gasoline lines generated much enthuasism for electric cars.

Todays's conditions are vastly different. The public has adjusted to the new level of petrol prices and availability is no longer a problem. Mileage today is about three times what it was a decade ago. The remaining members of the FVEAA are those who are genuinely interested in electric vehicle technology.

I propose that over the next few meetings, we review the state of technology and determine what direction the organization wishes to take in the future. As the first step, we will discuss the possible place that "Smart Power Chips" may have in future EV applications. The attached article will get you started to thinking on the subject.

Sincerely

Bill

W.H. Shafer

F.V.E.A.A.

FOX VALLEY ELECTRIC
AUTO ASSOCIATION
624 PERSHING ST. WHEATON, ILL. 60187

FIRST CLASS

ADDRESS CORRECTION
REQUESTED

NEWSLETTER ITEMS

ANY CLUB MEMBER WISHING TO SUBMIT ARTICLES, DRAWINGS, WANT ADS, EDITORIAL COMMENTS, SPECIAL NOTICES, ETC. SHOULD MAKE SURE IT REACHES ME NO LATER THAN 2 WEEKS PRIOR TO THE NEXT MEETING (about Feb. 10th) IN ORDER THAT IT BE PUBLISHED IN THE FEBRUARY NEWSLETTER. SEND TO: John Emde FVEAA Editor, 6542 Fairmount Ave. , Downers Grove, Ill. 60516

DUES ARE DUE

LAST REQUEST FOR MEMBERSHIP RENEWAL.

MEMBERSHIP LIST

THE FEBRUARY NEWSLETTER WILL HAVE A NEW AND UP TO DATE MEMBERSHIP LIST.

FUND RAISING

WE STILL HAVE A LOT OF 'COUPON BOOKS' AT $5.00 EA. THE BOOKS ARE AVAILABLE THROUGH DANA MOCK. THEY NEED NOT BE PAID FOR IN ADVANCE.

ALSO FOR $5.00 EA. WE HAVE A BUNCH OF 6 VOLT STANDARD AUTOMOTIVE BATTERIES TO SELL. THEY ARE DRY CHARGED SO YOU WILL HAVE TO ADD YOUR OWN ACID. I WILL BRING A GOOD NUMBER OF THEM TO THE MEETING AND THEY CAN BE PICKED UP IN THE PARKING LOT. (26 LBS. DRY)

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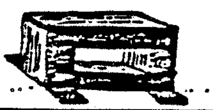

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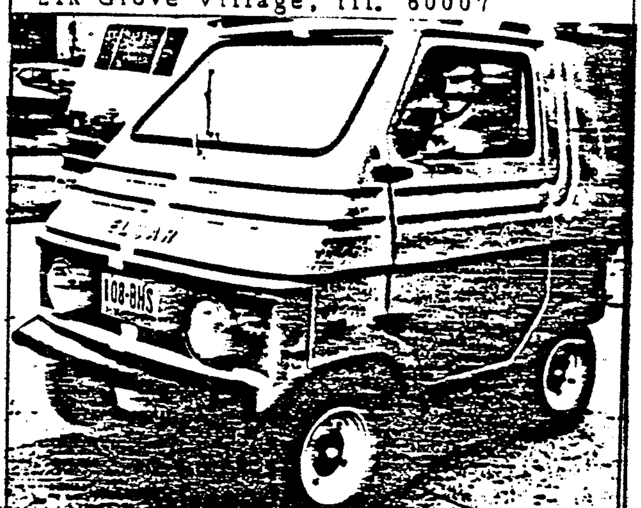

WILL SEPERATE

MUST SELL !!

PARTS FOR SALE

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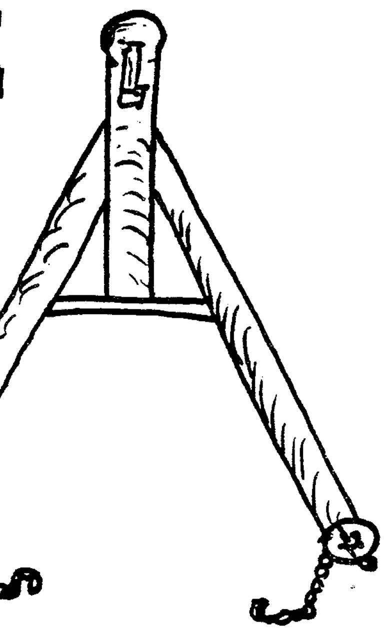
The F.V.E.A.A. club is now in possession of a universal type tow bar. Seems to be the type which can be attached to most any vehicle.
FREE use for club members.
Contact Dana - 759-8033



