rectifiers, Fig. 5. The charger has been designed to furnish 30 amp, yielding 1350 w of power to the batteries.

Control Circuit. The purpose of the control circuit is to provide three different traction-motor drive voltages, 12, 24, and 36 v, which in combination with the four-speed transmission will provide 12 steps in speed.

This is obtained by six power solenoids connecting the propulsion-battery sections alternately in parallel, series-parallel, and all in series. First, two banks in parallel provide 12 v. Then an additional bank is connected in series with the first two still in parallel. Finally, all banks are in series, providing 36 v for the motor amature.

The power solenoids are activated by microswitches operated by a cam plate, Fig. 6, connected to the accelerator linkage. Diode OR gates insure that the correct solenoids are energized in proper sequence without shorting out the individual battery banks, Fig. 7.

The field-excitation voltage is constant at all times. The excitation current can, however, be reversed, which in turn will change the direction of motor rotation, shifting the vehicle electrically into reverse drive.

During the regenerative-braking mode the motor acts as an electric generator with full field excitation, charging the propulsion batteries connected either in the 12- or 24-v mode depending upon the degree of braking action and the speed of the car. Braking takes place automatically whenever the foot is lifted from the accelerator pedal. Below a minimum threshold speed regeneration will cease and the vehicle is brought to a complete stop using the regular hydraulic brakes of the car.

Another function of the control circuit is the series switching of the propulsion batteries when the charger circuit is energized. At the same time the field excitation battery is also connected to the 45-v bus voltage of the charger. Battery switching takes place automatically as soon as 110 v, 60 Hz is applied to the on-board battery charger.

Charging-Power Sources. Although the electric Corvair is at present usually recharged from 110-v 60-Hz power, provisions have been made to accommodate alternate power sources such as solar energy.

Concurrent with the development of our test-bed vehicle, research and development is carried out in our Solar Energy Laboratory at the University of Florida.

Fig. 4 Charge voltage versus cell temperature.

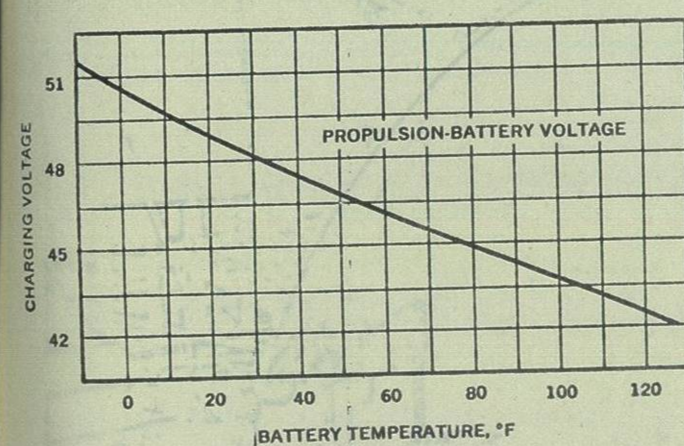


Fig. 6 Cam plate.

