February 1988

MEETING NOTICE

The next meeting will be **Feb. 19th**, at *CRAGIN FEDERAL SAVINGS & LOAN* 333 W. Wesley St. Wheaton, Ill. - Time - 7:30 P.M. sharp. Guests are welcome and need not be members to attend the meeting.

THE PRES SAYS

This will be the last issue of the FVEAA monthly bulletin for members who have not yet sent Treasurer Vana their $15 annual renewal dues. I urge you to re-up and not miss out on the activities.

The upgrading discussions at the last two meetings have produced results. Soon, we will be placing a group order for power transistors needed to modify existing 36-volt controllers for 48-volt operation. These units can also be used to build new controllers. If you want to participate in this order for the favorable price negotiated by Secretary Harris, you must let him know by Feb. 17 and send him your check for the number of units you want. Note: A purchase order form is inclosed in this newsletter for your convenience.

Members Stockberger and Meyers have been working on the battery charger printed circuit board design and we will soon be ready for a group order of parts.

At the Feb. meeting, we will view Member Stockberger's Australian videotape of last years solar car race. The technical discussion will examine the benefits and costs of electrical braking. An introductory article on this is included on page 3.

Bill

Meeting date : Feb. 19 th

F.V.E.A.A.

FOX VALLEY ELECTRIC
AUTO ASSOCIATION
624 Pershing St. Wheaton, Il 60187

FIRST CLASS

ADDRESS CORRECTION
REQUESTED

Minutes of the Fox Valley Electric Auto Association for January 15, 1988

The meeting was called to order by President Bill Shafer at 7:35 P.M.

V. Vana finally made the Treasurers report. Opening and closing checking account balance is $1,000.59. Opening and closing savings account balance is $799.20. There was no change, however there was mention that the annual dues are now overdue and altho some members have paid, there is still more to come.

John Stockberger talked about the on board charger circuit boards that he and Ken Myers have been working on and reported that he has spent $88.00 on the project so far. Ken Woods made a motion, seconded by Paul Harris that the club repay John. John is also to supply a parts list for this unit when ready.

Upgrading the Controller: There seems to be a lot of interest in upgrading the controllers now in use and substituting the MJ10021 transistor (to be called the MARY JANE) to do the job. The unit would need 11 of these at a purchase price of $11.00 each, or a total of $121.00. The membership voted to authorize Paul Harris to negotiate for the very best price avaliable. Anyone wishing to purchase a package of Mary Janes should send in their check, made payable to the CLUB along with the purchase order form, found elsewhere in this bulletin. Please mail to Paul Harris in time to get in before the deadline...which is February 17, 1988. Thank you. For those of you brave souls that wish to build a controller from scratch, John Stockberger will offer to help by furnishing some construction ideas and also has various boards and parts for sale. John Emde mentioned that batteries will be needed by various members soon and we should be looking into a source for the best price....Dana Mock is still interested in MOSSFETS.

THE TOPIC OF BUMPER STICKERS was brought up by Ken Woods and he distributed some sample photocopies of what ours should be to those members who might know of a printer where we could get a good price. The standard size is 3 3/4" X 15". The minimum order seems to be 125 for approx. $120.00 in one color or $165.00 for 2 colors. Paul Harris suggested Yellow stock with black letters. Dick Ness and Paul Harris to check for best prices.

CLUB CAR: Stillsitting, no change. former member has a shop in Oak Park, but declined to repair.

TOW BAR FOR CLUB: Jack Cahill volunteered to make the tow bar, by making a copy of Dana's present one after club decides that we will not scrap the car. Al Glowiak to supply the material, except for the hitch.

