AUGUST 1985

MEETING NOTICE

THE NEXT MEETING WILL BE FRIDAY AUG. 16th, at MID AMERICA FEDERAL SAVINGS 250 E. ROOSEVELT RD. WHEATON, ILLINOIS. - TIME - 7:30 P.M.

LETTER FROM THE PRESIDENT

It appears we have proved we can raise money for our club projects if we work at it. Through the efforts of John Emde , Donald Drake, Valadimir Vana, and myself, our last hamfest outing raised approximately $125. We thank the contributers.

In order to maintain momentum and increase revenue by this means it is important that each one of us suggest to their contacts that they donate surplus items or items they wish to sell, and thereby obtain tax deductions for a contribution to a not for profit organization.

We have recieved the promise of a donation of two additional motors and thus can proceed with construction of our planned controller test stand. Anyone interested in helping with this project please contact me.

Also we are proceeding with our kit car transmission project. Gates engineering company has promised us drawings of their transmission and will furnish technical support. They recommend that the people involved in the project vist their facility in Denver, drive the car, and get an idea of the size of the project. These arrangements are now being made.

I plan to be a little long winded in this and future letters since several members who connot attend our meetings have expressed a desire to participate in our activities in abstentia.

The next approach to raising funds is to implement one or more of the suggestions made by Paul Harris.

I hope we can have a fruitful discussion regarding the above projects at our up coming meeting. See you there.

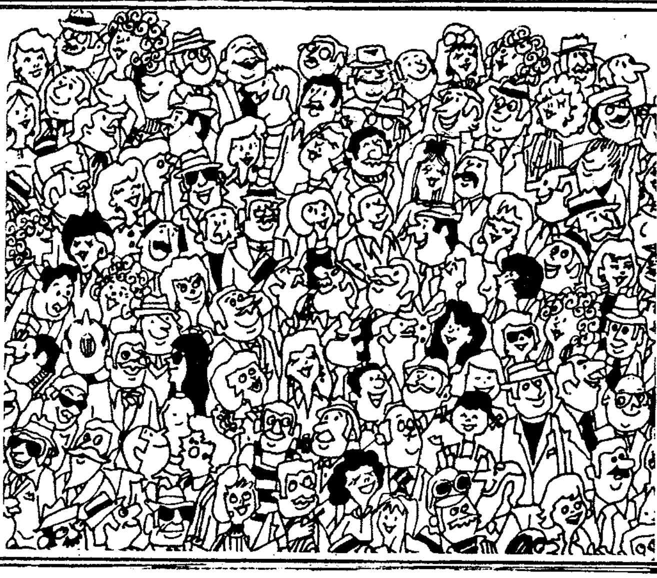
Sincerely

Dana Mock
Pres. F.E.A.A

F.V.E.A.A.

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

FIRST CLASS

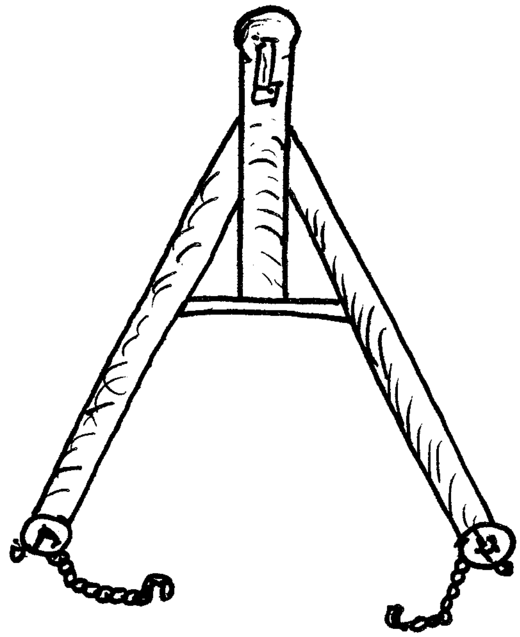


Just a portion of the crowd which turned out to see the electric cars on display last month at our meeting. The club wishes to thank those who brought their electric vehicles to the show.

Those participating were ; John Ahern - Fiat , John Emde - Subaru , George Krajnovick - Homebuilt , Dave Lambert - VW , Dana Mock - Horizon , and John Stockberger - Fiat

NEED TO TOW YOUR CAR ?

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



F.V.E.A.A.

"FOR SALE" "FOR SALE" "FOR SALE"

SOLID BRASS BATTERY CONNECTORS
solder on type fits # 00 & 000
can be used on either pos. or neg. terms.

75 ¢ each

F.V.E.A.A.

HAMFESTS 1985

The following is a list of the hamfests for the balance of the 1985 season. Have a good time.

August 24, 1985
Marshall Co. Radio Club
4-H Fairgrounds
Argos, Ind.

August 25, 1985
Il. State A.R.R.L. Convention
Kane Co. Fairgrounds
St. Charles, Ill.

Sept. 8, 1985
Sara Hamfest
Logan College Gym
Near Carterville, Ill.

Sept. 8, 1985
B.A.R.S. Hamfest
Santa Fe Park
Willow Springs, Ill.

Sept. 21 & 22, 1985
Superfest '85
Exposition Gardens
Peoria, Ill.

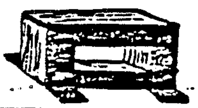
Sept. 28 & 29, 1985
Radio Expo '85
Lake County Fairgrounds
Grayslake, Ill.

October 21, 1985
Chicago Citizens R.L.
No. Shore Am. Leg. Pst. 21
6040 N. Clark, Chicago, Ill.

