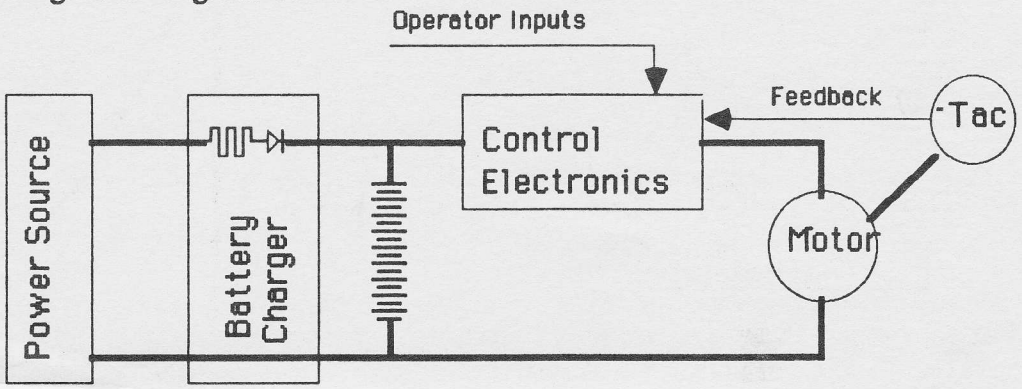
Electric Auto Association NEWS

JUNE 1988 Vol. XX No. 6

# ELECTRIC CAR - MOTORS AND CONTROLS

The ELECTRIC CAR-MOTORS & CONTROLS have the basic elements arranged as shown by the general diagram below.




The POWER SOURCE can be most any type that can be used to charge a battery.

1. House hold 60 cycle, single phase, 110 volts.
2. Commercial power 3 phase, 25, 50 or 60 cycle, 120/208 volts.
3. A gasoline, diesel or turbine driven generator. This could be AC or DC type generators.

The BATTERY CHARGER must be chosen to work from the POWER SOURCE to charge the BATTERY at the voltage required. This could be a simple current limiting resistor and diode to prevent reverse current from battery, to a very specialized design to have current limiting, voltage limiting, with time control that will control charging under almost any condition. The charger could be built into the vehicle or at the power source. This is the choice of the designer-builder of the car at all times.

The BATTERY voltage selection is usually made to make it possible to charge from a 110 volt 60 cycle line direct without having to use a transformer.

The DC voltage output of a single phase 60 cycle 110 volt line is =(110)0.9=99.0 volts.

The battery, in this case, could consist of 16-6 volt boxes, which would give 96 volts. Allowing for input line voltage varriations and the voltage drop across the control devices used in the battery charger give good charging capability under about all conditions.

The CONTROL ELECTRONICS must be chosen to match the BATTERY and the MOTOR characteristics for good operation. These may be any of the following:

