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Industrial innovation from university research

Universities and engineering, separately and in a sense jointly, are both presently under intense scrutiny. The universities, after a period of expansion lasting nearly forty years, have recently been subjected to a reduction in funding averaging some 15% and, as might be expected, were only able to adapt to the reduced support with difficulty. In particular most institutions felt that the price of responding to the request of the University Grants Committee to afford some protection to the schools of engineering was too high and, by and large, declined to do so. At the same time, and following the publication of the Finniston Report, the Engineering Council was set up with the task of reviewing the engineering profession and improving, if possible, the standards of education, training, qualification and performance overall.

At the time when funding is being reduced the universities are being asked to improve efficiency, introduce training elements (Finniston's EA1 and EA2), more design, manufacture and economics, and to broaden their courses. Closer integration with industry is called for, with engineering academics making closer contact with 'the real world', whatever that might be. I happen to hold the view that, by and large, and given the existing constraints on resources and time, engineering departments do a remarkably good job. The degree of contact with industry and the associated amount of financial support in many instances is little short of staggering. Universities, unfortunately, are not adept at public relations and much of their work goes unheralded.

Indeed, most of the staff of all professional faculties are practitioners of their subject. The medics are involved with the National Health Service and private medicine, whilst our law colleagues serve on magisterial benches, appeals courts, judical committees, courts of inquiry, and so on. The extent to which the Faculty of Engineering at Southampton interacts with industry may be judged from the fact that it receives more money from outside sources than comes from the University Grants Committee. We operate half-a-dozen industrial units; individual staff have launched a dozen or so industrial companies; others act as consultants; and we have frequently been top of the league table listing the ratio of the amount of external funds to the numbers of teaching staff. This is no mean record but it is not untypical of engineering faculties elsewhere in the UK. Obviously there may well be room for further improvement but let credit be given for the progress already made.

It is frequently suggested that academics should not be content to interact passively with industry but should set up enterprises themselves. As indicated above, many have already done so, but a number of factors have to combine for there to be a reasonable chance of success. The attitude of university authorities is beginning to change from reluctant and cautious acquiescence (with a few notable exceptions) to a recognition, indicated by the setting up of science or technology parks, of their value to the country, the university and to the teaching of engineering. It may be useful, therefore, to describe the setting up of one such company, York Technology, from the Optical Fibre Research Group at the University of Southampton, in order to illustrate what has been done, to encourage others to do the same and to see what lessons can be learned. It will be clear that the views expressed here are those of a university partner, who may well see the situation somewhat differently from his industrial colleagues.

Speculative

Research on optical fibre communications began in the Electronics Department at Southampton University in 1966. At that time the idea was a very speculative one and arose from earlier work in the same research group aimed at exploiting lasers for communications purposes. The concept of this new form of long-distance transmission line was quite challenging with no great certainty of success. The idea was to investigate whether it might be possible to replace copper wires and electric currents in telecommunications systems by glass fibres and light. For four years Southampton was one of only three laboratories, all in the UK, working on this topic. Interest quickened in 1970 with a report from the USA that a relatively low attenuation had been achieved in a glass fibre. From about 1973 onwards progress began to accelerate and since then a number of major advances have been made, many of them by the Southampton group. The installation of optical fibres in telephone networks is now taking place on a large scale, so that the early speculative research has come to fruition.

The Southampton team has always been organised on a professional basis and comprises about six full-time research fellows, as well as six research students and three members of the teaching staff, together with visiting fellows from overseas. A research group with this type of structure can compete internationally in research, train research students more effectively by enabling them to work alongside experienced researchers, and contribute to undergraduate teaching in an authoritative way. In fast-moving

Academics and industrialists sometimes find common cause in developing a new idea or device. How often does this happen; and what are the necessary conditions for success? In this article, Alec Gambling, who has been closely involved with one successful company, describes its origins and growth.

