BROAD HISTORICAL SURVEY

INTRODUCTION : EARLY HISTORY

In the preparation of this record, a certain amount of personal information is essential, in order to emphasise why and how certain developments took place. The steps taken by any organisation in its forward march are sometimes deliberate, sometimes forced by circumstances and sometimes the result of a combination of opportunism and forward planning. In the present instance all these combined, and they are reviewed against the background of chemical industry as it existed half a century ago.

As was customary at the beginning of the century, I received my early education at the village school (Chasetown in Staffordshire) up to the age of 13, when with the aid of a County Scholarship I transferred to the nearby Queen Mary's Grammar School, Walsall. My years there coincided with World War I, so that they were difficult in many ways. Although the war ended in November 1918 when I should have been due for call-up for military service, the normal progress of my school life was disrupted, with the result that I was only able to Matriculate (Joint Board 1st Class) a year later in 1919.

With the help of a County Major Scholarship I went to Birmingham University in the rather tough "ex-service" year 1920, taking chemistry, physics and mathematics with a view to qualifying for the teaching profession. I was thus working with and competing against men matured by several years of active service, which was not easy (albeit good training) for a boy direct from secondary school. In spite of this - or probably because of it - I graduated B.Sc. (Hons. School of Chemistry 1st Class) in 1923 and

M.Sc. in 1924, with chemistry as my main subject. In this year I was awarded a Fellowship by the Salters' Institute of Industrial Chemistry, and spent a further year at Birmingham with a Ph.D. in view. Here again external circumstances influenced my programme, and instead of proceeding with training for a Teaching Diploma, I opted to devote my efforts to industrial chemistry, and on the advice of my Professor I went to the Eidgenössische Technische Hochschule in Zurich under Professor Fierz-David. It was here that I made my first contact with the almost unknown branch of chemistry designated "plastics". I worked in the laboratory next to the department of Professor Hermann Staudinger, where the foundations of plastics were being laid. It is of interest to record that Staudinger antagonised the professional chemical world by stating that there was a family relationship between all long-chain organic compounds, and that these plastics as he called them, constituted a separate branch of organic chemistry. My thesis on "The Physical Properties of Cellulose Acetate" gained me the degree of D.Sc. (Tech) (Doktor Technischen Wissenschaft) in 1927, after which I spent a further year in Zurich as "Assistent" to Professor Fierz.

I was fortunately able to apply my work on cellulose acetate when I returned to England (and married) in 1928 and was appointed as the Chief Chemist in the Non-Inflammable Film Co., a new organisation designed to make cellulose acetate and photographic film (so-called non-inflammable) by a completely untried process. Not surprisingly this was found to be unworkable, and after three vain and hard years, during which I travelled widely in Europe to find a satisfactory alternative, it closed in 1931, leaving behind debts, a £500,000 plant, and a disillusioned staff. I was retained by the Liquidator: the rest of the staff dispersed into a market then at the height of the 1930/31 depression.

In the then prevailing circumstances it was hopeless to look for anything but a low-grade appointment, and although I had very little to offer beyond an extensive chemical technological education, and a few years of considerable frustration in the cellulose acetate and film industry, I decided to strike out on my own as a consultant in these my specialised fields of experience. The designation "consultant" was the only way I could approach industry, but I had actually very little to offer in the way of experience in the conventional manner of established consultancies, such as those of Dr. Oberlander and Dr. J.A.V. Underwood, so I decided to supplement my experience with practical work, in other words to "sell" research. This at the time was mainly centred in universities where "industry" was then a "dirty" word, so that I was able to take advantage of their prejudice, and collect a number of projects which although small, were sufficient to keep me occupied, and gave an income sufficient to cover my modest needs and provide additionally for a daughter born in 1930.

CONSULTANCY : WORKING ALONE

I set out to work on the basis of exclusive "retainers" covering either cellulosic products and/or films, these being the areas in which I had quite extensive and varied experience. In this connection I received invaluable assistance from my very good friend Phil Chaumeton who retained me to assist his company, The Cellulose Acetate Silk Co. Ltd., of Lancaster, who were engaged, together with Courtaulds, in litigation against British Celanese. This case made legal history in several ways, and I personally was instructed to make a complete up-to-date survey of technical and patent literature on cellulose acetate, a task which occupied many months, and almost continuous attendance at the Patent Office. When this was completed

I was fortunate to follow the case in the High Court, from the earliest days, and including several years later, the appeal in the House of Lords. In this connection I sat for many days behind Sir Stafford Cripps, and gained from this, experience which was invaluable to me years later, when I had to give evidence and advice in a similar capacity.

Whilst this work monopolised my activity in cellulose acetate, I was free to work on film. Here again I was fortunate to have the assistance of my good friend Gordon Couzens, who retained me on behalf of the British Xylonite Co. Ltd. to advise and ultimately to establish a film-producing plant to cope with cellulose acetate and cellulose nitrate. The fact that my two major clients worked closely together was of great assistance to me, since knowing the process details of each, I was the better able to co-ordinate their production, and the victory of Courtaulds was a great boost to our morale in our work against the common competitor Celanese.

This satisfactory arrangement was extended when, a few years later, I was retained by the Geigy Company (the British Branch of Geigy Basle) who were among the pioneer manufacturers of dyestuffs in Britain. Here again my friendship with Harold Clayton was my introduction to what for this company was a diversion in the manufacture of plasticisers for cellulose acetate. Geigy aimed not only to produce the conventional plasticisers, T.P.P. (triphenyl phosphate), T.C.P. (tricresyl phosphate), and the lower phthalate esters D.M.P. and D.B.P., but also products more efficient, albeit chemically more complex. This addition of a third client who soon became a collaborator with the other two, gave me a dual role, and knowing the processes they worked I was able to advise as was necessary

without divulging the details to any one of them. In any case, my close personal friendship with Chaumeton, Couzens and Clayton made any such a circumstance unlikely.

It was thus by great good fortune that my early work was soundly based on cellulose acetate and its related products, plasticisers for these, and films and any other compositions which were cellulose based. Very naturally we had our eyes on a possible substitute for celluloid, which had remained unchallenged to any serious extent for many decades. This was where the Cellulose Acetate Silk Co. (soon to change its name to LANSIL, for Lancaster Silk), was established to produce acetate silk and what was colloquially referred to as "non-flam celluloid", a mouldable combination of cellulose acetate and plasticisers.

These three fields of retained activity fitted in excellently, and were as much as I could cope with at the time. It was satisfactory as long as I was dealing with patent literature and general advice, but the need soon came for some practical work, for the production of films and/or moulding compositions.

PRACTICAL WORK COMMENCED IN BEDDINGTON

To cope with this difficulty I built a wooden shed in the garden of my semi-detached rented house in Beddington, Surrey, which I flattered with the designation of my laboratory. My apparatus, apart from assorted glass-ware, consisted of a small Werner-Pfleiderer mixer (Gallenkamp £7.10.0), and a sheet of plate glass with open top "scaper" spreader for film casting. Most of my practical work related to the preparation of film or moulding compositions, with a variety of plasticisers, and

evaluating their physical properties such as, clarity, stability, moulding properties and, in the case of film, extensibility. I did a certain amount of work on cellulose acetate as such, mainly to test the effect of type and quantity of catalyst, type of cotton or wood pulp, using a large glass "pickle" jar as acetylation vessel and mainly hand stirring, until I could afford the luxury of a motor and metal stirrer blade. Viewed from the present day sophisticated apparatus, I often wonder that it was possible to obtain useful results with the simple apparatus at my disposal, but of course much less was expected in those early days. Actually I spent relatively little time in my "laboratory" since my litigation work necessitated almost daily visits to the Patent Office, or to the office of Dr. Oberlander, with whom I was working on the Celanese/Courtaulds case.

A minor activity, but one worthy of mention by reason of its relationships to my work as a whole, was the manufacture of laminated safety glass. I was retained by Newtex Safety Glass Co. Ltd., a subsidiary of J.M. Newton, and a spin-off from the old "Non-Flam". This gave me contact with the Neutex Sicherheitsglas G.m.b.H of Aachen, Germany, which was in competition with the old Benedictus process using celluloid as the interlayer, worked by Sicherheitzglas Kinon, also of Aachen. This preparation of thick cellulose acetate sheet, of high clarity and good colour, combined with the production of a bonding "bath", consisting of solvent and plasticiser, was an interesting experience, as much from the technological viewpoint as also the fact that I saw German laminated glass in full production. Neither the British nor the German firms had much success when "toughened" glass became a commercial possibility some years later, and on this side of the Atlantic at any rate, the laminated material was less favoured.

THE FIRST THREE YEARS - THEN TRANSFER TO EWELL

Thus my first three years 1931-3 were fully occupied, and what is more the projects were interrelated, indeed a development in one was frequently of assistance in another. By this time however my activities in the garden shed had attracted the attention of my neighbours, and as I had no planning permission, the Croydon Council gave me notice to demolish my shed. This I did, and more. As my lease terminated at this time, I left Beddington and purchased a house on The Green, Ewell, Surrey, with an extension to the garage which gave me a reasonable working laboratory capable of dealing with most of my problems. I also purchased further apparatus including an analytical balance, torsion balance, heating oven and a reasonably good microscope. I was thus fitted to deal with most practical enquiries which related mainly to volatility determinations in film or plasticisers, and the effect of heat on films. During this period I made regular visits to my main clients, The Cellulose Acetate Silk Co., in Lancaster, Geigy in Manchester and the British Xylonite Co. in Brantham. Literature collection and preparation for the Courtaulds/Celanese case took up a considerable portion of the time, and as I had no assistance whatever, I had to type my own letters and reports. To deal with projects requiring more space, I established a laboratory at the works of one of my clients at Mitcham in Surrey, The London Capsule Co. Ltd., who were manufacturers of "Petrolite" petrol containers for smokers. Naturally my aim here was also to replace the gelatine used as container, by cellulose acetate film (Bexoid). Unfortunately the latter part of what I think of as my "solo" period was marred by illness, and this was aggravated by the war in 1939, which restricted my travelling, but it gave me more time to devote to literature collection. This gradually accumulated to such an extent that it was impossible to store it (mainly

on 5 x 3 cards suitably classified) in the space available at my home. With this and the increasing enquiries I decided to find laboratory accommodation near at hand, and to this end I purchased a house, No. 1 Ewell House Grove, in Ewell village. As my work related mainly to war-time needs, the authorities turned a blind eye on "planning", and I was given permission to use the house "for the period of the war and six months thereafter". This ended the "solo" period of my development in the Autumn of 1941, and as far as plastics were concerned was almost the end of an era. It may be opportune to digress at this point from the main theme to elaborate what I had in mind.