November 3, 1985
Late Fall Hamfest
Lake County Fairgrounds
Grayslake, Ill.

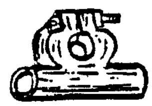
FOR SALE FOR SALE FOR SALE FOR SALE FOR SALE

STEEL LAMINATED CHOKE CORE
can be wound with 10 turns of # 00 cable. (approx. 12 ft.)



$5.00

SOLID BRASS BATTERY CONNECTORS
solder on type fits # 00 & 000
can be used on either pos. or neg. terms.



75 ¢ each

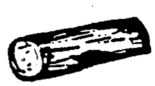
200 AMP. RELAY

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

$15.00

ONLY A FEW LEFT

BLACK HEAT SHRINK TUBING
use to finish end of battery cables.
shrinks from 3/4" to less than 1/2"
using a gas flame or heat gun.



50 ¢ per foot

400 AMP. RELAY

$45.00

LIMITED SUPPLY

12 V COIL
Single Pole Single Throw
Overall Dimensions 5¼"L., 2½"W.

- ALSO - SOME HEAVY BATT. CABLE + FREE TUBING

ITEMS AVAILABLE AT CLUB MEETINGS

"FOR SALE" PARTS

ELCAR
Chassis with fiberglass body --- 100.00
10 Trojan batteries,
less than 800 miles on them --- 200.00
Lester batt. chgr. 48v & 12v --- 100.00
Lambert transistor controller --- 400.00
6 H.P. GE series wnd. 48v Mtr. - 150.00
Don Kubick 437 - 0453
249 Arlington Heights Rd.
Elk Grove Village, Ill. 60007

PARTS FOR SALE - - - -

CAR INSURANCE: where the discounts are

Like almost everything else these days, the cost of car insurance is going up. But there are ways to save from five to 30 percent on your premium—a variety of discounts are now offered by many insurance companies.

Ask your insurance agent if you are eligible for any of the discounts below. Not all discounts are offered by every insurance company or in every state.

Driver training. Applies to families with high-school-age drivers who have passed state-approved driver-education courses.

Good student. For the families of student drivers in high school or college who maintain at least a B average.

Student away at school. Applies to families of student drivers who attend school at least 100 miles from home and do not have a car at school.

Multicar. For families who insure more than one car on the same policy, coverage for each car is less.

Passive restraints. Your car must be equipped with either seat belts that wrap around you automatically when you close the door or air bags.

Antitheft devices. Your car must be equipped with an alarm and/or a device that makes the car inoperable without the ignition key.

Females 30 to 64. A woman must be the sole driver in her household.

Senior citizen. Usually offered to drivers age 65 and older; some companies begin it at age 55.

Farmer. For full-time farmers. (They drive in rural areas with little traffic.)

Accident-free drivers. Offered to drivers who have gone a certain number of years—typically three—without an accident.

Defensive driving. Offered to adults who have completed a course to improve their driving.

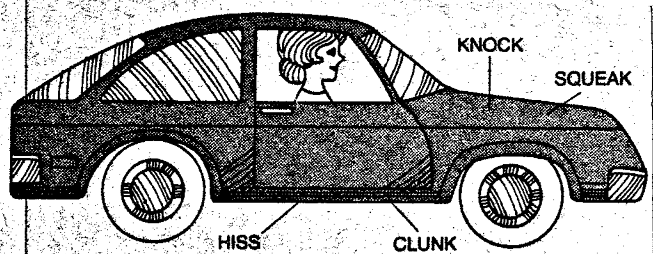
Nonsmokers. Offered by a few insurers.

Nondrinkers. Applicants must attest that they never drink alcoholic beverages.

Low mileage. Offered to those who drive less than average—often 7,500 miles a year or below (drivers who belong to car pools may also be eligible).

For answers to questions on these or other insurance matters, call the Insurance Information Institute's hot line, 1-800-221-4954. —*M.H.J.F.*

What your car is telling you



Does your car make mysterious noises while you drive? Do strange smells drift by when you idle at a stop light? Are there fresh stains on your garage floor?

Your car is giving you warning signs of impending mechanical trouble; detecting it early could mean spending less on car repairs. Here are some of the most common signals:

IF YOU HEAR

. . . knocking or pinging in your engine: the timing is probably off; have it checked. *Tip: If the problem persists, try using higher-octane gasoline.*

. . . the engine running on after the ignition is turned off: have the timing, idle, and fuel mix checked.

. . . high-pitched squeak, whine, or screech: a loose or worn belt. *Tip: If the air conditioner is on when you hear this noise, turn it off and keep it off until the belts are fixed.*

. . . hiss, over time becoming a loud roar: the exhaust system is worn or damaged; have it serviced.

. . . clunking or whining when shifting (in automatic-transmission cars): have the universal joint (part of the drive shaft) checked for wear.

IF YOU FEEL

. . . the brake pedal depress more than normal before the brakes grab: probably low brake fluid—there may be a leak in the system. Have the brakes serviced immediately. *Tip: Pump the brake pedal; this may temporarily restore braking.*

. . . pulling to one side when driving straight: probably an underinflated tire or misaligned wheel. Have both checked. *Tip: Drive a short distance across an empty parking lot, hands off the wheel. Note any marked drift.*

. . . pulling to one side when braking: most likely a damaged brake system; have it fixed right away.

. . . shaking in the car seat or steering wheel at high speeds: possibly imbalanced wheels or a damaged tire; have these serviced. Have the front-end alignment checked too.

. . . bouncing or rocking when braking or cornering: the shock absorbers probably need to be replaced.

