Electric Auto Association NEWS

FEBRUARY 1988 Vol. XX No. 2

DEMI Lithium-Air Power Systems

A Technology Overview

A new class of electrical power system is moving from the laboratory to practical commercial and industrial applications. This power system is based on the direct oxidation of Lithium metal in air to produce electricity. This process, which occurs at room temperature, yields up to one hundred times the energy to weight ratio of conventional batteries. In some applications, it can achieve several times the energy density of gasoline powered systems.

Introduction

The Lithium-Air System produces electricity by reacting with oxygen in air. The oxidation products then react with atmospheric CO_2 yielding lithium carbonate as the final "discharge" product. The system can be indefinitely recycled by a separate chemical reclamation process which ultimately runs on electricity. Thus, the overall system is a mechanically refueled, externally recharged "battery".

This technology is expected to facilitate a broad new range of portable electrically powered equipment in applications which were too costly and/or too heavy when operated by conventional batteries. Near term applications include powering portable computers, medical equipment, radio gear, gardening tools and small vehicles. Over the long term automotive and ultralight aircraft power are feasible. In fact, DEMI powered a compact car with an early version of this lithium technology in 1985.

Some Direct Comparisons

One way of comparing energy systems is to compare the useful energy obtained from the primary fuel versus the weight of that fuel. Typical units of measure are Watt Hours per Gram, KWHr/Kg or Hp·Hr/lb. Such a comparison follows:

Pb, Cd or Zn in "conventional" batteries	300 WHr/Kg.
Gasoline in a car engine	2000 WHr/Kg.
Lithium in DEMI Lithium-Air Power Systems	9000 WHr/Kg.

Another more practical way to compare technologies is at the system level, considering the power source as a "black box". The following is a direct energy density comparison between three systems with a 4000 WHr total capacity, in a configuration suitable for powering electrical hand tools all day at a construction site:

Car batteries (lead acid)	30 WHr/Kg.
Motor generator (gasoline)	150 WHr/Kg.
DEMI Lithium-Air Brief Case System	800 WHr/Kg.

Some Application Examples

A portable personal computer with a high resolution color CRT and a hard disk could be operated all day from a single "Shirt Pocket" fuel cartridge. Likewise, other computerized test and analytical equipment could be powered in a similar way.

Briefcase sized free-standing Lithium Power Systems can replace conventional gasoline motor generator units. Such systems can be several times lighter than their gasoline counterparts. Furthermore, they operate without the noise, vibration, high temperatures and toxic exhaust of hydrocarbon systems.

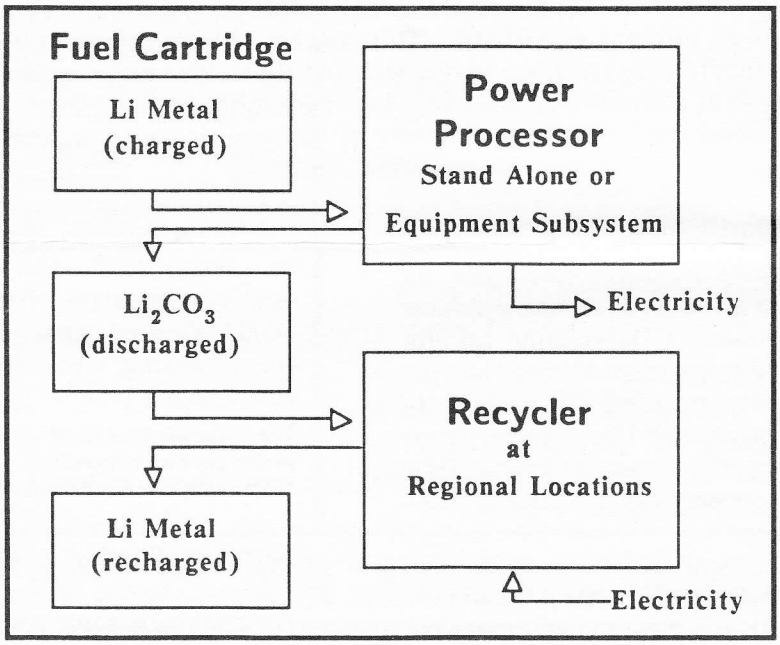
For example, a "briefcase" power pack can produce several hundred watts to power construction tools, gardening tools, a camp site or a field laboratory. The total capacity of such a system is determined by the lithium fuel load in the plug-in fuel cartridge. Such cartridges can be sized to operate for one day to over one week continuously. →

Lithium-Air Systems can be used to power wheel chairs, golf carts, tow motors and robotic or "autonomous" vehicles. In such cases the system should be configured specifically for the power level, capacity and form factor of the vehicle. In general, Lithium-Air Systems can provide quiet, pollution free, electrically renewable power at an overall system weight equal to or better than hydrocarbon fueled systems.