THE BIRTH AND GROWTH OF THE PLASTICS INDUSTRY

When I commenced research on cellulose acetate in 1925, this material was regarded as one well known but little tried, but of potential by reason of its relationship with cellulose nitrate the commercially important celluloid. Much research was devoted to turning cellulose acetate into non-inflammable celluloid but without much success, as apart from its slow-burning properties, it lacked all the advantages possessed by the nitro compound. At that time other interesting chemicals were being developed, notably phenol formaldehyde and urea formaldehyde, but it was not generally accepted that these had any basic relationship, and certainly no close relationship with the cellulose derivatives. The work of Staudinger and others proved that this was not the case; they were all complex long-chain materials, and were eventually known under the general family name of plastics, (and in the case of phenol formaldehyde "Bakelite"). Even so, although when I came to use cellulose acetate

on an industrial scale in 1931, it was still looked on as an outsider, but was gradually accepted as a plastics material, at least in certain academic quarters. At that time there was certainly no plastics industry as such, but the position was clarified with the formation of the Institute of the Plastics Industry in 1931, and the Plastics and Polymer Group of the Society of Chemical Industry in 1932. Apart perhaps from celluloid, all these materials were accepted reluctantly by industry as cheap substitutes, and they had a hard fight to gain industrial recognition. Time, and the demands of the 1939 war, changed all this, and by 1941 plastics were accepted as materials in their own right, and not just cheap substitutes for wood, metals or ceramics. In this change publicity played no small part, and my own monthly review column "Plastics" in the prestigious "Times Industry & Engineering", which I commenced in 1935 (and continued monthly for twenty-five years), together with the Pelican book "Plastics" which was published by Penguin Books, and in which I collaborated with my colleague Gordon Couzens, in 1941, may have played a minor role. The extensive sales of this Pelican served to show that it was considered the "starter-for ten" by many of those anxious to learn the fundamentals of plastics and processes, many of whom are now leaders in the industry in this country and abroad. Although this was by no means the primary aim, this publicity was of benefit to me personally as an independent consultant. The only difference was that I was now regarded as a consultant in plastics, and not merely in cellulose plastics. Such was the diverse nature of the materials and processes within what was rapidly becoming an industry in its own right, that it was impossible for one man to deal with problems and projects from all sides of the industry. I therefore decided to recruit men with varied experience

in thermoset as well as thermoplastics fields, reserving cellulose acetate for my own specialised attention. Although entirely unplanned, my decision to move into larger premises in 1941 was therefore extremely opportune, and was justified by the increase in enquiries which I soon received, in addition to my original retainers on cellulosics, film, plasticisers and laminated glass.

NEW LABORATORY - NO. 1 EWELL HOUSE GROVE

The house at No. 1 Ewell House Grove was a substantial detached building, with spacious dining room and lounge with kitchen and larder and "usual offices" on the ground floor, and corresponding four bedrooms and bathroom on the first floor. They were conveniently placed to operate a separate "discipline" in each room. The main lounge I reserved as my office and reception room, but necessity soon made a change necessary, the large room being given over to physical testing, whilst I located my control office in a small front bedroom. Initially I arranged in addition to physical testing an organic laboratory, technology in the kitchen, chemical store in the larder, and solvent store in the erstwhile coal bunker. The garage was extended several feet and housed the large operating plant which included a 50-ton Finney press, manually operated, a 4' x 2' steam-heated oven, two stainless steel 2-gallon reactors, and miscellaneous items required at the process development stage.

The various laboratories were fitted throughout as necessary with Gallenkamp prefabricated cupboard and sink units and power, water and gas were laid on. At the time I gave little thought to the matter, but in retrospect it is surprising that the power cables, which were only

designed for a private house, carried the load which was at times put upon them. A motorised flat-bed film-casting machine was built by a small Ewell engineering works, and this was housed in the physical testing laboratory on the ground floor by reason of its bulk and weight. The most elaborate unit in physical testing was a standard Hounsfield Tensometer which was power driven and adjusted for varying speeds. For the rest, the demand was mainly for glassware and chemicals; the latter included both common reagents and solvents, and those most likely to be used as plasticisers, or in their preparation.

Pride of place was given to the library in the main bedroom, the small back room serving as the general office with telephone exchange (Plan 7) installed. Library shelves provided me with exercise in simple carpentry, but proved quite efficient and at first adequate to house my literature collection, which by now had grown to considerable proportions: the card index drawers changed location to meet changing needs, but eventually found place in my office. The bathroom provided space for a photographic dark room, indeed I found photomicrographs most useful in much of my work both on film and on cellulose acetate. The keynote of the whole layout was flexibility, and indeed this continued throughout our work; apparatus, plant and space had to be arranged or changed to meet the needs of varying projects, even though these were on a small scale at the start.

THE END OF "SOLO" WORKING : I ACQUIRE A STAFF

Having secured an adequately fitted location, my next need was staff, as quite obviously I could not cope alone either with the volume or the diversity of the enquiries. These indeed became more varied and beyond the initial cellulose field as the wartime demands extended the use of plastics where metals had previously been employed. Secretarial assistance was my first need, as this released me of a chore which occupied time better spent on actual projects. The extent of the secretarial staff (with the addition of a "lab-boy"), can be judged by the fact that our first week's petty cash expenses amounted to 12/7½d.

The first major forward step came when I was able to take a young graduate as my personal assistant, Mr. C.A. Minors, who had a certain amount of industrial experience at United Insulators Ltd., and was in charge of the technological work which was gradually increasing, and a little later Mr. W.G. Grant from B.O.C., who was responsible for physical testing.

During this period much of my own work was concerned with cellulose acetate, and in particular with the production of high-acetyl material approaching the fully acetylated triacetate. In spite of the advantages offered by this material the fact that it was soluble only in a toxic solvent such as methylene chloride, prevented its progress against the conventional acetone-soluble secondary cellulose acetate, which was produced in bulk for rayon manufacture. During this period I acted as sales agent for Lansil, which was a side-step from my normal professional work, although a very profitable one. The search for improved plasticisers for cellulose acetate for film and sheet continued to occupy much of my

personal time, and proved the value of the progressive union between my three clients Lansil (cellulose acetate); Geigy (plasticisers) and Bexoid Ltd. (sheet and film).

THE DEMAND FOR PRACTICAL WORK BEGINS TO GROW

One Government project is worthy of mention, since it was in advance of its time. This was for W.A.T.E. (West African Testing Establishment), and was to determine the effect of variation of type and/or content of plasticiser in cellulose acetate (C.A.) film. It involved the preparation of a large number of films which were sent to WATE for exposure. The results showed some striking differences after treatment in the West African sun. This project extended over several years. All the film tests at the time were fundamental and simple, especially when viewed from the time gap of forty years, but they provided the foundation on which many elaborate technological developments have been based.

Some interesting enquiries came from the then rapidly advancing field of injection moulding which had been based on Eichengrün's work on cellulose acetate, but was hampered for many years by the stranglehold of the Eichengrün British Patents controlled in this country by F.A. Hughes & Co. Although initially limited to the production of small units, injection moulding of "CA", and more particularly of polystyrene, obviously had future potential.

One area of activity worthy of mention, and one which provided a number of problems, was the coating of wire net with a solution of

cellulose acetate, which was sold under the trade name of "WINDOLITE". This consisted of wire mesh of about 8 strands/inch coated with a thin layer of cellulose acetate by passing it through a solution in acetone of approximately 20% concentration. Crude solvent recovery was devised, but the economics were such that the solvent could be neglected as far as cost was concerned, but not unfortunately, as far as environmental pollution was concerned. The manufacturers claimed that the high u.v.-transmission of this material made it useful for horticultural purposes, but it is doubtful if this was really the case. One great advantage however was the fact that it could be cut to size and shape with wire-cutting snips, and this made it useful for application in pre-fab "greenhouses", and also for advertisement signs, in the days before PVC, polythene and "Perspex" took over. During the war, both wire and fabric-net based material, usually deep blue coloured, were widely used during the "black-out". Again the convenience of a readily foldable material in rolls of approximately one yard wide, was a great attraction. Having regard to the relatively thin coating of cellulose acetate (it was only a few "thou" at the centre of each minute "window"), the material had excellent weather resistance, and the "CA" provided good insulation properties and protected the metal mesh. It is of interest (and indeed surprising) that I still have some of the early material in use in my garden, and this must be at least fifty years old - so much for the doubtful weather resistance of "CA". The process had been developed on an empirical basis, so that there was quite a lot of practical work to be done, and routine quality control both of the raw materials and the finished product was essential. Thirty years ago "WINDOLITE" was almost a household word with agriculturalists, but to-day it appears to have been completely replaced by the various grades of unreinforced and

reinforced polythene and PVC.

Generally speaking, during the "forties" our enquiries kept pace with the appearance of new plastics. Industry became more plastics-minded, indeed in many cases went to the other extreme, and tended to use plastics for purposes for which they were entirely unsuited, much to their own and the materials' detriment. As the work built up, I found it necessary to take on further staff, and particularly chemists (including one qualified lady), who had had experience in specific areas of plastics technology.

The coating of fabric and wire net naturally suggested the possibility of coating fabric, as had been done with nitrocellulose for many years, in the production of what was known as synthetic leather or "patent" leather. In this field, however, cellulose acetate could not compete, as it rapidly became brittle, and nitrocellulose-based material retained its market for leather substitutes, "trunk cloth" and the like. Nevertheless it provided avenues of research which were within our broad field of operation.

Whilst on the subject of coating with thermoplastics, brief reference must be made to what was generally referred to as "flame" coating, a project which came a little later and with which we had active connection for many years. This was based on the use of the "Schori" gun, with which the finely comminuted polymer was blown under high pressure through a flame, so that it arrived partially molten on a desired surface. Complete covering and homogenisation of the coating

was obtained by surface heating with the gun, without the projection of polymer of course. The process had been successfully applied to metal powders for some years, but it appears to have been less successful with plastics, where it was limited to those thermoplastics with sufficiently low melting point which did not decompose under the subsequent heat treatment. Again this was an interesting applicational field which provided us with a number of projects, but which did not develop before it was superseded by better methods. One of these was applied particularly to PVC and polyethylene, and involved the coating of complex metal objects with thermoplastics by dipping the heated metal into a bath of powdered polymer. This adhered to the heated metal; the thickness being controlled by the time of immersion and the melting point of the polymer used. Again this was a process which though relatively simple produced a number of "snags", which provided interesting projects for our laboratories.

Among the materials which came along at this time, and indeed which occupied our attention for many years, were the polyacrylates, and in particular polymethyl methacrylate. Initially this was used as a substitute for gutta percha in the production of dentures. At first it was used only for high-class private work, but it soon became the general demand when it was used within the National Health Act. The production of the monomer, its conversion into a polymer which could be worked by the dough (Kulzer) process to give first dentures and later dentines, was a valuable area of work for our laboratories for many years. ICI had pioneered the material with their expensive and patent-protected "KALODENT", but when the material came into general use at low cost, there were many manufacturers ready to get on the "band wagon". Such

was the nature of the enquiries which came to us that we reserved our freedom in the field of dental and other prostheses, and the working of the polymer found many applications. The monomer was costly when produced by direct synthesis, but the price rapidly fell when monomer of good quality was obtained by the pyrolytic decomposition of scrap "Perspex" sheet, for which "crashed" RAF and Luftwaffe bombers provided a convenient source. This incidentally was a useful "spin-off" for research which came to us, as any impurity in the monomer was naturally detrimental to the polymer. I formed a company, together with my friend R.H. Cole, under the title Plastics Products Ltd., specifically to produce methacrylate and related polymers, but this was later incorporated in the Cole Group, my own connection being that of consultant. As in many other cases, what started as something simple became more complicated as the users became more critical, and the molecular weight, bead size and regularity and doughing time, became items of vital interest. Our work was thus partly creative research with a variety of acrylic-based polymers, and partly control and testing of commercial products manufactured by our clients.