SMART POWER

Chips that combine electronic intelligence with electrical brawn can make equipment smaller and more efficient

by Herb Brody

HIGH TECHNOLOGY/DEC 1985

A new class of electronic chips is coming on the scene to bridge the gap between the disparate worlds of electrical power and electronics. These "smart power" devices, on which low-voltage signals control high voltages and currents, could reduce the size and cost, and increase the reliability, of any system where electrical equipment is put under computer command. Automobiles and automated factories could shed much of their trouble-prone wiring, computers and other electronic equipment could be made more compact, and consumer appliances such as refrigerators and air conditioners could become more efficient. So far, however, smart power has remained more a buzzword than a commercial reality.

The lure of smart power has hooked companies ranging from start-ups to established semiconductor manufacturers like Motorola and Texas Instruments. General Electric has mounted a massive effort in the technology, which the company expects will constitute a $1 billion market in the mid-'90s (up from about $50 million in 1984). "This is a revolutionary way to apply power," says J. Larry Smart, general manager of GE's power electronics semiconductor department (Syracuse, N.Y.). "These devices let you leverage more features into a product at less cost." GE's development of smart power devices was its second largest R&D program last year, according to Smart, topped only by a project to develop a new jet engine. "Smart power is to power electronics what the microprocessor was to signal electronics," he says.

Such analogies come up often in discussions of smart power. Microprocessors, as well as simpler chips, "do nothing that could not have previously been done with big piles of transistors," says Michael S. Adler, director of the power electronics laboratory at GE R&D labs (Schenectady, N.Y.). Similarly, "you're not doing anything with smart power that you can't do with lots of discrete components." The difference, he says, is that "now certain applications will become cost-effective, size-effective, and weight-effective" because a handful of smart power chips can replace hundreds of separate components—several printed circuit boards full.

The principal advantages of integration are the potential for lower cost because of the smaller amount of silicon, and higher reliability due to the smaller number of parts and connections. Such advantages remain largely theoretical, however; smart power chips are now being made only in small quantities and are often several times as expensive as an equivalent circuit of discrete components.

Advances in several semiconductor technologies underlie the development of smart power. Of key importance was the advent in the late '70s and early '80s of a type of transistor that could control large electrical currents while drawing very little current itself. Consisting of three layers—metal, oxide, and semiconductor—these "MOS-gated" transistors are switched on and off with the application of a low voltage; they are therefore amenable to integration with electronic signal circuits, which typically produce a small voltage and very little current. Until MOS technology emerged, the bipolar transistors used to control high currents required a substantial current input.

A crucial requirement for smart power is the ability to put low-voltage and high-voltage components on the same silicon chip. Microprocessors and other "intelligent" electronic devices operate with low voltages, typically 5 volts. But electrical equipment like motors and lights usually run off the 110- or 220-V ac power line. In addition, there are a growing number of electronic systems that demand several hundred volts; examples include electroluminescent flat panel displays and nonimpact printers. The most compact way to apply smart control to these loads is to put low-voltage elements like logic gates on the same chip as the switches that govern transmission of the higher voltages.

Unless special measures are taken, however, the high voltage coursing through the "power" part of the chip will interfere with the delicate low-voltage operations on the "smart" side. The most common techniques for keeping high and low voltages in their place are junction isolation and dielectric isolation. In junction isolation, p- and n-type semiconductors are juxtaposed on the chip at strategic points; as long as it receives a high enough bias voltage, the p–n junction conducts current in only one direction and so acts as an electrical barrier. GE now markets a junction-isolated IC that can take a 5-volt signal input from, say, a microprocessor and use it to control an output of up to 500 volts.

Dielectric isolation requires a silicon wafer on which a thin layer of silicon dioxide has been grown. Crystalline silicon is deposited in "tubs" on top of the oxide; circuit elements are kept at an electrical distance from each other by the surrounding area of nonconducting, or dielectric, oxide. Although dielectric isolation is somewhat more effective than junction isolation, the oxide-coated wafers are expensive, and the devices require nonstandard fabrication steps that limit the utility of this technique.

The need to carry high currents, as well as high voltage, is one of the biggest challenges for smart power technology. Ordinarily, increases in current must be accompanied by increases in chip area. A way around this is to arrange the device so that the current flows "vertically"—that is, entering the top of the chip and exiting through the bottom; vertical flow allows a much smaller chip area for a given current than does lateral flow, in which charge moves sideways within a single layer of silicon.

