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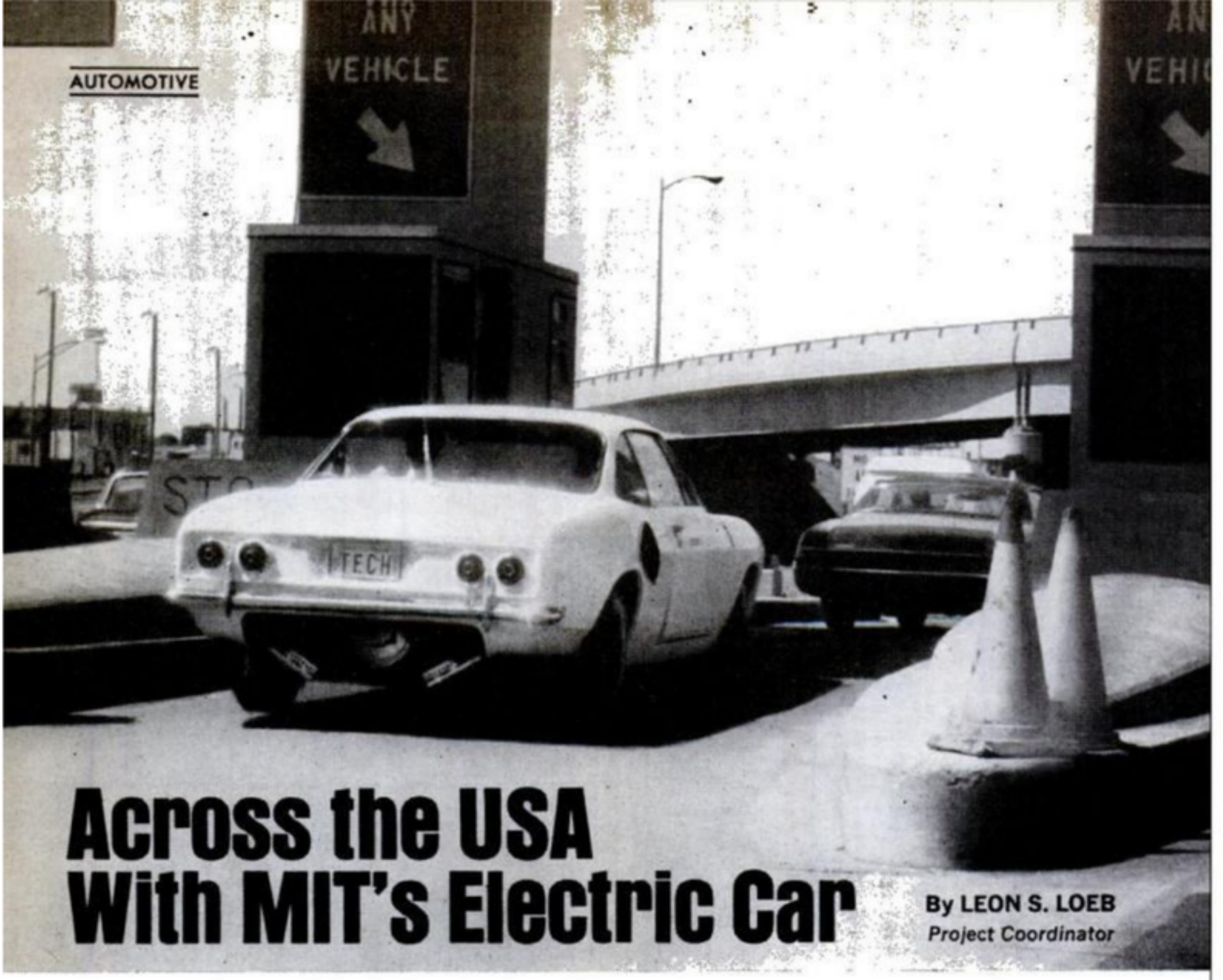


Across the USA With MIT's Electric Car

By LEON S. LOEB
Project Coordinator

Starting from opposite coasts, MIT and Caltech students raced battery-powered cars across the country. Caltech won by 30 minutes. Both teams learned a lot about electric cars. Here's an exclusive report by the MIT team leader

NONE OF US NOTICED the number "13" on that first toll booth. Even if we had, we felt lucky just to be off the starting line.