PLASTICS AS BONDING AGENTS

Another area of our work concerned the use of plastics as bonding agents and adhesives, indeed it was the idea to produce a synthetic bonding agent which had prompted the early work of Baekeland decades before, and which led to the development of "Bakelite".

As the years of the war continued there became a growing shortage of natural raw materials, notably (apart from metals) of leather and wood. Industry was faced with the problem of regenerating scrap of

all types, and one of the problems which was put to us was to reconstitute leather and wood. The bonding of scrap leather was not easy, since the temperature necessary for this, degraded the mass, so that it became brittle and useless for the purposes in view. All our efforts in this direction were without success and were eventually abandoned.

The reconstitution of sawdust, using either PF or UF resins, was a more attractive proposition, and it proved to be one which occupied our laboratories for many years both during and after the war. Initially it was envisaged to press a mixture of sawdust or wood chips with the necessary resin in a multi-platen press, and some reasonably satisfactory products were obtained. It was one thing to produce such a sheet in sizes up to 8' x 4', but it was quite another to get industry to use them. One of our clients (Mr. W.J. Fischbein) conceived the idea of rolling the sheet out in continuous lengths between matching endless metal bands. To do this at the temperature essential to cure the resin was no easy matter, as our years of work proved. We soon found that there was as much selection needed in the geometry of the wood "particle" as in the resin binder, as reference to this project later in this history will show.

Plastics as bonding agents proved attractive to a number of engineering firms who visualised the substitution of plastics-bonded paper or fabric sheet in place of metals. Notable among these was Thompson Bros. of Bilston, long established manufacturers of tanks and more particularly of road tankers, where my friend Marshall Hutcheson the Chief Technical Manager (and later a Director), played a lone hand to introduce plastics as coatings and as bonding agents. Unfortunately his Board of Directors could only think in terms of stainless steel, in which they were leaders in the industry. The first step in favour of plastics came when they used PTFE as internal coatings for viscose production vessels for Courtaulds, where metals had proved inadequate and where the performance of the plastics lining was good.

Attempts to convince the Board that glass-fibre reinforced plastics had a future in the manufacture of road tankers were unsuccessful, and it was only after repeated trials, which eventually convinced the technical designers in the major oil companies that there was a future in this line, that some progress was made. This is not surprising since at that time reinforced plastics such as the GRP so widely used today was in its infancy, and though they were sceptical of its use, Thompson Bros. showed some courage in going so far as to produce prototype vessels in place of their conventional stainless steel. Prospects appeared good until at a survey meeting held at Chessington and attended by senior representatives of the oil companies, they realised that reinforced plastics would support combustion, and this was the end of the matter for many years. In spite of this setback Mr. Hutcheson persevered with his support of reinforced plastics, and his efforts were eventually successful, with the result that under a new Directorate, Thompson Bros. used plastics in one form or another

wherever possible. Our association and progress with this company continued until it was eventually taken over by John Thompson Ltd., when we lost contact with developments. Time has proved that our early advice was sound, and it was psychology rather than technology which defeated us. In short we were ahead of our time in this very traditional field, but the idea was well founded as subsequent development of GRP has proved.

THE LABORATORY AT WALSALL

Since in the early 40's Ewell was in the front line as far as danger from enemy bombers and particularly "doodlebugs" was concerned, I decided that for the sake of possible continuity of work it would be wise to have a second laboratory, out of the danger zone. I rented the top floor of what was then the Borough Analyst's laboratory in Lichfield Street, Walsall, Staffs. My reason for this selection was two-fold. In the first place there was the safety angle, and second Walsall was in the centre of the lacquer industry and the home town of my brother-in-law C.J. Taylor. As far as safety was concerned that was satisfactory, but my hope to get work in the lacquer and adhesive field met with very little success. The laboratory was under Dr. H. Kitchen, with Mr. Cheetham, who is still on our staff at Ashtead, as his deputy and his eventual successor. Members of the Walsall staff paid periodic visits to Ewell to keep informed of the work going on there, and to give help where necessary.

GROWING NEED FOR MORE SPACE AND PROBLEMS OF FINANCE

From the number and diversity of the enquiries which we received in the later years of the war and in the post-war period, it was evident that both staff and working space would have to be increased. At that time the former was not so difficult as there were plenty of newly or partly-trained assistants ready to enter what had then become the attractive field of plastics. As I have already mentioned, the publication of the Pelican "Plastics" in the Penguin series, together with my monthly column on plastics in the "Times Trade and Engineering", were also good publicity for our work and advice. It is of interest to note that during this period, owing to the British restriction of secret information, it was necessary to look world-wide, and some of my information actually came from the German publication "Kunststoffe", which came into this country via USA or Spain.

As staff increased, and the demand for chemicals and apparatus increased more than in proportion, the question of finance had to be contended with. From my earliest days I had worked on the basis of

financing out of income. This was relatively simple as long as I worked alone, since I took as salary all that remained when expenses and development charges had been met, and I was able to operate from my home. Things were not so easy when I had monthly salaries to meet, and rates on the Ewell House Grove to pay, but fortunately there was no rental as I had purchased the house freehold. There came a time at the end of the war when I had to change my financial basis of work from an all-in retainer to a partial retainer and/or ad-hoc payment on a time/materials basis for individual projects as they came along. There came a time also when I had to charge a "consultancy fee", usually £5 if the client came to me, or £10 and expenses if I visited the client. This was very necessary since I was selling knowledgeable time, and many clients, or I might more accurately call them enquirers, would come to see me for a talk on a specific subject without any thought that the information I was giving was worth money. By making a fixed charge (which I remitted if the enquiry developed into an actual project) I was able to protect myself from what I looked upon as "fishing expeditions", which the ICI's and BIP's of this world could carry in their overheads. At that time I made no overhead charge so had no basis on which to protect myself, other than a definite consultancy fee. I worked on this basis during the whole of our period at Ewell, always building up out of income. At the time I thought this was the safest policy, and as far as possible aimed at having two months' cash in the bank to meet unexpected emergencies. In retrospect I am not so sure that this was the best, but it was the only safe way I could see. It had the disadvantage that there were occasions where I had to turn work away for the lack of the requisite apparatus, and this I could only afford when I had earned sufficient cash to meet the demand. To have borrowed the necessary capital, either from the bank or otherwise, might have been

wiser, but when I had the responsibility of the livelihood of 12 or more assistants on my hands, I could not afford to take the risk. I felt that as long as we could pay our way and still keep the laboratories fully occupied with viable projects, this was the best policy. At any rate my "go-slow" policy worked well enough, and it was not long before I had to look for more commodious accommodation. I should have had to do this in any case as my permission to use a private house entirely for laboratory purposes was limited by the Local Council to "the war or six months thereafter". In actual fact they were very considerate and allowed me to remain long after this deadline until 1950, no doubt possibly because they were assured that our work was of national importance. Looking back I sometimes wonder how we managed, not only to survive, but to accumulate capital to provide for future accommodation. This may have been in part due to the fact that salaries were relatively lower compared with the fees which the work could command, and I had no difficulty on this latter point.

THE CHESSINGTON LABORATORIES

Alternative accommodation was less easy to find than I imagined, as for my own sake and that of my staff and clients, I wanted to remain as near as possible to Ewell and of course to London. Thus the search was a matter of years rather than months, before I found a suitable solid 3-storey Victorian house, "Oaklands", at Chessington, Surrey, with 2 acres of ground providing for possible expansion. To obtain planning permission for change of use was not too difficult, especially in view of the fact that it fell within two Boroughs, Esher on the West and Surbiton on the East.

Since the subsidiary laboratory at Walsall had not proved as successful as we had anticipated or hoped, it was decided that as this was on a short lease, we would move the whole operation on to one location, and in the end we settled for "Oaklands". The property included a gardener's house, which would prove useful for a caretaker, and it was on the edge of open country so that, on one side at any rate, we should run no risk of trouble to neighbours. In this case I purchased the freehold of the property out of my carefully accumulated "savings", so that we were our own masters and had no landlord to deal with, which was a good advantage, as it proved in the long run, as we had to make so many changes in the layout and structure to meet the ever-changing needs of our projects. One advantage, which we did not fully appreciate at first was the fact that Chessington via Surbiton was only twenty minutes from London by fast train (of which there were many) so that for staff or clients, travelling time was cut to the minimum. The Ewell property was sold advantageously and this provided a useful basis for the outright purchase of the new location, and in due course the complete equipment and staff of 15 transferred to Chessington. It was only when the move was made that we realised just how much plant, equipment, sample materials, records and literature we had accumulated during our ten years at Ewell. Indeed we were horrified to see the danger to which we had been exposed there, since the loft was used as a general store, and contained a large number of samples of nitro cotton from which the methanol "damping" had long since evaporated. Mercifully that particular spot escaped Hitler's fire bombs, as otherwise the proverbial "Roman candle" would have been nothing by comparison.

At Chessington we had the problem of Ewell over again only on a much larger scale. In addition the house had no electric supply and heating was difficult, so the first problem was to have the place wired for light and power, and to instal central heating. In a way this was an advantage, as we were thus able to deal with this dual problem specifically for a laboratory, and did not have to modify domestic layout. I employed a London architect but was unable to accept his suggestion of a glass front and spiral staircase, and adhered to the not unattractive Victorian front and spacious staircase.

To turn the old house into a practical working laboratory was a fascinating problem. As at Ewell, we proposed to segregate the various laboratories according to the type of work to be carried out. The rooms were large and well connected, and although the hallway and landing took overmuch of the total volume, this was later reduced and put to useful purpose. The hall at any rate, together with the porch outside, provided an attractive entrance and reception space. In addition to the three large ground-floor reception rooms, which were allocated as library, general office, and an operations laboratory, there was a large one-time billiards room which was excellently suited for a general organic laboratory, particularly as it was single floor, and had direct access to the garden. One large room (the original "best" bedroom) was taken as the Board Room and main admin office, whilst two smaller bedrooms were made into one long room to house the whole of physical testing. The second floor, approached by a secondary staircase was reserved for miscellaneous operations, and these were quickly found and put to good use (including some physical testing), even to using the space round the large-capacity water storage tanks.

The original servants' quarters, kitchen, larder, scullery, coal store, needed a certain amount of attention from the builder, but this was not very difficult. Further space was obtained by building out on the coal store to give extra space with foundations sufficient to take a second storey should this be necessary at a later date. The whole of these "servants" rooms was allocated to technological work and housed hydraulic presses, hot twin rolls, drying oven, ball mills etc.