. . . too much play in the steering wheel: have the steering mechanism checked for damage or wear.

. . . delayed shifting or gear slipping in automatic transmission cars: probably a leak in the transmission system; have the fluid level checked and the system's vacuum hoses inspected for leaks. *Tip: Look for reddish drips on the ground where you usually park. (Transmission fluid is red.)*

. . . jerking or shaking when idling: a variety of causes; it's probably time for a tune-up.

IF YOU SMELL

. . . smoky, oily scent: engine may be dangerously low on oil. ***Do not drive—you may ruin your engine.*** Pull over and wait for assistance. *Tip: Check for oil leaks on your garage floor; oil is dark brown or black.*

. . . burning rubber: could be overheating belts, damaged hoses, or a short in the electrical system. Turn off the air conditioner if it's in use and head for the nearest service station.

. . . acrid smoke: overheating brake pads or linings. Pull over and allow brakes to cool before continuing. Have the brakes checked for wear. *Tip: Make sure the emergency brake is off.*

. . . sweet scent: probably a leak in the antifreeze or coolant system (including the radiator). Have leaks repaired as soon as possible. *Tip: Check for greenish-yellow liquid (the color of antifreeze) on the ground under your ca*

For a helpful booklet on car care, send a self-addressed, stamped envelope and 25 cents to Car Care Council, Dept. GH, 600 Renaissance Center, Detroit, Mich. 48243. —*H.M.*

ELECTRIC TRACTOR, DESIGN & PERFORMANCE

Department of Agricultural Engineering
South Dakota State University Brookings, S.D. 57007

Brian Vik, Grad. Research Asst.
Ralph Alcock, Asst. Professor
Leslie Christianson, Assoc. Professor

SUMMARY :

A battery powered tractor developed at Agricultural Engineering Dept. of South Dakota State University is described, and its advantages and limitations discussed. Some preliminary test data is provided indicating the energy consumption for various tests, and the effects of ambient temperature on battery capacity used.

INTRODUCTION:

Prior research has indicated that electric vehicles for farm use may be both technically and economically feasible (Christianson, et. al., 1981). This research also indicates that an electric farm vehicle could perform nearly all the livestock and utility tasks now performed by petroleum powered tractors.

The electric vehicle has several advantages over the conventional diesel tractor. One of the most attractive is the flexibility offered in terms of the use of a range of primary energy sources. Electricity may be generated from many different sources, while the internal combustion engine is dependent upon the supply of a liquid fossil fuel. It is also likely that the price and availability of electricity in the future will be much better than for fossil fuels. An added benefit can be gained if the electric vehicle is recharged during off-peak times. This would enable the consumer to purchase the energy at lower, off-peak rates, and provide the electricity generation system some load management potential. Other advantages of an electric tractor would include: quiet operation, no exhaust fumes, easy starting, mechanical simplicity and durability, and the ability to handle short duration overloads which would stall a comparably sized internal combustion engine.

The major limitation of the battery-powered tractor is the low energy density (energy per unit mass) of the battery pack. Despite the better energy conversion efficiencies of the electric vehicle, a very large battery mass would be required to provide the operating time and range of a conventional vehicle. Owing to this limitation, the electric tractor can only be considered as a "task specific" vehicle, i.e. designed for chore-type tasks around the farmstead. Table 1 compares the battery mass requirements necessary to give an energy capacity similar to conventional petroleum fuels.

The objectives of this project were to build, demonstrate and evaluate a battery-powered tractor suitable for chore routines on farms. This paper outlines the design criteria developed for this vehicle, together with preliminary test procedures and results.

DESIGN CRITERIA:

In the interest of time, a decision was made to modify an existing vehicle rather than attempt to build an entirely new prototype. Initially, several alternative vehicle designs were proposed, and from comparisons with vehicles on the market the Versatile[1] 160 tractor was selected as the basis for the electric tractor. This is a four-wheel drive, articulated frame vehicle with a reversible seat which facilitates its use as either a loader/utility or field tractor. The 160 is powered by a 62 kw diesel engine with a hydrostatic transmission.

[1]The use of trade names in this paper is not meant as endorsement of that company by the Agricultural Engineering Department or by South Dakota State University.

The powertrain conversion basically consisted of replacing the diesel engine, fuel tanks and hydrostatic transmission with a battery block, two SCR (Silicon Controlled Rectifier) controllers, a traction motor and a PTO/hydraulics motor. Both motors were sized to provide torque and speed characteristics compatable with the existing gear train. This approach allowed the use of as many of the existing vehicle components as possible.

Batteries:

The battery pack was sized to provide energy for approximately four to six hours of light-duty work on a single charge. The pack consists of two 32 cell blocks, with a nominal operating voltage of 128 volts. They provide a total battery capacity of 340 Ampere-hours at the 6 hour discharge rate, or 43.5 kilowatt-hours. Each battery block is 0.89 m in length, 0.5 m in width and 0.59 m in depth. The total battery mass is 1850 kg, giving an effective energy density of approximately 24 wh/kg. This energy density is low when compared with advanced lead-acid batteries, some of which have energy densities as high as 38 wh/kg (Vincent, 1984). These energy densities are much lower than those available with petroleum-powered vehicles, as is evident in Table 1.

The battery condition is checked by electrolyte specific gravity readings. The specific gravity in two pilot cells, one in each battery block, is checked on a daily basis, and the specific gravity of the electrolyte in all of the cells is measured once per month. The battery is recharged when the specific gravity readings indicate that battery capacity has been reduced to approximately 20 percent of its nominal rating. Recharging takes up to ten hours, depending on the final discharge state of the battery prior to recharging.