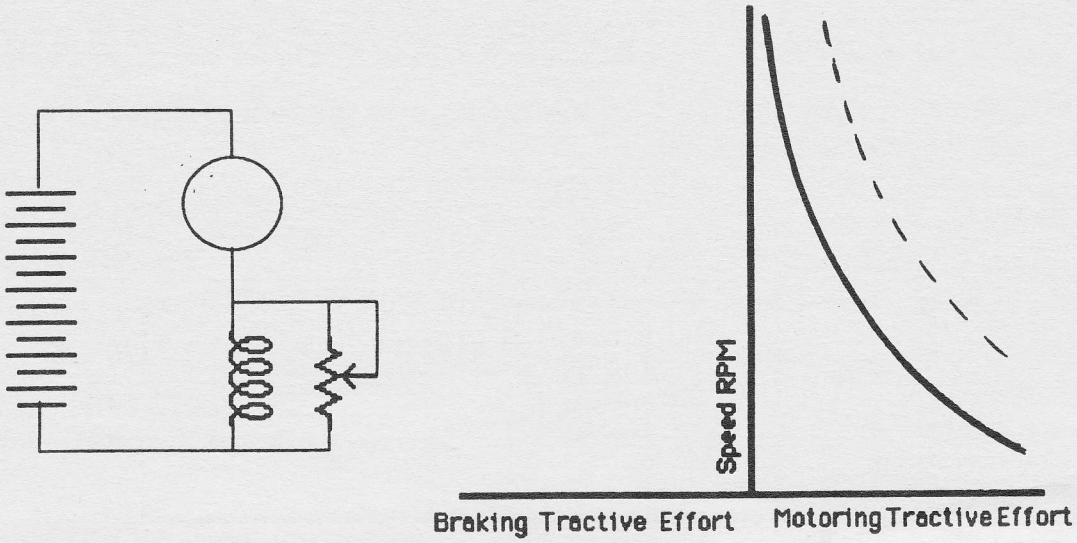
1. Contactor-resistor switching schemes.
2. Silicon controlled rectifier switching such as choppers.
3. Transistor systems connected as choppers.
4. Mos-fet devices connected for choppers or pulse width modulators.
5. Any control devices that may be used to control voltage and current.

CON'T Pg.2 tru 6

The CONTROL ELECTRONICS must have the ability to measure the voltage, current and the motor speed. This gives the ability to protect the motor over its complete operating range. The motor speed should be measured at the motor shaft before any couplings to the car so that if the coupling or other parts break the motor will not over speed and possibly destroy itself. There should be operator inputs to tell the control to operate in motoring or breaking and just how much. There should be a car velocity input especialy if gear-ratio shifting is used.

## SERIES MOTORS

The SERIES MOTOR with its characterstic speed-tractive effort curve is shown below.



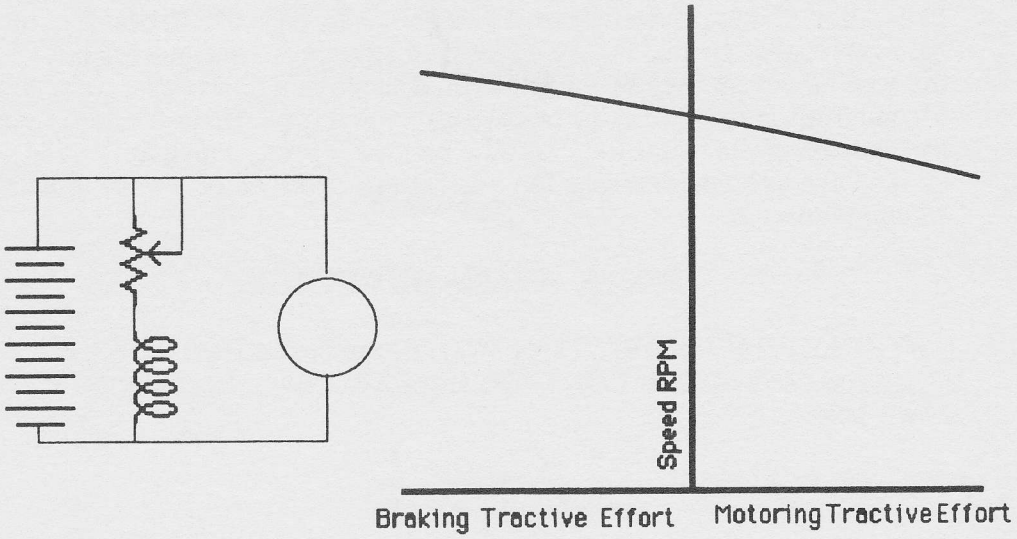

The SERIES MOTOR is noted for its large "SPEED-TRACTIVE EFFORT" variation. It is sometime referred to as a wide range torque converter. This makes it desirable for electric car use.

