scientists doing the work must be held "accountable in retrospect".

It also turns out that this category of innovative research, with the customer identified after the event, is enormously beneficial to the laboratory as a whole and I would now like to explain why. When our project work has a well-defined customer, whether industry or Government, we do not concern ourselves too much about the market for the final products of the research; naturally we assume the customer knows why he wants our help. This means that our contribution is purely technical. However, when we are backing our own judgement that the research will pay off then we are obviously obliged to think through for ourselves how the idea might be applied. Subjecting our scientists to thinking this through against the needs of the potential customer (the market place) produces greater realism in our thinking and, quite frankly, a greater humility about the worth of the idea 'per se'. This, I believe, helps us to have a better "rapport" with industry because we have thought through the problems and risks they face in exploiting a new idea. It also helps us to think about opportunities in a more mature way.

In describing the development and general results of our industrial programme to date, I have not had time to describe any technical or administrative details nor to relate the various problems which we have faced up to and overcome. We have, of course, had a number of problems such as in the management and control of these programmes, in the re-allocation of staff, in the training of staff to understand and work to commercial criteria, and in motivating the staff to undertake the industrial programmes with the same enthusiasm and vigor which they applied to atomic energy research. During the last 4-5 years we have naturally learned many lessons, and are continuing to do so in the practical applications. One lesson which we did learn very quickly is that the demands of industrial research, although different in many ways from those of fundamental research, are every bit as intellectually challenging and demanding.

To summarise, we have now had about 5 years experience at Harwell in changing from a laboratory almost entirely financed through the atomic energy vote in Parliament to one in which a large section of the laboratory is financed by many customers on a contract basis. We have, of course, had to work hard to make the transition but we now accept what Rothschild would call the customer/contractor relationship as a quite natural way of working. If this principle is to be extended to cover more of the laboratory's work, then it is, of course, necessary that the relationship be a good one and cover some long-term as well as short-term objectives: we have learnt well from the reactor programme how essential an element of "underlying" research — in our nomenclature — is for the health of an applied programme.

We have noted with pleasure the emphasis Rothschild gave to multi-functional laboratories — because Harwell is now clearly a multi-functional laboratory. We see a number of advantages to this but one point is so important I must make it explicitly. Psychologically, the most difficult decision to make on any research project is to stop it, but in a multi-functional laboratory everyone has a high incentive to phase out good programmes in favour of the wide choice of even better programmes. This sharpens our own judgement and optimises our use of resources.

During these past few years we have had a very exciting time in developing our new programme, and in meeting the challenges inherent in doing so. I believe that the enormous stimulus which we have found in doing so has been extremely beneficial to the life and spirit of the whole laboratory.

---

*A Framework for Government Research and Development. Cmnd. 4814.

GOVERNMENT, RESEARCH & DEVELOPMENT, AND INDUSTRY

by
S. B. Marsh,
Technical Director,
Standard Telephones & Cables Ltd.

In the UK, the extent of direct Government involvement in Electronics R & D has probably been greater than in any other field, except Atomic Energy. In Defence this has come about through the existence of powerful Government Research Establishments, many of which, although in existence prior to 1939, were greatly strengthened and developed during the war years. In the post-war years considerable strength has been maintained due to the continuing pressures on Defence and the ever-increasing application of eletronics to all weapons of war. In the civil field there is major direct activity in Electronics applied to Telecommunications at the Post Office Research Station and more general direct contributions are made by other Government Establishments such as NPL and RSRS.

During my career I have worked at the PO Research Station, at the Royal Radar Establishment, have been Managing Director of Standard Telecommunication Laboratories, the subsidiary research company of STC, and am now Technical Director of STC, so I feel particularly privileged to be able to talk to you to-day on the topic you have chosen for discussion.

I would like to begin by reviewing briefly how these various Government agencies have made their contributions in the past, the current situation, and finally try to make some suggestions for the roles which might be played by them and Industrial R & D organisations in the future. In doing this I shall have to stray somewhat into the field of procurement because of the close relationship between this and R & D.