Basic Concepts

Lithium-Air Power Systems produce electricity via basic electrochemical reactions like a battery, but require a complex electromechanical processor for support. For a small portable electronics system this *power processor* is about the size and complexity of a floppy disc drive. In an automotive scale system, the power processor is similar in complexity to a car engine. Although the processor is mechanically and electronically complex, it is inexpensive to produce due to the nearly exclusive use of plastic parts and microprocessor control.

The lithium fuel is supplied to the power processor in *fuel cartridges.* In very small systems and specialty applications these fuel cartridges can be single use disposable components. However, in order to achieve operating costs in line with conventional fuels (instead of high cost primary batteries) the lithium fuel must be recycled. This can be done at regional recharging/recycling centers. The plastic system components have a very long life subject only to normal mechanical wear.



The Lithium-Air System has one expendable; the carbon cloth membranes which obtain oxygen from air. These cathodes can be single use items in small systems or 1000+ hour components in large systems. Medium and large scale systems incorporate independently serviceable air cathodes which can be snapped out and cleaned like air filters.

Handling Safety

Conventional lithium batteries use hermetically sealed construction to protect the highly reactive lithium and electrolyte from air and water. In fact, some types of lithium batteries will explode if opened.

DEMI has made a major breakthough in stabilizing the Lithium-Air System so it operates in open air and can be briefly exposed to direct water spray with little effect. In fact, medium and large scale DEMI Lithium-Air Systems can be opened for inspection while operating and can be serviced in normal shop environments.

Shelf Life

The lithium fuel cartridges have a several year shelf life when sealed in a protective air free bag. Once the fuel cartridge is opened or initially activated the lithium fuel starts to oxidize at a rate determined by the cartridge design.

Small static fuel cartridges must be used within hours to a few days of initial activation. Larger systems meter the lithium fuel into the reaction zone on demand and can have a partial discharge shelf life of months. (In comparison NiCd batteries typically lose their charge in one month or less.)

In all cases the final end product is lithium carbonate which is created by the eventual exchange reaction of all other lithium discharge oxidation products (LiOH, Li_2O, etc.) with atmospheric CO_2 to form carbonate. Lithium carbonate is a neutral powder that should not be injested, but does not represent a major health hazard from accidental skin contact. (Many pottery clays contain significant amounts of lithium carbonate so you have most likely eaten from dishes containing Li_2CO_3.)

Safety Certification

DEMI intends to obtain appropriate independent operating safety certification for each major system configuration. Because of the complexity of such processes, initial uses will be limited to industrial applications. However, there is a trend towards consumer use of large lithium primary batteries which represent a much greater accident risk than the corresponding capacity Lithium-Air Systems. If this trend continues, consumer applications of Lithium-Air technology should be possible. →

Background

Lithium is an alkaline metal closely related to sodium and potassium. Lithium is the lightest metal and has a very high battery voltage. Because of these two facts lithium is generally regarded as the ultimate battery fuel.

Animals and hydrocarbon engines get half of their total fuel out of the air as oxygen. Conventional batteries carry "onboard" oxidizer thus greatly increasing their overall weight. It has long been recognized that a power system based on lithium in an "air-breathing" configuration could theoretically achieve very high performance.

Alkaline metal air batteries were first reported over 100 years ago in France. These early batteries used water, caustic soda and alcohols as electrolyte and were very difficult to control. Later designs used mercury to reduce the reactivity of the metal and hence increase its controllability. This addition drastically reduced the energy density of such systems thus making them unattractive.

By the mid 1960s researchers focused lithium development efforts on organic solvent based electrolytes. Such systems are extremely sensitive to water contamination and therefore can not use atmospheric oxygen as the oxidizer. These batteries have very low power output and are burdened with heavy oxidizers. Consequently they are typically only four to eight times better than conventional zinc or lead acid batteries. However, a wide range of lithium batteries are now available based on this general concept. Such batteries power watches, long life flashlights, cameras and military equipment.