1. The heavy line is for FULL FIELD operation.
2. The dashed line is for WEAKEND FIELD operation.

The SERIES MOTOR should be operated FULL FIELD during starting and up to the point the maximum BATTERY voltage is applied. This gives the highest tractive effort per ampere and efficiency. The shape of the curve in the high tractive effort (high current) is under the control of the motor designer. If he causes the magnetic circuit of the motor to saturate, he can raise the speed curve for the same tractive effort. This is not always best because the tractive effort per ampere is reduced.

When the SERIES MOTOR is operated with WEAKEND FIELD, the tractive effort per ampere is greatly reduced and the motor commutation sometimes shows sparking or possibly will flash-over. Operating in weakend field is like operating a car in OVERDRIVE, you can increase the speed on level road but it will not be any good on grades.

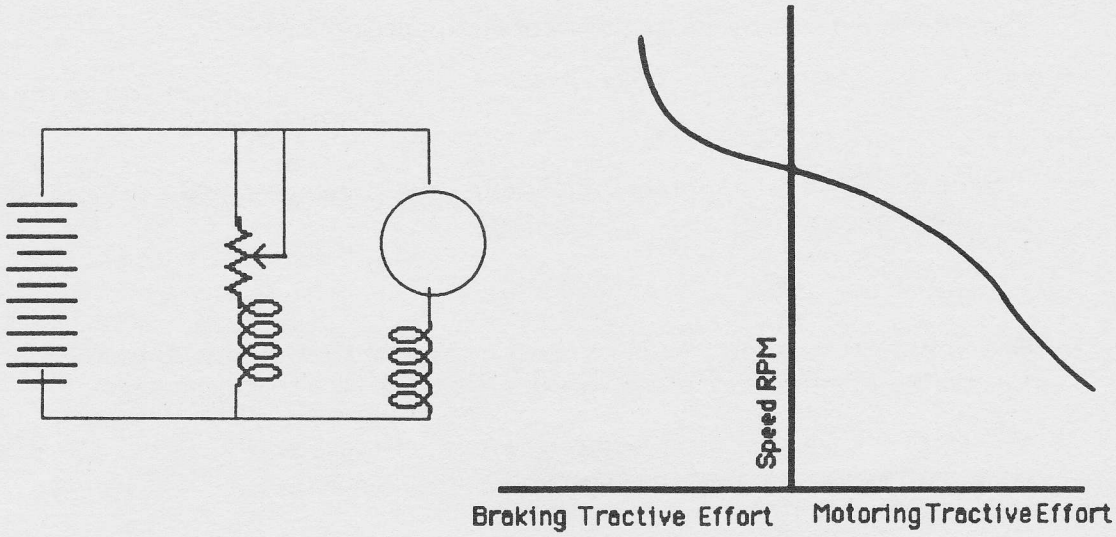
The SHUNT FIELD MOTOR with its characterstic speed-tractive effort curve is shown below.




The SHUNT FIELD MOTOR is noted for its small speed variation vesus tractive-effort curves. This makes it hold to small speed changes with load, and can be used to return energy to the battery if the speed increases much above the motoring speed. This is a good characteristic for hilly terrain if you want to keep the speed changes small without a lot of control. It does require a current limiting control in series with the armature during accleration up to the base speed of the motor. Speed can be increased above the base speed by weakening the shunt field to go faster. Again as the field is weakend to any degree, the tractive effort per ampere is reduced and commutation may become unacceptable as the speed is increased, the overall efficiency of the motor is reduced.