Traction Motor and Transmission:

The output power characteristics of both the Versatile 160 and the SDSU Electric Choremaster are designed to match the ideal power source characteristics shown in Figure 1. This curve shows the inverse relationship between vehicle speed and tractive effort required to provide a constant 40 kw drawbar power. The hydrostatic transmission (figure 2) provides a very good approximation of the ideal curve up to about 60 kN tractive effort. The electric drive (figure 3) does not approximate the ideal curve as well as the hydrostatic, but it can provide a great deal more slow-speed torque. This large torque "back-up" could be a great advantage for a utility tractor.

The traction motor is a General Electric series-wound DC motor, with a one-hour rating of 36 kw. Because the electric motor is rated according to its ability to dissipate heat, it can provide substantially more power for short periods of time, as shown in figure 4. This electric motor has a five-minute rating of 71 kw, and a one-minute rating of 102 kw. The traction motor characteristic curves are shown in figure 5 by way of comparison with the hydrostatic output curves shown in figure 6.

Power-Take-Off and Hydraulic Systems:

The power-take-off and hydraulic pump are driven by the same motor. This is a GE series wound motor, with a one-hour rating of 17.5 kw and was chosen for the low-speed torque and power it can provide for starting heavy pto loads. The hydraulics system is unchanged from that provided on the Versatile 160 tractor.

Controllers:

Two Cableform SCR controllers were used to vary speed of the electric motors. This is achieved by varying the mean voltage at the motor which is determined by a combination of frequency and pulse width modulation. The pto/hydraulics motor controller is separate from the traction motor controller, allowing the operator to independently vary pto and vehicle speed.

The controller for the traction motor has the additional features of a reversing switch and a bypass contactor. The reversing switch allows infinite speed control in either direction and provides for dynamic braking of the vehicle. The bypass contactor is used for short periods of maximum power. After the SCR controller has reached 100% of its capacity, the bypass contactor is closed and the motor is connected directly across the battery for maximum voltage.

TESTING:

The test objectives were to:

1) Verify that all components were functioning correctly by operating the tractor through several chore-type routines,

2) Compare the energy-use characteristics of the electric choremaster to those of a comparably-sized conventional diesel tractor,

3) Evaluate the effects of battery temperature and state of battery charge on overall vehicle performance.

Initial Testing:

During the course of the vehicle testing, four design deficiencies were noted.

The first problem was caused by using the series-wound motor to power the hydraulics package. When the hydraulics system was used, the power demand on the motor caused its speed to decrease rapidly. This resulted in a loss of hydraulic power and a potential for loss of steering power. This problem has been countered by installing a feedback system allowing a set motor speed to be maintained.

The second problem resulted from driving the power-take-off and hydraulics systems from the same motor. Operator control is needed for the

pto, but, the hydraulics system requires power availability on demand. Modifications to this arrangement are currently being planned. Two options considered are the use of an accumulator for the steering system, or the installation of a third, compound wound motor to provide power for the hydraulic pump.

The third problem was the coasting effect encountered when traveling with the control lever left in the neutral position. In order to stop the tractor, the operator must either reverse the traction motor, to provide dynamic braking, or use the transmission brake. Operating experience has shown that this is a very undesireable feature, especially for chore-type work.

The fourth problem noted was the high center-of-gravity of the vehicle which resulted from the placement of the battery mass. For future developments it is proposed that the battery mass be placed as near to the ground as possible.

Powertrain Comparison Testing:

To evaluate the performance of the Electric Choremaster powertrain, comparison tests were run with the Versatile 160. The output characteristics of the two vehicles are very similar, as described in a previous section. Performance was measured in terms of energy use and energy cost. Energy use was measured with a DC kilowatt-hour meter on the Choremaster. A graduated cylinder measured the fuel consumption of the 160 and the energy content of the fuel was determined using a "bomb" calorimeter.

Three chore-type duty cycles were established for the comparison tests. The routines were simplified as much as possible, to ensure a high degree of repeatability for both tractors. All tasks were replicated at least five times for each tractor.

The first task was a loader-use routine. A steel plate weighing 7.8 kN was placed in the loader. The weight was raised to a height of three meters and then lowered. This weight was lifted and lowered ten times per routine. Several throttle settings were experimented with for the Versatile 160 engine. The results for two throttle settings (the first tried and the most efficient) are reported.

The second chore routine was a stop-start driving cycle. The 7.8 kN weight was left in the loader, and loader height was fixed. The tractors were driven through an 800 meter course with 4 stop/start points, two obstacles to steer between and a short segment of grade with a 10% slope. The terrain and manuvering required dictated the use of second gear for both tractors.

The third test routine was a light hauling task. A grain wagon, loaded with 2540 kg. of corn was pulled around a 1200 meter roadway. Various road surfaces, slopes and turns were included in the course. The tests were repeated in second and third gear for both tractors, to investigate the effects of powertrain load level.

Cost comparisons are based on $0.37 per liter ($1.20 per gallon) diesel fuel, $0.06 per Kilowatt-hour electricity rate, and $0.04 per Kilowatt-hour off-peak electricity rate. The energy use figures for the choremaster include a 70% efficiency for the battery and charger combination.

The mean energy use and mean energy cost of both tractors for all duty cycles are compared in tables 2 and 3. A Student's T-test was used to statistically compare the tractors. For all duty cycles, the Electric Choremaster used significantly less energy, and showed significantly lower on-farm energy costs.