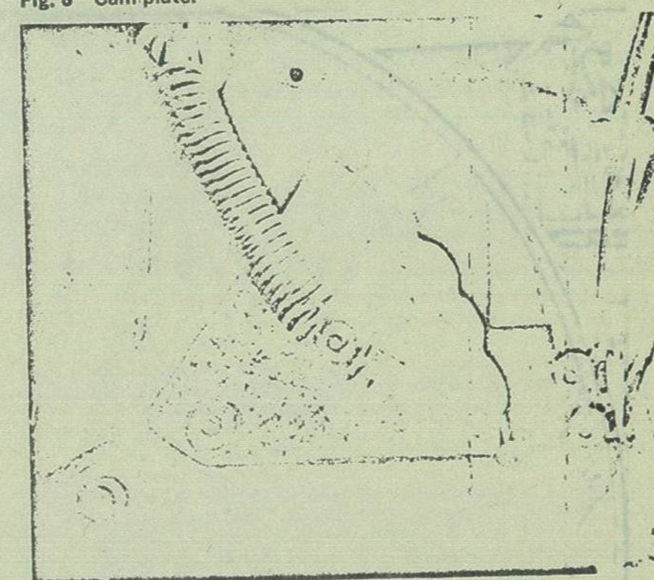
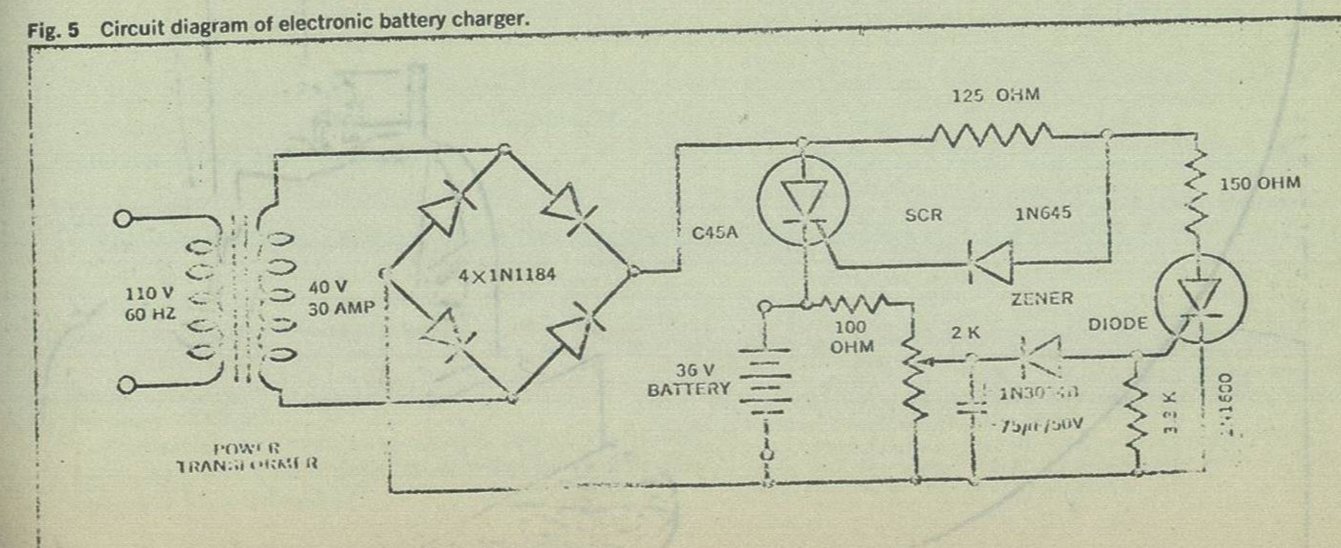


Fig. 5 Circuit diagram of electronic battery charger.



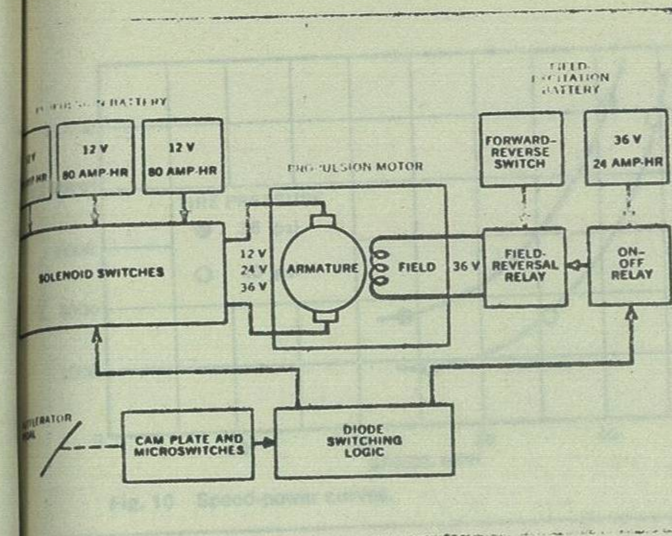


Fig. 7 Diagram of control circuit.

Emphasis has been placed on the Stirling-cycle solar engines coupled to d-c generators to recharge the Corvair. Fig. 8 shows a $\frac{1}{3}$-hp hot-air engine with a 5-ft solar collector and a d-c generator. Fig. 9 presents