## COMPOUND MOTOR

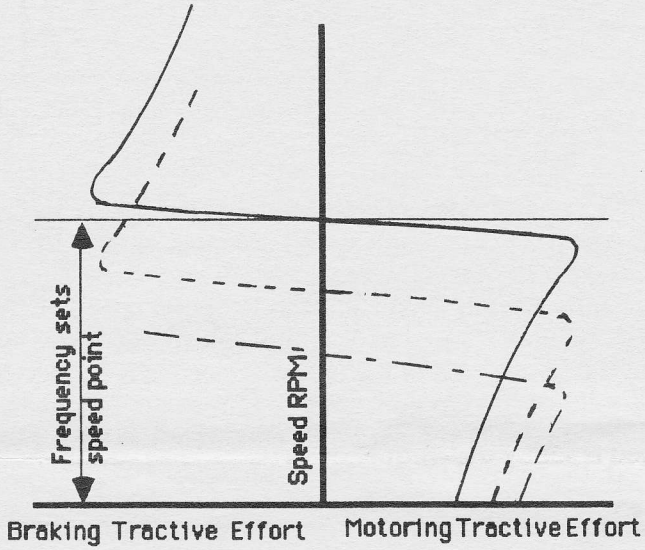
There are two types of COMPOUND MOTORS, differential and cumulative compound, only the cumulative compound motor will be considered here. The series field aids the shunt field when in the motoring mode of operation. The SPEED-TRACTIVE EFFORT curve is shown below.



The CUMULATIVE COMPOUND MOTOR can be made to have the characteristic of the series motor in the high tractive effort region but have the speed limiting of the shunt motor. In addition, if the speed tries to increase above the base speed, braking (return energy to the battery) results. By making the series field ampere-turns equal to about 30 to 50 percent of the total ampere-turns, the machine will operate as a differential compound generator and automaticaly limit the braking tractive effort as shown. Different base speeds can be chosen by controlling the shunt field and the control is pretty much automatic. Again the shunt field weakening will decrease the tractive-effort per ampere with possible effect on the commutation.

## THREE PHASE INDUCTION MOTORS

The THREE PHASE INDUCTION MOTOR can be used for an electric car. It does require quite a complicated set of CONTROL ELECTRONICS. The speed-tractive effort curve is shown below.




Industrial THREE PHASE INDUCTION MOTORS are usually made for 120/208 volt 60 cycle operation. The least weight usually would be a two pole machine. This would have a full load speed of about 3450 RPM. This would require a higher BATTERY voltage, with the complication of BATTERY CHARGER. There are a number of other considerations that must be taken into account.

The speed point is set by the frequency of the applied voltage.

RPM=120 F/P

F=frequency in CPS (cycles per second)
P=number of poles

The tractive effort,to be kept constant during a speed change, must have the voltage varried with the frequency.

VOLTS=(120/208) 60/F

The voltage at constant frequency must be kept at close to the desired value, since the tractive effort,within reason, will vary directly as the square of the voltage.

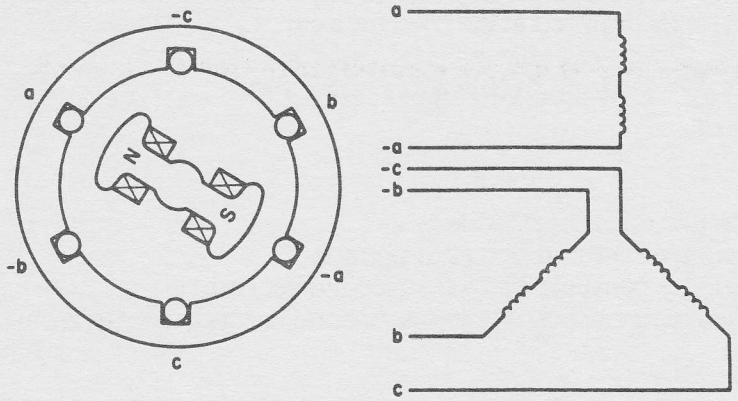
The RPM of the motor must be fed back to the ELECTRONIC CONTROLS in order to control the motor speed and tractive effort.

The ELECTRONIC CONTROLS must be able to supply the three phase power to control motor operation, it also must be able to receive the three phase power and convert it bach to DC at the proper voltage so that the BATTERY will accept it.

