# GENERAL DISCUSSION, SECOND INTERNATIONAL MEETING ON LITHIUM BATTERIES, PARIS, APRIL 27, 1984

The Lithium Battery Conference concluded with a panel session chaired by Boone B. Owens (Medtronic Inc., USA.) Panel members included Dr P. Bro (Southwest Electrochemical Co., USA), Dr P. Lenfant (SAFT, France), Dr H. Ogawa (Matsushita Battery Industrial Company Ltd., Japan), Prof. C. W. Tobias (University of California, Berkeley, USA) and Dr E. Voss (Varta Batterie AG, FRG). Following the overview presentations* by Drs Bro, Lenfant, and Ogawa, the meeting was opened for general discussion. Although remarks were recorded, some editorial changes and deletions have been made for clarity, hopefully without changing the content; these remarks were of sufficient general interest for them to be published below.

*S. Megahed, Rayovac (U.S.A.):* I would like to direct my question to Dr Bro. The question concerns the current priorities for lithium development. Market development and cost reduction are given the highest priority and production technology is coming third. With the influx of lithium (battery) technology throughout the world, and particularly the advances that were made in Japan on better ways of packaging and on large scale production, don't you think our philosophy should be first to make it good and then to make it cheap? Further, can't you make it cheap by emphasizing the production technology that we are desperately needing in this country?

*P. Bro:* I take it that by this country you mean the United States? The whole question of production technology and product design is very closely interwoven. I am not entirely convinced that the American industry is making the right decision by not funding more capital resources into production technology. I have a sneaking suspicion that the Japanese have moved ahead in the expectation of a very high volume demand. Although I think they cannot, today, make very much money by utilizing fully their production capability, I think that with what they have they are able to satisfy today's market at a modest cost and they just may run away with the show. So I wish American industry would invest more in fully mechanized production technology.

*S. Megahed:* My next question, for Dr Ogawa, is about lithium–carbon monofluoride and lithium–manganese dioxide. I think I heard you right, but I would like you to repeat why you think manganese dioxide is an explosive system whereas the carbon monofluoride is not.

*H. Ogawa:* There are two points. Number one is we think the electrolyte itself is a little dangerous. The second is a mechanical point; when the lithium–manganese dioxide battery is mechanically shocked, it sometimes

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explodes. That is why we think the lithium–manganese dioxide system is not so safe compared with the lithium–carbon monofluoride system.

*H. Taylor, Duracell Inc. (U.S.A.):* Maybe I should make a comment in that regard. Let me start by referring to what Dr Bro said in his ladder of priorities. I agree that the large companies in the U.S. are looking at the widespread consumer market. They are putting most of their effort into the development of a safe product. In other words, safety is their first concern rather than automation of production to reduce costs. I think the Japanese, early on, have recognized this in the development of some of their carbon monofluoride cells. In the 1970s lithium cells may well have realized the maximum in performance capability but, concurrently, many of the lithium systems of this period were of questionable safety except for military markets. However, I think everyone recognizes that over the years the safety of the lithium products has improved significantly. For example, some of the slides that our Japanese colleagues have just presented refer to electrolytes (in lithium–manganese dioxide cells) which contain lithium perchlorate in PC–DME organic co-solvents. In fact, that is not the electrolyte of choice that Duracell Company or Matsushita use in cell sizes other than coin cells or small button cells. For example, no perchlorate is used since it is known that perchlorate is a very strong oxidant whose presence is not desirable in a cell which could be inadvertently over-heated by short circuit. My point is that just as the Japanese have done with the carbon monofluoride product, others are doing similar things with, for example, the lithium–manganese dioxide products. We should be aware that what we are striving for in the U.S. is safety first; I think we can state that the lithium–carbon monofluoride cell is a safe product, and the lithium–manganese dioxide system is getting much, much closer to the same type of safe product. To-date, consumer marketing of lithium–manganese dioxide cells includes only the small cells of demonstrated safety.