Interest in Lithium-Air-Water Systems flared in the 1970s briefly. A group at Lawrence Livermore National Labs actually proposed developing a Lithium-Air Automotive Power System in 1975. However, control problems have continued to keep this technology from the marketplace.

DEMI Lithium-Air Development

Dreisbach Electromotive Incorporated has developed a proprietary organic electolyte in conjunction with a radical new battery geometry for its Lithium-Air technology. This new technology yields spectacular energy densities with good power density, controllability, shelf life and safety.

The principle penalty in this technology is its high inherent system complexity when compared to conventional batteries. For that reason DEMI is initially targeting high value applications such as portable electronic instruments which can justify the inclusion of the Lithium-Air power processor. Applications where small gasoline engines can be replaced are also possible near term candidates.

Lithium Power System Comparison

Conventional Lithium Batteries
- Low power
- Dangerous if punctured
- 4X to 8X conventional battery energy
- Long shelf life, but high price

Lithium-Water-Air Batteries
- High power
- Up to 100X conventional battery energy
- Very unstable
- No shelf life
- No commercial applications to date

Demi Lithium-Air (organic electrolyte)
- Moderate power
- Up to 100X conventional battery energy
- Stable with moderate shelf life
- Refuelable/economical operation
- Developing commercial applications

DEMI has fabricated a broad range of prototypes based on this technology ranging from a few watts to over 10KW output. Operating durations have been demonstrated from less than one hour to more than one week. Some systems have been in use for several years, thus providing a basis for system life projections.

The company is actively working with potential OEM users of the technology to develop commercial product specifications for market applications. DEMI is prepared to enter into exclusive supply and distribution agreements with OEMs for specific market segments. →

More detailed information is available by executing a non-disclosure agreement with Dreisbach Electromotive, Inc. Technology demonstrations and technology evaluation prototypes are available to qualified prospective OEMs.

July 1987

DEMI Lithium-Air System General Specifications

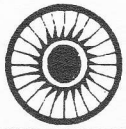
Overview:	Mechanically refuelable externally rechargeable electrical power system.
Key Elements:	Power processor, fuel cartridges and external recharger/recycling system.
Fuel:	Lithium metal and components of air.
Discharge Product:	Li_2CO_3.
Consumables:	None.
Wear Items:	Air cathodes and electrolyte.
Lithium Energy Output:	6,000 to 9,000 WHr/Kg.
Overall System Efficiency:	35 - 70% (wall plug to battery output).
Maximum Power Density:	1,000 W/Kg (observed).
System Energy Densities:	Up to 4,000 WHr/Kg.
Practical System Sizes:	Total energy: 100 WHr to 100 KWHr or more. Power: 20 Watts to 10 KW or more.

PC/Instrument Power Pack (Projected) 40 watts - 4 to 8 hours

Power Processor:	8" X 6" X 1.75" wt. 1 lb. (450 g.) (1/2 high floppy form factor).
Fuel Cartridge:	3.75" X 5" X 1" wt. 6 oz. (170 g.).
System Capacity:	160 WHr (at 4 to 8 hour running time).
Power output:	programmable ± 5v and ± 12v @ 40 watts total via integral high frequency switching power conditioner. (Line adapter plugs in place of fuel cartridge for AC operation).
Cost Proforma:	Power Processor: $200.00 (OEM). Fuel Cartridges (new): $10.00 (retail). Recharging Cost: $5.00 (retail). Instrument Operating Cost: $1.00 to $2.00 per hour.