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research it is essential to be able to change direction sharply and quickly, as new results and ideas emerge, and this can be done more easily with a cadre of research fellows. Despite the basic and investigative nature of the research, strong contact has been maintained with industry. For some years we have supplied fibres of special design, and performed sophisticated measurements and consultancy work on a commercial basis, through the Departmental Wolfson Industrial Unit, to a large range of customers in many parts of the world. There are many informal contacts and industrial staff have been seconded to the university for training in this new technology.

The research programme is centred on a fibre fabrication facility, one of the very few in the world available in a university, and involves a study of new materials, fibre structures and propagation characteristics. When new components and properties are invented it is usually necessary to devise new methods of measurement. Thus the research group has always had a strong awareness of the need for advanced instrumentation for optical fibres and many of its contributions have been on this topic. A particularly novel example was the development of a rapid and accurate method of measuring the refractive-index distribution in composite preforms from which fibres are drawn. Existing techniques either involved cutting of the preform in some way or lacked resolution and precision.

Until 1980 the commercial work had been carried out mainly through the Wolfson Industrial Unit. With the invention of the preform-scanning instrument it was clear that the potential for exploitation existed; we also realised we required a manufacturing facility, together with a degree of expertise in such aspects as marketing, production, design, development and sales which did not exist in the university. Several companies were asked whether they would be interested in manufacturing and marketing such an instrument, with no success. It became clear that the range of potential customers was small and specialised. A large established company was therefore unlikely to be motivated (or adventurous) enough to accept the challenge. At first this lack of response from established industry was seen as a great disappointment, but turned out to be a blessing in disguise.

The start of York Technology

Fortunately, one of the people approached welcomed the opportunity to enter the rapidly-emerging optical fibre industry and a powerful team was quickly contacted and assembled. It comprised two people from the University Research Group (both of whom, interestingly enough, started life as electric power engineers); a managing director who resigned his post with a medium-sized electronics company forming part of a multi-national grouping; a chairman who is director of several other companies and has had experience as a managing director of a start-up electronics company; a retired chief scientist of a large American company; and an electronics designer who is also a lawyer. The last two are American. These six people formed the board of the company. They had impeccable academic qualifications — four of the directors had doctorates — as well as a wide range of experience in research, marketing, sales, product development, business and production. In the early discussions agreement was quickly reached in setting up a manufacturing company based, initially at least, on the research expertise in the university. In this way York Technology was born.

YORK TECHNOLOGY — DIRECTORS

EXPERIENCED CHAIRMAN

EXPERIENCED MANAGING DIRECTOR

PROFESSOR — RESEARCH LEADER

RESEARCH FELLOW — INNOVATOR

ELECTRONICS ENGINEER/PATENT LAWYER

RETIRED CHIEF SCIENTIST

FINANCIAL EXPERT (Later Appointment)

We began in 1980 as a private limited company with a starting capital of £200,000 raised by the directors and other shareholders, including the British Technology Group. The first product was the preform-scanning system which had been patented through BTG from whom a manufacturing licence was negotiated. The professionalism of the research and evaluation work at the university, and the skills of the key staff recruited into the company, are illustrated by the speed with which this invention was put into production. The company moved into an empty sausage factory in late November 1980 and the first prototype instrument was displayed at an exhibition in San Francisco in April 1981. In the first year of operation 12 pieces of equipment to the value of a quarter of a million pounds were ordered, 80% of which were delivered during that same year.

At the outset it was realised that a high technology company of the kind we have embarked on cannot be successful without supplying a world market, so a subsidiary, York Technology Incorporated, was set up simultaneously in Princeton, New Jersey, USA. In addition an agent was later established in France and the Seiko Corporation acts for the company in Japan.

Our first product, the preform analyser, is a specialist instrument and the 'customer set' is limited to optical fibre manufacturers and research laboratories. We remain the only manufacturer of such an instrument. The second product is a comprehensive modular device for making six or so precision measurements on the fibres themselves. Despite the fact that an optical fibre is capable of propagating over distances nearly a hundred times greater than copper cable, and with over one thousand times the information capacity, the active region is extremely small. The core diameter is only 50 μm (about the thickness of a human hair) in a multimode fibre and a minute 5 μm in single-mode fibre.