I should also point out that any lithium consumer product designed for high rate requires a thermal safety device. The lithium–carbon monofluoride cells used in the Kodak and Olympus cameras have such a thermal device incorporated. The reason is that without this device, molten lithium can extrude from these cells when they are short circuited. As a matter of fact, I think that is very indicative of the safety of the lithium products. In a lithium system intended for use as a multi-cell battery, whether it is manganese dioxide, carbon monofluoride, copper oxide, iron sulfide or any other new system that comes along, it is not desirable that the lithium reaches its melting point in any abusive situation. What one is talking about, then, is thermal protection as an absolute.

*P. Bro:* At the risk of being labeled an historian I would like to second Dr Taylor's remarks and remind you of the history of the development of other battery systems. For example, when the mercury cell was developed in the fifties, you won't believe the number of explosions and incidents that

occurred, and today, of course, they are practically nonexistent. Even today, with alkaline cells and lead–acid batteries, every month quite a few reports of incidents are coming in. Naturally, we don't publish those things because that's an established technology accepted in the market place, but there's money passing every year to pay for injury and damage to equipment. It's just the focus on the lithium as a new techology that makes it particularly visible in the market place. Just to give you some numbers, during the last year or so more than 3 million lithium–$SO_2$ cells were made and among all these cells there have been less than 20 incidents. Now that is a very good record. What I would like to suggest is that as the cell is developed, as Dr Taylor emphasized, you will see improvement and you will see a much safer cell available in the future than you have available today. The product that is available today, however, even for some of the higher rates, is not as bad as one might at first think from some of the inflated reports.

*S. Wolsky, Ansum Enterprises (U.S.A.):* I'd just like to make another comment on the subject of safety. Anybody who is out looking at the market development situation will agree that safety is parallel in importance with market development. That is the first question anybody asks. It is true alkaline cells are still blowing up. They don't always vent when they are supposed to vent, but that's a problem of a different order of magnitude from lithium. We are talking about a new consumer product which has to withstand scrutiny in a more sensitive environment and is subject to new rules. So safety is a paramount thing, and as Harry (Taylor) pointed out there will be thermal devices to protect them.

Now I have a question for Dr Ogawa and also one for Dr Lenfant. I read recently that Panasonic has announced a rechargeable lithium battery and I am wondering if you can provide some information on that, and for Dr Lenfant I was a little surprised that when you ran down the list of all the lithium batteries, the copper oxide system did not seem to show up anywhere or, at least, is not more important than you seemed to indicate.

*H. Ogawa:* Referring to the rechargeable lithium battery system, we are presently developing the fundamental technology. The rechargeable lithium battery is not yet commercially available.

*P. Lenfant:* The lithium–copper oxide system appears in a reasonable position on the slide which I projected. I have not insisted on that system because SAFT is, so far, the sole battery company manufacturing the system. As far as the market is concerned, we have two major applications — heat counter and oil logging.

*C. Schlaikjer, Duracell International, Inc. (U.S.A.):* I'd like to ask Dr Ogawa if he could enumerate the particular applications he sees for the rechargeable button cell with lithium metal or alloy.

*H. Ogawa:* We are looking at two possible applications. The first is as a memory backup, and the second application, if we can establish good reliability, is to replace nickel–cadmium and lead–acid batteries for some of the cordless applications.

*C. Schlaikjer:* As a coin cell they could probably be used for the memory backup, but you would need larger cells for the other application, wouldn't you?

*H. Ogawa:* You are right. For the coin-size cell the only application is as a memory backup. To replace the lead–acid or nickel–cadmium batteries, we have to make a larger battery.

*R. Huggins, Stanford University (U.S.A.):* I'd like to make a technical comment that relates to some things which I mentioned in my own talk today; this has to do with the use of lithium alloys as negative electrodes. One of the things I neglected to mention is that one can make alloys with much higher melting points than lithium metal and, if one is seriously concerned about the melting of lithium as a safety problem, I am surprised that I don't see a number of the manufacturers visibly working on alloy electrodes rather than elemental lithium electrodes.

*P. Bro:* Just a quick response to that. The fact that you don't see it doesn't mean it doesn't happen.