The choice of an induction motor does not appear to be good, since they have a poor power factor when starting, with high current requirements. The design of the ELECTRONIC CONTROLS require larger capacity, with a number of control complications that do not seem to justify the cost for what could be obtained.

## PERMANENT MAGNET 3 PHASE AC MOTOR

An elementray three-phase two pole motor diagram is shown below.




The following discussion will be limited to permanent magnet (PM) poles only. The PM motor does not require any magnetic field excitation, which eliminates slip rings and electrical energy, for the rotating field poles. The field excitation on motors in the size that would be used, 5 to 15 horespower, would require 3 to 6 percent of the input power. The smaller motors would require the higher percent input.

The PM motor speed is set by the frequency of its applied voltage.

RPM = 120 F/P

F = Frequency in cycles per second (CPS)
P = number of poles

The three phase AC voltage is obtained from a solid-state inverter by using pulse-width modulation at the frequency required for the motor RPM or car speed. The PM AC motor is called SYNCHRONOUS MPTOR since its speed is determined by the frequency of its applied voltage. The toque or tractive-effort of the motor can be held nearly constant as the motor is acclerated if the voltage applied to the motor is varried directly with the frequency. This is sometimes referred to as constant volts per cycle.

The General Motor's SUNRAYCER CAR that ran in the "Pentax World Solar Challenge race across Australia" used an 11 pound, three-phase, 6 pole AC motor. It developed about 4 horsepower, at 1.5 horsepower its efficiency was approximately 92%. A belt-drive, with a 4 to 1 reduction, was used to the left rear wheel. The drive wheel was approximately 20 inches in diameter. This requires a motor RPM = 4000 at 60MPH, the applied inverter frequency had to be 200 cycles per second. The power inverter had a peak power rating of 7 KW at approximately 98% efficiency. The voltage was a nominal 109 volts, from a 68 cell silver-zinc battery. The pole position sensing is an 8 bit resolver, which will give the rotating pole position to 1 part in 256 of a revolution or a pole position to 1 part in 42.67 or about 8.45 electrical degrees.

A car wheel mounted motor is under developement by UNIQUE MOBILITY of Denver, Colarado. A motor would be mounted in each wheel for maximum tractive-effort capability.

UNIQ Motor - Design Objective vs. Test Results

| | Design Objective | First Stage Test Results |
|---|---|---|
| Power, HP | 40 | 23 |
| RPM | 12000 | 8500 |
| Weight, pounds | 10 | 12 |
| Peak Efficiency % | 97.6 | 95.5 |
| HP/pound | 4.0 | 1.9 |

This could be used in a HIGHBRED car or a strate electric car. Good light weight motors are nearing a reality, now to get the cost down to where people can afford them.

The ELECTRIC AUTO ASSOCIATION NEWS for April of 1988 had a very interesting write up on a NICKLE-IRON battery that shows good promise for the future.

The following information is for some of you who want to know a mathematical expression how much tractive-effort is required at the road for a car.

$$TE = \frac{W}{G}\frac{dv}{dt} + W \sin(\Theta) + A V^2 + BV + C$$

Where:

TE = tractive effort in pounds
W = weight of car and driver in pounds
G = gravity constant 32.16 feet/second/second
$\frac{dv}{dt}$ = the change in velocity in feet/second/second. acceleration is positive. deceleration is negative.

$V$ = velocity in feet/second
$\Theta$ = grade angle in degrees. up grade is positive. down grade is negative.

The constants A,B&C are obtained by coast down test on level road on a calm day or by towing the car on level road on a calm day and measuring the force at three different velocities. The velocities picked should be like 15, 30 & 45 MPH so that the three constants can be determined with a fair degree of accuracy.