FOR THE GOOD AND WELFARE: Jack Cahill asked if any progress on the HYBRID project. The study is in limbo project got to be more than club members' interest at present. John Stockberger and Dana Mock both feel that the HYBRID noise problem would destroy the effect you try to create with an electric vehicle...no noise..no polution..etc.
RALLEY: Club should have a function in future..this summer...so members are asked to have their cars brought up to working condition.A future program is scheduled.
C.V.T. John Newton is trying to obtain one from his European sources for the club.
Dick Ness spoke about the idea of setting up a display at the Kane County Fair grounds and also selling electronic materials etc. It is held the 1st Sunday of the month..probably $50.00 per space..Dick to look into and see what shakes.
VIDEO PROJECT: Pres. Bill Shafer is to look into trying to obtain a angel for the club and a producer.
The meeting was adjourned at approximately 9:23 P.M..
Respectfully submitted

Paul P. Harris, Secretary

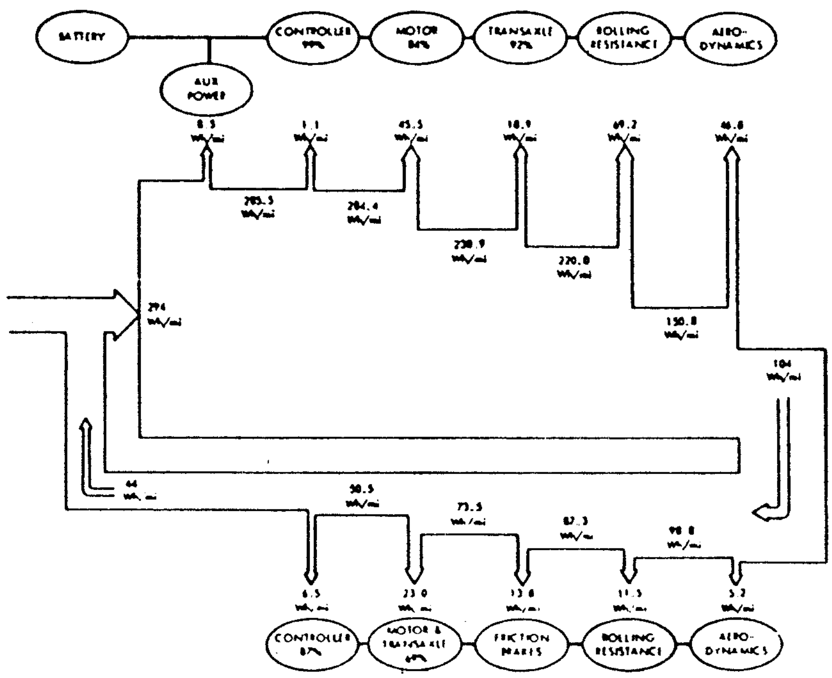
REGENERATIVE & DYNAMIC BRAKING

William H. Shafer 1/23/1988

Regenerative braking is used to recapture the kinetic energy of a moving car when it is brought to a stop. Returning energy to the battery has two beneficial effects; it increases the car's range by a relatively small amount and it also reverses the local polarization of the battery plates which can extend battery life. The energy is recaptured by causing the drive motor to act as a generator with output fed back into the propulsion battery. To force current into the battery, the generator output must be higher than the no-load terminal voltage of the battery.

The generator output is dependent on two variables, armature speed and magnetic field strength. With high motor rpm, initial output current can be several hundred amps and could be detrimental to brushes and commutator. As the car slows down, armature speed decreases and voltage declines to a point where no further energy is returned to the battery. This decline can be offset up to a point by increasing the field current as speed declines, or by downshifting the transmission.

Tests on experimentalelectric vehicles and computer simulations have shown that a practical recovery of the energy supplied for propulsion is about 10-15%. The figure shows GE's ETV-1 performance.



ETV-1 Energy Flow Distribution over the SAE J227a D Driving Cycle

Dynamic braking is simpler than regenerative. In this application, the motor terminals are disconnected from the power source and reconnected to a suitable resistor. The field remains energized and constant. The motor output is converted into heat by the resistor. Dynamic braking is used by diesel-electric locomotives and to bring electric lawnmowers to a quick stop.

The article by J.F. Rittenhouse accompanying this issue of the FVEAA monthly bulletin discusses how aircraft starter-generators used by many of our members in their conversion projects can be connected for regenerative or dynamic braking.