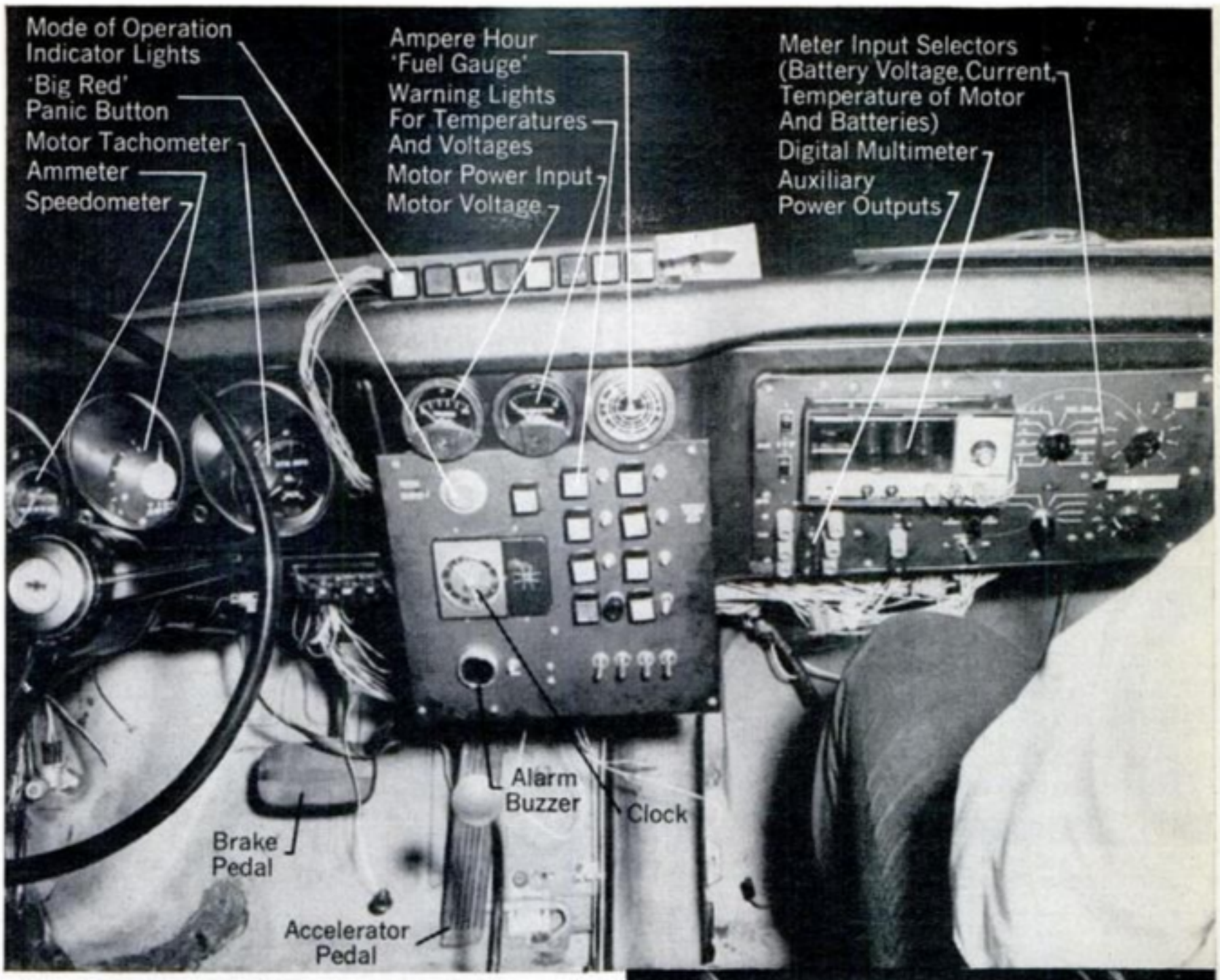
At the start of the race, with the sun beaming down, MIT banners dancing in the breeze and fellow students cheering us on, our excitement hid what only we knew: Things looked bad for MIT's "Tech I" Experimental Electric Car.

We had been working on it right up until the time we wheeled it to the starting line only an hour and a half before the planned 12:00 noon takeoff on Monday, Aug. 26. Earlier, we had to scrap our plan to run with an advanced-design electronically commutated motor, Dave Saar and W. Sumner Brown's part of the project, and install a conventional d.c. motor like those used on forklift trucks.

A shakedown run with d.c. motor started Friday night and ran well into Saturday. At this late date, we encountered some real problems in our modifications of the car, a 1968 Corvair. For one thing, the motor was overheating. The series-wound 15-hp unit is rated at a nominal 120 volts and was overheating while operating from our 100-volt nickel-cadmium battery packs, due to the increase in average current draw at the lower battery-pack voltage.