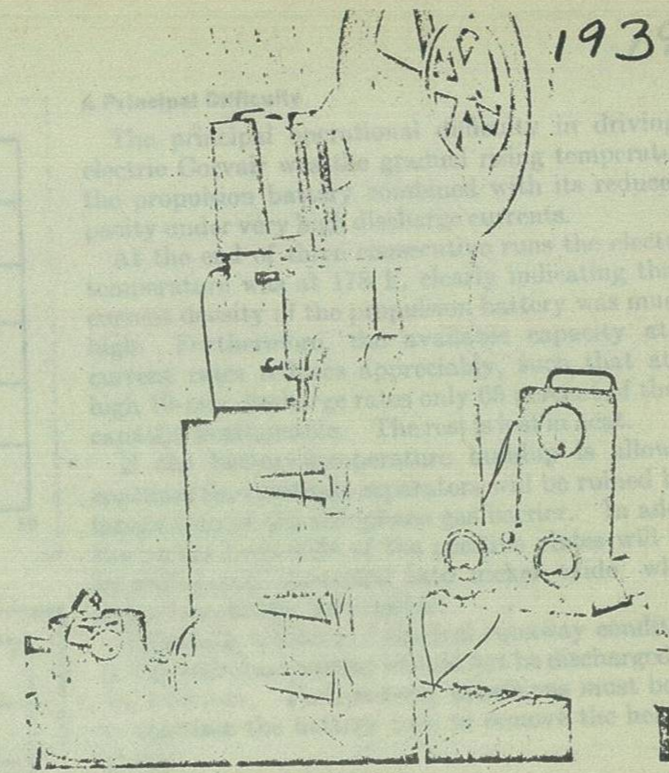
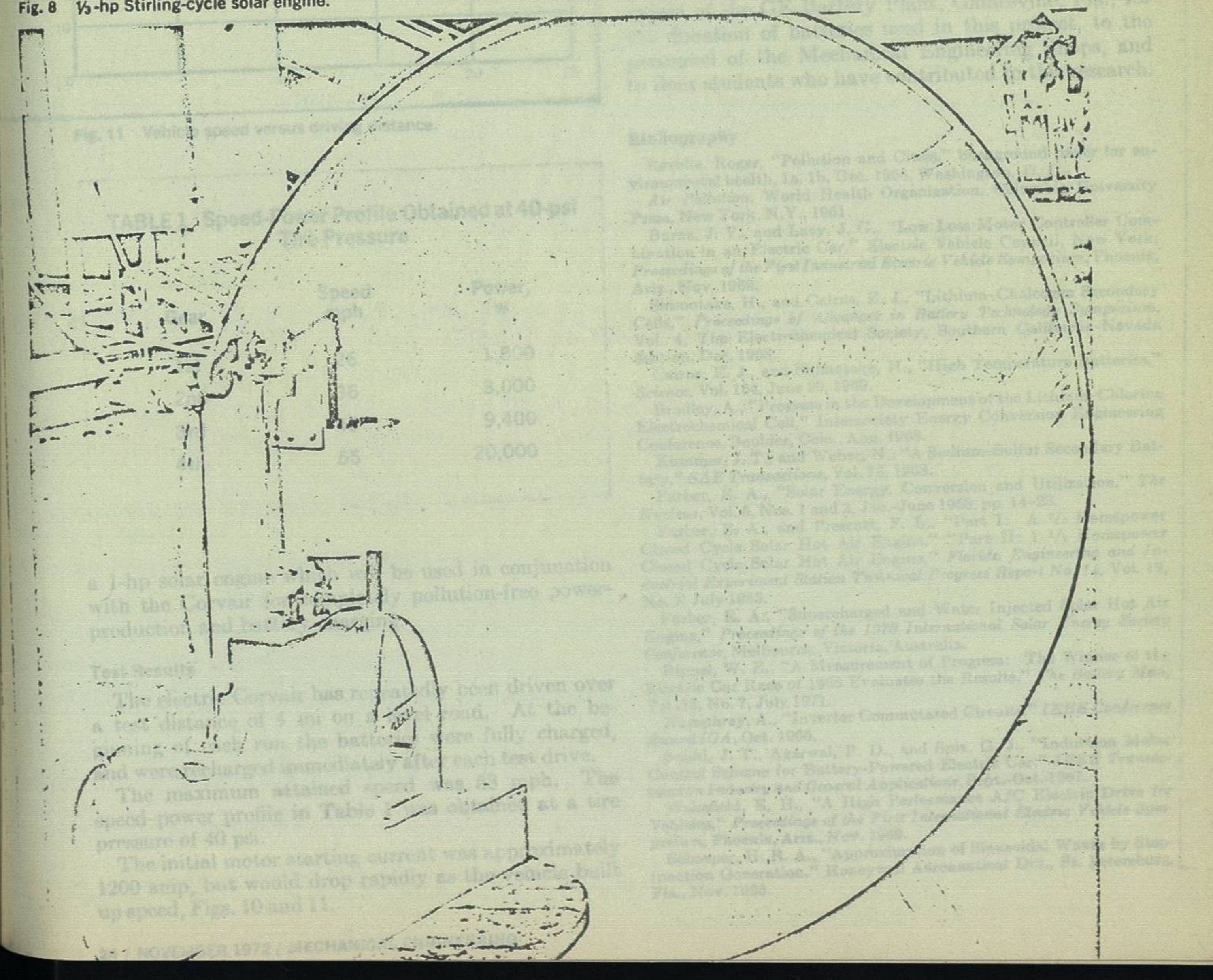


Fig. 9 1-hp solar engine on test stand.