FVEAA PAID MEMBERSHIP AS OF FEB. 8 1988

IF YOUR NAME IS NOT ON THIS LIST - THIS WILL BE YOUR LAST NEWSLETTER !!
UNLESS OF COURSE YOU SEND YOUR DUES TO OUR TREASURER - MR. V. VANA

PHONE #	Y/N ?	MEMBER	ADDRESS	CITY	ST	ZIP
312 668-1426	Y	JOHN AHERN	624 PERSHING AVE.	WHEATON	IL	60187
312 696-9170	Y	CHRIS BARSKI	10117 DEVON CT. # 35	ROSEMONT	IL	60018
312 968-7052	Y	ALFRED BRINKMEYER	4323 DEVON ST.	LISLE	IL	60532
312 629-3989	Y	JACK CAHILL	1 S 736 VISTA AVE.	LOMBARD	IL	60148
312 228-5952	Y	DALE COREL	595 GATES HEAD NORTH.	ELKGROVE VIL.	IL	60007
312 544-6312	Y	FRANK DELMONICO	5629 BOHLANDER AVE.	BERKELEY	IL	60163
312 968-2692	Y	JOHN EMDE	6542 FAIRMOUNT AVE.	DOWNERS GROVE	IL	60516
514 764-9733	Y	LEONARD FISHER	6351 AMSTON DR.	DUBLIN	OH	43017
301 992-0621	Y	WM. T. FORDE	9257 GRAPEWINE CT.	COLUMBIA	MD	21045
312 841-0180	Y	JOHN FOSTER	14318 UNIVERSITY AVE.	DOLTON	IL	60419
312 968-2486	Y	ALEXANDER GLOWIAK	101 RUMSEY RD.	WESTMONT	IL	60559
312 877-7290	Y	HENDLY HALL	530 LAWN DRIVE	LOVES PARK	IL	61111
312 232-0344	Y	EVERETT HARRIS	214 NEBRASKA ST.	GENEVA	IL	60134
312 674-6632	Y	PAUL HARRIS	9421 N. KILDARE	SKOKIE	IL	60076
312 282-4828	Y	THOMAS KAMINSKI	4828 W. WARWICK	CHICAGO	IL	60641
312 834-0370	Y	GEORGE KRAJNOVICH	17W381 EISENHOWER RD.	OAKBROOK TER.	IL	60181
312 534-2686	Y	JOHN KRUEGER	10 LOCUST PL BOX 102	MONEE	IL	60449
312 437-0453	Y	DONALD KUBICK	249 ARLINGTON HTS. RD.	ELKGROVE VIL.	IL	60007
312 850-7246	Y	LAD KUCERA	8 ARTHUR AVE.	CLARENDON HIL	IL	60514
312 983-8236	Y	MARK MELNICOFF	65 FINCH CT.	NAPERVILLE	IL	60565
312 742-2052	Y	CHARLES MILLER	156 S. WESTON	ELGIN	IL	60120
317 784-8661	Y	PHILLIP MULLIS	325 WOODHILL DR.	INDIANAPOLIS	IN	462[illegible]
312 584-6057	Y	KENNETH MYERS	1303 INDIANA	ST. CHARLES	IL	601[illegible]
312 889-7757	Y	RICHARD NESS	2129 N. NARRAGANSETT	CHICAGO	IL	60639
312 255-1665	Y	FRANK PIETROLONARDO	1122 E. THOMAS ST.	ARLINGTON HTS	IL	60004
312 231-8160	Y	JOSEPH POLLARD	29 W. CHILDS ST.	WEST CHICAGO	IL	60185
312 XXX-XXXX	Y	BOB RANDERSON	25 S. SPRING	LAGRANGE	IL	60525
312 383-0186	Y	WILLIAM SHAFER	308 S. EAST AVE.	OAK PARK	IL	60302
312 879-0207	Y	JOHN STOCKBERGER	2S643 NELSON LAKE RD.	BATAVIA	IL	60510
312 429-4955	Y	CARL SWICK	7550 WILLOWWOOD CT.	ORLAND PARK	IL	60462
312 246-3046	Y	VLADIMIR VANA	5558 FRANKLIN	LAGRANGE	IL	60525
312 420-1118	Y	KENNETH WOODS	1264 HARVEST CT.	NAPERVILLE	IL	60565

TURN YOUR RADIO ON

Here's an informative and entertaining radio program. It's called CAR TALK. The program is a call in show with an 800 number. Two brothers are the hosts and at times are very humorous with their helpful answers to callers auto problems. Have a problem with your electric car ? Call them and lets hear what they come up with.