The level of powertrain loading affected the fuel efficiency of the diesel tractor, but was negligible for the electric vehicle. The implication is that the electric tractor has a relatively high fuel efficiency over a wider operating range, as compared to the equivalently sized diesel unit.

Preliminary Battery Tests:

A fourth duty cycle was established to evaluate the effects of battery temperature and battery charge. The tractor was driven around 5 km of paved roadway once a day through two charge cycles. In each of these cycles, the vehicle was maintained at the full speed setting of the controller. For the first cycle, the tractor was parked in a building maintained at a temperature of about 20 degrees C. In the second cycle, the tractor was left outside overnight. The initial battery electrolyte temperatures for this cycle ranged from -3 to 10 degrees C.

Analysis-of-variance techniques were used to evaluate the effects of:

1) initial battery electrolyte temperature and charge level on the time taken to complete the duty-cycle,

2) initial battery temperature and initial charge level on percentage of battery capacity used, and

3) vehicle temperature on energy required from the battery to drive the tractor through the duty cycle.

The results of the analysis-of-variance shows that:

1) initial battery temperature had a highly significant effect, and that initial battery charge level has no significant effect, on the time required to drive through the duty cycle.

2) neither initial battery temperature nor initial charge level had a significant effect on the percent of battery capacity used, but the interaction between battery temperature and initial charge level did show a significant effect.

3) the ambient vehicle temperature has a highly significant effect on the energy required from the battery.

One conclusion that can be made from these results is that, for cold weather operation, improved vehicle performance can be expected by protecting the vehicle from the cold. This improvement is probably due to a higher battery discharge efficiency and to lower drivetrain losses at the warmer temperatures. More detailed tests are underway to evaluate the effects of these and several other parameters on vehicle performance.

CONCLUSIONS:

A battery powered tractor suitable for chore routines has been constructed and is currently under evaluation.

Preliminary testing of the vehicle has indicated the following:

1) Four design problems were noted and modifications are currently planned,

2) The electric choremaster used significantly less energy for chore tasks than a comparably sized diesel tractor. For the tasks which required high engine loading of the diesel powered tractor, the energy and cost savings were 57-59% and 13-16%, respectively. For low engine loading, the energy and cost savings were 68-72% and 35-42%, respectively.

3) Initial battery temperature significantly affected the time required to complete chore tasks, and its interaction with initial battery charge level significantly affected the proportion of battery capacity used.

4) Ambient temperature had a highly significant effect on the efficiency of the drive train, as measured after battery. Further tests are underway to evaluate the significance of this on the battery capacity requirements.

REFERENCES

Alcock, R. "Battery Powered Vehicles for Field Work." Transactions of the ASAE 26(1): 10-13.

Resen, H., P. Calkins and L. Christianson. "Electric Vehicles: Assessment of Potential For North Central Region Farm Operations." ASAE Paper No. 81-1547.

Vincent, C.A. "Battery research is back in business", New Scientist, March 29, 1984. pp. 34-39.

Table 1. Comparison of Fuel Energy Densities.

FUEL SOURCE	ENERGY DENSITY MJ/Kg	CONVERSION EFFICIENCY ASSUMED	EQUIVALENT TO 100ℓ PETROL.(Kg)
Petroleum	44.2	0.20	74.1
Diesel	43.0	0.26	58.5
Lead-Acid Battery	0.086	0.504*	15,112
Advanced Lead-Acid Battery	0.135	0.504*	5656-9627

*A battery charge-discharge efficiency of 0.7, a controller efficiency of 0.9 and an electric motor efficiency of 0.8 were assumed. These are cited as typical efficiencies by the respective manufacturers, viz:- General Battery Corporation, Reading, Pennsylvania; Cableform, Stockport, Cheshire; and General Electric Company, Erie, Pennsylvania.

Table 2:

TASK	DESCRIPTION
1	Loader-use routine
1a	Versatile engine at 2000 rpm
1b	Versatile engine at 1400 rpm
2	Stop-start driving cycle
3a	Hauling task, second gear
3b	Hauling task, third gear

Table 3: Energy Use Comparisons

TASK	DIESEL	ELECTRIC	ON-FARM ENERGY SAVINGS
1a	6.42 MJ	2.05 MJ	68%
1b	4.79 MJ	2.05 MJ	57%
2	14.13 MJ	3.38 MJ	76%
3a	23.93 MJ	6.78 MJ	72%
3b	16.50 MJ	6.75 MJ	59%

Table 4: Energy Cost Comparisons

TASK	DIESEL	ELECTRICS NORMAL RATE	ELECTRICS OFF-PEAK RATE	ON-FARM COST SAVINGS
1a	5.23¢	3.41¢	2.27¢	35-57%
1b	3.90¢	3.41¢	3.76¢	13-42%
2	11.51¢	5.64¢	3.76¢	51-67%
3a	19.50¢	11.30¢	7.53¢	42-61%
3b	13.44¢	11.25¢	7.50¢	16-44%