Planning of the new accommodation was an easy matter; to carry this out was not too difficult, with the aid of a London contractor at first, but later more usually with a local builder. With no disrespect to the architect we found we could get along better without him, since we worked quite empirically making our layout as flexible as possible, so that it could be quickly changed to meet the needs of changing projects. Plumbing was somewhat of a difficulty to give adequate water and vacuum-pump points, and the same applied to gas, where our demand was much greater than the original domestic layout, and we had to have an extra large meter located next to the oil-fired heating boiler which had been installed in the spacious cellar. In prospect the move appeared a daunting one, both physically and financially, in actuality it was not too difficult, and ultimately we were able to take it in our stride without dislocating the flow of work which was our means of livelihood, and which was continued as unbroken as possible at Ewell and Walsall. In the meantime we found a caretaker who, with his mother and spinster sister, took up residence in "The Lodge", and gave valuable assistance in some of the initial cleaning up work before the builders got going. This was Mr. Len Pigrome and his sister Winnie, and it is a pleasure to say that they gave us loyal and efficient service until they retired

indeed until long after the operation at Chessington was terminated. Len, as he was always called, was particularly helpful during the transfer from Ewell, since many of our early plans had to be changed, and Len was there to see that they were put into operation practically. He also had the task of making what had once been partly the garage, into a habitable unit designated "The Lodge", and to protect the property generally in non-working hours.

The transfer from Ewell was gradual and over a period; as already stated it was necessary to keep our work going whilst the change was taking place. That this was possible was largely due to the co-operation of the staff, following the practical lead of Mr. Unsworth who had been in charge at Ewell, together with Mr. Minors, Mr. Shelton and Mr. Ives, who were responsible for various sections of the Ewell work. Looking back it is surprising that the transfer to Chessington went forward so smoothly and, as at all other times, the expense incurred was met from our daily work without any assistance from the Bank Manager. Fortunately the property market was on the up-and-up, and I was able to dispose of No. 1 Ewell House Grove very satisfactorily, in spite of the fact that it would take some time before the chemical atmosphere returned to normal, to say nothing of the small garden which had for several years provided a useful "grave yard" for polymerisations which had gone astray. No serious complaints were received, so that presumably the new owners were able to cope with the polymeric residues, and no doubt the neighbours were pleased to see us depart and to breathe pure air once more, air which was free from what my neighbour termed "strong vinegar", but was actually acetic anhydride/ acetic acid.

PROBLEMS OF WORKING ON THE NEW LOCATION

The transfer was eventually substantially completed, and we were down to work on our new location in March 1950, together with most of our Ewell staff who lived conveniently near to make the daily journey. Further staff were recruited, and fortunately in those days "plastics" was an attractive field to many chemists and enquirers, even though plastics as such were still not looked on with favour by industry generally.

Early in the occupation of the new premises we were faced with an unexpected difficulty - food. Chessington (Hook) in the 50's was a very small village and there was no reasonable restaurant or snack shop, so at the start sandwiches were the order of the day. It was here that Winnie Pigrome came to our assistance, by providing hot mid-day meals (meat and 2 veg) in "The Lodge", which the "customers" collected and carried across to the main building where the dining room on the ground floor (now the library) once again functioned as such, although possibly it had never served so many and varied customers. Morning and afternoon tea were produced in the various labs or at central points in the offices, although I never favoured having food in the laboratory from safety and health reasons. Lunch over, the library once more took over its normal role and work proceeded, and thanks to Winnie the "customers" appeared happy and the charges were moderate. Expenses generally were reasonable for staff who did not have their own transport; a few pence into Surbiton or Ewell and a shilling or so up to Waterloo. As I have already mentioned, this facility for travelling from Town was a great help to our clients, many of them coming from the Midlands or North of England, although there was initially some confusion between Hook Surrey, and Hook, Hants, near Farnborough.

Although we were able to keep the work flowing during the time of transfer, it was naturally some time before we had everything in place as we needed it for fully operational work. The most significant change was in physical testing which had grown considerably and was well organised by Mr. Ives. New Gallenkamp or Cygnet sectional benches and sink units throughout the building made all the difference, and the laboratories soon took on an attractive appearance and really "looked the part". Miss Chadbund who had come from the Walsall lab to Ewell now acted as general secretary and cashier, and paid the wages to weekly staff each Friday. Many of the staff worked on a monthly contract basis, others preferred weekly pay, and as there was nothing on account of Saturday morning work at first, this made little difference. Official working hours were 9 - 5.30 p.m. with Saturday to 12.30 p.m. but in practice working hours were very flexible and frequently depended upon when a condensation, pressing or what-not was completed! Those were the days when the work was dominant, time was subsidiary.

The transfer from Ewell to Chessington went quite smoothly over a period of several months, and as we did not have to clear the old location against a specified time, it was possible to transfer apparatus and personnel as the projects in hand demanded. Fortunately Mr. Unsworth, Mr. Ives, Mr. Minors, Mr. Dean and Mr. Shelton, together with other assistants and the secretarial staff, moved at the same time, and Miss Chadbund who was lodging in Ewell, was able to take over the accounts and some of the office work.

The disposition of the various departments as operational units in the new premises worked out much as we had planned, and this, together

with the fact that much of the transfer time was voluntary, made it possible to keep the projects working without serious interruption. The building extension to the old kitchen was completed, and it was not long before the greenhouses on the North wall of the garden were converted into laboratory working space without, it must be admitted, planning permission. In spite of the fact that in the main, except for the rear wall, these were single-brick structures, they made excellent ancillary laboratories right up to the end of our occupation of the site. In this process the elegant walnut tree, the vine (supposed to be an offshoot from that at Hampton Court), and in due course the tennis court disappeared, and the whole site took on a workmanlike appearance, in spite of the fact that much of the layout was made piecemeal.

INCIDENTAL PROJECTS

During this period the work came to us from a number of unexpected quarters, some of it having no connection with plastics. An example of this was the preparation of "bubble solution" which came from my retainer with the Ealing and Pinewood film studios. This was glycol-based and was prepared in large solvent (40 gal) drums, and transported to Ealing, whence it was taken to various locations where it was used for publicity purposes. Most of the "soap" bubbles which were blown out into Piccadilly Circus were from the solution we prepared. Personally, I was not attracted to the project as I thought it was "debasing the image" so to speak, but as long as we could get the raw materials (and the film studios had ways of doing this), we continued to produce, and the financial returns were, by comparison with our routine projects,

quite handsome, and came at a time when the laboratories needed all the capital I could spare to make them operational.

Another interesting project which came to us about this time from Doulton Ltd., was again a side-step from plastics, though related thereto. This was an attempt to extrude a mixture of a plastics material with the conventional ceramic "pug", or to injection mould it into the desired profile, and then to fire the mass, thereby regenerating the ceramic, minus the plastic "flux". The concept was an interesting one, and although it had a measure of success in the laboratory, it was never a commercial possibility as far as we knew.

THE NEED FOR ENGINEERING FACILITIES AND OTHER PROBLEMS

Although the new set-up at Chessington gave us increased facilities, these were almost entirely chemical, or physical testing, and we depended for any engineering service on James Boniface, a very efficient retired engineer, together with outside help. This again brought us up against the problem of space and engineering plant capable of giving the service we required. To meet this need we erected three "Cranleigh" prefabricated concrete buildings (60' x 40'), side by side, where the tennis court had once been, with space between which was covered in to give yet more space at a later date. Having the space, we acquired light engineering plant, with the necessary operating personnel. The electrical side of this work was also important and we were fortunate that Mr. Ray Bradley, who was in charge of the electrical installation in the main house for the electricity authority SEEBOARD, decided that he liked the look of our set-up in preference to his supervisory appointment with SEEBOARD. This worked very well, so well in fact that Mr. Bradley holds a senior position in the YTEC laboratories

today. Much of this early engineering work required preliminary drawings, and even though we were at times able to chance our arm on the basis of rough sketches, engineering drawings were often necessary, so much so that at one time we had five drawing boards manned by qualified draughtsmen, which occupied almost half of one of the "Cranleigh" buildings.

I have already referred to some of the early difficulties, namely the provision of food for a growing staff. For some time the library doubled as a dining room, and the food was cooked by Winnie in the small kitchen in "The Lodge". In a relatively short time the staff had increased to 50 and to provide a hot mid-day meal for such a number was beyond Winnie's limited facilities. We decided to purchase prefab buildings, relics of the war, which were being demolished at the time in East London, to make way for permanent blocks of flats. They were functional rather than beautiful, the main difficulty was where to locate them. The obvious position was next to "The Lodge", but this was in the Surbiton sector of the ground, and the Surbiton Council pressed us to put them in front of the house, which was in the Esher sector. After much negotiation, logic and good planning prevailed, and two units of the prefabs were transferred from the East End of London and erected in "L" formation next to "The Lodge" in the Surbiton area. This provided not only a "canteen" and the necessary kitchen, but added office space if necessary, a "ladies' room" and conference rooms. The demolition, transport, and the re-erection of these buildings was not an easy matter as they tended to fall apart rather than fix together. These buildings were completed in due course, and the driveway from The Lodge and canteen was re-styled with a second gate to the main road to facilitate "in" and "out" traffic, so that the front garden with its roses and rhododendron

bed made an attractive approach to the main house and easy access to The Lodge. The canteen, with the three "Cranleigh" buildings and the completion of the laboratories in place of the greenhouses on the North wall, gave us adequate space, and it only remained to provide a solvent store and open-air bay for drums in the middle of the garden area, and as far away as possible from our own and neighbouring buildings. As I have already said, the whole layout was essentially functional both outside and inside, and at that time we had the problem of a cycle store rather than a car park, which came later. This preliminary work had extended over several years in the early 50's, and in the meantime the in-flow of work had continued so that we were able to cope with the constant expenditure, the "control" of which was in the hands of Miss Chadbund. Having joined the Walsall staff in 1946, Norman Cheetham, together with his assistants Eric Dixon and Reg Williams, moved to Chessington with all the plant, apparatus and chemicals from Walsall in 1950, so that for the first time we had a working entity on one location, which greatly facilitated inter-discipline communication. It is interesting to see to what extent this was synergistic, the whole unit operated more efficiently and profitably than had the separate units apart, and this I am pleased to say continued with good will of the staff, through the whole period of our time at Chessington. It is interesting to look through my visitors' book at this time, to see visitors from firms totally remote from plastics who came to us for advice and experimental work. Much of this was in the nature of feasibility work, but quite frequently we took the laboratory stage on to the plant, either at the client's factory or in our own now considerably expanded operational space.

The following years proved the wisdom of our early decision not only to increase space to a maximum, but to increase our engineering and drawing office facilities. Very soon our enquiries took on an engineering bias, we not only had to supply compositions and suggest materials, but to prepare prototypes so that our clients could actually subject the products to test and customer approval. We now had facility to build what in some cases were full-scale units, so that these could be transferred to the client's works in toto, as I shall describe later. In addition to a number of ad-hoc enquiries we still operated on a retainer basis, but this was only in the sense that we worked for one client in one particular area of development, but charges were made for all work carried out by our staff, and provision was made for overheads which, including power, heating, etc., now amounted to a significant figure. Most of the junior staff were paid on a weekly basis, senior staff monthly. All work was strictly confidential to each client, hence the need for exclusivity in some retainers. By 1958 we were retained by 29 clients, among them some names significant in manufacturing industry; some of them have since merged with other companies so that they no longer exist as we then knew them.