Lateral flow, however, is standard for logic and control ICs such as those based on CMOS (complementary metal oxide semiconductor—a technology that yields fast, very low-power devices). Integration of CMOS logic with vertical MOS power on one chip is difficult, and usually the power transistor is removed to a separate piece of silicon. The result is a hybrid that, while no longer matching the strict definition of smart power as one-chip integration of power and control, still reduces to two chips what might otherwise take dozens.

One product that became feasible only with the advent of smart power is the electroluminescent (EL) flat panel display (see "Electroluminescence," p. 42). An EL panel needs several hundred volts to light up. This voltage is supplied by a grid of electrodes in response to the much lower voltages generated by a keyboard or a computer memory. A horizontal electrode carries about 200 V to an entire row at a time; then column electrodes are pulsed with a smaller voltage (40–90 V) to produce a glow at the intersection. Before the advent of high-voltage ICs, this task required a 19-inch rack containing over 700 discrete components, says Christopher N. King, executive vice-president of Planar Systems (Beaverton, Ore.), the major U.S. maker of EL displays. "This is hardly appropriate when your whole pitch is thin-ness," he says.

Now, a single printed circuit board can hold all the smart power chips needed to operate an EL display. "The market for smart power display drivers will explode—as soon as we get our costs down," says William Numann, marketing manager for power integrated circuits at Siliconix (Santa Clara, Cal.). Siliconix is not alone in bidding for the display driver market; competitors include Texas Instruments (Dallas) and Supertex (Sunnyvale, Cal.). In addition to EL panels, which most analysts expect will gain rapidly on liquid crystal displays in the coming decade, smart power will be needed for plasma displays and perhaps for smectic LCDs—a new high-contrast display technology that requires higher voltages than those now common for today's twisted-nematic LCDs..

Selling a new chip technology within the electronics industry is one thing; convincing engineers in other, more conservative industries may prove a more difficult task. But it is there—where electronic signals must direct electrical might—that smart power has its greatest potential.

Every time some bright auto engineer adds another automatic electric feature to a car, a new wire must be added connecting the load (say, a motor or light) to a switch on the dashboard or the door, and to the battery. As a result, "the wiring harness is getting to be wrist thick," says Jim Siegel, marketing manager at Ford Motor's electrical and electronics division (Dearborn, Mich.). "It's hard to bend and therefore hard to install. And its size and weight are especially troublesome as we go to downsizing and aim for aerodynamic design."

With smart power, not only could the wiring harness be made much smaller, lighter, and more flexible, but inherently unreliable electromechanical relays would be replaced by solid-state devices. There is consensus in Detroit that this new approach to wiring will come, probably sometime in the 1990s, even though no cars now in production use it.

In the proposed scheme, the act of flipping a switch would not directly close a circuit; instead, it would send a digital signal through a thin communications wire loop that hooked up to a smart power device at each load. The signal would be encoded with a message such as "headlights, turn on." Control circuitry on a smart power chip at the headlights would decode the signal; this circuitry would trigger an on-chip transistor to begin passing current from an incoming power cable to the lamp filament. The chips at other loads would recognize the signals as not being for them and would not switch.

In principle, this approach would require only two wires to serve the entire car: the thin, low-voltage signal wire and a single power cable. If fully implemented, such a "multiplexed" wiring system would take about 25 pounds of copper out of a car. Smart power multiplexing will first appear in Ford cars in about two years, says Leonard J. Groszek, technical planning manager for the automaker's electrical and electronics division; a fully multiplexed car will probably arrive in five or ten years. GM seems to be following a roughly similar timetable. "I would expect a significant increase in multiplexing in the 1989 model year," says Edward G. Whitaker, an engineering manager at GM's Delco Electronics division (Kokomo, Ind.). "There are 52 wires leading into the door of a Cadillac," he says. "We want to reduce that to three: control, power, and ground."

Besides reducing an electrical system's bulk, smart power could add diagnostic capabilities. After receiving a signal to turn on, the chip could put a message on the signal wire confirming that it had done so, permitting a dashboard status display of all the car's lights, electric windows, and so on. Since the smart power device could easily sense whether current was actually flowing to the load, it would detect and report a burned-out lamp (or a stuck power window) via the signal wire. Such functions are certainly possible with discrete components, but "an integrated smart power chip could do what now takes 10 discrete components," says Whitaker. He estimates that future GM cars will use 20–30 smart power devices each.

Obstacles remain, however. The biggest one is that smart power devices are not yet available on the cheap and plentiful basis that automakers are comfortable with. "It's a potentially huge market, with perhaps hundreds of devices per car," says Groszek. "We need large quantities of 50¢ devices, versus the present limited quantities at several dollars apiece. The semiconductor industry has talked about making millions of these devices a week, but nobody's doing it yet. There's still a lot of work to be done."