Briefcase Power Pack (projected) 500 watts - 8 to 40 hours

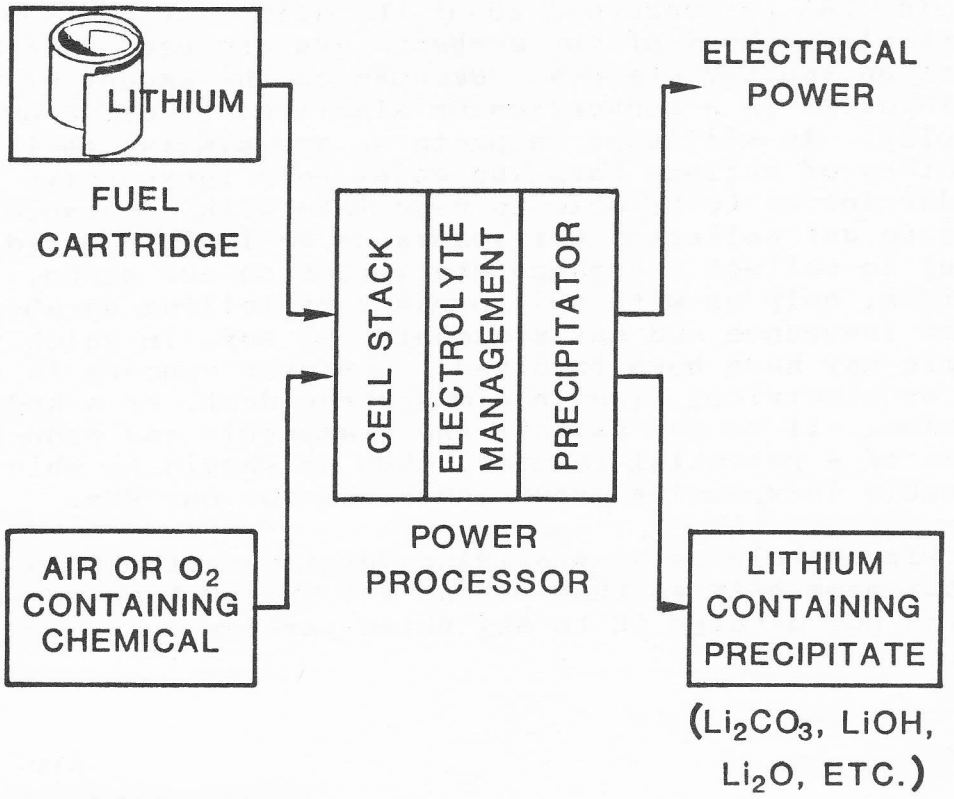
Briefcase:	16" X 20" X 6" wt. 18 lbs. (8 Kg.).
Fuel Cartridge:	1 day wt. 7 lbs. (3 Kg.). 1 week wt. 18 lbs. (8 Kg.).
Power Output:	50 watts idle, 500 watts peak. 12v DC nominal. Optional 110v AC or other power conditioner.
System Capacity:	with day cartridge 4,000 WHr. with week cartridge 20,000 WHr.
Cost Proforma:	Briefcase power pack and cartridge: $800.00 (retail). Recharging costs: Day pack: $20.00. Week pack: $40.00. System operating cost: $1.00 to $2.00 per hour.



DEMI

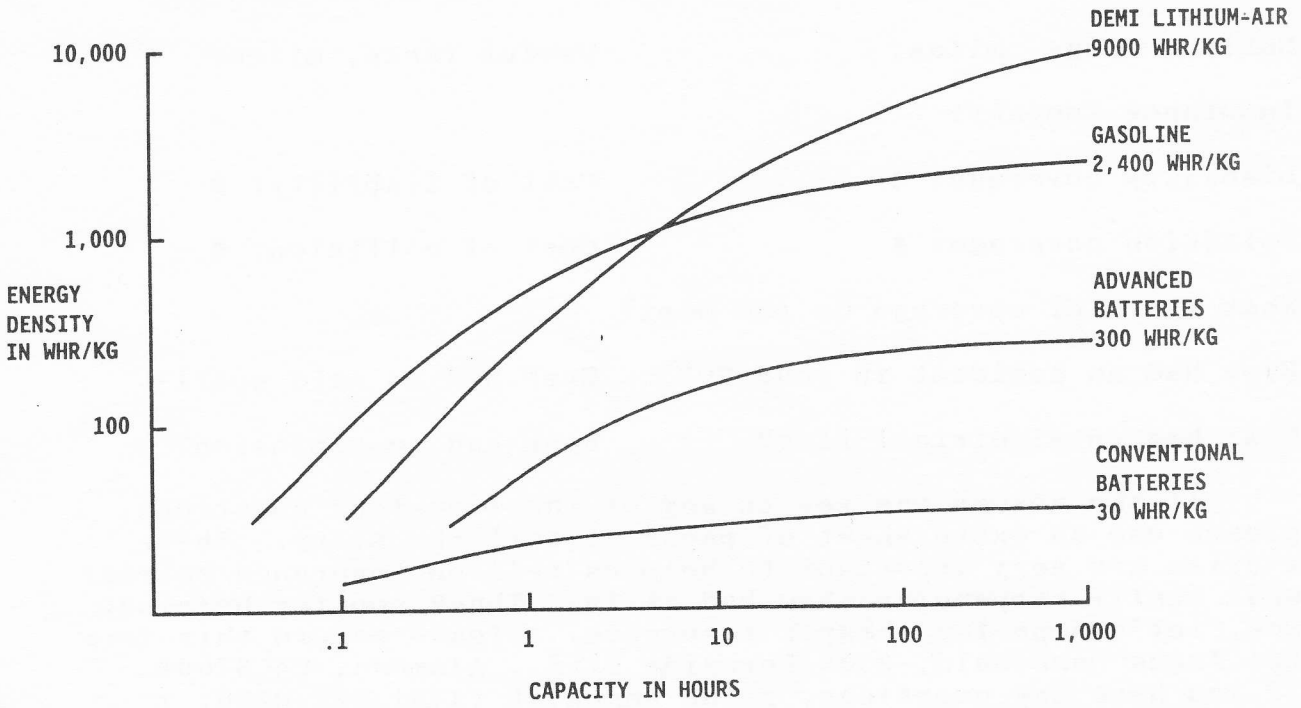
Dreisbach Electromotive, Inc.
212 Anacapa St. Santa Barbara, CA 93101
(805) 965-0829