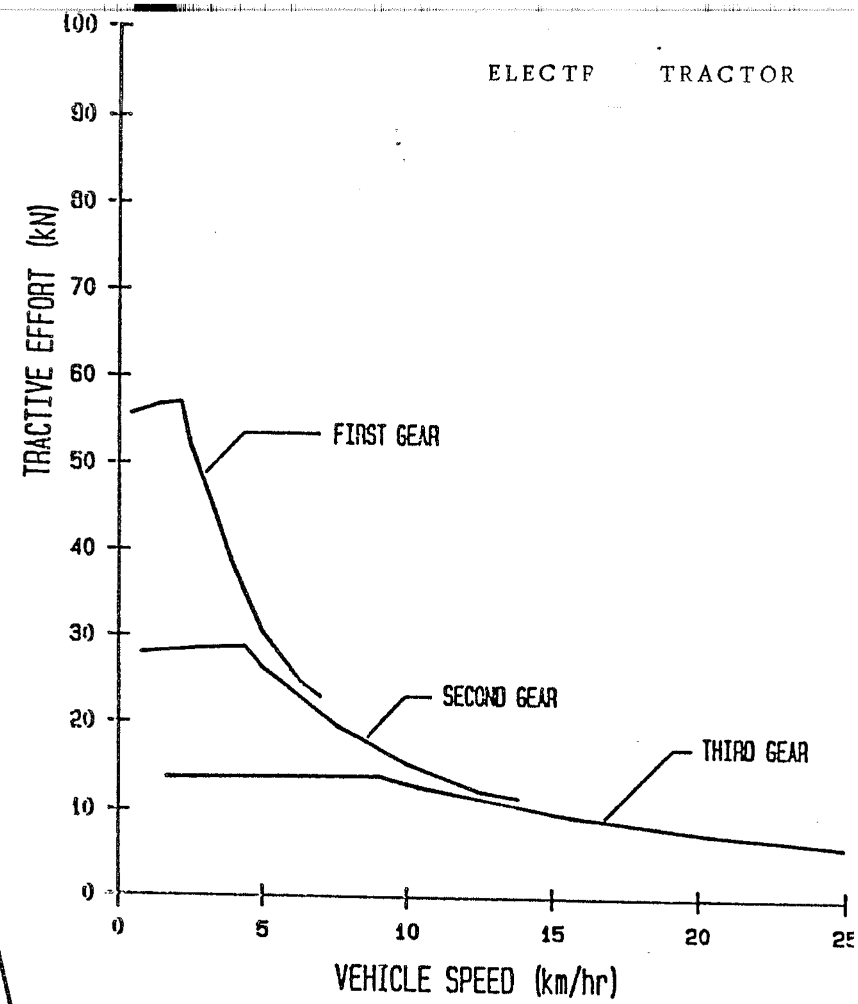


FIG 2 HYDROSTATIC OUTPUT CHARAC

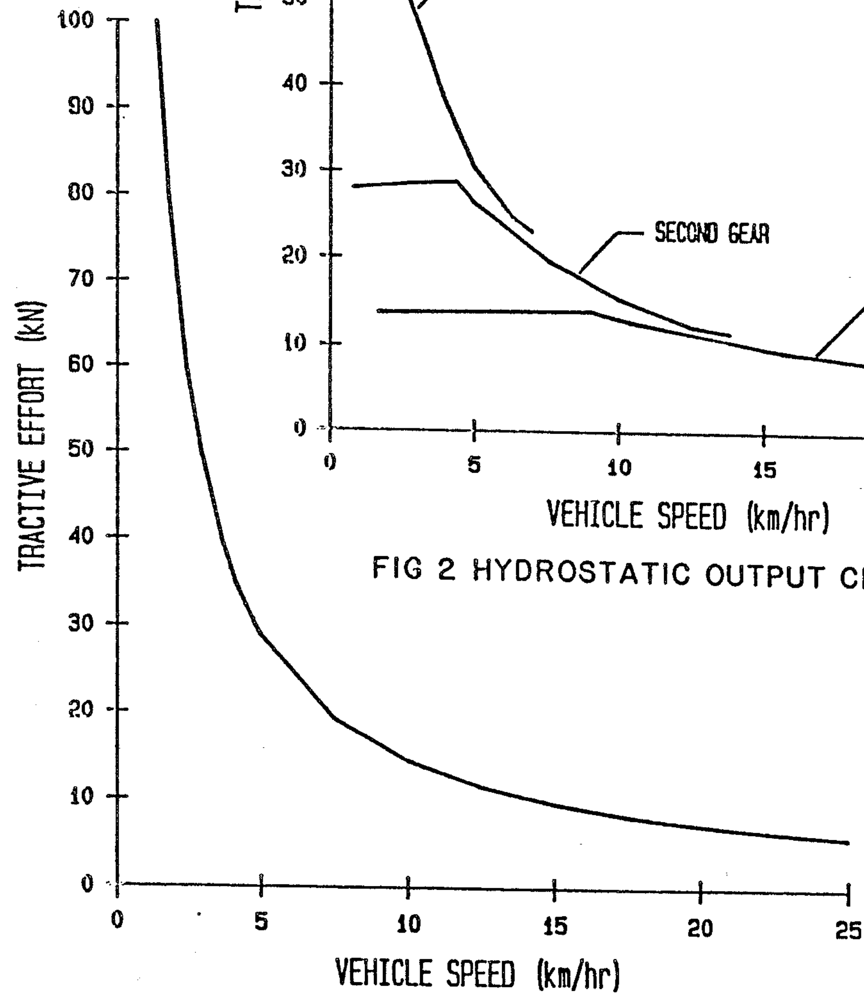


FIG I IDEAL POWER SOURCE CHARAC