In order to make accurate measurements of the fibre properties it is necessary, therefore, to locate and control the position of tiny spots of light to a spatial resolution of 0.1 μm (four millionths of an inch). The Automatic Fibre Characterisation Instrument is, as a result, an amalgam of highly sophisticated optics, electronics, control engineering, software and mechanical engineering. The concept of this instrument was initially discussed in April 1981, before the first product was fully launched.

One of the modules of this instrument is being developed under a licence from the Plessey Company; another is the result of a research project in York Technology itself; a third is a direct transfer of technology from the university laboratory; and the remainder are being developed in the company with consultancy advice from the university. In all of the instruments great emphasis is being placed on the speed of measurement and the minimisation of operator skills. It has been estimated that over 20% of the cost of optical fibres derives from the many measurements required during production, so that a reduction in measurement time implies a reduction in manufacturing cost. Sophisticated computer control is thus used throughout.

Expansion in world markets

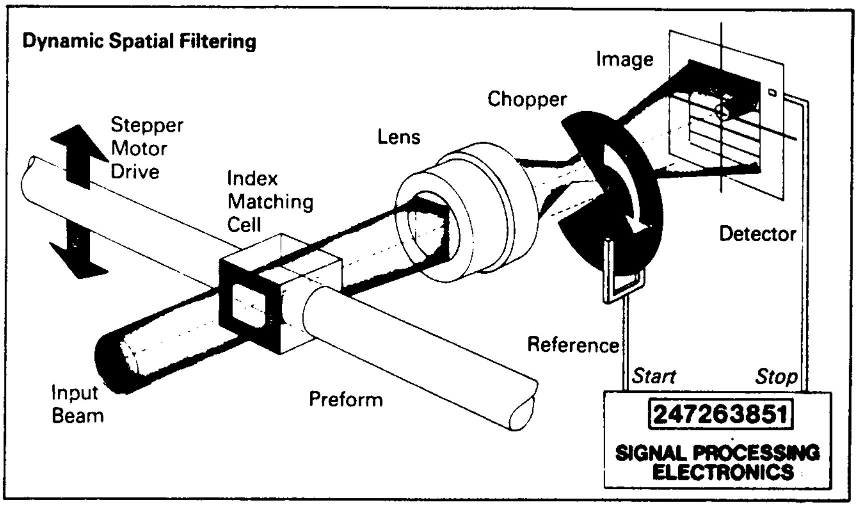
Since its modest beginning the company has grown rapidly and now employs more than 50 people of whom 65% hold first degrees or other professional qualifications, 37% hold master degrees and 20% have doctorates. Additional accommodation has been acquired in Hampshire and also in New Jersey. The University at Southampton plans to develop a Science Park to which York Technology has expressed an interest in moving.

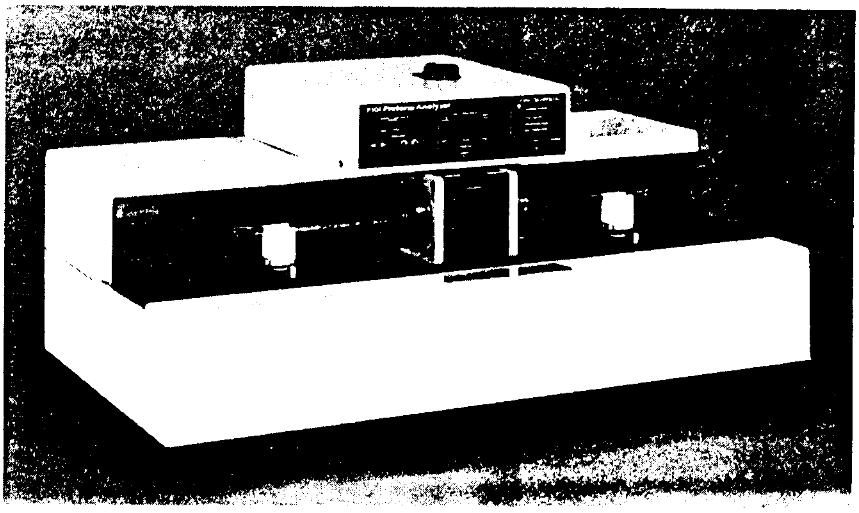
A second company has now been formed to market special fibres and fibre components arising from the research programme in the university and elsewhere. As indicated above, a certain amount of commercialisation of University research projects has been carried out in the past via the Wolfson Industrial Unit but development and production facilities are lacking. The new company will provide the additional manpower, financial backing, design and production tools to exploit the research much more extensively. Suitable financial backing for the venture is now being sought.