A similar multiplexed wiring idea using smart power has turned up in a factory communications system recently introduced by GE's Automation Controls Department (Charlottesville, Va.). In many of today's automated factories cables radiate octopus-style from a central computer to the various machine tools, robots, and material-handling conveyors under its command. With GE's system, a single power cable and a single signal wire run to each computer-controlled machine. There, a module containing a smart power chip receives instructions from the computer to turn on or off or to change speed. The chip decodes the instruction and feeds the appropriate drive voltage into a power transistor that controls the electrical power to the machine.

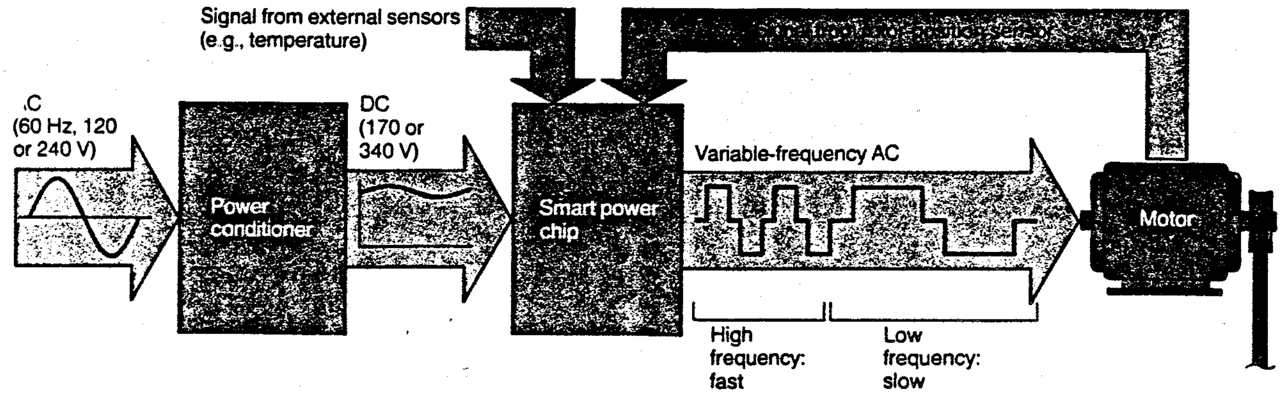
As in a multiplexed car, these smart power switches provide a handy way to monitor whether a machine is functioning properly. The chips continuously sense current and voltage and transmit the readings to the computer; too much current or voltage indicates a short circuit or some other system fault and prompts the computer to issue a command to shut down that piece of equipment—rather than blowing a fuse or circuit breaker that would interrupt several machines. GE claims the system should decrease downtime by 50%.

In cars and factories—as well as in many consumer products—the load that is being controlled is often an electric motor. Indeed, an estimated 60–70% of the electricity generated in the U.S. is consumed by motors. Much of that power is wasted. Often the inefficiency stems from the inability to vary the speed of the motor. A smart power motor controller permits precise, continuous speed variation and hence could provide vast energy savings.

Without smart power, there are two main ways of getting variable output from a motor. One is to use a direct-current (dc) motor, which lends itself readily to variable speed. But dc motors are expensive and unreliable; the carbon brushes they require to induce a magnetic field in the rotating element (rotor) are easily damaged. The other approach is to take the fixed-speed output of an alternating-current (ac) motor and adjust it externally, as with gears or (for an air blower) baffles. However, while ac motors are relatively cheap, these additional components reduce efficiency and reliability and add cost, and in any case do not provide precise and continuous control. A new class of motors under development could use smart power to attain variable speed without the need for a dc motor's troublesome brushes or an ac motor's inefficient add-ons.

These "electronically commutated motors" (ECMs) work by switching power on and off to the motor windings to create a series of pulses whose timing

Variable-speed motor



A motor controller containing a smart power chip could convert constant-frequency ac to dc, interpret sensor input, and decide how fast the motor should run. It could then switch the dc power on and off to achieve that speed.