THE DEMI LITHIUM-AIR POWER SYSTEM



SOURCE: DREISBACH ELECTROMOTIVE, INC. 8/87

A POWER SYSTEM ENERGY DENSITY COMPARISON
(INCLUDES FUEL AND ENGINE OR OTHER CONVERTER)
LOG-LOG PLOT



SOURCE: DREISBACH ELECTROMOTIVE, INC. 8/87

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EV INSURANCE

The EAA is concerned about the high cost of insurance for our vehicles. Most of our members' EVs are used intermittently and driven short distances. Because of the amount of work we have invested in a conversion we also tend to drive our cars very carefully. In all these respects we are similar to the collectors of antique cars who enjoy very inexpensive insurance. In order for us to be able to negotiate with insurance carriers to try to get collector car insurance we feel it would be very helpful to collect insurance statistics on our group. Please, therefore, help us with this project by telling us about your present insurance and any accidents, if any, in which your electric may have been involved. A proper concern is an acid spill or electrical fire in a major accident, or a hydrogen explosion. If we can satisfy the reasonable and proper worries of a potential insurer, then we should be able to buy reasonably inexpensive group insurance for our EVs.

Please help us by providing details on the form below. We ask your name only so that we can get in touch to verify details and will not divulge it to any third parties.

Name:

Address: Zip:

Telephone: ( )

Make & model of car: Year:

Miles driven last year: Number of drivers:

Age & sex of each driver:

Is the car driven to work? How many miles each way?

Maximum range, miles: Useful range, miles:

Insurance Company:

Liability coverage: $ Cost of liability: $

Collision coverage: $ Cost of collision: $

What types of coverage do you want?

Ever had an accident in your EV? Ever had an acid spill?

Ever had an electrical fire? Ever had an explosion?

If the answer was yes to any of the last four questions, please use an extra sheet of paper to tell the story. These stories are very important to help us tell an insurance carrier what really happens and how bad it is. Thank you for helping. Now, let's hope for cheaper insurance. Please return this form to: Angus MacDonald, 3335 Fernside Blvd., Alameda, CA 94601. If you have any questions, phone Angus at (415) 522-0280.

WIND RESISTANCE TEST

Rolling resistance tests on Lloyd Wenzel's 1974 Honda Civic were reported on previously in this newsletter. The East Bay/Contra Costa Chapter of the EAA continued testing this vehicle by measuring its wind resistance with different size wheels.

As in the earlier tests, three combinations of tires and wheels were used:

1) The original 12" wheels front and back;
2) 12" wheels in front and 15" wheels in back:
3) 14" wheels in front and 15" wheels in back.

Combination (3) had the lowest rolling resistance. Combination (2) was about 2% worse, and combination (1) was about 12% worse than combination (3). The same high quality steel belted radial tires were used in the wind resistance tests as were used previously in the rolling resistance tests.