CAR TALK can be heard every monday night at 7:00 to 8:00 P.M. C.S.T. on N.P.R. (National Public Radio). In the Chicago area, it's on WBEZ 91.5 FM. Other areas - consult your listing for the N.P.R. station in your area.

THE PERFECT MOTOR FOR EVs

THERE IS NO MOTOR MADE OR DESIGNED JUST FOR THE ON ROAD ELECTRIC VEHICLES. The ideal motor would be: Compound wound - 20 Hp - with welded commutator - 10K RPM test - 4K to 5K RPM at 48V or 96V - small and light. This type motor is not yet manufactured. We have, however, some choices available.

The 2CM 76/77 Aircraft Starter-Generator, comes closest to the ideal specs. This machine is almost indestructible - at 10,000 RPM and over 1,000A without failure, working up to 72V without problems. Regenerating breaking is easily available.

Shunt Motors - field voltage with a shunt motor should be kept at maximum at all times. There is no advantage in varying the field on any shunt motor. This is the most common mistake made. No electric vehicle should be driven without regenerating breaking; this protects the brakes from damage. The small cars, normally used, do not have brakes designed to stop the extra 800 to 900 pounds of batteries.

Popular Motors Now in Use:

BALDOR - 10 Hp, 96V, designed as a universal power source for stationary machines with soldered commutator - sensitive to overspeed. Large and heavy.

PRESTOLITE - 20 Hp, 96V - series only - requires extra circuits for regeneration. Good size and weight. Designed for in-plant burden handling.

AIRCRAFT GENERATORS - the most available: 2CM76/77 EA40 or any 400A 28V units. Work very well up to 72V. They are small, light and strong. They can be used at 48V, with good speed, with two banks of batteries.

Clarence Ellers

GENERAL ELECTRIC TYPES 2CM76/77 STARTER-GENERATORS

by J. F. Rittenhouse

The GE 2CM76/77 starter-generator is one of a family of such units originally used to provide large torque to turn over large aircraft engines using thousands of Amperes of battery current and then, when the engines are running, to provide up to 400 Amperes of 30 Volt DC current to charge the batteries and to power auxilliary aircraft equipment.

Figure 1 is the basic schematic diagram of this type starter-generator. The connections to this unit are as follows:

A — The shunt winding connection using not more than 30V positive current.

B — The positive drive battery connections used as a generator.

C — The series winding connection to the drive battery positive from 24V to 72V.

D — The equalizing connection used when two or more of these units were connected in parallel in aircraft. Used here for shunt winding chassis ground.

E — Drive battery return (negative) always used in conjunction with all Configurations. This connection has in it the compensating windings for adjusting brush positions when used as a motor.

OVER →

Figure 2 shows the connections when this unit is to be used as a compound-wound motor. This type of connection is suggested for electric car use as it has a good amount of torque but will not overspeed. However, it does not have the torque of the pure series-wound motor connection. Shunt field battery positive is connected to A and the negative is connected to D and car chassis. This voltage should not be over 30 volts and should be controlled by a resistance or field-control to provide not over 8 amperes at the lowest speed. The drive battery is connected to C (positive) and should be through some type of armature controller. This battery current can be up to 400 amperes at from 24 to 72 volts. The negative drive battery is, as always, connected to E.