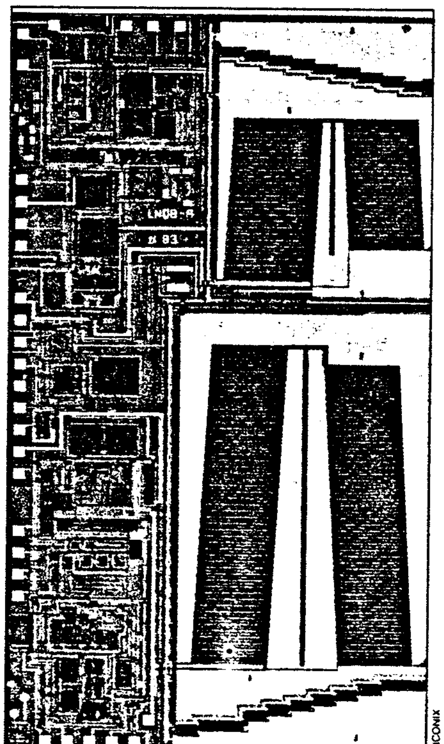
and duration govern the motor's speed. (A motor working directly off ac power will spin at a rate that is some multiple of the fixed 60-hertz line frequency.) With smart power, the action of these power switches—and hence the motor's speed—can be tied to some externally sensed variable, such as temperature. "It's now possible for motor speed to be varied as a *function* of something," says William J. Ehner, general manager of the technology department at GE's motor business group (Fort Wayne, Ind.).

Smart motors could revolutionize the way appliances work. In today's air conditioners, for example, the compressor is cycled on and off repeatedly in order to maintain a desired degree of coolness. This stop/start action wears out the motor. A smart motor could run constantly, speeding up and slowing down in accordance with the continuous feedback it received from an electronic temperature monitor. Avoidance of frequent starts and stops, says Ehner, also reduces the size of the motor needed for a given horsepower output; motors are designed to be large enough to handle the surge current they draw upon starting, which is several times larger than the current drawn any other time. There are other possible uses, too. Washing machines, for example, could do without the expensive and trouble-prone mechanical transmission now used to translate a fixed-speed motor rotation into the variety of motions needed to agitate and spin the clothes.

So-called traveling appliances, such as electric hand drills and kitchen beaters, could also become more effective with an electronically commutated motor. Such machines now attain variable speed without electronic commutation by converting ac input to dc. In so doing, however, they waste a lot of power and generate radio-frequency noise that can interfere with electronic equipment in the vicinity.

Not only would an ECM increase efficiency and reduce interference, but it could make the appliances more responsive as well. An electric drill, for example, could automatically speed up to overcome the resistance of harder wood or metal, as could a kitchen beater when batter started to thicken. Such a capability would require sensing the position of the spinning rotor relative to the rotating electromagnetic field of the stationary coil. The rotor slips behind the field as the motor works against a tougher load; an electronic sensor could respond to this slippage by signaling the smart power devices to increase speed or to pass more current.

Although smart power is not a technical necessity for making an ECM, the large number of components otherwise needed may make it an economic necessity. "Until there are large quantities of smart power chips available, there won't be much electronics in motors," says Thomas Selis, engineering manager of Westinghouse's small motor division (Lima, Ohio). GE's Ehner agrees, but adds an optimistic note. "We're now within striking distance of high-volume consumer applications" of smart variable-speed motors, he says. Ehner predicts commercial introduction of such motors with fractional-horsepower outputs during the next year. Motors of that size are commonly found in such appliances as refrigerators, air conditioners, and heat pumps.



SILICONIX

Logic signals processed on the low-voltage left side of the chip control an array of high-voltage transistors to operate a flat panel display.

But if U.S. appliance makers have plans for smart power products, they aren't talking about them. "They won't even tell us what they're doing," says Robert Edwards, a consultant with the National Association of Homebuilders' Smart House project (HIGH TECHNOLOGY, May 1985, p. 60); the Smart House is a proposal for integrated home control that would rely heavily on the introduction of smart appliances. Edwards says the silence stems from manufacturers' nervousness about competition from Japan, where companies such as Hitachi and Toshiba are reported to be working on similar technology.

Motor manufacturers have in general remained aloof to the attraction of smart power—largely because the products now available don't measure up to the demands of the job. "What we want is a $10 chip containing six power output devices that can handle 10 amps and 400 volts," says Maurice James, director of advanced technology at Emerson's motor division (St. Louis). "That's a long way off."

The few electronically commutated motors now available—such as the one GE makes for its variable-speed ceiling fan—still use discrete components rather than integrated smart power chips. But "there will not be any cost breakthroughs with discretes," says GE's Ehner. "You have to integrate."

The ability to adjust a large current output with a small signal input would not be limited to motors. Another possibility involves using induction heaters to provide hot water at the tap on demand—avoiding the waste caused by storing hot water in a tank until it is called for. An induction unit produces heat in proportion to the frequency of the ac input. A temperature sensor at the faucet could send readings to the smart power chip at the heater; the chip could adjust the frequency in order to maintain the desired temperature, much as a smart motor controller adjusts frequency to vary speed. This feedback loop would be impractical without electronics that could control the induction heater's frequency according to a continuous low-voltage input signal.