The decision to market on a worldwide basis has been fully justified. Customers for the company's equipment comprise the major fibre and cable manufacturers, research and development laboratories, and users of optical fibres. More than 90% of production is exported. The biggest market sector is Japan, the next major sector is the USA and the third is Europe.

Obviously the critical criteria for the success of any company are its financial viability and the acceptance of its products in the market-place. York Technology has survived the first three years and in the present economic climate this, in itself, is cause for satisfaction. More than that, however, the initial phase of expansion has been completed and a period of consolidation is enabling plans for further development to be formulated.

This thumbnail sketch would not be complete without mentioning three additional factors, which have contributed appreciably to our financing, reputation and morale. The first was a grant from the Department of Industry under the Fibre Optics Scheme. Support of this kind is vital in helping a small start-up company in a new, sophisticated technology. The second was the award of the first, national, prize to the university and the company in the Academic Enterprise Competition run by the British Technology Group in 1982. The object of this scheme was to stimulate and reward academic staff for initiative in setting up commercial and manufacturing organisations. The first prize of £50,000 was a great stimulus to York Technology and a great compliment to the university. The third factor was the award of the Gyr and Landis prize, administered by the Institution of Electrical Engineers, awarded annually for outstanding innovation in instrumentation. It was conferred on four of the engineering staff (including one of the directors) for their concept, leading to research and development, of the optical fibre characterisation modular instrument.





P101 equipment for measuring refractive-index distribution in preforms from which optical fibres are drawn.

Pain, Performance and Profits

York Technology has been established as a normal, independently-operating, manufacturing company having no formal link with the university. Nevertheless the informal contacts are strong since it was initially based on the expertise and new developments in the Optical Fibre Research Group. It has been in operation for only three years and no comment can be made on its long-term viability. However the commercial performance so far has been excellent and prospects for the future are very promising. What are the problems of university staff becoming involved in an industrial operation in this way and what are the benefits, not only to the university but also to the company?

The benefits to the company are straightforward but nontheless important for that. A new product — there is no other version on the market — has been developed as a result of the university research and is being sold worldwide. A second major product, also unique in its modular conception, has been launched and is rapidly gaining acceptance in a very competitive market. There has been collaboration, not only with the university but also with a major British electronics company (Plessey) in the design of one of the modules. Further products in the field of fibre sensors are being engineered into practical products (and under appropriate licensing agreements) as they become available.

A major factor in the rapid commercial acceptance of York Technology, with its sophisticated products, has been the international reputation of the University Research Group, as well as the advanced technical knowledge and experience it provides. A not inconsiderable advantage has been the fact that we know personally many of the other workers and practitioners in optical fibres and in the initial stages were able to provide the names of key people. The company thus does not have to advertise its products in trade magazines, for example. Not only did the university provide a reasonably complete dossier of potential customers, it has also been able to advise on customer requirements and the need for new products. It has also provided access to patents and their protection via British Technology Group.