In order to measure the effect of wind resistance, the car was driven at a constant 45 MPH and the propulsion battery voltage and current were recorded. This was done for each of the three combinations of tires and wheels. Each test was repeated in opposite directions over the test route in order to compensate for a slight grade and mild wind conditions. With 12" tires in front, the speedometer read the true speed. With 14" tires in front, the speedometer reading had to be corrected. The correction factor is the ratio of the diameters of the 12" and 14" tires, or (21.5 inches)/(24.5 inches) = .87755. Therefore, in the third test, the speedometer indicated .87755 x 45 MPH = 39.5 MPH.

The following table contains the test data:

TIRE SIZE, FRONT:	REAR:	DIRECTION DRIVEN:	BATTERY VOLTAGE, VOLTS:	BATTERY CURRENT, AMPS:	BATTERY POWER, KILOWATTS:	RANK:
12"	12"	North	98-100	120-130	11.76-13.00	Worst
12"	15"	North	"- "	100-110	9.80-10.00	Best
14"	15"	North	"- "	110-120	10.78-12.00	
12"	12"	South	"- "	90-100	8.82-10.00	Worst
12"	15"	South	"- "	50-60	4.90- 6.00	Best
14"	15"	South	"- "	80-90	7.84- 9.00	

The results were consistent for both directions. The small tires in front with large tires in back (combination (2)) was the best. Combination (3), large tires front and back, was the next best. Combination (2), small tires front and rear, was the worst.

Cont't Pg. 8

A possible explanation of these results could be that the wind resistance of the vehicle is reduced by tilting it up in the rear. The car is level using combination (1), which produces the worst result. Improvement is made with combination (3), in which the rear of the car is slightly higher than the front. With combination (2), the rear is much higher than the front, and this gives the best result. Perhaps this tilt directs less wind flow to the bottom of the car, where the uneven surface creates turbulence, and more flow to the top of the car, which is smooth, thus reducing drag.

CONCLUSION:

It appears that the best choice is the original 12" wheels in front and large wheels in back. This gives the lowest wind resistance and is within 2% of the lowest rolling resistance obtained with large wheels front and back. Since the Honda has front wheel drive, small wheels in front also improves the drive train gear ratio.

The next best choice is large wheels front and back. Depending on the type of motor used, this combination may be necessary in order for the vehicle to be able to reach an adequate top speed. The test vehicle presently uses a Baldor 7544D series motor, which has a maximum speed of 3200 rpm. With 12" front wheels, top speed is limited to about 50 MPH. The use of a Prestolite MTC-4001 motor, which can run above 5000 rpm, would allow the use of 12" front wheels without imposing this limit on the vehicle's top speed.

In either case, the use of larger wheels in the rear is also desirable for supporting the weight of the batteries, which are located in the back seat area.

Please note that the results presented here are for the 1974 Honda Civic only and may not be valid for other vehicles.

Jon Gabel, 11/15/87

Lithium Con't

AN ELECTRICAL ENERGY COST COMPARISON

CONVENTIONAL ENERGY SOURCES	COST PER 100 WATT HOURS
WALL PLUG POWER (@ .10 PER KWHR)	$.01
GASOLINE VIA A PORTABLE GENERATOR (4,000 WHR/GAL AND $1.00 PER GAL)	$.025

CONVENTIONAL BATTERIES	
ALKALINE "D" CELL	$14.15
ADVANCED LITHIUM "D" CELLS (PANASONIC BR-CT2P)	$120.66

DEMI LITHIUM-AIR	
NEW LITHIUM COST (WITH NO RECYCLING) (BASED ON $25.00 PER LB. AND 2,500 WHR/LB.)	$1.00
LITHIUM RECYCLING ENERGY COST (AT 25% WALL PLUG EFFICIENCY)	$.04

SOURCE: DREISBACH ELECTROMOTIVE, INC. 8/87

EV Marketplace

FOR SALE

JMJ ELECTRIC HORIZON, FIVE DOOR HATCHBACK. 16 TROJAN T-105 BATTERIES, CABLEFORM SCR ELECTRONIC CONTROLLER, LESTER 12/96 VOLT AUTOMATIC CHARGER. INTERIOR/EXTERIOR NEW CONDITION! GLC! RENOVATED, CHECKED OUT, & GUARANTEED BY CLARENCE ELLERS. CALL: (408)248-2588 or write 2892 Mesquite Dr. Santa Clara, CA 95051.