THE GROWTH OF PHYSICAL TESTING

During the early 50's one significant change took place in our work which is worthy of mention; this was the increased demand for physical testing. Fortunately we had anticipated this in our initial allocation of space, and under the control of Mr. Ives physical testing paid for itself, and was a supporting service to much of our other work. Such was the

growth that the space need was very soon apparent, as will be recounted later. With the increased demand in this and other areas came the need for more and better apparatus. In a few cases this could be charged to the work in hand, but in the main it was self-financed, a method which I have already stated we had continued from our earliest days at Ewell. Another change taking place at this time was the gradual broadening of our areas of operation and we were no longer limited to plastics, although this provided the main basis other than for physical testing. One logical extension which was related to plastics was the testing and analysis of oil and oil products, and here again reference will be made to this later in this narrative. Looking back over a time-gap of nearly 30 years it is difficult to say what happened when; the former is easier, but generally speaking I have endeavoured to trace the continuity of events, even though in some cases this has meant a little repetition. During the whole of this time the staff had gradually increased and we were joined by Mr. Goodchild, Mr. Riley, Dr. Frenkel, Dr. Barb, Mr. Flavell, and Mr. Redfearn, Mr. Titow, and Mr. Mikucki in the 1952-53 period, to mention but a few of the senior members. I had hitherto taken personal responsibility for all financial aspects, down to the point of negotiating personally with the Inspector of Taxes, who I found very helpful on many occasions, particularly in allowing as capital expenditure all glass apparatus and consumable chemicals.

FORMED DR. V.E. YARSLEY (RESEARCH LABORATORIES) LTD. 1950
CHANGED TO YARSLEY RESEARCH LABORATORIES LTD. 1962

There came a time however when I thought it wise to form a limited company to spread the responsibility, and this I did in July 1950 with the assistance of Stanley Spofforth and Mr. R.J. Williamson MBE, under the title of Dr. V.E. Yarsley (Research Laboratories) Ltd., with myself as sole Director and Mr. Williamson as Company Secretary. Current finance, including payment of weekly staff and the ever-increasing materials and service bills, was still in the hands of Miss Chadbund. During this period the extent and diversity of the enquiries showed that the Chessington venture had paid off, and our enquiries, or "E-numbers" as we called them, increased. Some of the early records have been lost, but in 1957 we had already reached E No. 4100. To cope with increased work load we took on more staff, and were joined by Dr. W.C. Webber, who had recently retired from Shell, in 1960. This growth and the consequent changes needed a revision of our basic structure, and was effected in a change of name to Yarsley Research Laboratories Ltd. in 1961, with myself as Chairman, Dr. Webber Vice-chairman, and Directors Mr. Flavell, Mr. Ives, Mr. W. Toft (representing I.C.F.C.) and Mr. Birrell. who joined us on his retirement from B.X., with Mr. M.W. Henderson as Company Secretary, Spofforth and Company with Mr. Williamson, accountants and auditors.

The continued growth of the physical testing section encouraged me to separate this from the plastics and technological work, and to form it into a separate subsidiary in 1955 under the title of Dr. V.E. Yarsley (Plastics Testing) Laboratories Ltd., changed to Yarsley Testing Laboratories in 1961. This gave emphasis to both the title and the function, and made the assessment of the working and profits less complicated. Emphasis was given to this and to the overall basic

structure of the laboratories in the annual report I issued in August 1961, and I think I can advantageously quote from my report issued to the shareholders. These, I should have mentioned, included a number of the staff, and the £1 shares issued at a premium of 10/- and subsequently adjusted by an allotment of 1 for 2, may be taken as an indication that the staff had faith in the company and were ready to back its future. This I may emphasise once again, was the first time that outside capital had been brought into the company, and it is gratifying that a substantial number of shares was taken up by the prestigious I.C.F.C., which I think I am correct in saying, was supporting a purely research (as opposed to a manufacturing) organisation for the first time. Although Yarsley Testing showed an overall profit, after writing off all preliminary expenses, of only £79 for the first sixteen months of working, it was at least an independent start, and was definitely indicative of future potential. In my 1961 report I said :

> "The Shareholders are aware of the reorganisation of the Company which took place last November, when the Industrial and Commercial Finance Corporation Ltd. financed the purchase by the Company of the property, plant and fittings and in addition took up 40% of the increased shareholding. At the same time Yarsley Testing Laboratories Ltd. became the wholly-owned subsidiary of this Company, and additional Directors were appointed to the Boards of both Companies. As this reorganisation took place during the financial year under review any comparison of the results of this period with the previous year would be misleading. Nevertheless, the past year has been an encouraging one, and I am sure you will agree that a Group profit before tax of £25,487 is satisfactory. I am very pleased that we have been able to recommend a dividend of 10%, but as this is on capital that has been subscribed for only half the year it must not be regarded as setting a precedent for a similar rate of dividend in future years.
>
> Without being complacent and making due reservations for the difficulties of the time through which we are passing, I think the immediate future is promising. In spite of the adverse economic conditions, orders continue to flow in: we have currently a number of long-term contracts from United Kingdom Government departments, work is being

sponsored by the United States Army, and two large contracts from an American commercial organisation were recently obtained. In addition, negotiations are nearing completion for a joint venture by Yarsley Testing Laboratories Ltd. and a firm of oil surveyors for the analysis and testing of petroleum products. We hope that this will provide a steady flow of work for our subsidiary. We are therefore looking for additional laboratory staff at all levels and are seeking to enlarge the laboratory space available. The shortage of space is presenting us with a problem as the "Oaklands" site does not allow room for very much expansion. We are endeavouring to circumvent the difficulty to some extent by making better use of the space available, and to this end we have made a start by fitting out the technological extension as an organic research laboratory. To relieve the pressure on administrative space we have purchased a house in Clayton Road to free the "Lodge" for office use, but the local planning authorities have refused to grant permission for the change. This matter has now gone to appeal.
We are pleased to welcome Mr. T.L. Birrell who joined our Board on July 1st, 1961 and I am sure that his knowledge and experience of the plastics industry will be of considerable benefit to the Company. Mr. Birrell has spent many years in the industry and before joining us was Managing Director of Halex Ltd."

OIL TESTING : BRETT YARSLEY SERVICES : TESTING MOVED TO ASHTEAD

In spite of the fact that the move to Chessington had given us more space, and the organisation generally had benefited by being on one location, the space requirement was soon pressing again, particularly as the increase in enquiries persisted and more staff had to be taken on to cope with this. Some measure of help was given by partitioning off parts of some of the larger rooms, and moving part of physical testing (which at the time was the main growth area) up to the second floor, the original servants' quarters. The space need was intensified in the early 60's when our work on the testing and analysis of oil products resulted in a partnership between Yarsley Testing Laboratories Ltd., and Caleb Brett & Son, with the formation of "Brett Yarsley Services" in 1961, following discussions between Mr. Ives and Keith Brett. Brett's had the connections but no laboratories, we had laboratories and experienced staff but lacked connections.

It was soon quite clear that the Chessington space having been used to the limit, some extension would be needed, and this would have to be on an outside location, which we were anxious to avoid, as it would inevitably complicate administration and to some extent hinder the interdepartmental service which we had used to this point to such good purpose. In actual fact our problem was a dual one as not only did we need more space for YTL, but also for its off-shoot Brett Yarsley Services, which had already installed its first octane rating machine on the Constructors John Brown research site at Leatherhead, Surrey.

Fortunately we were able to solve both these problems when in 1966 we took a long-term lease (as it appeared at the time) up to 1987, on part of a one-time phenolic moulding factory in The Street at Ashtead. These

premises were in a very dilapidated condition but the 16,000 sq ft was just what we wanted, and although the cost of refurbishing, fitting with bench and sink units, and the subsequent move from Chessington exceeded our original cost estimate, the move was a wise one. I had always been of the opinion that there might be a time when the demand for external research and development might diminish, but with the plastics (and other) industries becoming more quality and standards conscious, the need for testing would increase. This indeed proved to be the case, and although the initial years of YTL at Ashtead were difficult and costly, the wisdom of this "side-step" was never really in doubt. At about the same time it was clear that the same applied to the "fledgling" Brett Yarsley Services, and this company moved to a small factory block at Leatherhead to join the octane rating machine already there. I emphasise "small" because it enabled the entire working of "BYS" (as it was called for short) to come under one roof. At Ashtead, we now had adequate space to instal a Denison tensile testing machine, and an E-type "Tensometer", both of which were large units by laboratory standards. Ashtead had the added advantage that we could set out for show as well as for use, the very considerable and attractive instruments and general apparatus which we had acquired in the meantime. Here also we were able to allocate adequate space (or so it appeared) to thermal testing and the actual building of thermal conductivity units, some of which we actually exported. Very soon YTL made a name for itself in the thermal testing field, thanks largely to the efforts of Mr. Riley backed by generous assistance from the N.P.L., who no longer continued to offer routine testing in this field.

FIRE TESTING ESTABLISHED AT ASHTEAD

The extra space also enabled us to enter a new field of considerable potential, which was inadequately catered for in this country, namely fire testing. Here again the units conforming to British Standards were large, so we started with the relatively small spread of flame furnace. Again our forethought paid off, as with the growth of quality control, the need for tests of flammability as well as heat conductivity increased. The cost of fitting YTL with the necessary apparatus and laboratory furniture was quite considerable, but it was gradually absorbed in the overall working of the organisation, and the removal to, and refurbishing of the new site, was phased to ease the load somewhat over a period 1966/67. Strangely enough for once we had too much space, and the single bay which was unoccupied earned its quota as a store for an outside company for several years until our own needs, following the subsequent vacation of the Chessington site some years later, made it necessary for our own use. At this time our total staff had increased to 140 - 150.

YRL EXPANDS AT CHESSINGTON

These extensions were excellent but for one defect, it meant that the organisation was now on three locations, and although the new premises at Ashtead were only seven miles from Chessington and two miles from Leatherhead, this decentralisation had its disadvantages. It was however fortunate in one respect, in that most of the staff lived conveniently near, so existing staff could remain with us and the increase in work which followed these moves could be catered for by new staff. Meanwhile back at Chessington the Yarsley Research staff had been able to "spread its wings" a little, but with the growth of enquiries over-all, and the

need of some of these for larger and specific apparatus and plant, the provision of little "cubby holes" which we graced with the designation of "offices", the old house was soon working to capacity including the top floor (attic) and the outside building additions. It is possible that where YTL suffered temporarily by the change in location, YRL gained. 1966/67 was indeed a critical but difficult period, and it was characteristic of the goodwill and spirit of the staff that the difficulties were smoothed out. Albeit the little group was on three locations, 'YRL', 'YTL', and 'BYS' worked together, in spite of the fact that there were some occasions when members of the staff were inclined to take the view of "we and they", especially when there was a question of capital expenditure, in what was an increasingly capital intensive operation. Advantage was taken of the move of YTL to Ashtead to rationalise the overall working plan of YRL at Chessington. For some time it had been apparent that there were disadvantages in the departmental system, and in order to foster closer co-operation among staff of varying disciplines, the departmental boundaries were (metaphorically) removed, but preserving the broad chemical and applicational bias overall. This reorganisation (if it can be so called) was strengthened in 1967 by the appointment of Mr. Flavell as Assistant Managing Director, and of Mr. L.W. Turner as a Director of YRL. During this period YRL work continued to flourish, and we obtained some worthwhile contracts from the USA, which to some extent compensated for the fact that some of our U.K. Government contracts were coming to their logical conclusion. Some of the YRL projects were long-term and were able to profit by the increased space made available.