UNIVERSITY CONTRIBUTION

ADVANCED TECHNOLOGY

'NORMAL' TECHNOLOGY

COMPLETE CUSTOMER SET

KNOWLEDGE OF CUSTOMER REQUIREMENTS

NEW PRODUCTS

PATENTS AND PROTECTION — BTG

The rapport between York Technology and the group is excellent at all levels and because of the university link the company has been able to attract first-rate employees at bachelor degree and PhD levels. The potential for continuing collaboration with the university is sound and it is intended that the existing close interaction shall continue. To ensure commercial success it is essential that it should do so. It is interesting to note that as the engineering and production side of the business continues to expand, the link with the university shows no signs of lessening.

Clearly there has been a major transfer of research results and technology from the university to York Technology. The Research Group has been active in this respect with other companies for the past ten years and, indeed, still is. New markets for British products have been created in the USA, Europe and Japan. It might be remarked that the sale of optical communications equipment to Japan, which has itself set out with massive government backing to capture world markets in this technology, is a tribute to the excellence of the products, the professionalism of the company and the stature of the research group.

So far the principle benefit to the university has been a greatly increased awareness of industrial activity on the part of teaching staff, research staff, research students and a few undergraduate students. For example, eight group personnel have acted as consultants to York Technology and have advised on a range of topics from product development to software design. The two university-based directors of the company have naturally been involved with all aspects from financial planning through engineering and production to long-term strategy. These two people have, in effect, embarked on new and exciting careers with a fascinating and challenging vista opened to them.

The research students in particular see a new dimension to their research and begin to appreciate the difference between an academic laboratory and commercial research. They can also, as the occasion arises, obtain experience, which is invaluable for their future industrial careers, by collaborating directly in the transfer of their research results into practical equipment. Interestingly enough the industrial connection has proved a useful recruiting feature with research students, who like to have illustrated to them the industrial relevance of their research, basic and long-term though it is. The feedback into university research is also beneficial, not directly in suggesting new approaches since the good academic research group should be able to lead industry in this respect, but more subtly in creating a greater awareness of practical problems and methods of implementing research ideas.

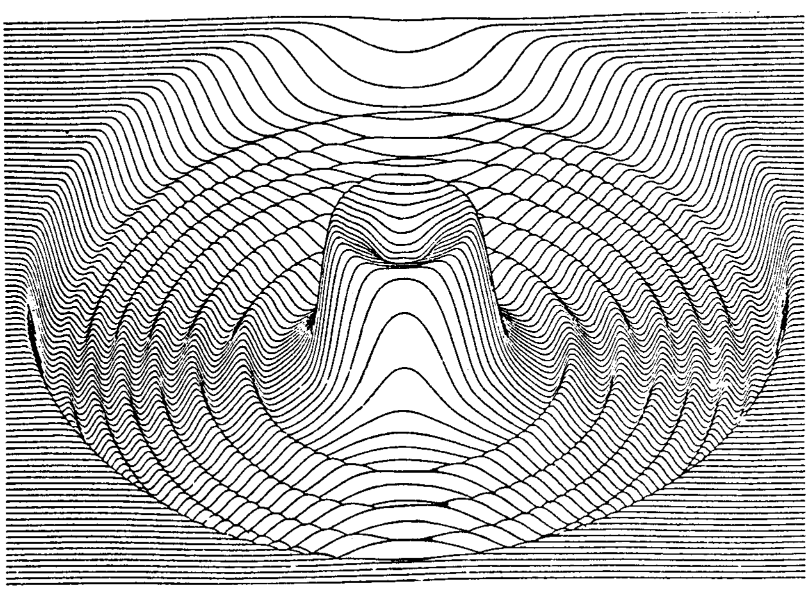
Naturally the university benefits financially, albeit in a modest way so far, from the overheads charged by the Wolfson Industrial Unit to York Technology for services which the latter commissions. The overhead income is divided between the unit, university central funds and the department.

