Journal of Power Sources, *14* (1985) 247 - 250

LITHIUM BATTERIES U.S.A. — AN ASSESSMENT

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Summary

Lithium batteries have become firmly established in the United States. Their near-term growth is expected to be significant and to occur principally in the areas of high reliability, premium performance, and specialty applications. The extent to which they will penetrate the general consumer markets in competition with alkaline batteries is dependent on the extent to which their safety can be improved and their cost reduced.

Historical aspects

The development of lithium batteries in the United States began during the early 1960s, motivated by the need for high energy density, portable power sources. Their successful development demonstrated that they possess these and other desirable characteristics that render them the preferred choice for a variety of applications today.

In assessing the present status and the probable future trends, it may be useful to examine some historical patterns, Figs. 1 and 2. Beginning with the Zn/HgO batteries developed during World War II in response to military needs, their commercial acceptance developed slowly. It was not until the emergence of transistorised consumer products during the 1950s that the

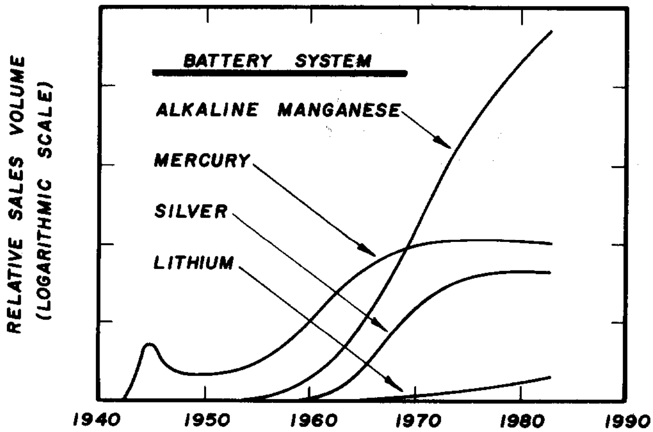

Fig. 1. The evolution of primary battery production volumes.

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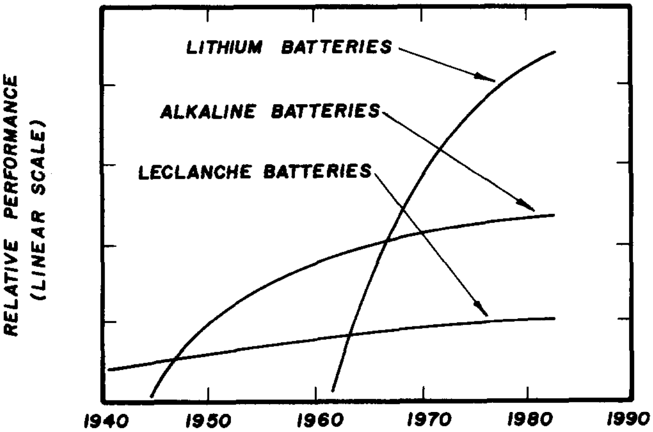

Fig. 2. Recent performance trends in the development of primary battery systems.

Zn/HgO technology entered a rapid growth phase. Its period of gestation spanned 15 - 20 years. The alkaline Zn/MnO_2 batteries, whose technology is similar to that of the Zn/HgO system, emerged during the late 1950s and experienced a rapid growth, primarily in response to the explosive growth of portable consumer electronics. The alkaline Zn/MnO_2 technology had a gestation period of 10 - 15 years. Its present rapid rate of growth reflects market expansion rather than technological developments. The alkaline Zn/Ag_2O batteries were developed in response to the perceived need for a higher operating voltage for some consumer products. Their technology is also similar to that of the Zn/HgO batteries, and their period of gestation spanned about 10 years. These patterns show that the rate of emergence of a new battery technology depends upon:

(i) The extent to which the new technology satisfies a need not met by any existing system;

(ii) the degree of novelty of the new technology;

(iii) cost and marketing considerations.

Considering the overall rate of development of the lithium battery technology, its period of gestation of about 15 - 20 years appears to be reasonable. It may be noted that the overall pattern masks some widely different growth rates. Lithium batteries gained a rapid, early acceptance in the implantable pacemaker market, and in some high rate, low temperature applications where existing systems performed poorly. In the general consumer markets, however, lithium batteries have experienced a slow rate of growth.