Some of our work was covered by British and foreign patents, but according to our method of working, these were immediately assigned to the

sponsor where they came under the "retainer" heading. Patents were also taken out to cover many of our own developments, but in the main we lacked the capital and opportunity to bring these to financial fruition. Reference will be made later to a number of our larger projects, since these are of technical as well as historical interest. It is significant to note that many of our ideas and developments which failed to make the grade at the time (including my own particular favourite "triacetate"), have since proved successful as money spinners. To some extent, and in many directions, we were ahead of our time, and were no doubt frustrated in part by the fact that we operated an exclusive "retainer system" in the main, a method which for lack of capital I had been forced to operate in my earlier days. As the retainers expired, either because the company or the project reached its inevitable end, we took on more ad-hoc project work, which fortunately came our way in reasonable quantity. Up to the late 50's we waited for the work to come to us, and we generally found that our record was a good one, and satisfied clients brought other work our way or gave us recommendation. It is regrettable that professionalism still persisted, and as a Fellow of the Royal Institute of Chemistry I was not allowed to advertise. I fought against this but was over-ruled by the then President, himself a Consultant. Eventually this rule was relaxed and we were able to publish a very modest brochure to tell the industrial world what we were and what we could do. To some extent we had for many years side-stepped the rule by the publication of our monthly technical survey under the apt name of "POLYMERICS". Designed originally for myself and staff information, this was widely published and although not a money spinner, at any rate paid for itself, and reached its 100 issue in 20 years. This publication and the very appropriate name we coined for it, has since been discontinued, but the specialised section on "Additives" still continues, and its circulation is steadily increasing.

In spite of the fact that by the late 60's, plastics were still only partially trusted, there was growing tendency to use them in place of wood and metal. Personally I had always had faith that plastics would eventually take their rightful place as engineering materials provided they were correctly applied, and that design was in, and for, plastics. To endeavour to develop the structural side of the industry I formed a company under the name of "Structoplast" Ltd., together with my friend Mr. H. Bridgwater, of Bridgwater Bros., contractors. My hopes here were never realised, as the company was clearly the poor relation of the main construction business of Mr. Bridgwater, and he eventually absorbed 'Structoplast' in his group of companies.

B.Y.S. LABORATORIES LTD. FORMED

Progress continued through the late 60's on the three locations, and fortunately sufficient work came along to maintain the staff, which had grown to about 150 at the peak period. At the end of 1966 Brett Yarsley Services was overpressed with work and appreciated the extra space it had acquired, which enabled it to put down a second octane rating machine. About this time also the relationship was strengthened by the formation of a company B.Y.S. Laboratories Ltd., with the partners Caleb Brett & Sons and Yarsley Testing Laboratories having a 50/50 holding. Throughout these chaning times we were fortunate in having a loyal staff. From time to time we lost some of our good men (and women), frequently the change being that they went to the client for whom they had been working, which in some cases meant that we lost both man and client: this was of course a risk we had to take.

Working conditions were improved at Chessington which was throughout the centre of operation, and after disputation with the Council, Miss Chadbund was located in the small room in "The Lodge" which was of course technically a "change of use". Eventually, as already stated, the Lodge was given over entirely to the information centre with Mr. Shelton in charge, and Miss Chadbund and Miss & Mr. Pigrome moved into the house opposite, No. 139 Clayton Road. In view of all the changes taking place within the three companies, it is not surprising that profitability was lower, and indeed it reflected the conditions in industry, particularly in plastics. In 1969, following a reorganisation within Caleb Brett & Son Ltd., they offered to purchase our 50% holding in the oil testing company, which we accepted. Although now separated each had the possible assistance from the other, although YTL had little call for oil analysis or examination, it being more logical to go direct to Brett. A sad consequence of the union with Brett was that Mr. Ives left us to take charge of the new and enlarged venture. We were sorry to see him go to become Technical Director of Caleb Brett as he had been with us from the Ewell days, and was one of the early recipients of the 20-year presentation (usually a wrist watch), about which I shall make note later. I am personally grateful to Mr. Ives as head of YTL and a Director of the main company, for the valuable assistance he gave us through all the difficult years, and I am pleased to say that this friendly and cordial relationship between us has been maintained.

Although we were never actually short of work in YRL and YTL, the day of the long explorative contracts had gone, and at the end of the 60's many companies were doing much of their own research "in-house", and of course the vast volume of data and general information published world-wide on plastics, rendered outside work such as ours unnecessary to some degree. To counter this we adopted the policy of friendly collaboration with organisations, independent like our own, but specialising in other branches of technology, so that there was no danger of competition.

Our first experience in this direction was not a very happy or successful one. We took over the chemical and chemical engineering sections of Sondes Place Research Institute of Dorking, which was a diversionary subsidiary of Steel Bros., Far East Trading Merchants. The more active and profitable testing section was retained unchanged by Sondes. A number of the staff moved from Dorking to Chessington, and reciprocally some members of the Chessington staff went down to Dorking as was necessary according to the projects in hand. This change gave us a certain amount of added space and some large-scale plant units including a Niro laboratory-size spray dryer of Danish manufacture, which was a useful supplement to the laboratory unit which was already in operation at Chessington. This was useful in that it gave us the possibility of carrying out full-scale trials for clients, whereas we had hitherto been able to work and evaluate only on small quantities. We also transferred to Chessington the Sondes very ancient X-ray unit operated by Mr. Gale, but this was of limited use to us. In actual fact Sondes had very little to offer in the way of new or extended projects, and one by one the adopted staff left

Chessington, so that we were left with little more than the extended space for large-scale trials. By contrast the Sondes testing section had continued to expand, largely on the basis of such projects as extended tests for "Which", and as this needed more space, it was agreed that it would be more to the advantage of Steel Bros. to take back the space we rented, rather than to embark on new buildings specifically for testing. By mutual agreement the arrangement with Sondes was terminated, although several of the staff remained at Chessington for a short time. The large Niro spray dryer, which was actually on loan to Sondes, was taken back by the manufacturers, and once again we had to depend on our small-scale unit which was sufficient for most of our needs. Although this diversion was in itself a failure it had the effect of making our policy more out-going, and fortunately did not detract from further activities of a similar nature, as was soon to be seen.

About this time significant changes took place in our organisation. When Mr. Ives left us to take charge of the Brett company, our former associate, and the one which he had done so much to establish and develop as already stated, we took the opportunity of this change to make re-arrangements in our organisation to give a closer degree of integration between 'YRL' and 'YTL', by giving Mr. Flavell and Mr. Henderson executive responsibility for both companies. They were appointed to the Board of YTL together with Mr. J.A. Mead who was also appointed as General Manager of YTL. Mr. Turner was relieved from his technological executive duties to enable him to devote his full time to developing new business for both companies, effectively to act as Sales Director for YRL and YTL.

We had already established a working arrangement with the Fulmer Research Institute of Stoke Poges, which was the leading R & D organisation in the field of metals and ceramics, was well based, and had an excellent reputation both in the U.K. and abroad. Following the initial suggestion of closer working together, several meetings took place between Dr. Duckworth, Mr. Flavell and myself, which further emphasised the logic and practicality of the proposal for a more active collaboration. Both organisations were members of the Association of Consulting Scientists (ACS), and were in complementary fields of technology. Furthermore Fulmer had done work in plastics and had ideas to extend this, a move which some form of closer working with Yarsleys would render unnecessary. Collaboration between the organisations had proved to good purpose in the case of some multi-disciplinary projects, where Fulmer's expertise was of valuable support to work which was essentially in the plastics field. In any case the logic of a possible collaboration, even to the extent of a merger, was emphasised by the difficult and changing conditions in industry in the early 70's.

The far-reaching survey of research in the U.K. which followed the publication of the Rothschild and Dainton reports, caused a critical re-appraisal of research generally in the U.K. in Government, academic and industrial sectors. In the case of the last in particular, this had resulted in some of the larger firms making a curtailment of "in-house" research, a circumstance which could indeed react to the benefit of the independent research establishments,

A further stimulus in this direction was anticipated from the NEDO report published at the time, which drew particular attention to the need for "greater attention to research and development".

FULMER AND YARSLEY RESEARCH MERGE : 1973

It was opportune that at this time the Yarsley working showed improvement. This was particularly the case of YTL which had a difficult start, but where current progress justified my original feeling that independent testing should increase, even though research and development might not show the promise of such a future. It was a great personal pleasure therefore to see that in our very friendly discussions with Dr. Duckworth, Yarsleys were not negotiating from a position of weakness, which was good for both sides. The decision was not an easy one, but eventually it was agreed that Fulmer (which was owned by the Institute of Physics) and Yarsley should merge, a decision which was supported by both Boards and by the Yarsley shareholders, and finally became effective at the end of April 1973, rather an appropriate time as May 1st was the Yarsley "birthday". For my own part I can record with pleasure the friendly nature of all our negotiations with Dr. Duckworth, and in particular the fact that the proposed merger would link YRL with an established organisation of outstanding prestige, and one working in a complementary field of technology. The proposed combined organisation could thus claim to be expert in the whole field of materials science, metals, ceramics and plastics. One result of the merger was that the Chessington property, land and buildings, into which we had put nearly 25 years of hard work, did not form part of the arrangement, and had to be closed down. It remained a separate entity and an asset for the shareholders in the Yarsley organisation. For the disposal of this property a separate company was formed, B.T.Y. Properties Ltd., these being the initials of the three directors, Birrell, Toft and Yarsley. The new Fulmer/Yarsley organisation took over a portion of the Ashtead lease up to 1983, on the basis that this would give adequate time to

establish the joint working on a completely new site capable of extended development. This left a small portion of the lease up until 1987 which has recently been taken over by Fulmer, thus giving time to consider future plans for expansion, and security for the staff at Ashtead. I was appointed a Director of the Fulmer/Yarsley organisation at the time of the merger.

It was relatively easy to agree such a major change on paper, but there was more to it to put this into operation. As I have mentioned already, the "FOR SALE" board went up on the Chessington property. It was subsequently purchased by the Kingston Council, and it was with sorrow that I saw this fine old Victorian house demolished, whilst the outbuildings including 'The Lodge' were retained.