The advantages of a linked university/industrial operation of this kind are considerable, but there are difficulties to be overcome which should not be underestimated, neither should they be exaggerated. The most obvious is that the university staff have their normal research and teaching duties to perform and the industrial work is essentially an out-of-hours activity. It is sometimes frustrating to the company when a response to requests for assistance cannot be given immediately. However, to be of maximum long-term value (and research is a long-term activity even when directed towards applications) the university side must resist the temptation to turn itself into a development unit.

The attitudes of colleagues

The attitude of one's colleagues is of some importance. Fortunately at Southampton the tradition of industrial collaboration and service to the community is a strong one — going back to 1863, in fact — when the then Hartley Institution gave the first-ever course for telegraphers, with an intake of 30 students per year. Thus not only permission but encouragement is given to our activities, especially within the Engineering Faculty. More active support is not possible but is neither sought nor expected. Elsewhere, on the other hand, one senses a more negative feeling; that while interaction with industry in a passive role is acceptable, the entrepreneurial step of becoming involved in establishing and running a

Three-dimensional refractive-index distribution in an optical fibre preform showing the central core region, six layers of cladding glass and the surrounding substrate.



manufacturing company is somehow not quite nice. Far from toleration there can be active hindrance. This is a national malaise, not simply a university one, which is being cured only slowly through changes in social attitudes, beginning in schools. Overall, the difficulties are more of principle, rather than practical ones, and can be overcome by determination, diplomacy and plain commonsense.

The well-known 'existence theorem' demonstrates that university staff can successfully become involved in setting up commercial enterprises to exploit their research. York Technology is only one such case and there are many others; for example, there were well over a hundred entries for the Academic Enterprise Competition run by the British Technology Group. Why then are there not more, and can any steps be taken to encourage others? Unfortunately a number of criteria have to be satisfied simultaneously before a successful enterprise can be launched.

The Southampton University team has been carrying out research on optical fibres since 1966 and the drive to produce a practicable new technology has been evident from the beginning. The senior staff involved have also remained the same. So what was it that changed between 1966 and 1980? The answer, of course, is a very simple one: the market. In 1966 the research was exploratory and speculative; industry was not aware that it was going to require optical fibre technology; so that there was no market. By 1980 optical fibres were in the initial stages of exploitation and it was becoming clear that they would have a major impact in telecommunications. Equally important for the nascent York Technology, there were few existing firms operating in the fibre instrumentation field.

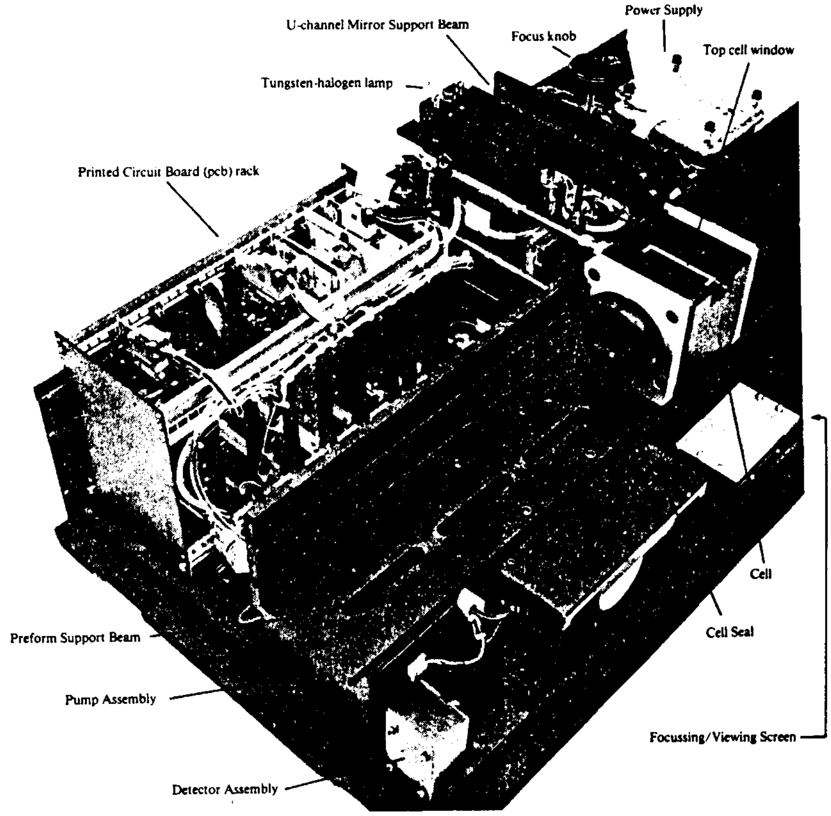
Thus *timing* was crucial in determining when a *market*, the prime requirement, was ready for exploitation. Given the market, a *product* must be provided which, to have maximum impact, must be inherently sound, must obviously meet the needs of the market, have its own niche, be 'user friendly', economic (which does not necessarily mean cheap) and beat the pants off the opposition. There must also be the potential for development and improvement in the face of inevitable competition.

