the estimated properties of two hypothetical air-batteries. The first, the Zn-air battery, is hypothetical in the sense that it requires much further development and refinement before it can qualify for mass-production and automotive use, even though it is operative today and a prototype might be running a vehicle in 2 or 3 years. The last entry in table 3, the H_2-air battery, is yet to be designed, but this device might essentially be considered an electrolytically regenerative H_2–O_2 fuel cell, eliminating the O_2 tanks, and using pressurized air for the oxidizer. Its energy density was calculated by postulating a slight improvement of extant cell-stack design, and adding the least-weight of necessary H_2 tankage, plumbing, and pumps.

Hydrocarbon and several other fuel cells are omitted from table 3 because of their nonregenerative nature and their excessively low-energy densities, even though much of the research activity [6] in energy conversion is in this area. This type of fuel cells are quite feasible as electric power-generating units for cars, in the intermediate run, preceding the ultimate advent of light-weight low-cost batteries.

In all entries of table 3, the energy density, d, depends on the frequency and length of deep-discharge time. The time for discharge shown is assumed roughly to be the anticipated range divided by a representative mean speed. The distance a battery-operated car can travel before requiring either a recharge or refueling is here defined as the range of the vehicle. The range is determined by the maximum energy deliverable by the motor, which is

$$0.92YWd \quad \text{or} \quad 0.45Wd \text{ watt-hours} \ . \ . \ . \ . \tag{9}$$

where 0.92 is our assumption for the average motor efficiency in converting electrical energy to mechanical work.

The energy in (9) is expended in the work done by the engine to overcome tire and aero drag. This work is the sum of the drag forces—expressions (3) and (5)—times the range, R, when the car is traveling at a steady speed, v, on a level road on a windless spring day. This work (foot-pounds) equals

$$\{(0.01+5\times10^{-5}v)W+[0.0083+4.2\times10^{-6}(W+150)]v^2\} \\ \times(R, \text{ miles})\times(5{,}280 \text{ feet per mile}) \ . \ . \ . \ . \tag{10}$$

Equating energy and work; that is, expressions (9) and (10), gives the range of electric cars driven at steady speed to be

$$R, \text{ miles}=\frac{d}{0.0442+2.21\times10^{-4}v+\left(\frac{0.0395}{W}+1.86\times10^{-5}\right)v^3}$$

The range under this purely fictitious driving condition is shown in figure 8. The width of the band is representative of the dependence of R on W, the lower bound being for W equals 2,000 pounds and the upper for W equals 3,000 pounds.

[6] M. Barak, "Fuel Cells—Present Position and Outstanding Problems," Advanced Energy Conversion vol. 6, No. 1, January–March 1966.