YARSLEY RESEARCH LABORATORIES LTD. MOVED TO STOKE POGES

The dispersal of the operational sections from Chessington was not an easy one, since a large volume of records and literature together with plant and apparatus had to be re-located. Fortunately it was possible to do this stepwise, as "BTY" did not insist on the originally agreed date of transfer. Arrangements had to be made to cope with this influx at Stoke Poges and Ashtead, and the final solution appears to have been the logical one. It had originally been planned to accommodate the organic chemical work in a new building at Stoke Poges, but this space was allocated to other activities, and a temporary new Cranleigh building was erected as a chemical laboratory, under the control of Dr. Jappy and Mr. Atkinson. Part of the heavy plastics plant went to the "Foundry", with Mr. Mugridge in charge,

where space was provided to receive it. The work on coatings and polymer technology under Mr. Mikucki, was housed in a small laboratory in the "Yarsley" building. The housing of the library, records and journals was not an easy matter, and Mr. Shelton who was in charge of this section, was hard pressed to house even the most essential of his long collected treasures. Some of these had to be discarded including the C.I.O.S. and B.I.O.S. reports, which recorded the German war-time technology and which we had found of so much use in our early work at Chessington. We were clearly in a new era in plastics, and under the ever constant demand for space we had to take the forward rather than the retrospective view, and in many cases, sentiment and memories of the past had to be forgotten. The company was newly designated as "Yarsley Research Laboratories Ltd., A Division of Fulmer Research Institute Ltd.", with Dr. Duckworth Chairman and Mr. Flavell as Director and Manager of the operations on the new location. It was fortunate that most of the senior staff from Chessington opted to transfer to Stoke Poges, and as this was 25 or so miles away, a daily transport mini-bus was provided, which took the names FULMER/YARSLEY boldly painted on the side, daily through the countryside. In addition to these changes, Mr. Flavell took control from his new office, together with his Secretary of 15 years standing Mrs. A.G. Allen, with Mr. Turner and Miss Chadbund across the corridor. Mr. Mikucki was able to move his entire section, and Dr. Titow divided his time between the two locations (Stoke Poges and Ashtead) accordingly as it was convenient for the projects he had in hand.

The transfer was eventually completed in September 1973, and considering the complexity and the distance between Chessington and Stoke Poges, the work in hand suffered minimum disruption. It was

no doubt somewhat difficult for the Fulmer staff to have such an influx of "outside" personnel. The Chessington location soon presented a deserted appearance, and continued thus until the engineering section and Mr. Cheetham with his staff moved in September 1973, when the space which had been rented at Ashtead to Modern Health Foods Ltd., which comprised an entire prefabricated building, was eventually cleared. The complete site at Ashtead then came mainly under the YRL control, Mr. Cheetham's department and the engineering section being the "odd-men-out" so to speak.

It had been hoped originally that with the newly provided space at Stoke Poges, and the extra "bay" at Ashtead, that there would be adequate accommodation for some time to come; in actual fact this was far from the case. The problem was complicated by the fact that in the meantime the Group had taken over a plastics moulding consultancy company located at Newhaven, Sussex, which was controlled by Mr. Manns. Since this provided a complement to the work and facilities we had already, this company, I.P.E.C. (Polymers) Ltd., was absorbed into the group with YPEC being taken as the registered name. For the brief period of its existence I was Chairman, and the Directors were Mr. Dewey, Mr. Turner and Mr. Manns. Yet again work was on three locations, Newhaven and Ashtead, and centred for general and administration purposes on Stoke Poges.

Working progressed on the three sites, and most of the current projects were maintained, until a disastrous fire at YTL, Ashtead on May 6th 1974, came as a serious setback. This was serious not only in that it completely ruined much of the plant, (including Mr. Cheetham's small-scale thin-film machine), but it destroyed many (if not most) of

his records and plans vital to this work, and also a number of books and records, many of which could not be replaced. There was of course the personal side to this disaster and loss, since it meant that Mr. Cheetham and the Engineers had to work under very difficult conditions until the results of the fire could be made good. Most seriously affected was the thin-film unit, since this was an area of work we had made particularly our own, and one for which any future possibilities would depend on the production of suitable samples, and if possible a working unit on which to test the feasibility of clients' polymers. Mr. Cheetham had the knowledge of both the machine working, and the patents and all that went with them which had perished in the fire, but the loss, both present and for future potential, was a serious one. Eventually a "Phoenix" arose from the ashes, and the charred space was soon resplendant with new apparatus and Gallenkamp unit benches, but the central point of all which could not be resurrected speedily was the film machine.

Y.T.L. MOVES TO REDHILL

It soon became apparent that further space would be required, and as this could not be provided either at Stoke Poges or Ashtead, it was once again essential to look for a substantial building, as the essential time element ruled out the possibility of building a new and completely all-inclusive working centre. To this end Mr. Dewey spent many long weary weeks and combed the surrounding country, with Stoke Poges as the centre in view. Naturally this was no easy matter; quite the contrary. After many "possibles" had been considered and ruled out, Mr. Dewey's perseverance was finally rewarded, and it was decided to purchase the

laboratory complex at Redhill which was just about to be vacated by British Industrial Sand. This provided not only adequate space for immediate working, but had a level 3 acres extension, capable of future development. There were naturally many snags, not the least of which was the inadequacy of the gas supply, which the proposed extension to the fire-testing unit made necessary. It had long been evident that fire-testing at Ashtead had a limited term there, as not only were extended plant facilities essential to comply with BS.476, but the fumes of pyrolised PVC and the like which poured over "The Street" when the West wind was blowing, would inevitably strain the tolerance of the neighbours in the adjoining streets, who had suffered so many years of phenolic smells when the (McMurdo) war-time factory was there.

Not surprisingly the negotiations for the possession of the Redhill site were somewhat protracted, but when these were completed the transfer of apparatus and personnel commenced, leaving Stoke Poges virtually as it was before the advent of "Yarsley", and dispersing the Yarsley sections between Ashtead and the newly acquired Redhill. Here again there was difficulty on the horizon as far as Ashtead was concerned, since the lease was due to expire in 1983, and we were soon to learn how quickly time catches up on apparently remote dates. The name of 'YTL' disappeared as a separate limited company. YRL, managed by Mr. Flavell, with Mr. Cheetham, Mr. Mikucki, Dr. Jappy and Mr. Shelton, occupied Ashtead. The heavy engineering and plastics processing plant from Stoke Poges and Newhaven and the testing activities from Ashtead were located at Redhill, with Mr. Dewey in control, and assisted by Mr. Mead Mr. Trafford, Mr. Riley, Mr. Berry, Mr. Mugridge, together with Mr. Manns.

and Mr. Jupe from Newhaven. The independence of the Redhill Centre was eventually completed under a new company name, "Yarsley Technical Centre a Division of Fulmer Research Institute Ltd.", with Dr. Duckworth as Chairman, Mr. Dewey Managing Director, and Mr. Mead General Manager. This new arrangement was logical but costly, but it brought together on one site all the essentials to plastics, plant, analytical and fire testing, leaving YRL space at Ashtead to extend large-scale synthesis, plastics applications such as thin-films, coating compositions, adhesives, and the information section. YTEC, still flying the original (and somewhat weather-worn) YRL flag, was opened formally by Mr. Bob Cryer, M.P., Parliamentary Under Secretary of State, Department of Industry, on 14th April 1978, and once again the Fulmer Group was in business for comprehensive working in plastics, which with the expertise at Stoke Poges and Ashtead, maintained its position of complete coverage of materials, and adequately fitted both in experience and plant to face the demands of the 80's.

The changes recorded in this brief historical survey have been many and diverse, although the reasons for change or expansion were always clearly evident. Overall they have proved satisfactory for the clients and the staff, and the Group as now constituted should be capable of stabilisation and consolidation, at least until 1987 when the Ashtead lease is due to expire. Extension might be possible beyond that date on short term, since it is the rumoured intention of the Mole Valley UDC which had replaced L.U.D.C. to demolish the buildings and those of the UCS covering the whole area, and replace them with houses or flats.

The position at the time of writing (May 1980) was clarified in a News Release which was issued by the Board at the end of January, which was as follows :-

> "With the continued expansion of Fulmer Research Institute Ltd., it is now necessary to distinguish between the parent company and the operation on the Stoke Poges site, which at present use the same name. The Stoke Poges site has therefore been incorporated as a Subsidiary company under the name FULMER RESEARCH LABORATORIES LTD., to give it equal status with the other Group sites at Ashtead, Redhill and Slough.
>
> The Directors of Fulmer Research Laboratories Ltd. are Dr. W.E. Duckworth (Chairman and Managing), Mr. G.B. Brook, Mr. M.A.P. Dewey, Dr. G.I. Williams and Mr. E. Sugars, Secretary.
>
> The title Fulmer Research Institute Ltd. will now relate only to the holding company of the Group, of which Dr. W.E. Duckworth is Chief Executive, and Sir Ieuan Maddock, Chairman".

It would be impossible to end this documentary section of my narrative without reference to some of the secretarial staff, particularly my personal secretaries, to whom no reference is made in the text. The first, and a member of the staff of five I had at Ewell was Miss Reeves, who doubled as my secretary and indexer of my literature collection; her zeal over several years laid the foundation for work carried out at Chessington. She was followed by Miss Chadbund who kept things running till she was overwhelmed with accounts and general records. Next came Miss Thorn who acted not only in a secretarial capacity, but as organiser of social functions and generally as manager of staff welfare: she was in fact ready to assist in any necessity even to doubling up for staff when laboratory photographs were taken. When she left I was fortunate to "inherit" Mrs. Bloomfield from Dr. Webber.

Here again I was lucky to have a person on whom I could thoroughly rely, and who could not only type speedily and immaculately, but could correct my mistakes, remember promises I had made for appointments, and generally to keep me "on the rails". Her work also included the appointment of female staff and dealing with pensions, redundancies and such like matters. Towards the end she suffered serious eye trouble, but in spite of this pain and handicap, she kept going as long as she was fit to come to the laboratory. Very fortunately she is now recovered, and is in happy and useful retirement. Among the other long-serving members of the secretarial staff special mention must be made of Mrs. Allen, Mrs. Chizlett and Mrs. Daniels, the last two are fortunately still with YRL at Ashtead. Although he does not come under the same category, my grateful thanks to Mr. Henderson. He joined us when I had a "grown-up" staff which was working to a system which had operated in earlier days. He was quietly efficient, and very quickly reorganised our system of records and finance, and such important matters as agreeing the overhead rate with the Government Auditor, a duty which required tact as well as clear-sighted accuracy.