Secondly, we discovered that our packaging of the batteries was such that they weren't getting enough cooling air. They, too, were overheating. While they weren't permanently damaged, their reduced capacity cut the last leg of our shakedown run to a scant 17 miles. As the saying goes: Back to the drawing board!

While the batteries were getting a very slow discharge followed by a very slow recharge, which is the standard treatment for the recovery of cells reduced in capacity by overheating, our gang of almost-frantic undergraduates kept their cool and



attacked the problem of getting batteries and motor to keep theirs.

Copper coils were fitted around the motor to circulate water from a sump in the "bilge" of the front battery compartment. This scientifically calculated measure, combined with the advanced state-of-the-art technique of throwing wet

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THE AUTHOR coordinates the simultaneous start of the MIT and Caltech cars at 12:00 noon on Aug. 26

THE OPPONENT, a VW converted to battery power by Wally Rippel, a Caltech graduate, leaves California

NICKEL-CADMIUM cells, rated 75 ampere-hours each, are installed

BACK SEAT AND FRONT BOOT contain 320 cells arranged in four, 80-cell, 100-volt packs. Headlight cutouts are also cooling-air scoops

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towels on the motor at charging stops, did the trick.

Battery cooling, which had already been planned for by Fred Kern, and Norm Marx's body modifications of ducting air flow into the front compartment through the headlight cutouts, past the front battery packs, into the passenger compartment, around the rear battery packs, and out the exhaust vent scalloped into the right side of the Corvair, could only be improved slightly. We raised the top pack of 80 cells in the rear area about four inches above the bottom pack to allow more air flow. We got the batteries, all 2000 pounds of them, back into the car, got everything reconnected and amazed ourselves by making it to the starting line for the gun.

With New Englanders Chuck Kaminski and Jim Martin, electrical engineering juniors, piloting and copiloting, Tech I zipped down the Massachusetts Turnpike in an impressive start. At 50 mph, 5200 pounds of electric car and drivers effortlessly passed a press truck loaded with photographers and kept the back-up caravan, including *PM*'s Bill Hartford, jockeying their infernal, pollutant-producing internal-combustion-engined vehicles in order to observe what was to be the first electric car to cross the continent. (We got to Caltech before Wally Rippel got to MIT in his lead-cobalt, battery-powered VW, but total adjusted time, taking into account towing time, gave Wally the win with a total of 210 hours and 3 minutes to our 210 hours and 33 minutes.)

My car, "Unit Zero" in our CB radio link, pulled up to lead position to spot charging stations along the route. Using a charging unit engineered by Bill Carson, mechanical engineering senior, cells can be charged in 10 minutes with 400 amps.

"Unit One," or Tech I, the electric car, radioed nothing but good reports until we were 25 miles out of MIT. At that point the car radioed an alarm and came to a quiet, dead stop on the shoulder of the pike. Behind it pulled "Unit Two," a test-equipment and luggage-loaded station wagon, driven by Prof. Richard D. Thornton, our indefatigable advisor from the Dept. of Electrical Engineering. Fred Kern pulled his '65 green Corvette in ahead of Tech I to hook up for the tow into the charging stop at Worcester—first of 53 prearranged charging stops at power company stations where high current would be available.

The actual reason for the shutdown, which came far short of the expected charging interval of 80 miles, was exhausted batteries. Apparently the prerace slow discharge and recharge treatment was not entirely successful and the batteries could not be charged up to full capacity. This problem continued for several charging stops until we hit Albany. There we decided that piling ice cubes on the batteries might enable us to discharge them even further. The only danger was that the cubes would all slide down the drivers' necks in a quick stop. They gambled, and the ice did increase our range. But by the time we reached Buffalo our range was back to 20 miles or so. During the first 400-some-odd miles of the race our car was towed about half the distance and this really hurt our chances.