Present activities

Existing Technologies

The main thrust of the US battery industry in the lithium area today is directed at the exploitation of the present state of the art in an attempt to establish an expanding, viable lithium battery business. Accordingly, the principal emphasis is placed on market development, cost reduction, and the development/acquisition of the appropriate production technologies. In support of these objectives, the present R&D efforts are concentrated on the problems that need to be solved to render lithium batteries acceptable to larger segments of the consumer and specialty markets. Particular importance is attached to an enhanced safety for consumer applications and an increased reliability for specialty applications.

Although lithium batteries appear to have a non-vanishing hazard potential which is the more significant the higher the rate capability and the voltage of the cells, their residual hazard potential can be lessened by the use of proper designs, circuit controls and operating procedures. A concensus is emerging that it is possible to improve the reliability of many of the lithium systems by means of suitable designs and manufacturing controls. This holds the promise that the high reliability obtained routinely with the pacemaker lithium batteries can be extended to other classes of lithium batteries, for a variety of applications, at an acceptable cost.

New Technologies

Thin film solid state batteries are receiving some attention, motivated in part by the desire for a battery that can be fully integrated with micro circuits. The concept involves a power source and a circuit constructed on the same chip or substrate, employing either a single integrated battery or a distributed power source. The operational acceptability of such integrated devices is contingent on the low power requirements of the new circuits and on the high energy density of the emerging lithium batteries. Present efforts are concentrated on solid electrolyte studies and the functional integration of the battery components into thin film units.

Smart batteries involve the use of programmable micro circuits to control the operation of lithium batteries. This work is motivated by the recognition that such controls can improve both the safety and the performance of high power lithium batteries. Standard size cells and batteries, as well as high capacity, high rate, single cells, are coupled with circuits programmed to deliver specified high/low voltage outputs in response to external or pre-programmed commands. The miniaturisation of the circuits makes it feasible to design such power sources without detracting excessively from the intrinsic, high performance capability of the lithium batteries.

Polymer batteries have received substantial funding in the U.S. It is thought that lithium in conjunction with polymer electrodes and electrolytes may provide advantages both from the point of view of power density and manufacturability. However, the performance of practical cells to date and their recognised deficiencies suggest that some time will pass before polymer batteries can compete successfully with available batteries.

Rechargeable lithium batteries have received some attention during the last twenty years and continue to do so. Considerable progress has been made, but much remains to be done. A modest recharge capability can be achieved with the realisation of an increased energy density relative to existing, normal temperature secondary batteries under carefully controlled conditions. There is an expectation that practical improvements will be forthcoming and that rechargeable lithium batteries will find a ready, future market.

Some prospects

Lithium technology has progressed beyond its probationary phase and has entered a period of slow, sustained growth in competition with other established systems. Figure 3 may provide a perspective on that competition. It shows that the cost/performance index is practically the same for most of the battery systems of interest, assuming a high volume production. Other factors are likely, therefore, to control the market acceptance of the different battery systems. Typically, the growth of the primary battery markets has paralleled that of the consumer electronics markets. This trend is likely to continue, and the growth of the lithium battery markets may be expected to depend upon how successfully lithium batteries can compete with alkaline batteries. Equivalent energy costs notwithstanding, experience suggests that consumer markets favour lower priced products, other factors being equal. Because of the higher price per unit product for lithium batteries, their sale in the general consumer market may be expected to be sluggish, but their sale in specialty markets should be significant and continue to grow.

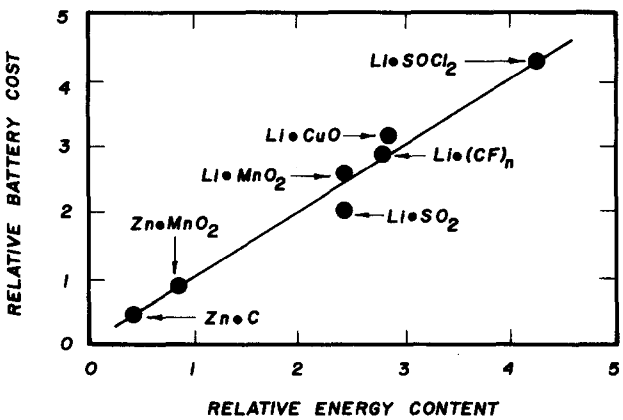

Fig. 3. Estimated 1982 energy costs of some primary battery systems based on a projected high volume production of lithium batteries.