A *business plan* is also a sine qua non and is necessary anyway to raise the necessary financial backing. It should state clearly the target to be aimed at, as well as the timetable and route by which it is to be achieved. Some degree of flexibility is desirable but the business plan must provide a yardstick against which progress, preferably in the forward direction, can be gauged, particularly when the going gets tough and there is a danger of becoming bogged down in a myriad of everyday details.

Finally, nothing will be achieved without the right group of *people*. They must be entrepreneurial by nature, ready to commit themselves wholeheartedly to the undertaking, able to work with, and inspire, confidence in their colleagues, be adaptable, and have the will, initiative and drive to succeed in the face of difficulties and setbacks. While it is being optimistic to expect all of these, and other, virtues to reside in one person, they must be present in large measure in the team as a whole. The range of corporate knowledge required includes marketing, business acumen, technology, production, research and development, accountancy, as well as management. All too often individual inventors and engineers have attempted to set up commercial enterprises on their own and have met with considerable and unnecessary difficulty. By and large the education of professional engineers in this country does not provide sufficient exposure to non-technical aspects to make them realise there are essential skills which they lack. This is one of the problems being tackled by the Engineering Council and in the meantime teamwork is essential, but the size of the team need not be large.

Applied research in universities can be exploited by industry in a number of ways. The simplest, and commonest, is when the results provide an addition to the general background knowledge of a subject which is transferred through the literature or by personal contacts. At the same time the university forms a source of skilled manpower and techniques. Another is when the research is patented and made available under licence from British Technology Group, or other sources. As part of this exercise, or separately, staff may become consultants as individuals or through university industrial units. All of the above activities may take place at any stage in the development of a research project. As research reaches the stage of application, university and industrial staff can collaborate on a problem of mutual interest.

The most exciting method of exploitation is where the academics take their faith and commitment in both hands to form, preferably with others, their own companies. For this to be done successfully many factors, including the research itself, must be at the appropriate stage of development and the timing has to be judged carefully. It happens more frequently in this country than is generally realised, to the great benefit of academe, industry and the economic health of the UK, but not as often as it could and should. Not all such ventures will succeed. It has been estimated that in the USA for every five new firms starting in this way two fail, two achieve a modest respectability and one becomes a real winner. Initially at least we are not likely to produce a better record of performance but the target is well worth aiming for.



Inside the P101.

YORK GROWTH

November 1980
Start — 2 employees (Winchester and Princeton NJ)

April 1981
Prototype exhibited San Francisco

May 1981
Concept of second product

July 1981
First production equipment

December 1981
17 employees

December 1982
Detailed design of product 2

April 1982
Product 2 exhibited, Phoenix, Arizona

July 1982
First prize of £50,000 in academic enterprise competition

June 1983
Product 2 deliveries

August 1983
New premises (Chandler's Ford and Princeton, NJ) 50 employees