We decided to make a last-ditch call to Gulton Industries, manufacturer of the batteries, to see if there was some way to regain their full capacity. They suggested a cure-or-kill approach, over-charging them approximately one-and-a-half times their rated capacity. This really worked. We sailed past Buffalo to the next charging stop, 35 miles west—the first leg the

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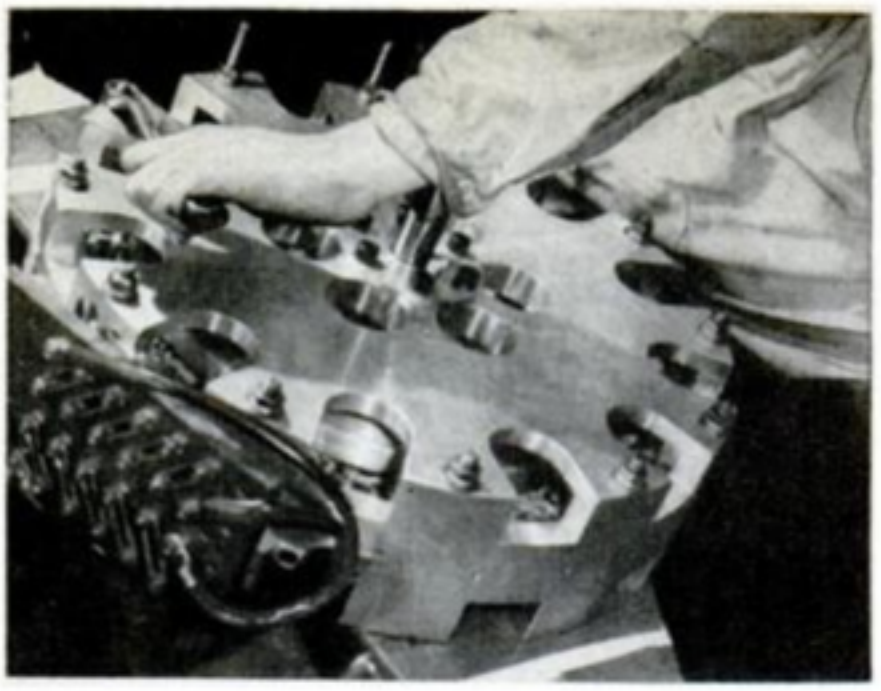
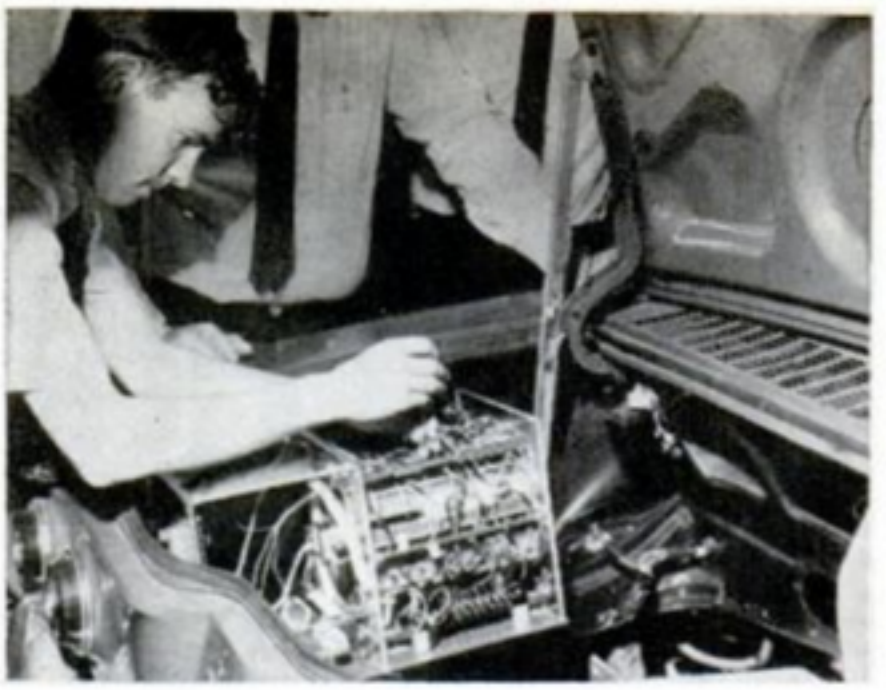


SOLID-STATE COMMUTATED MOTOR (SSC) gives high power-to-weight but wasn't ready in time for race



TRANSISTORIZED CONTROL UNIT for SSC motor provides high frequency switching of stator currents

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car made a full run under its own power.

The next leg was a full 60 miles, and all of us were flying high when we cruised up to the transformers an hour and a half later. More "good" news greeted us in Ohio when we learned that Wally's "Socket-to-me" VW was down and out in Arizona with a burned-out motor.

While we gloated, he got another and got back on his way—after losing many hours.