*H. Taylor:* I'd like to make another general comment without over stating the obvious. The performance penalty that you suffer when using these alloys is quite substantial. Indeed, there may be problems with the manufacturability of the product. One beautiful thing about lithium is that you can wind it, bend it, twist it, shape it into whatever you want, but whenever you start to alloy it with different material, I'm not sure all that is possible. You end up costing yourself a lot of dollars in terms of manufacturing cost. Going on with this question of cost for the moment, the only way the lithium products are going to get to any consumer market is at a distinct cost disadvantage until the manufacturing cost is reduced by automation. That's a point Dr Bro made, and though the Japanese have automated some cells, I still think it costs them an arm and a leg for each battery they sell.

*S. Megahed:* Question to Dr Ogawa again regarding the rechargeable coin cell. I am just wondering if you can make a brief comment on the non-battery-like devices and their effects on the rechargeable coin cell. I am thinking specifically of the so called 'super capacitors' that are being used right now by the NEC in Japan. Where do you think this will fit relative to the rechargeable battery you are working on?

*H. Ogawa:* When we use a lithium alloy as the anodic material I have already told you about the fundamental technology. In that case we can obtain

2 or 3 times higher energy density than the NEC 'super capacitor' and our gold capacitor.

*S. Megahed:* Are there any cost advantages?

*H. Ogawa:* We assume that the lithium battery will cost less since you only have to use two cells whereas, with the 'super capacitor', they have to use three cells.

*R. Moshtev, Academy of Sciences (Bulgaria):* I would like to ask Dr Ogawa whether he could give us some data about the eventual applications of the big lithium–manganese dioxide battery which was recently described by the Japanese firm, Yuasa. They have reported a prismatic lithium–manganese dioxide battery with an upper limit of about 30 A h capacity.

*H. Ogawa:* We are told that this is finding application in many types of communication equipment and also for telephone stations and navigation.

*E. Voss:* I would like to propose that we should return to our original topic which is to comment on the future of lithium batteries. Dr Lenfant has given some projections for the future sales of lithium batteries until 1988. Our quotations are very similar. Therefore, I may make only one or two comments. The 1983 estimated market of 150 million US dollars is about 3 to 4% of the total primary battery market or 1.5% of the total battery market in the world (excluding the East European countries). Consequently, the Li market is comparatively small. If you consider the amount of lithium necessary for the 1983 battery production, it is about 40 tons and this is of the order of 1% of the total consumption of lithium. In other words: there is very little impact on the price of lithium. We have heard from the various speakers today that the lithium battery market is mainly an original equipment market. I suggest we should consider how we can turn the lithium market into a consumer market which supposedly would be a high volume market. Are there any proposals from the audience or the panel?

*P. Lenfant:* Consider the major companies in the consumer primary battery business. For example, there is a U.S. company that makes a 9 volt battery. If they were to develop a higher performance replacement battery, they would sell fewer batteries as a result and lose money. So why should a well established and profitable primary battery company want to bring lithium batteries into the consumer market place? They can do it, but why? Why should they make all the investments to bring out a new lithium battery when they are already selling in this market and they won't increase their sales? I think these questions should be directed to Dr Ogawa because it's a fact that most of the consumer lithium batteries are coming from Japan. By the consumer market you mean the replacement market, right? The majority of the developments in consumer lithium batteries, I believe, are coming from Japan or Japanese controlled companies.

*C. Tobias:* There hasn't been much attention devoted at this meeting to the future of rechargeable lithium batteries. I believe there is a great incentive to develop electric automobiles and therefore normal temperature rechargeable batteries. A very serious effort is underway in the U.S. where the government is providing substantial support for research and I am not willing yet to admit defeat. Although the potential market for EV batteries is enormous, I subscribe to the view that if our (U.S.) government would ask the people to pay a realistic price for gasoline in the U.S. the prospects for the electric car would greatly increase. Don't forget that the U.S. consumer pays less than half (the European price) for gasoline. Therefore it is within the power of the government to generate further interest in electrics or to reduce interest in alternative modes of transportation. I feel that normal temperature lithium batteries could very well be viable alternative energy sources. High temperature batteries are promising, but I think that the ultimate answer is not yet in sight.

*B. Scrosati, Università di Roma (Italy):* I have a general question which I would like to address to all three speakers. All of these batteries are primary batteries. Looking to the future, when all of these millions of batteries are used and are then thrown away, do you think there will be any problem associated with waste removal of these batteries? What are your suggestions as to how we can get rid of this waste?