Fluorescent lights are another large potential market for smart power, especially since more and more office buildings are installing computer-based energy management systems (EMS). Signals from the EMS based on time of day or on the amount of available sunlight could be fed directly to the lamp's ballast (the device that controls current flowing into the tube). A smart power chip at the ballast could act on that signal to control the light output.

Even without being connected to an EMS, a smart power lamp ballast could save energy. The key is its ability to convert the 60 Hz from the power line into a much higher frequency, typically 12 kilohertz. The high frequency makes the lamps about 10% more efficient; the light-emitting ions in the tube don't have time to revert to a non-glowing state before being zapped by another peak of current.

The advantage of higher frequency has been known for some time, and electronic ballasts are already available to peform this conversion, using many discrete components. But the introduction of smart power chips into ballasts promises a new dimension in lighting control. By cramming control and power-handling functions on the same chip, an electronic ballast could be made cheaply enough to make a dent in what has become a commodity market.

"In 10 years, all fluorescent lights will have smart power ballasts," says Peter Shackle, engineering vice-president at Telmos (Sunnyvale, Cal.). The obstacle is not so much in the technology, he says, as in the marketing. Ballast making is an old industry, and "with a chip you're breaking the rules." For example, Advance Transformer (Chicago), one of the major ballast makers, just introduced its first electronic unit—but it uses discrete components.

"We are investigating smart power technology," says Alan Fisher, vice-president for marketing and strategic planning at the company, which is a subsidiary of North American Philips. And Robert Burke, engineering manager at Litton's Triad-Utrad division (Huntington, Ind.), another ballast maker, predicts it will be at least 1–3 years before smart power ballasts hit the market, and even then they will be in specialty applications.

Makers of low tech electrical equipment such as lights may hesitate before adopting something as exotic as smart power, but quicker acceptance will probably be found in the computer and peripherals industry. One or two chips, for example, might replace a board's worth of components now needed to regulate the electrical power flowing into a computer's logic circuits.

While smart power would allow some reduction in size and weight, its more important potential benefit is improved reliability. Power supplies are the single most failure-prone part of many electronic products, including personal computers; reducing the number of components should cut the failure rate. For now, a separate transformer would still be needed to step down the 110 volts from the wall into the 5-V levels used by microprocessors and other logic components.

"The power supply on a chip is now commercially feasible."

Eventually, however, a small transformer might be combined with the high-voltage IC in a single package, says Thomas Daly, product manager at GE's power electronics department. Although such a hybrid configuration is now considered prohibitively expensive because it requires hand assembly, Daly predicts that cost will drop "phenomenally" with automated production techniques now being developed. Adds general manager Smart: "The power supply on a chip is now commercially feasible."

Smart power should be applied more widely outside the computer and electronics industries as the devices become able to handle larger amounts of power. The challenge is to develop chip packages that remove the heat from the silicon before damage ensues. One method is to connect the package to a large piece of metal, which serves as a heat sink. If no such heat sink is available in the system itself—as in a computer with a plastic chassis—it may be necessary to attach a metal fin to the rear of the package to conduct heat out to the air.

Most smart power devices are still made on a custom basis, but standard products are starting to appear. For example, high-voltage, low-current chips for driving flat panels are available from Texas Instruments, Siliconix, and Supertex. The latter recently licensed its technology to Mostek (Carrollton, Tex.), an established semiconductor manufacturer whose capacity for high-volume production should push prices down. Telmos expects to come out this month with a standard line of chips combining CMOS logic and 500-volt output. Motorola (Phoenix) offers devices that function exclusively as circuit protectors; the chip shuts off power if voltage or temperature exceeds a preset value. Motorola is known to be interested in supplying smart power chips for future multiplexed cars, too. The company plans to introduce a chip for this application next month. Controlled by low-voltage logic input signals, the device will switch up to 16 amps of current. So far only a few samples have been delivered, but volume production should begin around mid-year, according to product planning manager Jack Takesuye.

Competition should heat up with GE's recent decision to begin marketing smart power ICs. The company's semiconductor department has already been making high-voltage ICs and power MOS transistors, but until now has sold them primarily to other GE operations; the motor division, for example, uses the components in its variable-speed ceiling fan. Now the company is looking to sell smart power chips to the outside world.

GE is aiming squarely at high-volume markets. It recently built a semiconductor fabrication plant in Raleigh, N.C., and refurbished one in Syracuse specifically to make smart power devices; the two plants have a combined annual capacity of $250 million worth of chips, according to Smart.