But smiles were really wiped off our faces when in Indiana. While charging up, a bronze motor terminal went zap! It melted into a blob, obviously from a short circuit, but we still don't know what caused it. It took ten hours to repair the damage and install a new terminal.

Back on the road, we "supercharged"

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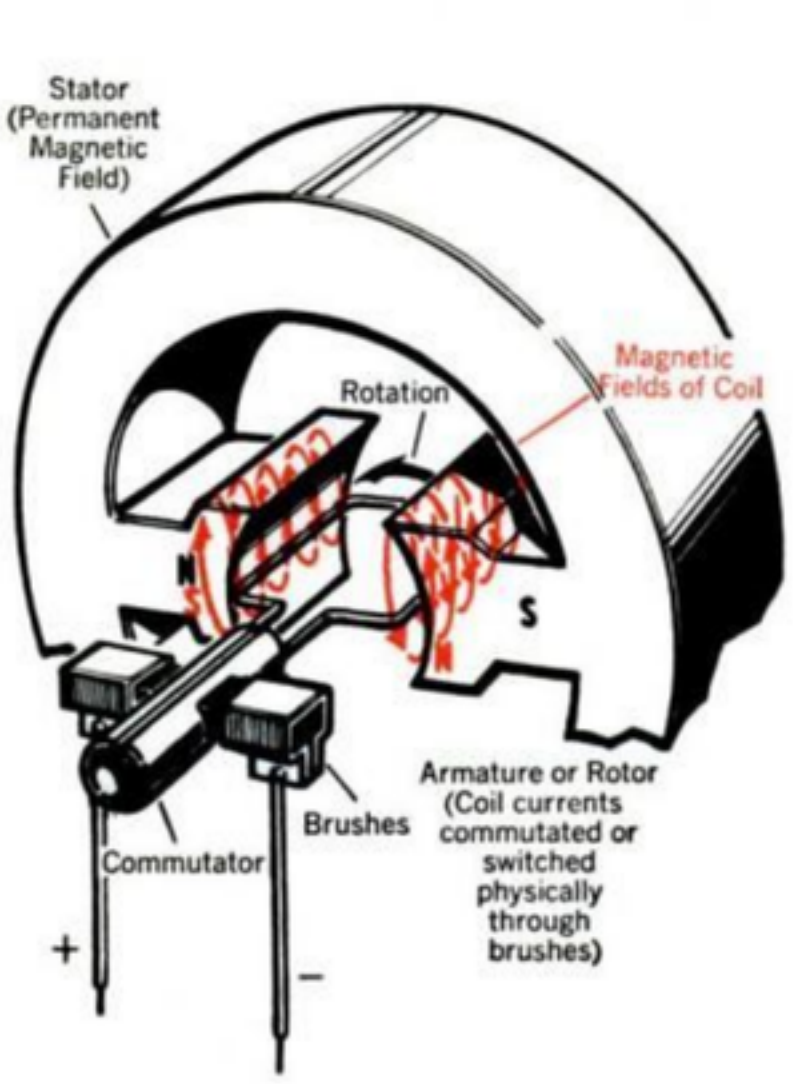
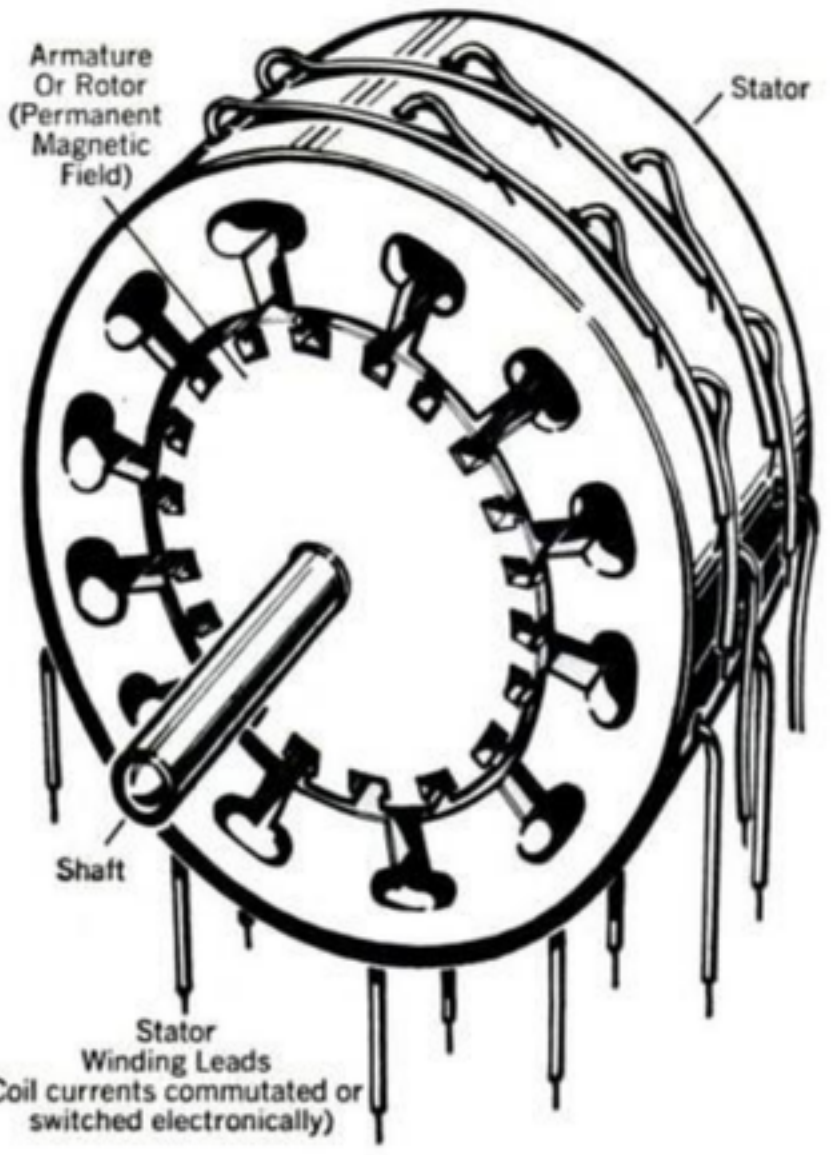
A CONVENTIONAL D.C. MOTOR, which was planned to be just a back-up for a high-efficiency solid-state commutated (SSC) motor, ran the whole race. Drawings below compare the two types. D.c. motor at left turns when opposite magnetic poles on stator and armature repel one another. Single coil (representing many on a real armature) has magnetic field established by current through it. Split commutator switches direction of current to switch poles so opposites keep repelling to maintain rotation. In the car, armature shaft connects to the transmission. SSC motor at the right has permanent magnetic field on armature while magnetic fields in the stator are rapidly switched electronically at higher frequency than possible with a commutator. Students are anxious to get back to work on the highly efficient SSC motor design