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FOR SALE

Nine (9) Electric VW Rabbits, converted by SCT Corp. Sold for over $15,000 ea., and have run between 13-36,000 miles. W/O batteries-$1000 each or offer. Also have motors W/O bodies. CALL: (313) 373-2300 Rick.

* * * * * * * * * *

Seattle. CALL: Tony (206) 367-8084 eves. or (206) 784-9492 days, write M. Tony Feralio 11540 Greenwood Ave. N. #4, Seattle, WA 98133.

ELECTRIC AUTO LIQUIDATION

All items in factory new condition and are priced at 50-60% of quantity wholesale cost 1980. Quanity prices available. GE 99v. 23hp series motors, $600. 96/12V, 20-40amp transformers (110V Pri.) $110. 48/12V transformers (110V Pri.) $70. Prestolite 48V, 15hp series motors $500. Contactors, H/B 24V coils, 75-150 amp. SPST & DPST $45. Contactors, H/B 24V coils 300-600 amp SPST $65. ALL FOB MASS. METERS (600 AMP, 50+100V). Motor adaptors for Fiat 128/X1-9/Strada & Renault Le Car/GL, cable, hardware, SCR components. CALL: (707) 468-1603, Write Stevenson, 1201 Parducci Rd. Ukiah, CA 95482

* * * * * * * * * *

WANTED

JET Electra Van parts, rebuildable series motors, repairable SCR/Transister Controllers. Also 60-72V Battery Chargers & Transformers. CALL: (707) 468-1603 or write Stevenson, 1201 Parducci Rd. Ukiah, CA 95482.

RUSSCO

Coming early 1988 the new high torque Russco motor, manufactured by General Electric, Modified by Russco. Twice the torque of the famed Prestolite. Available Russco's programable field controller and the new high output H O 400 controller, instant regenative braking & dynamatic braking, of course.

RUSSCO THE INNOVATOR

FOR SALE

Modified 1976 VW Rabbit, 96V. Prestolite motor, Russco 500 Amp. Controller, Lester 12/96V Charger, ALCO T-105 Batteries, Tow bar, New brakes and tires. Top speed 70 MPH, Endurance at 25-30 MPH 100 miles. Has Won serveral efficiency & speed awards. Price $2500, will deliver in Calif. CALL: Fred Schiller (707) 585 9540.

* * * * * * * * * *

ADS must be received with payment by the 10th of the month, for the following month's issue. AD rate is min. 1 to 5 lines $5.00. 1/4 Pg. $15, Full Pg. $50.00, Full Pg. 2 sides $80.00, WANTED - TRADE - FOR SALE, etc. Mail to EAA 1249 Lane St. Belmont, CA 94002

CALENDAR

FEB. 1-5: APEC '88-IEEE Applied Power Electronics Conference and Exposition--Fairmont Hotel, New Oreans, LA (617) 870-9182.

FEB. 3-6: Int'l Symp. on Batteries & Fuel Cells. Karaikudi, India.

FEB. 10-12: "Electric Van Commercialization Benefits & Opportunities A Utility Initiative" EVDC/EPRI Nat'l Conference. Queen Mary, Long Beach, CA.

FEB. 17: Melbourne, Australia; 2PM Tour of ASEA (Robots) (03) 546-9130.

FEB. 20: Santa Clara Chap. History & Evolution of the Hybrid drive system, Clearence Ellers speaker. Also Project "X" ALL INPUT WELCOME, COME WITH YOUR IDEAS!!

FEB. 29-MAR. 4: SAE CONGRESS & EXPO DETROIT, MI.

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PHONE (415)591-6698

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Electric Auto Association NEWS

FEBRUARY 1988

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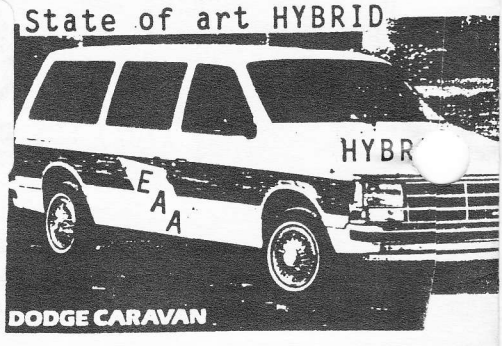
Address Correction Requested

HELP!! PROJECT-X
State of art HYBRID



PLEASE
TIME DATED MATERIAL - DO NOT HOLD