This outpouring of smart power chips will be targeted first to makers of automobiles and electric motors. The company is betting that if smart power becomes prevalent in these ubiquitous machines, the huge volume demanded will drive prices down to where the devices will be suitable for applications now considered marginal—and for others not yet imagined. □

Herb Brody is a senior editor of HIGH TECHNOLOGY.

For further information see **RESOURCES,** ***p. 69.***

SO WHAT'S NEW

SEVERAL WEEKS AGO SENATOR WARREN MAGNUSON STIRRED UP CONSIDERABLE INTEREST BY COMING OUT STRONGLY FOR THE RETURN OF ELECTRIC CARS. MAGNUSON COMES FROM ELECTRIC-POWERRICH WASHINGTON STATE.

SUBSEQUENTLY, FORD MOTOR COMPANY'S ALERT PUBLIC RELATIONS DEPARTMENT HELD A PRESS CONFERENCE TO REPORT ON ITS PLANS TO BUILD A COUPLE OF ELECTRIC CARS BY NEXT SPRING AND TO EXHIBIT A NEW SODIUM/SULPHUR BATTERY.

THIS HAS PROVOKED MANY ERUDITE AUTOMOTIVE AFICIONADOS TO WONDER, "WHAT GIVES? IS IT A PHONY OR NOT?" THE BEST GUESS AT THIS STAGE IS THAT THE CARS (WHICH WILL BE FITTED WITH CONVENTIONAL LEAD-ACID BATTERIES) AREN'T SIGNIFICANT, BUT THE NEW BATTERIES MAY WELL REPRESENT A TRUE BREAKTHROUGH BECAUSE OF THEIR GREATER USEFUL LIFE.

FORD OFFICIALS, SOME OF WHOM ARE THINKING ABOUT A NOBEL PRIZE FOR THE INVENTORS, BELIEVE THE BATTERY MAY WELL HAVE MORE APPLICATIONS OUTSIDE THE AUTOMOTIVE FIELD, WHERE A LONG-LIVED, STATIONARY POWER SOURCE COULD PROVE WORTHWHILE.

AFTER ALL IS SAID AND DONE, A BATTERY-POWERED FORD FALCON WOULD STILL REQUIRE ABOUT 500 lb. OF BATTERIES, ABOUT 320 lb. OF ELECTRIC MOTORS AND A SYSTEM OF CONTROLS. THIS WOULD ADD UP TO A GOOD DEAL OF COST, WEIGHT, COMPLEXITY AND DRIVER TROUBLE. THE MAIN ADVANTAGE IS ABSENCE OF SMOG-PRODUCING EMISSIONS.

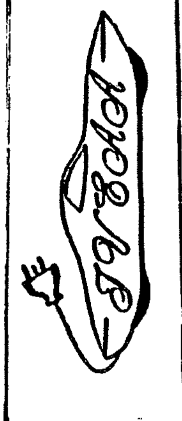
HOWEVER, ADVANCING TECHNOLOGY OFFERS SOME FUTURE HOPE FOR ELECTRIC CARS IN AT LEAST TWO WAYS. ONE IS THAT THE TRANSISTORS NOW AVAILABLE WOULD MAKE CONTROLLING SUCH A VEHICLE MUCH MORE EFFICIENT AND SIMPLE. ALSO, ATOMIC ENERGY MAY PRODUCE MUCH CHEAPER ELECTRICITY IN THE FUTURE.

WHILE FORD HAS BEEN GETTING THE ELECTRIC-CAR PUBLICITY, GENERAL MOTORS HAS BEEN WORKING RIGHT ALONG AND NOW HAS A BATTERY-EQUIPPED CORVAIR OPERATING. IT'S DRIVEN BY A SERIES OF SILVER-CADMIUM BATTERIES WORTH A REPORTED $27,000. SUBSEQUENT TO FORD'S ELECTRIC-CAR ANNOUNCEMENT GM'S PRESIDENT, JAMES M. ROCHE, COMMENTED, "WEIGHT, COST AND EFFICIENCY ALL HAVE BEEN PROBLEMS ASSOCIATED WITH ELECTRIC POWER. HOWEVER, POLLUTION HAS BEEN A PROBLEM ASSOCIATED WITH CONVENTIONAL ENGINES -- A PROBLEM THAT ELECTRIC CARS CAN SOLVE."

FROM : CAR LIFE MAGAZINE JANUARY 1967 !!!! .

1967 ?