*P. Bro:* If you don't mind Bruno (Scrosati) I would like to come back to the comment of Professor Tobias first and then come back to you. It is not for me to question the wisdom of the U.S. government in its various policies. In regard to rechargeable batteries, I think that for the next decade we can look for reasonable funding for research, but I haven't seen anything sufficiently practical to warrant engineering development at anything but a toy scale.

In so far as Bruno's question regards waste disposal, we have an expert in the audience and I may suggest that Dr Wolsky answer that question.

*S. Wolsky:* I think that you have a good question Bruno. Historically, the random disposal of batteries has been generally accepted except for mercury-containing cells in Japan and some European countries. Unfortunately, it will likely be a long time before lithium production quantities are sufficiently great to warrant concern. Even then it is probable there will be no problem.

*K. Jones, Cordis Corp. (U.S.A.):* I want to return to the question previously raised, illustrated by the electronics field. The Japanese seem to develop a whole system and I wonder whether the Japanese are generally in the market first because they develop a system around a new battery, whereas others look at new batteries replacing other existing batteries.

*H. Ogawa:* In Japan now we are thinking also that the replacement market will come in the future. We are thinking of three types of batteries. At this moment there are only coin-sized and pin-sized lithium batteries on the retail market; for the cylindrical size we are thinking of putting them into the market in the near future, for example, in cameras. Secondly, we think the 1.5 V systems will be replaced to some extent by a lithium cell. Thirdly, the lithium–manganese dioxide system, with other types of electrolytes, will be used, for example, in calculators. The safety will be taken care of and it will also be on the market.

*S. Wolsky:* I just wanted to make one comment on why a large company should do something in the lithium field. Having come from Duracell which used to be P. R. Mallory, I think it's pretty obvious. Duracell went from around a 75 or 80 million dollar a year company to around a billion dollar per year company in about 10 years. So, as long as the people who are sitting on the panel from the large companies sit very complacently, they are opening up a tremendous opportunity for the small aggressive companies.

*B. Owens:* Are there other comments on the safety of lithium batteries, are there comments on new areas of research and development? Are there any predictions on what the areas of break through will be in the field of lithium batteries?

*J. Downarowicz, Centralne Laboratorium Akumulatorow I Ogniw (Poland):* I have a rather general question. What is the possibility of photovoltaic cells replacing the low rate applications of lithium batteries?

*P. Bro:* The answer is I don't think so. First, I have not yet seen the amorphous silicon cell prove itself in the market place. If that happens then I think we can sit down and discuss it.

*Y. Leroy, SAFT Company (France):* I am sorry, Dr Bro, but it has already happened. For example, for credit card applications lithium button cells have already been replaced by photovoltaic cells. So, there are markets where this may happen.

*P. Bro:* We're not looking at something that is all black and all white. The question is what fraction of the memory market will the photovoltaic cell take. I will have to see someone convince me that they can replace more than just a small part of that market.

*H. Ogawa:* Looking at the comparison of photovoltaic cells and lithium cells, take, as an example, the simple electronic calculator without memory. We think photovoltaic cells may be used here. However, for those calculators that are multifunctional, we think lithium batteries will be more widely used than photovoltaic cells.

*B. Owens:* This has been a long and very interesting discussion today and now the meeting must come to a close. On behalf of all of the attendees at this congress I would like to express our appreciation to the Chairman who did all the necessary work to make this a successful meeting, Professor Michel Garreau. My second comment concerns the possibility of a continuation in this series of conferences. The number of participants increased from 110 at the meeting in Rome, 1982, to about 180 at this meeting. The number of papers increased from 40 to 58 and the number of countries represented by the participants increased from 16 to 23. The Scientific Committee feels that the high level of interest and scientific activity in the field of lithium batteries warrants another international conference in about 2 years. Professor Osamu Yamamoto of Mie University proposed hosting the 3rd International Meeting on Lithium Batteries in Japan. The Scientific Committee recommends that Professor Yamamoto's proposal be accepted and I am pleased to introduce him at this time.

*O. Yamamoto, Mie University (Japan):* Thank you Dr Owens. It is a great pleasure for me to announce that the next conference will be in Japan. I am pleased to invite all of you to attend the 3rd International Meeting on Lithium Batteries in 1986, in Japan.