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PROGRESS AND FUTURE EFFORTS IN SOLVING MAJOR PROBLEMS OF ELECTROCHEMICAL POWER SOURCES

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Efforts to develop batteries for electric-vehicle applications have been continued in Japan following the 1971 - 1977 national projects on electric vehicles and batteries. The conclusions reached in the latter projects were: (i) the lead/acid battery was more suitable for electric vehicles than any of the other "advanced" systems such as Na/S, Zn/air, Ni/Fe, etc.; (ii) for electric-vehicle use, the lead/acid battery requires an energy density of ~50 W h kg^{-1} at an adequate cycle life.

From research work following the national projects, the discharge performance of the Ni/Zn system was found to exhibit good prospects for electric-vehicle applications. Comparisons of driving tests between lead/acid and Ni/Zn batteries of close to the same weight are shown in Table 1. Inspection of this data clearly shows the advantages of Ni/Zn batteries in traction applications. However, a serious drawback of Ni/Zn usage is the very short cycle life of this battery. This problem has proved difficult to overcome, and an adequate solution is not expected in the near future.

Therefore, the lead/acid battery still remains the most appropriate power source for electric vehicles. However, it is the author's considered opinion that lead/acid traction batteries require substantial further improvement, especially in the areas of high-rate discharge (and charge) performance and battery cycle life. Future research efforts should consider innovative cell geometries in place of the conventional flat- or tubular- plate types. Such an approach may help to improve the hitherto poor high-rate discharge characteristics of the lead dioxide active material in the positive plates. The lead dioxide electrode has a serious limitation in that the discharge product is non-electrically conductive lead sulphate, and this limits the discharge capability which must have a high rate under electric-vehicle service conditions. If the discharge products are all electrically-conductive, the resulting battery will be most promising for electric vehicle applications. Thus, it appears that the only way to improve the present poor characteristics of the lead/acid battery is to develop new types of plate construction. In taking such an approach, two fundamental facts should not be ignored, namely, (i) the practical load of electric vehicles places great demands on conventional lead/acid batteries; (ii) the discharge product of lead dioxide, lead sulphate, is not conducive to long battery life in electric-vehicle service. In order to achieve acceptable life, assistance such as mechanical pressure and/or tension from outside, or novel cell geometries, must be given to the lead dioxide

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TABLE 1

Performance of lead/acid and nickel/zinc batteries in electric-vehicle service

Battery type	Lead/acid	Ni/Zn
Battery weight (kg)	140	142
40 km h^{-1} constant speed driving (km/charge)	38	86
Urban driving (km/charge)	33	75

TABLE 2

Specifications for battery service in load-levelling and peaking applications

Battery parameter	Load-levelling use	Peaking use
Cycle condition:		
charge (h)	7 - 8	7 - 8
discharge (h)	10	3 - 5
Expected cycle life	> 2500 (10 years)	> 1750 (10 years)

plate material. If such efforts are successful, then the lead/acid battery will be the most suitable power source for electric vehicles, both technically and economically.

The other major problem in the field of power sources is the development of efficient batteries for load-levelling use. In Japan, national projects in this area commenced in 1980, and cover the development of improved lead/acid, Na/S, Zn/Cl_2 and Zn/Br_2 battery systems. In order to satisfy power supply needs in Japan, batteries are required for both load-levelling and peaking service. The specifications of these two types of battery usage are given in Table 2. These specifications may be too severe for new batteries such as Na/S, Zn/Cl_2, Zn/Br_2, etc., despite the outstanding progress already achieved on these systems. The above load-levelling criteria also make exacting demands on the improved lead/acid battery, but the specifications for peaking use are not so difficult to meet. Present work in this area indicates that W h efficiencies >80% and cycle lives >2500 could be attained in peaking applications. However, although the improved lead/acid battery shows promise in peaking use, in the author's opinion, considerable futher efforts are required in battery improvement, especially in meeting the requirements of cheaper battery construction, more efficient means of battery recharging, and lower battery maintenance.

Another major problem in the field of power sources is to bring to commercialization new types of high-performance battery including Li(Al)/FeS, Na/S, $Zn/Cl_2(Br_2)$, Ni/Zn(Fe), etc. Although these alternative batteries offer good prospects of superior performance over existing types, there are many operational barriers to be overcome. It is the duty of scientists and technologists throughout the world to continue their research efforts on these battery systems.

The final area of power sources receiving attention is that of fuel-cell development. In both the United States and Japan, fuel-cell programs have reached the large-scale demonstration stage. Results obtained from these programs are expected to bring into realization this other power source concept.