During the period in which I have had any knowledge of it, the pattern of Government involvement in R & D for civil telecommunications has remained relatively unchanged. The PO Research Station has concentrated primarily on basic research and on the basic techniques associated with the application of advanced electronics to Telecommunications. With a few notable exceptions, e.g. ultra-high reliability transistors for submarine cable systesm, the industry

has been solely responsible for product development and manufacture. Over the years, however, the major telecommunication equipment suppliers have developed and broadened their own competence and all now also maintain their own research laboratories.

The relationship between PO and industry in the field of development has consequently always followed the contractor/customer relationship advocated by Lord Rothschild. Any inhibiting effects this might have had on long-range research have been circumvented by significant free-ranging research activities in both the PO and Industrial research laboratories. One might, however, question the adequacy of the contractor/customer relationship between PO and public.

In a complex network like the telecommunications network in which equipments must interwork within and beyond the borders of the UK the operation of the customer/contractor relationship calls for extremely precise specification of requirements. Logistic considerations of maintenance training, and spares holding and supply also often require sub-system or even unit interchangeability between manufacturers resulting in great depth of detail in these specifications.

The degree of technical and operational competence necessary to produce such specifications is easily underrated.

In contrast to the civil situation, Government involvement in Defence R & D has changed considerably over the years. During the war, the extreme emergency and the urgent need to make full use of any electronic device which might contribute to a successful outcome, resulted in a situation in which Government Establishments carried out a great deal of engineering development and even made equipments which were used in operational service. Industry largely copied these equipments produced by the Establishments, doing what they could to increase their suitability for volume manufacture. This was effective largely because people were highly motivated and powers existed, if necessary, to compel the right grade of effort to be applied to the priority tasks. There were, for example, innumerable instances of civilian scientists and engineers being "co-opted" into the Services to operate and maintain complex prototype equipments. Cost was no object. An important point was also that nobody hoped equipments produced in this way would have to have any long Service life.

With the return of peace, the urgency of need decreased, the importance of economics increased and the directing powers on labour disappeared. It was no longer possible, nor desirable, therefore, to continue in the same way. The result has been a gradual change over the years to a situation very similar to that existing in civil telecommunications. The pattern was set in the early fifties by the definition of development responsibilities of "Policy Authorities", normally Government HQ staff, "R & D Authorities", normally members of Government R & D Establishments and "Design Authorities", normally industrial companies. The system differs slightly from the PO technique in that specifications tend to be produced mainly in outline by the R & D Authority, much of the detail being filled in jointly by R & D and Design Authorities as development proceeds. This difference arises principally from the fact that military developments tend to be closer to the "state-of-the-art" and striving more for the ultimate in performance than do civil developments. Within these limitations, the customer/contractor relationship is generally adhered to, reinforced by the existence of formal development contracts.

Now, what of the future?

I see nothing basically wrong with the current sharing of activities between Government and Industry in the two fields I have mentioned so far — civil telecommunications and military electronics. What is needed is a clear rethink and definition of the *objectives* these activities are intended to achieve, particularly in the case of Government Establishments. Followed by action to set the size and programme to that necessary to achieve these objectives.

What should these objectives be? Let us work back from product manufacture and development.

I feel strongly that the correct place to do product development is in industry, where the product is to be manufactured. It is only in the manufacturing environment that the constraints imposed on design by capital investment and labour characteristics can be properly appreciated and the cost implications of ignoring these constraints brought home to the designer. I do not even question the fact that manufacture should be carried out in industry since, whatever ideals one holds, the only practical spur to efficienty and cost control in manufacture seems to be the competitive environment.

But, how about industrial research?

In the field of electronics, where technology is developing at an extremely rapid rate, it seems inevitable that industrial companies must maintain a modest amount of research activity. In my view this should be strictly applied research (i.e. foreseeable as making a possible contribution to the business of the company or directed towards achieving a solution to a known major problem) and have, as a subsidiary objective, maintenance of an awareness of world-wide activities of potential interest to the company so that future trends in technology can be assessed. This latter objective is normally met by participation in conferences and symposia and by keeping up with available literature, this is most effectively done and the activity appraised by active participation in the fields of interest to the company.

Under no circumstances can I see a case for basic research (i.e. research with the sole objective of increasing human knowledge) in the industrial environment, although some companies might wish to sponsor such research at Universities.