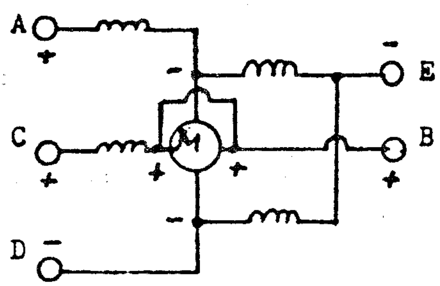


Figure 1

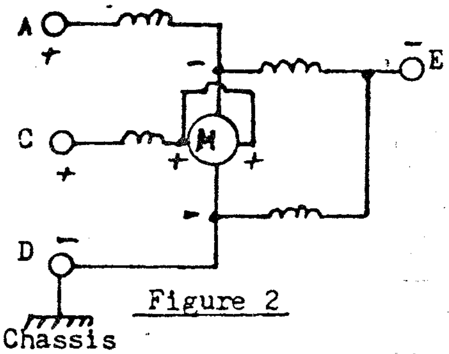


Figure 2

Figure 3 is used when it is desired or required to have a lot of torque for short periods of time as in passing, hill climbing, etc. This is the unit connected as a series-wound motor. The shunt winding (A to D) is not used, resulting in a large surge of power (at large ampere loads). The positive drive battery is connected to C at from 24 to 72 volts. The negative drive battery is connected, as always, to E. WARNING: This type of use requires that the motor always be loaded or it will "run away" such that it will tear itself to pieces, i.e. keep it connected to the drive train when used as a series-wound motor.

Figure 4 shows the unit connected as a shunt-wound motor/generator. In the configuration the 2CM76/77 can be used to regenerate power when the car is coasting or coming to a stop. To achieve this, the shunt power must always be on windings A to D (as for the compound-wound) but the battery connections to B and E must be through a large-current diode connected in reverse from connection B to the battery when the foot is released from the throttle. To use this unit as a shunt-wound motor, the series winding at C is not used. This winding can also be connected in and out of a double switch that connects to C when the foot throttle is depressed and connects B when released. A shunt-wound but uses less power, when cruising, than either the compound-wound or the series-wound connections.

As can be seen from Figure 4, this type of starter-generator is very versatile in that it can be connected as any one of the three most common motor types. By the proper connections and judicious use of relays, controllers, battery connections and wiring, the type 2CM76 and similar motors can be used to advantage if large quantities of power are required for short periods of time, if medium power is required as in average traffic conditions or if cruising power and regeneration is required as on highways and when in stop and go traffic.

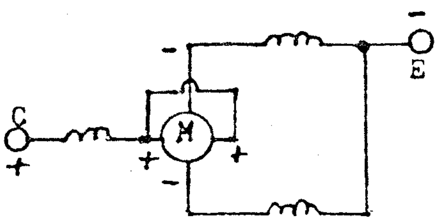


Figure 3

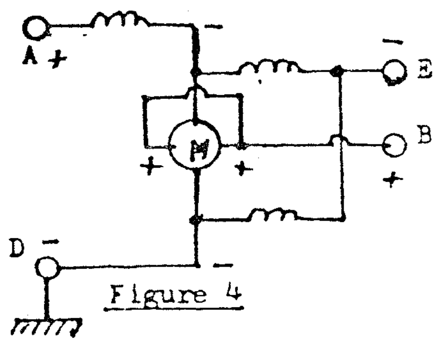


Figure 4

GM SUNRAYCER WINS

The GM Sunraycer

The General Motors Sunraycer won the inaugural transcontinental World Solar Challenge race in Australia, outdistancing its nearest competitor by more than 966 kilometers. The solar-powered car crossed the finish line near Adelaide, South Australia around 11:30 AM (local time) Friday the 6th of November.

General Motors entered the Solar Challenge as a practical technical project to develop and demonstrate technology in light-weight structures and materials, low-speed aerodynamics, high-efficiency batteries, light-weight motors and power electronics, as well as photovoltaic cells and panels.

What started out as a solar program to motivate teenage students at the Warragul Technical School of Southern Australia in late 1984 (see *SunWorld* Volume 10, No. 1) grew very quickly into an event of tremendous significance and implications for the fields of solar energy and transportation. In November 1985, the Warragul Technical School's Solar Seeker was the first solar-powered car to journey the 3500 km from Warragul to Karumba, on the shore of the gulf of Carpentaria. That journey took an exhausting 43 days.

The six day, 3200 km long journey of the Sunraycer and its crew will not be the last record set in solar-powered travel. May this achievement motivate and inspire us all to think in new ways about how we may live in the future.