EXHAUSTED BATTERIES forced Tech I to the side of the pike for its first of several tows of the race

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—as we came to call the overcharging treatment—our way from station-to-station with no problems. Batteries were up to about 100 percent rated capacity. Relieved of technical worries, our drivers must have found the going too easy, so they proceeded to get lost. They switched from Interstate 80 to U.S. 66 as planned, but took the northbound direction—that's not the way to California! I was too far ahead for them to have seen me. I headed south while maintaining radio contact as usual. I wondered why reception began to fade. Alas, I was quite alone. Tech I, with its entourage of towing car, support vehicle and judge's car, was six miles closer to Canada and closing the distance. Somehow, somewhere they all managed to U-turn and my reception got better.

This goof was quickly forgotten when Tech I rolled into Dwight, Ill., under its own power and we realized it had logged 86 miles, the longest single run of the race. Top speeds for the race were 55 mph on level ground, 75 mph downhill.

The long haul from the Midwest to the California line went quite smoothly. Except for getting lost in St. Louis, incurring a leaky cell by blocking a vent cover, starting electrical fireworks at an Oklahoma power pole and being sirened to the curb by local police, we found the race no different than a pleasant Sunday drive in the family car.

But on the final day of the race, we lost it. Fatigued as we were, we did ourselves in with human error. A wrong connection on our charging unit in Newberry, Calif., wiped out the unit, and then towing the car in low gear instead of neutral overrevved the motor and destroyed the armature and commutator. We couldn't get a new motor in the eight hours it would take to tow Tech I to Pasadena, so we towed and took the penalty. Towed across the finish line!

It was a lost race no matter how you figure it, but an exciting one and an educational one. And when several of us from the MIT team present papers on electric-vehicle technology at the annual meeting of the Institute of Electrical and Electronic Engineers in Boston this month, the race will have given a boost to continuing research on a feasible exhaust-free electric car. ★★★

FILLING 'ER UP with electricity isn't as easy and quick as pumping gas into the family car—not yet