BY E.W. AMES

## STANFORD SOLAR SHOWCASED

The campaign to develop large scale photovoltaic energy sources took a large step forward with the dedication of the Photovoltaic Utility Scale Application (PVUSA) testing site in Davis, CA on April 4. The ceremony consisted of several short, optimistic speeches given by powerful proponents of solar energy, using the Stanford University Solar Car Project's display as a back drop. Particularly noteworthy speakers included United States Congressman "Mr Solar" Fazio, Chairman of the California Energy Commission, Charles Imbrecht and others representing the Electric Power Research Institute, the Department of Energy, and Pacific Gas and Electric.

Though dignitaries abounded, the real stars of the show were the Stanford Solar Car Project and Mr. Robert Schneevei's exhibits that illustrated solar and electric's vast potential. While the Stanford groups mock solar residence with the EAA electric Chevelle denostrated a practical application, Schneevei's provided some pizazz, unveiling his recently-completed electric bicycle. Media members were quick to capitalize upon these ready-made props, and all interviews were conducted in front of these exhibits.

Also noteworthy were the deserts included in the catered lunch provided by Mustard Seed catering, Absolutely sinful.

EVA's illustrious Secretary and Editor of our Bulletin has chosen to vacate to Europe for R & R. This envious writer wishes him well and hopes for his speedy return in time for the next Newsletter.

* * * *

Our April meeting was well-attended, and rewarded with the latest information from Les Adam, Pres. of AZ Industries, Temecula, Ca. His company produces super magnets of the lanthanide element #60, Neodymium, alloyed with Iron and Boron. It was a totally interesting presentation as the use of these magnets will benefit our electric vehicles with smaller, more powerful, light weight motors. They have plans to produce motors in the future. Les was kind enough to leave a number of back issues of their fantastic publication "Magnets in Your Future". Thank you!! I have been hoarding a two year old copy for that many years. They also conduct seminars at their factory and these are called "Meeting of the Minds".

Les Adam continued to surprise our membership by introducing Ian Jamieson of Triple "O" Seven Corp. who announced a Los Angeles to New York alternative energy race, Cannonball Run, scheduled for September 1989. The ink was scarcely dry on the initial publicity brochures, and a generous supply was left for members to pick up at meetings. Both companies are involved in promoting this event. Rules governing participants will be set forth in future releases.

The initial brochure features in full color on the cover an electric vehicle with which our membership is totally familiar. EVA club member, and former Secretary & Editor of our bulletin for many years, Vic Schisler, built the car a few years back and sold it to Mr. Jamieson. I was priveleged to meet Vic for the first time when we attended a 3 semester course on electric vehicle manufacturing. It was at this time that Vic built his car, and I started construction on my SolarWind.

* * * *

Our May meeting will consist of a moderated discussion from our membership concerning the many new developments affecting our club, and electric vehicles in particular. Over the years many of us have been reluctant to spend <u>only</u> the few hours from 9:30 to noon at meetings, and we continued discussions over lunch and sometimes till almost 3 PM. For me this has been very productive, but for only 8 or 10 who show up. We need input and ideas from all members. This meeting is our opportunity to be heard, and the obligation of members to share problems or ideas. We have a broad spectrum of talent in each member and we sincerely seek your participation.

We have never had finer support from our electric utilities, Air Quality Management, or some of our legislators. We <u>will</u> have super-conductivity at reasonable temperatures, high tech magnets and motors, and super batteries before some of us complete our dream machines. We are on a "roll" and need to increase the momentum. Let's fill the meeting room!

Your patient indulgence on this abbreviated letter is requested.

Hurry back Mr. Editor!!

Ken Kruetz V.P.