Fig. 8 $\frac{1}{3}$-hp Stirling-cycle solar engine.



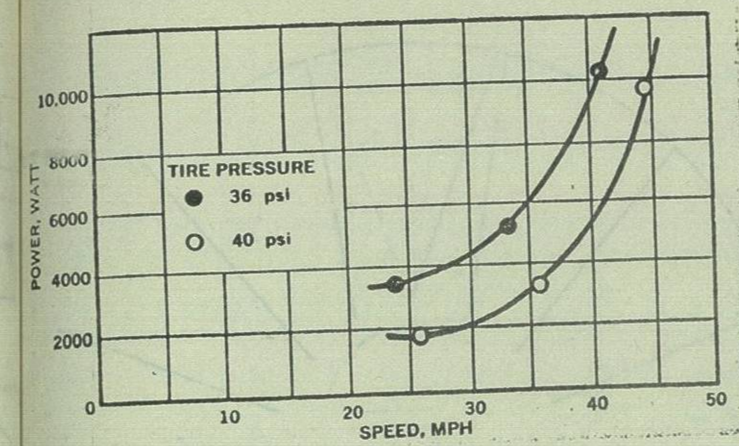


Fig. 10 Speed-power curves.

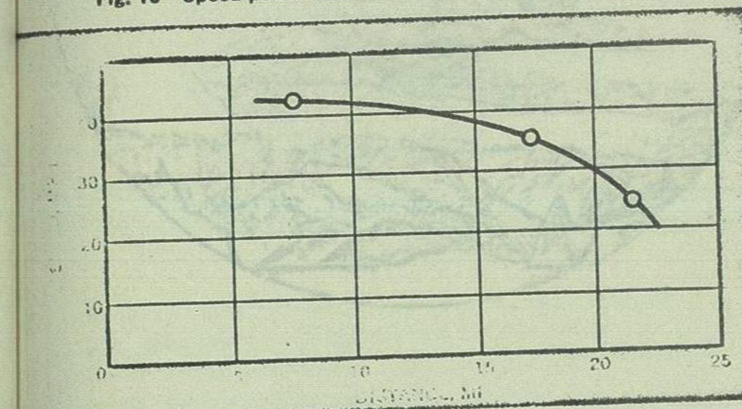


Fig. 11 Vehicle speed versus driving distance.

TABLE 1 Speed-Power Profile Obtained at 40-psi Tire Pressure

Gear	Speed mph	Power, w
1st	26	1,800
2nd	36	3,000
3rd	45	9,400
4th	55	20,000

a 1-hp solar engine which will be used in conjunction with the Corvair for completely pollution-free power-production and battery-charging.

Test Results

The electric Corvair has repeatedly been driven over a test distance of 4 mi on a level road. At the beginning of each run the batteries were fully charged, and were recharged immediately after each test drive.

The maximum attained speed was 58 mph. The speed–power profile in Table 1 was obtained at a tire pressure of 40 psi.

The initial motor starting current was approximately 1200 amp, but would drop rapidly as the vehicle built up speed, Figs. 10 and 11.

A Principal Difficulty

The principal operational difficulty in driving the electric Corvair was the gradual rising temperature of the propulsion battery combined with its reduced capacity under very high discharge currents.

At the end of three consecutive runs the electrolyte temperature was at 178 F, clearly indicating that the current density of the propulsion battery was much too high. Furthermore, the available capacity at high current rates reduces appreciably, such that at very high 10-min discharge rates only 65 percent of the total capacity is attainable. The rest is lost in heat.

If the battery-temperature buildup is allowed to continue the electrode separators will be ruined by disintegration of the cellophane gas barrier. In addition, the nickel hydroxide of the positive plates will be dehydrated and converted into nickel oxide, which is electrochemically irreversible.

Therefore, because of thermal runaway conditions, a nickel–cadmium battery should not be discharged above the 1-hr rate. Furthermore, provisions must be made to ventilate the battery cells to remove the heat effectively.

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