ITEMS AVAILABLE AT CLUB MEETINGS



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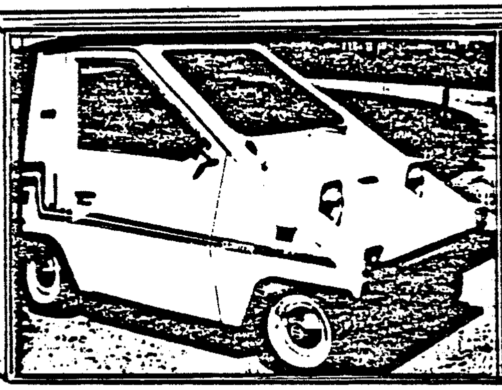
200 AMP. RELAY

24-28 Volts D.C. U.S.A.F.

$15.00
ONLY A FEW LEFT



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MOTOR REBUILT - AUGUST '84
VERY GOOD CONDITION
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FOR SALE

THE AUTO:
problem child with a promising future

MASTODONS of the interstates might have lived forever had it not been for petroleum prices. As recently as 1978, gasoline sold for less per gallon (in constant dollars) than it had in 1960. Now prices tick ever upward as reserves grow shorter and supplies less secure.

Shown above on the left is a car typical of those now on the American road (average age, 6.4 years; average miles per gallon when new, 13.1). On the right is a car with features designed to reduce, or even eliminate, petroleum use.

Yesterday's dreamboat, today's gas guzzler, is overweight (22 times heavier than a 150-pound driver), overpowered, oversize, and very, very thirsty.

In the late 1970s standard American cars were downsized by trimming weight and exterior dimensions. Redesigns produced smaller and lighter vehicles with only half the cylinders of the once dominant V-8 engine **(1)**. Front-wheel drive eliminated the shaft **(2)** from transmission to rear differential and saved 300 pounds. More weight in such areas as bumpers, hood, and body panels **(3)** may be lifted by substituting plastics and aluminum for steel. Overdesigned chassis **(4)** may be safely pared or replaced by integrated frame-and-skin shells as used in aircraft fuselages.

Although smaller cars are stingier with petroleum, they are not necessarily more efficient. Of the energy released in combustion only 12 to 15 percent is finally applied to move the car. Most of the rest is lost due to the basic thermodynamic inefficiency of the engine and escapes as heat. The remainder is drained off by such factors as aerodynamic drag, rolling resistance of tires **(5)**, transmission slippage **(6)**, internal friction **(7)**, idling, and air conditioning **(8)**.

Just to push air out of its way, a car uses 50 percent of available energy at 55 mph but 70 percent at 70 mph. Large frontal areas create air turbulence and drag **(9)**. Bodies derived from wind-tunnel testing promote smooth air flow around the vehicle **(10)**. Such details as mirrors, rain gutters, trim, and wheel wells and covers **(11)** can be improved aerodynamically. Fuel savings can be as much as 10 percent.

At cruising speed, rolling resistance of tires on the road consumes half the available horsepower. Radial tires can reduce fuel consumption as much as 3 percent. Puncture-proof tires of plastic **(12)** could save even more and eliminate the cost and weight of a spare tire and wheel.

Automatic transmissions inflict a mileage penalty of about 10 percent compared to manual gearboxes. Continuously variable transmissions promise even better mileage, as does a stop-start engine that shuts down if a car is idling or coasting, cutting gas consumption by about 15 percent. A touch on the accelerator restarts the engine.

Better lubricants **(13)** and bearings will reduce friction, and microprocessors **(14)** will monitor systems and command adjustments to keep them at peak efficiency without—even despite—actions by the driver.

As the price of petroleum for gasoline and diesel engines converges with that of alternate energy sources, new power systems should become widely available, probably beginning with battery-powered electric motors **(15)**. Their advantages: quietness, low pollution, and simplicity. Their disadvantages: limited range between recharges (which are also limited), weight, and bulk. New battery systems now under testing and development should give better performance. Efficiency may also be increased by using flywheels **(16)** to equalize power demands on batteries during acceleration and hill climbing.

Electric motors may be paired with small combustion engines in hybrid systems **(17)**—electric power for low speeds, combustion for highway cruising.

Power systems that run on compressed gases such as propane, methane, or hydrogen are more problematical for the personal car. Range is limited, distribution systems are not in place, and each station pump could cost $30,000. It remains moot whether so-called synthetic fuels (pages 74-94) could best be used directly in engines or to generate electricity.

Other combustion engines such as the gas turbine or external combustion may become options in the 1990s.

Proper maintenance of [illegible] can improve mileage 5 percent. And since combustion engines operate best at about 40 mph, traffic ideally should be speeded up in cities and slowed down in the country—the former difficult though possible, the latter unpopular and impractical.