From what I have said so far you can see that I find no case for product development in Government Establishments, which immediately poses the question "What, if anything, should they do, and why?" Here it is necessary to again separate the two fields of defence and civil communications.

In defence we have to face the basic fact that, since any potential enemy must be assumed to be making use of the latest electronic technologies, the defence must do likewise in order to maintain a

balance. A battle between forces armed respectively with machine-guns and bows and arrows would be a very one-sided affair. This gives rise to a need for applied research:

1) to develop new technologies for defence purposes
2) to maintain an awareness of other developments which could be advantageous in the military environment
3) to develop an awareness of future technological possibilities and timing (technological forecasting)
4) to provide the technological input required in the formulation of Operational Requirements.

In other words, the role of the Government Defence Establishments, as I see it, is acting as the scientific arm of the ultimate Service customer in advising him as to what is likely to be technically possible at some future date, in helping him formulate his customer specifications and in providing technical backing for his monitoring of the progress and performance of his industrial contractor.

In the case of civil telecommunications the interest in new technologies is rather different. Here the emphasis is primarily on concepts and technologies which will either:

1) provide existing services at lower cost — e.g. normal telephone service
2) provide extra facilities on existing services, ideally at no extra cost, e.g. STD (Subscriber Trunk Dialing), push button dialing; or
3) provide new services at a cost acceptable to the final customer (i.e. the public), e.g. visionphone.

You will notice that I have mentioned cost in all three objectives whereas in the military case I did not mention the word at all. This does not imply that cost is not important in the military field but simply that the relative priorities of performance and cost are different in the two fields, for obvious reasons.

A consequence of this difference in priorities is that any new technology, which tends to be expensive in its early stages and often more expensive than the technology it replaces, is usually used first in the military field where the increased cost can be accepted for the advantages obtained from its use. A classic case is semiconductor integrated circuits which were first applied in the U.S. Minuteman missle system for the reliability advantage they offered. In fact it is probably true to say that Minuteman could not have been effective without reliability of I.C.'s.

The stress on making *immediate* use of latest technological developments does not usually arise in civil telecommunications.

What then should be the objectives of Government research in this field?

Over the years very complex national and international networks have been built up, particularly for telephone and teleprinter communications, with fairly clear hierarchical structures. For development and procurement purposes defined product categories exist; switching and transmission of various types and subscriber apparatus.

Modern technological developments are, however, already beginning to blur these product boundaries and it is to be expected that this phenomenon will increase. On the other hand, since any one subscriber wants to be able to communicate freely with any other in the network, severe constraints on interworking of new and existing systems occur. One can therefore see a real need for system study and research directed towards compatible reconfiguration of the network to economically accommodate new services or improvements arising from technological development.

Again, an awareness of new technological developments and research into their potential for economic application within the telecommunications network is necessary, both as input to the system research activity and as part of the process of specification of requirements to industrial contractors.

As in the case of industrial research I see no case for basic research to be carried out by the Government in this area.

Nothing of what I have said so far need necessarily change dramatically the R & D programmes being carried out in the various organisations referred to. However, the motivation and programme detail and blance could well change, as could the sizes of the teams involved, from a clearer recognition of the objectives I have outlined which are broadly:

1) In Government, the R & D backing necessary to the production of customer specifications and
2) In industry, the development of products and the continued maintenance of capability to develop these products.

Such clear definition of objectives could go a long way to eliminating the *wasteful* scientific competition which frequently occurs at present between organisations which are complementary and not in commercial competition. I do not, however, regard duplication in research as necessarily counter-productive. I would accept apparent duplication arising from pursuit of clearly defined objectives — But I deprecate scientific "Band-wagons" e.g. Lasers.