GOOD SUB-IN KEN

COYOTE POINT

SAN MATEO

FOR INFO AND/OR DISH ASSIGNMENT
POT LUCK WE SUPPLY
THE MEAT




*Electric Auto Association*

# EAA 21ST BIRTHDAY PARTY

## Announcing...

## PENINSULA PICNIC

## JUNE

SATURDAY
25
@12
Noon

CALL: Mae (415)992-5453
Pat (408)734-8385
Lydia (415)591-6698

IMPORTANT NOTICE!!! Please vote for four of the following for additional members for the Nat'l EAA Board of Directors:

MARK (4) FOUR

Clarence Ellers, Publisher of EAA News ----------|__|
Johnathan Gable, President of East Bay Chapter ----------|__|
S. Lee Hemstreet, President of Santa Clara Chapter ----------|__|
Robert Kincheloe, Advisor to Stanford Univ. Inst. TV Network ----------|__|
Angus Mac Donald, Engr. Consultant ----------|__|
E. Stan Skokan, EV Dealer and HP Engr. Employee ----------|__|
Write In _____ ----------|__|

MAIL TO: EAA 1249 Lane St. Belmont, CA 94002

---

PROJECT X REBORN?

Are you interested in participating in a group effort to design a state-of-the art electric car? In exchange for your ideas and efforts you would receive the results of the ideas and efforts of all other participants in the form of complete plans and component source data.

That was the objective of the original Project X about fifteen years ago. Frank Willey started designing the famous Willey Controller as his contribution to that effort. If the rest of us had applied our efforts as effectively as Frank did we might have more and better electric cars today.

Several EAA members want to rejuvinate Project X and, this time, invite all interested EAA members everywhere to participate. Design-by-mail will be difficult but, with ideas from all participants, maybe it can be successful.

If you are interested in participating in Project X think about how you would suggest that a group effort by geographically dispersed participants should be organized and operated. Send your statement of interest and ideas to the interim chairman: Clarence Ellers, 2892 Mesquite Drive, Santa Clara, CA 95051.

* * * * * * * * * *

IN MEMORY OF IS TILLIN

This month Is Tillin was suddenly taken from our midst, while vacationing in Huntsville, Texas. Is was struck by a vehicle as he was walking to breakfast with his wife, Alma.

Is helped many of us initiate many projects and activities. Most recently he served as our Membership Chairman, and advisor to our Board of Directors.

Is will be sorely missed by many of us who associated closely with him for more than a decade.

FOR SALE

GE 23 HP series motors, new (in box) 2X torque of Prestolite, $550, 0-30 MPH under 10 sec. 60-65 MPH with 5 spd. trans.
48 volt Prestolite motors-new & used, meters $5, transformers misc. conversion parts cheap.
WANTED-JET Electra vans-parts any condition.
CALL: Stevenson (707) 468-1603/462-3944.

* * * * * * * * * *

FOR SALE

1974 Honda Civic conversion: Prestolite motor, Russco controller & Charger, runs but needs new batteries.
1981 Datsun 310 (Electricar) conversion, Prestolite motor, no batteries or controller.
CALL: Alma Tillin (415) 524-2242.

# CALENDAR

JUNE 5-9: Battery Council International (BCI) 100th Annual Converence, Osaka Japan.

JUNE 11: Fox Valley EAA & Ill Solar Energy Asso. in cooperation with Argonne Nat'l Laboratory are sponsoring an Electric Vehicle Show & Symposium at the Laboratory. CALL: Ken Woods (312) 420-1118.

JUNE 11: EAST BAY, PG&E Service Center, Rally Planing.

JUNE 13-16: 33rd Int'l Power Sources Symp. (LABCOM), Cherry Hill, New Jersey.

JUNE 20: Solar '88 Annual Solar Technologies Conf. Cambridge, MA.

JUNE 21-26: AUTOMOTIVE CHINA '88 International Exhibition on Automotive Ind. China International Exhibition Centre, Beijing.

JUNE 25: PENINSULA CHAPTER, Annual Picnic & EAA 21st Birthday Party. Coyote Point, San Mateo, CA CALL: Mae (415) 992-5453.

JUNE 27-JULY 2: TOUR De SOL--Switzerland--Solar Car Race, Seattle Member Ray Nadreau intends to enter his car.