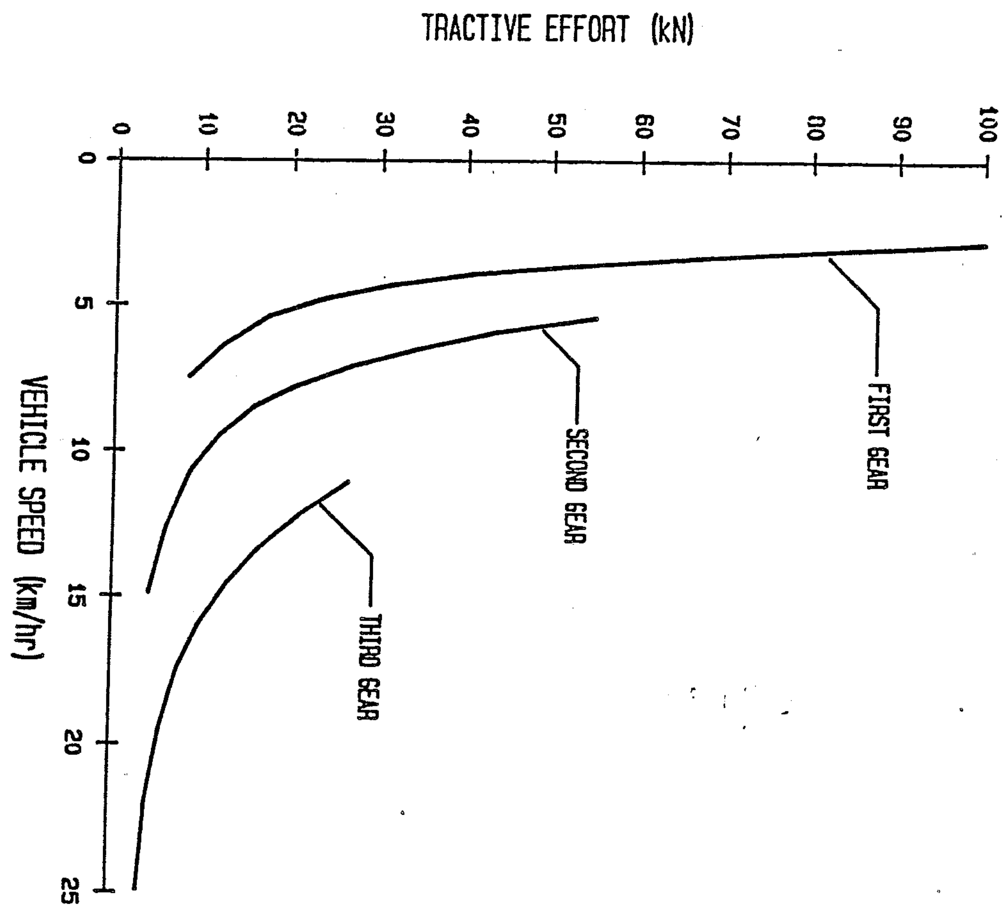


FIG 3 ELECTRIC CHOREMASTER OUTPUT CHARAC

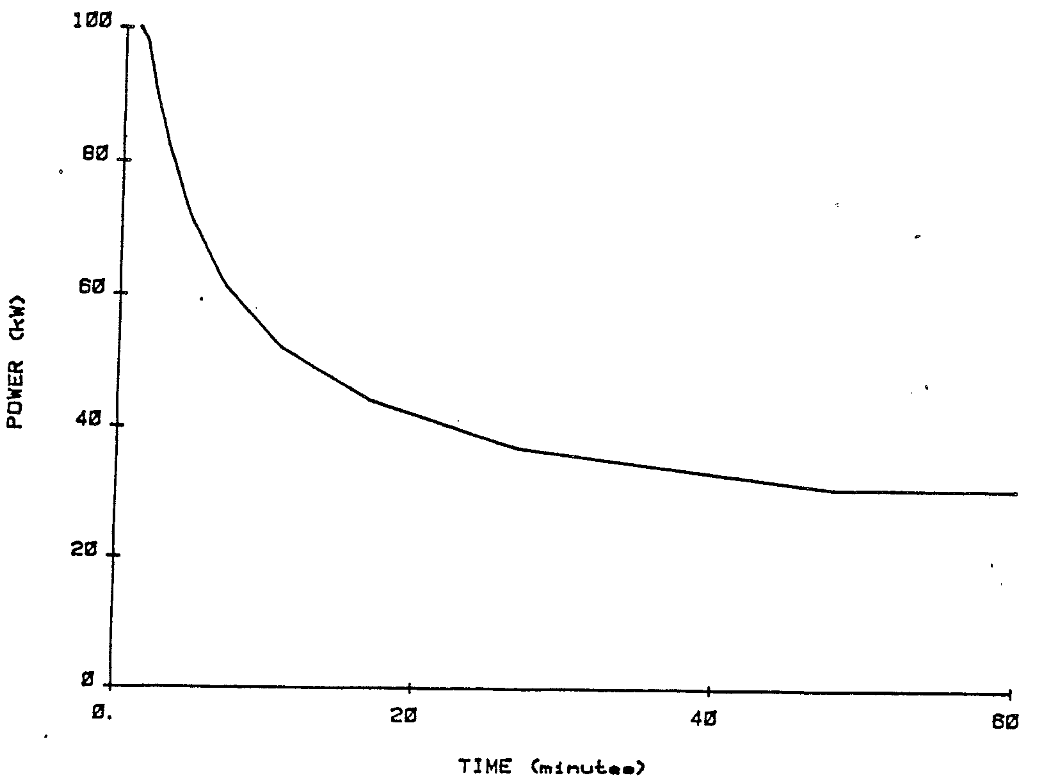
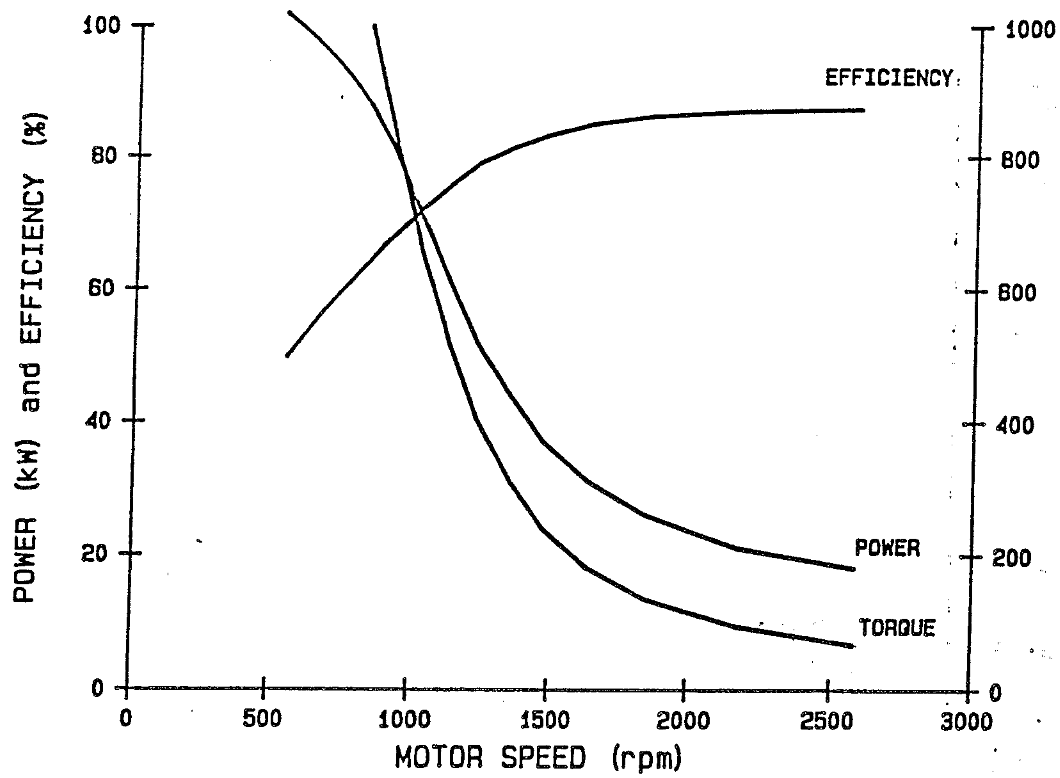