Solar Array, Batteries Power Electronics

The source of power for all the Solar Challenge racers was, of course, the sun. The GM Sunraycer used 7,200 of the K7 solar cells built by Hughes Aircraft Company's Spectrolab subsidiary. These are the same type cells used on Hughes-built communications satellites, such as the AUSSAT satellite for Australia. Each cell is 2 by 6 centimeters and .2 millimeters thick (about the thickness of a business card). Their nominal efficiency in converting the sun's rays to electricity is 16.5 percent.

Hughes' Space and Communications Group designed and built the curved solar array, which is about 2 by 4 meters. The cells are connected in series and arranged in 20 strings of 360 cells each. Although the intensity of the sun's rays and the temperature of the environment affect the output, the panel typically operates at 150 volts, providing 1,000 watts of peak electrical power at noon.

Batteries

An indirect source of power is the batteries. The Sunraycer uses 68 rechargeable silver zinc cells, each providing 1.5 volts and 25 ampere-hours, producing a total of 102 volts. The batteries were designed and assembled by Hughes' Space and Communications Group. They weigh a total of 27.2 kg., or one-fifth the weight of a lead acid battery of the same capacity. The silver zinc cells can operate at high temperatures and at high rates of charging with an energy recovery efficiency of 75 percent. Battery power is used early and late in the day to supplement the reduced solar power available at these times. The batteries are recharged by the solar panel during the two-hour periods just after sunrise and before sunset. The batteries can also be used to provide additional short-term power for acceleration and for hill climbing.

Power Electronics

Connecting the solar array to the batteries are the peak-power trackers. These are custom built direct-current-to-direct-current converters that optimize the voltage level on the solar array for maximum power. Each peak-power tracker is connected to two parallel strings of solar cells and delivers the maximum available solar power to the battery bus at the bus voltage. Ten trackers are needed for the entire array. The use of multiple trackers allows the solar array to be curved for better aerodynamics without losing solar power. Each peak-power tracker weighs 10 ounces and has an efficiency of 98.4 percent.

Connecting the power source to the accelerator and motor are the motor drive electronics. These circuits allow the driver to select cruise control, charge and discharge of the battery, and provide automatic regenerative braking, which allows the drive motor to run as a generator and feed power back to the battery, thus slowing the car. The motor drive electronics control delivery of the current to the motor to provide the desired torque output.

The system is a three-phase, pulse-width modulated motor drive circuit. Twenty power MOSFETS (metal oxide silicon field effect transistors) are used in each of the three phases. The system has an efficiency of 98 percent and weighs 3.6 kg. Consultant Alan Cocconi had responsibility for development of the power electronics system and associated instrumentation.

Aerodynamics

Designed by a team of engineers from AeroVironment, Inc., and General Motors, the aerodynamics of the Sunraycer give it a teardrop shape. The goal was to achieve extremely low aerodynamic drag, with low side forces during crosswinds, while still providing a suitable surface for the solar cells and adequate space for the driver. The shape was refined by use of an advanced computer program called VSAERO, developed by the United States National Aeronautics and Space Administration (NASA). The final configuration minimizes overall up or down aerodynamic forces on the GM Sunraycer at high speeds. Tests of a one-quarter model at the 10-foot GALCIT wind tunnel at California Institute of Technology (Caltech) in the USA exhibited the lowest drag coefficient *ever measured* at Caltech for a road vehicle.

Results of the wind tunnel tests on the Sunraycer helped the team to fine tune the aerodynamics with the addition of a small vertical fin, called a *strake*. Mounted on top of the vehicle just above the driver's head, the strake helps keep the car on the road by reducing upward lift in a crosswind. Six ventral fins located under the rear edge of the vehicle also reduce the effect of crosswinds on vehicle stability and control.

Aerodynamics was also a consideration in designing the wheels for the Sunraycer. To reduce aerodynamic drag the spokes are covered with plastic disks.

Light-Weight Structure and Materials

Canopy and Seating

The chassis of the Sunraycer is a welded aluminum tube spaceframe. A spaceframe is like a cage and is inherently lightweight. The chassis frame weights 6.8 kg, yet it supports a vehicle weighing 248 kilograms, including a driver (ballasted to 84.8 kg), electric motor, solar panel, batteries, and electronic components. Many types of race cars use spaceframe construction.