## EAA Chapters

ARIZONA: PHOENIX
Roger Smith 602-969-9667
P.O. Box 16800 #273
Mesa, AZ 85202

CALIFORNIA:
Burbank
Irv Weiss 818 841-5994
2034 N. Brighton #C
Burbank, CA 91504

East Bay
SCott Cornell 415 798-0909
60 Alan Dr.
Pleasant Hill, CA 94523

North Bay
Gordon Schaeffer 415 456-9653
211 Bellan Blvd.
San Rafael, CA 94901

Peninsula
Mae Bensen 415 992-5453
8 San Juan Ave.
Daly City, CA 94015

Sacramento
Carl Metcalf 916 486-0321
3654 Bausell St.
Sacramento, CA 95821

San Jose
Don Gillis 408 225-5446
5820 Hern St. #3410
San Jose, CA 95123

Santa Clara
Lee Henstreet
787 Florales Dr.
Palo Alto, CA 94306

OREGON; Willanette
Leslie Brundidge 503 390-3871
4040 Gary St. NE
Salem, OR 97303

TEXAS: Houston
Ken Bancroft 713 729-8668
4301 Kingfisher
Houston, TX 77035

WASHINGTON: Seattle
Bryan Lowe 206 632-4496
5011 9th NE
Seattle, WA 98105

WISCONSIN: Milwaukee
Dave Pares 414 481-9655
3251 S. Illinois
Miwaukee, WI 53207

NEW JERSEY: Hackensack
Kasmir Wysocki 201 342-3684
293 Hudson St.
Hackensack, NJ 07601

Vancouver, B.C.
VEVA 604 987-6188
543 Powell St.
Vancouver, B.C. V6A 1G8

NON-AFFILIATED GROUPS

CANADA
Ottawa, Ontario
Fred Green
Box 4044 Sta. "E"K1S 5B1
Ottawa, Ontario, Canada

NEW MEXICO: Albuquerque
Mike Lechner 505 848-2331
PNM Alarado Square
Albuquerque, NM 87158

Southern Cal-EVA of SC
Ken Koch 714 639-9799
12531 Breezy Wy.
Orange,CA 92669

DENVER CO DEVC
Genny Clark 303 451-5051

Fox Valley IL 312 879-0207
John Stockberger
2S 643 Nelson Lake Rd.
Batavia, IL 60510

Eastern 215 696-5615
P.O. Box 717
Valley Forge, PA 19482

For information on forming a chapter in your area write Electric Auto Association, 1249 Lane St. Belmont, CA 94002. For a sample copy of the newsletter send SAE #10 envelope.
PHONE (415)591-6698

EDITORS: - Walter Laski - John Newell - Bill Palmer - Paul Brasch - COMPILED AND PUBLISHED by Clarence Ellers. SEND IN YOUR PERSONAL AND CHAPTER NEWS AND COMING EVENTS. ARTICLES-Comments etc. all correspondence to address below

Electric Auto Association NEWS

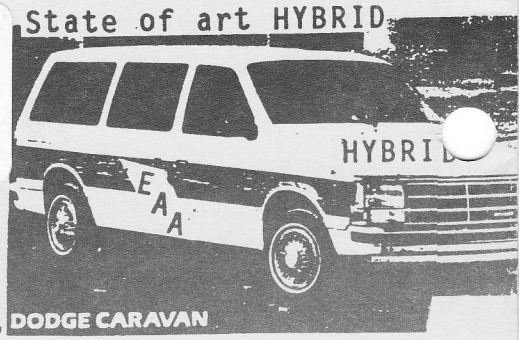
JUNE 1988

1249 Lane St.
Belmont, CA
94002

Address Correction Requested

NON-PROFIT ORGANIZATION
U.S. POSTAGE
PAID
SUNNYVALE, CA
PERMIT NO. 420

HELP!! PROJECT-X
State of art HYBRID




PLEASE
TIME DATED MATERIAL - DO NOT HOLD