batteries. We have addressed the challenge by employing a cell design that is not limited by the positive plate, in order to prolong its life. Reserve capacity fall-off with increasing cycle life has not been observed with initial electric-vehicle modules as compared with automotive batteries with similar construction. Thus, this approach appears feasible.

Future work will be to:

(a) Complete commissioning of the electric vehicle pilot line. Sufficient electric vehicle ISOA modules and batteries will be produced to establish production quality, unit costs and production and electrical production confidence levels.

(b) Expand the electric vehicle module and battery testing facilities to provide more testing circuits for the additional R&D and battery production programs.

(c) Continue the advanced battery R&D program with particular focus on increasing energy density and cycle life.

Recent publications

1 C. J. Venuto, Lead–acid developments, in collected program visual aids of *Second Annu. Battery and Electrochem. Technol. Conf., June 5 - 7, 1978, Arlington, Virginia,* sponsored by the U.S. Department of Energy Storage Systems, published May, 1978.

2 R. M. Meighan, Rationale for use of expanded grids in battery plates, paper presented at the *Fall Meeting of the Electrochemical Society, Pittsburgh, Pennsylvania, Oct. 15 - 20, 1978. Extended Abstracts of 154th Meeting,* No. 101, p. 269.

3 C. W. Fleischmann, Electric vehicle battery development, *SAE Tech. Paper Ser. No. 790158, presented to the Society of Automotive Engineers' Congress and Exposition, Cobo Hall, Detroit, Michigan, Feb. 26 - Mar. 2, 1979.*

4 D. P. Boden, C. W. Fleischmann and J. P. Badger, Development of expanded metal grids for electric vehicle propulsion, *ACS/CSJ Chemical Congress, Honolulu, April 1 - 6, 1979, Paper No. INDE 99.*

RESEARCH, DEVELOPMENT AND DEMONSTRATION OF LEAD–ACID BATTERIES FOR ELECTRIC VEHICLE PROPULSION

ESB Technology Company, 19 W. College Ave., Yardley, PA 19067 (U.S.A.)

The contract has been divided into two phases, namely, development of Improved State of the Art (ISOA) and Advanced Lead–Acid Batteries. Key technical goals are:

	ISOA	ADVANCED
Specific energy W h/kg @ 3 h rate	40	60
Specific power (W/kg)	100	150
Life cycles @ 80% depth of discharge	800	1000
Volume price $/kW h	50	40

The initial ISOA phase consists of determining the inter-relationship of 32 variables in flat plate batteries. Ninety-six three cell batteries have been built and given electrical tests. Performance goals of greater than 40 W h/kg and 100 W/kg have been attained with some combinations. Life cycling is in progress.

The second ISOA phase is directed toward a study of 32 variables in a new type of tubular lead–acid cell. One hundred and twenty eight, three-cell batteries have been built and these are being electrically tested as well as life cycled.

Phase I of the major subcontract with Battelle Columbus Labs. has resulted in the development of mathematical models for rectangular and radial grid designs. The cutting of molds to produce radial grids of improved conductivity and performance is in progress.

Installation of automatic-computer controlled test equipment has been completed and debugged and is being used for both electrical and life cycling.

Advanced battery development efforts are directed toward determining the feasibility and performance of a pile-type lead–acid battery. In addition, component evaluation will continue in an effort to obtain increased yields from positive plates, negative plates, and cells by utilizing more effective materials and reducing component weights.

Recent publications

1 G. S. Hartman and E. A. Rowland, Evaluation of battery performance for an electric vehicle with regenerative braking, *Proc. 5th Int. Electric Vehicle Symp., Philadelphia, PA, October 2 - 5, 1978.*
2 G. S. Hartman and D. L. Beals, Evaluation of battery performance using computer controlled test equipment, *14th IECEC, Boston, August 8, 1979.*
3 First Annual Report, September 1, 1978, *ANL Contract 31-109-38-4207* (in preparation).

RESEARCH, DEVELOPMENT AND DEMONSTRATION OF LEAD–ACID BATTERIES FOR ELECTRIC VEHICLE PROPULSION

Globe–Union Incorporated, Battery Division, 5757 North Green Bay Avenue, Milwaukee, WI 53201 (U.S.A.)

The objective of this project is to develop and demonstrate improved and advanced lead–acid battery systems for electric vehicles. Key technical goals for the Improved State-of-the-Art (ISOA) battery are a specific energy of 40 W h/kg at the 3 h discharge rate, a specific peak power of 100 W/kg