The body is made like a sandwich of Kevlar (trademark DuPont)/Nomex (DuPont)/Kevlar. The center portion of the sandwich, made of Nomex, looks like a slice of honeycomb. The honeycomb structure gives the body great strength and rigidity with very low weight (944 g/m^2).

With temperatures reaching 49 degrees celcius, the gold-plated canopy played a vital role in protecting the driver from the intense radiation of the Australian sun. The gold plating reflects 90 percent of visible light and 98 percent of the infrared radiation. Since the car was only driven during the day, the 10 percent of visible light available to the driver is sufficient. By blocking the infrared rays, the canopy helps to keep the driver relatively cool and, therefore, allows him or her to remain in the car longer, requiring fewer stops.

Even the seat was designed to keep the driver cool. Made like a sling or hammock, the nylon mesh allows air to circulate around the driver, helping to remove excess heat from his/her body.

For safety the driver was held securely in place with a lap belt as well as shoulder and leg harnesses that are attached to the frame of the car.

Tires, Wheels, Suspension, Steering

To minimize rolling resistance, the Sunraycer's wheels use bicycle tire technology. Custom built wheel hubs were designed by Dr. Chester Kyle, who developed much of the bicycle technology for the United States bicycle team in the 1984 Olympics. The 17-inch spoked wheels have aluminum rims and quick-mount hubs for fast wheel changes.

The four-wheel independent suspension, designed by Terry Stachell of the Chevrolet-Pontiac-Canada Advanced Vehicle Engineering Staff, uses MacPherson struts in the front and independent trailing arms in the rear with adjustable roll steer. The suspension uses steel springs with conventional gas charged shock absorbers.

The Sunraycer uses a technique for braking that actually feeds energy back into the batteries. The left wheel, which is the drive wheel, runs the drive motor as a generator when the driver takes his/her foot off the accelerator, thus feeding energy back into the batteries.

The steering wheel is 25.4 cm. in diameter and is the type used for Indianapolis race cars. It has a 12-to-1 steering ratio with one turn lock-to-lock.

Magnequench Motor

A new motor, designed by General Motors Research Laboratories (GMRL) powered the Sunraycer. Using recently developed super-strength, rare earth, iron-based permanent magnets, called Magnequench III, the motor has an efficiency rate of 92 percent, compared to similarly sized standard electric motors, which have 75 to 85 percent efficiency. Magnequench is a trade name for a patented process developed by GMRL and GM's Delco Remy Division. The motor weighs 3.7 kg and produces two horsepower continuously at 4,000 rpm, which is about 30 to 40 percent more than comparable sized commercially available motors. It uses six Magnequence magnets produced by Delco Remy and low-friction bearings from GM's N[illegible] Departure-Hyatt Division.

At the end of the Sunraycer's power train is a chain drive connecting the motor to the left rear wheel (4:1 ratio).

Magnequench motor features include 1) **high efficiency:** no brushes (no brush friction loss); electronic commutation (for wider magnet arcuates, more flux, less current — therefore, less current loss); stationary outside winding (better cooled, less resistance low current loss); special low-friction bearings; special thin laminations (low iron magnetization loss); and magnequench magnets (for more flux, less current — therefore less current loss); 2) **high power density (light weight):** electronic commutation for wider magnet arcuates and better space utilization; magnequench magnets (more flux in less space); and hollow shaft construction; and 3) **high overcapacity (high torque capability)** (for short periods; pulling [illegible] shoulder of road or hill-climbing): magnequence magnets and low loss design.

The motor design was optimized using computer programs developed at GM's Research Laboratories.

Magnequench Process

Named after the processing technology which instantly cools (quenches) a stream of molten metal contacting a spinning wheel in an oxygen-free environment, Magnequench combines Neodymium, Iron, and Born. Quenched at the rate of one million degrees centigrade per second, the rapid solidification process creates magnetic metallic ribbon-flakes in step one of a patented process as unique as the product itself.

Depending on subsequent processing, magnetic properties ranging two to ten times greater than ferrite magnets are possible. This enab[les] engineers and designers to reduce the size and weight of any device powered by an electric motor.