At this point I would like to digress for a moment to take a wider look at both R & D and Procurement since R & D is only effective if it is applied. At least in the field of defence, much of the R & D work carried out by industry has been financed through Government R & D contracts and there appears to have been an impression in Government that, as a result of this funding, equipment could be produced at prices competitive with, say, those obtaining for similar equipment in the United States. However, in the manufacture of any new product there is a "learning curve" during which teething troubles are being ironed out, operators are becoming practised, etc., while at product termination there are problems of surplus or out-of-balance stocks, etc. These periods both add costs to those which obtain in continuous production. In addition some manufacturing control functions which have to be performed are not necessarily linearly related to the volume of production. As a result most products have a pronounced price/volume relationship and usually the more capital intensive a business is, the more dramatic is this relationship. This means that if we wish to have national production and hence justifiably apply our national R & D we must be prepared to pay the price for it. Although I have referred

specifically to equipments the same remarks are true for the new advanced electronic components which make advanced equipment performance possible. A particularly important case to note is semiconductor devices whose manufacture is highly capital intensive and in which the price/volume characteristic is very steep. The price to be paid for anything limited to a national requirement is therefore relatively very high.

Since industry makes its money by manufacture the most important factor in effective utilisation of its R & D is a real market for its products at realistic prices. In saying this I am not implying that industry should be "feather-bedded" in any way but simply that, where the Government is the sole, or principal, purchaser of the products of R & D, it has a particular responsibility to recognise the economic effects of (frequently smaller) market volume. Without this recognition prices will be too low and R & D can, as a result, be wasted.

In free market conditions the onus is quite clearly on industry to determine potential market volumes and the prices necessary to achieve these volumes. The success or failure of any product and hence the effectiveness of the R & D is to a very large extent a function of how well this assessment is made.

This brings me naturally on to R & D in electronics for the free market.

In the same way that the market requirements have to be determined by industry so, I believe, should the associated R & D be carried out solely in industry. With a falling work load in some of our Government Establishments there has been a tendency to try to use the surplus capacity to contribute to R & D in the free market field. This is a classic case of a solution looking for a problem, which I deprecate.

While it is perfectly reasonable to allow skills within these Establishments to be hired by industry if required, I believe it is quite wrong to have a policy aimed at making these Establishments major contributors to R & D in free-market electronics.

This is, in no way, a criticism of the competence of the R & D personnel involved, since I do not believe University, Government, or Industrial R & D personnel can be identified at birth or at any early age. There may be some personal characteristics which bias an individual to one or other of these types of R & D but I believe there is fairly complete overlap of characteristics of the populations involved. The key differences between them stem from the environments in which they work, and I believe the only real environment for this type of R & D is the market-conscious environment of industry.

Readers of *Les Nouvelles* will note that it carried an item concerning the items given below. Now these lawsuits have been settled, according to this article:

New York Times — March 27, 1972

Settlement of two lawsuits relating to the manufacture of high pressure polyethylene in Sardinia, Italy, was announced March 20 by the plaintiffs, Dart Industries Inc. and El Paso Products Company, and the defendants, Societa Italiana Resine S.p.A. (SIR) of Milan, Rumianca S.p.A. of Turin and Stiral S.p.A. of Sardinia.

The suit filed by Dart and El Paso against S.I.R. and Rumianca last June in Federal Court in New York has been settled and the suit has been dismissed by agreement of the parties.

In addition, an earlier suit filed by Dart against Stiral, an S.I.R. subsidiary, in the Court of Sassari, Sardinia, charging infringement of Dart's Italian patents, has also been dismissed. The litigation in New York arose out of a dispute concerning royalty obligations of Rumianca, as a licensee of Dart and El Paso. It also involved a controversy as to whether S.I.R., in collaboration with Rumianca, which Rumianca denied and continues to deny, had wrongfully appropriated and used proprietary technology of Dart and El Paso in the construction and operation of a polyethylene plant at Porto Torres, on the northern coast of Sardinia.

In announcing the settlement, Dart and El Paso have stated that they concluded that S.I.R. and/or Stiral has not appropriated any of their proprietary technology.

The dispute concerning Rumianca's royalty obligations has also been resolved with the recognition of the mutual rights and obligations of the parties.

March 20, 1972

J. E. Bowler

"SOME THOUGHTS ON ROUTINE CLAUSES"

by
*J. E. Bowler**

A lecture delivered before the U.K. Chapter
at
STORNOWAY HOUSE, LONDON

(by kind permission of Firth Cleveland, Ltd.)

My text for this evening's sermon is taken from that well-known legal text-book "Alice through the Looking-glass" by Lewis Carroll. "When I use a word"