FIG 4 THERMAL RATING – TRACTION MOTOR



36 kW (rated) ELECTRIC MOTOR

FIG 5 TRACTION MOTOR CHAR

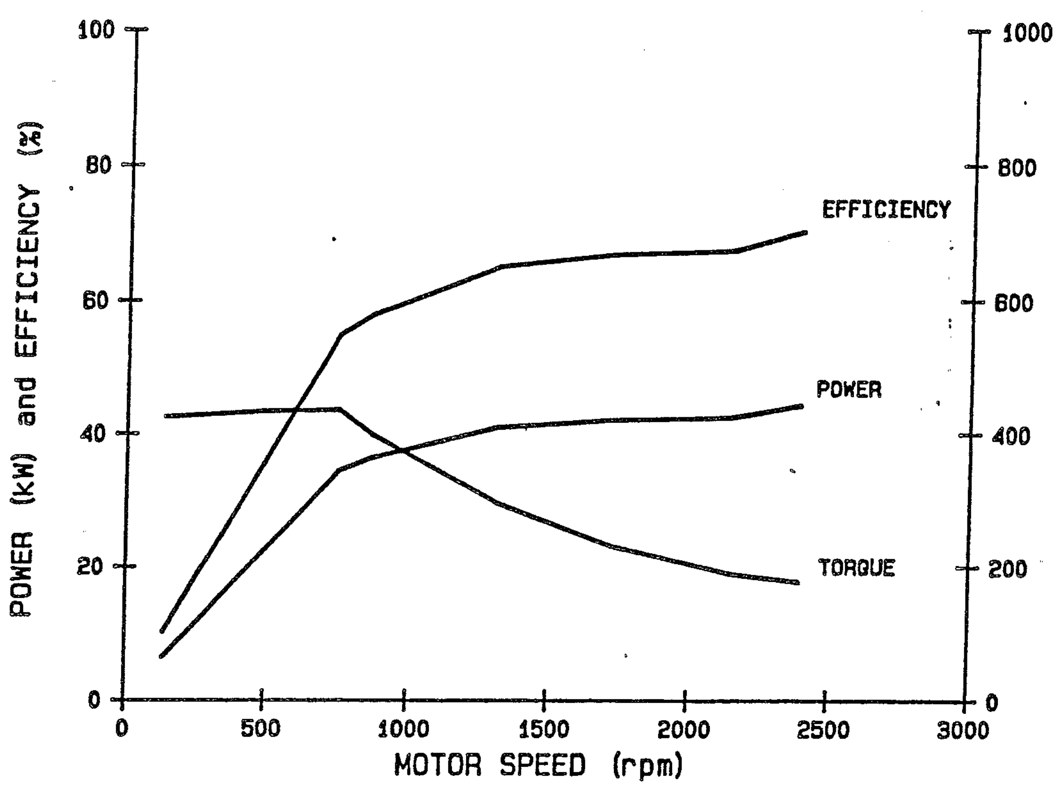


FIG 6 HYDROSTATIC TRANS CHARAC