Throughout the near forty years when I employed staff of many grades, I was most fortunate in gathering around me people who worked as if they were self employed, and this made much for the smoothness of the work in general and the happiness of the staff at work and in off-hours, when our various club activities came into operation. In retrospect I can only say a very sincere "thank you" to all those who helped me in building up and maintaining an organisation which in its way was almost unique. Throughout the years my staff had said "thank you" to me in the loyal way they supported the company throughout

its somewhat chequered career. This was evident particularly on the more personal side when they presented me with an elegant silver salver on the occasion of our Silver Jubilee in 1956, and an attractive radio, to mark the 45th anniversary. The Directors of Fulmer Research Institute were most generous in presenting me with a cut-glass Whisky decanter, together with a "charge" of the suitable liquid, at a very pleasant luncheon of the Board held at Newhaven, when I retired. This tribute and the kind remarks made by the Chairman Sir James Taylor M.B.E., when he made the presentation, were symptomatic of the cordial relations I had with the main company.

So far this narrative has been purely a documentary, indicating why and how changes were made; with very few exceptions no reference has been made either to what was accomplished during the half century under review, or to my own personal activities which, although in a way separate from those of the Company, had a definite connection with them. I shall make a brief reference to these and then finalise the survey with a brief outline of some of the work pioneered by the YRL Group, such outlines being prepared by those members of the staff who were directly concerned with the projects, and who fortunately are still with the Group, namely Mr. Flavell, Mr. Cheetham, Mr. Berry, Mr. Riley, Mr. Trafford and Mr. Shelton. Since it preserves the more direct continuity, I may be pardoned for dealing with my own activities first.

EXTRA-MURAL ACTIVITIES

My activities outside my professional work for what became known as the "Yarsley Group", are summed up in one word - Education. This was perhaps natural since as already recorded, my original aim after Graduation was to become a teacher. My acceptance of the Salters' Fellowship was conditional on my entry into industry, and the unfortunate consequences of my early work therein, have already been told.

In 1931 "plastics" was little thought of and was a word which appeared in few indexes. It was naturally assumed that it was just an offshoot of chemical industry, just as dyestuffs had been. Apart from Staudinger and his colleagues, few chemists paid special attention to these new nondescript materials, and apart from the German journal "Kunststoffe" which had pioneered them as members of the "Kunst" or synthetic family, few writers or publishers had taken any special note of them. It is therefore to the credit of my friends E.J. Wilkins and his colleague Macfarlane, that about 1928 they registered and launched the journal "British Plastics", and played an active part in popularising plastics as new and entirely different materials. Wilkins and his friends were responsible for the formation of what was regarded originally as a friendly "club" of those interested in plastics, mainly on the moulding side, since the manufacture was almost a monopoly of Bakelite and British Industrial Plastics. Part of the activity of this small group was to educate industry and the general public in the why and wherefore of the new materials, and mainly through the medium of British Plastics to inform industry of new developments in synthetics. The outcome of their efforts was the formation of the Institute of the Plastics Industry, (later to become the Plastics Institute)

and although I was not one of the original members, I joined soon thereafter and supported the late Kenneth Chance in his efforts to provide text books to cover the new science, which was not found as such in the chemical text books of the day. To this end he inaugurated "The President's Fund" supported by industry, and set up an Education Committee of which I was convenor and the first Chairman (about 1935), a function which I performed for 25 years. The President's Fund fostered not only lectures and courses, but most important published a series of monographs, single volumes being contributed by the then "experts" in the respective branches. On the academic side Dr. E.C. Pickering at the Borough Polytechnic arranged a series of lectures on "Synthetic Resins, Moulding Powders, and Plastics Materials". When the term of the President's Fund was concluded, the work was carried forward by the then President of the Plastics Institute Peter Allen (now Sir Peter), who formed the Plastics Industry Education Committee of which I was a member for many years and at one time Chairman. I resigned from this Committee two years ago. Although my work for the Insitute, (and for the Plastics Group of the Society of Chemical Industry of which I was Chairman for a period) was entirely altruistic and took a great deal of my time, it was indirectly a "back up" of my professional work, and spread the name of my company when this was ultimately formed. I was elected President of The Plastics Institute in 1953/54, and in 1955 became a member of the Livery of the Salters' Company (which was chemically biassed), and I became a Freeman of the City of London, and of the Horners Company, which for logical reasons had taken the fledgling plastics under its wing, to replace the almost defunct Horners industry. I delivered the "Plastics Lecture" to the Horners Company in the Drapers' Hall on October 29th 1964.

It would be too lengthy and possibly outside the scope of this survey to relate my many years on the academic side of the plastics industry, except perhaps to mention the "Staudinger Memorial Lecture" which I delivered to the Plastics Group of the Society of Chemical Industry at the Shell Centre, Waterloo, London, and the George Bray Memorial lecture to the Institution of Production Engineers in Leeds. This was all outside work, and a heavy burden in my early days. Nevertheless I persisted because I loved the work, and I felt that it was up to me to help the industry which had done so much for me. It was an indirect form of advertisement for my professional group, and many members of our staff over the years benefited from the educational facilities I had assisted in pioneering. In addition of course, many of the students and members of the Institute became clients of our organisation, and in many cases personal friends of myself and/or members of my staff. It is for this reason that I think that this part of my life's work should find a place in this survey, as it is a definite item in the history of "The Yarsley Organisation". Looking back over half a century it is good to see that the combined Institutes of Rubber and Plastics have grown to such importance, perhaps far beyond the hopes and aspirations of my colleagues and myself over the years.

SOME NOTABLE PROJECTS AND ACHIEVEMENTS

Thus far the narrative has in the main been historical and documentary. Inevitably there has been slight repetition in order to connect the changes which were taking place, particularly in the last twenty years. Brief reference has been made to a few projects which were perhaps more novel than of technical importance. The bread-and-butter of our work was more pedestrian and routine, both technological and testing, which represented the growing pains of what in the early days could hardly be called the plastics industry. We grew with the industry, and we provided what for many manufacturers was in effect a practical feasibility study. We supplied the idea in many cases, or the client had his own ideas; it was up to us to prove that they were practical and viable, before the client would expend the capital necessary to proceed to the industrial stage. In some cases our work proved negative, but even this was useful in that it prevented the client wasting his plant time to come to this decision. Fortunately we had relatively few such negative cases, and even where an original idea was discarded, there was frequently a "spin-off" which ultimately became profitable. Our field of activity was constantly changing and extending, and this is why we preserved the maximum flexibility in the layout and fitting of our laboratory facilities.

As time passed, not only did the nature of the projects change but also the clients themselves. Initially we were dealing with organisations which had a chemical bias, but this rapidly changed as engineering and consumer goods manufacturers diversified into this new and apparently attractive plastics field. An interesting example of this was the

Projectile Engineering Company whose business after the first war was naturally changing, and who in place of ammunitions decided to manufacture injection moulding machines. This was particularly interesting as this field appeared adequately covered at the time, and injection moulding as a process appeared to have serious limitations. Under changed auspices and name, this company eventually grew to rank among the makers of the giant automated injection machines as we know them today. Here our initial advice on feasibility and design was sought, and from the encouragement we gave to our clients, successful outcome was achieved.

Judged by modern standards, many of our early accomplishments may be scarcely worthy of recording, but it must be remembered that these were pioneer times for plastics in materials, processes, plant and products, so that the work we were doing was almost entirely pioneer and exploratory. Many subsequently successful developments in all these fields have proved that our work, though unproductive at the time, was on the right lines.

"Synthetic" Matches

One of the early projects, which on the face of it would appear a 'natural' for plastics, was their use in the production of matches. To extrude plastics of 'match-stick' dimensions appeared straightforward, which indeed it was, but to produce plastics compositions which would compare with the conventional wood 'sticks', was entirely another matter, as Mr. Shelton who conducted this project found out after many months of trial. Fortunately our clients (Bryant and May Ltd.) were prepared to take the view that if, after exploring every possible

alternative without success, it was unlikely that any competitor would be any more successful.

The simple match stick is in fact required to meet an exacting specification. The final product must meet some 14 property requirements which include, for example, (1) a "fibrous" break characteristic; (2) a 'clean' burning flame; (3) the ability to transfer the match head "flame" to the wood stick in a fraction of a second; (4) have a porosity to take up sufficient but not excessive quantity of paraffin wax to satisfy item (3), and a number of features associated with the colour, hardness, and uniformity of the wood itself. Because of these requirements and the natural form of wood logs, the final yield per log in wood-match production is low. The rough log must first be de-barked, and then machined concentric before veneering can take place. In producing the veneer the log must be held between centres which produces an unusable core. Some veneers will contain knots and cross-grain which make them unacceptable for match production.

It was considered that it might be possible to utilise these waste cores by reducing them to a "common denominator" such as woodflour or chips, to mix this with a powdered plastic and extrude the mix as continuous lengths of "match" dimensions which could then be cut to length and dove-tailed into the existing match manufacturing process at the "head-dipping" stage.

Cost, as in every commercial project, was all-important, but in this case we were endeavouring to synthesise a product having a very low unit cost. This limited the quantity of plastic binder to the

very minimum, but unlike the pressing of resin-bonded chip-board where a low resin content is adequate, the resin or binder in this case had to impart sufficient "flow" to the mass in order to make it extrudable through narrow die orifices - and wood is very reluctant to move under compression.

The project, extending over some 3 years, led us to explore many avenues, varying the wood form, resin or plastic binder, and the extrusion technique. It was soon obvious that even the low cost thermoplastics were 'out' on overall cost of the composite, and we eventually turned our attention to the lowest cost binder of all, namely, starch. This had an added advantage in that it produced a "clean" flame and a much higher percentage could be tolerated on cost grounds.

One very important feature of the finished match (not mentioned above) is that of density. For reasons of weight in connection with export etc. the match required to have a density of around 0.5, which is the density of the natural wood normally used in match production. This was a difficult parameter to meet as soon as a resin binder was incorporated and was quickly destroyed by any degree of compressionin the extrusion process. The use of starch binder did allow this density requirement to be maintained since some "gassing" occurred when extruding at high temperature due to the moisture content, and also due to the "blowing" of the starch granules (the starch was boiled before adding to the wood particles).

Although we were able to meet virtually all the necessary properties in our synthetic product, the project failed in the processing stage.

Anyone who has seen the production rate in a match-making factory, will appreciate the almost impossible task of achieving a rate anywhere near this using an extrusion process, despite the use of multi-orifice dies.

Thus it was that a negative result at the end of a project was acceptable to the client, for it proved that, within reason, no competitive product was likely to appear based upon the apparent versatility and scope offered by the plastics materials and processing technology, and time has proved this to be the case.

Cigarette Tips

Logically following the work on match-stick production was perhaps the project to produce the ideal cigarette filter tip. This came at the time when "tips" (if they were used) consisted mainly of cotton wool, and had little connection with the possible health hazard which the cigarettes of that time embodied. This project lasted many years, and again it was for a client who was content to examine possible alternatives, rather than to have any specific end in view. The ultimate end was of course to cut out from the cigarette smoke all noxious constituents, nicotine, tar residuals etc., and this indeed we succeeded in doing to the extent of removing all flavour from the smoke, which was of course not very attractive to the smoker, who thus paid good money to inhale pure (or nearly so) hot air.

The project was carried out for many years by Dr. Titow, and during this work he explored almost all expanded polymers and polymers carrying fibrous reinforcement. The natural selection had of course been cellulose

acetate, since nicotine has a solvent action on C.A., and the normal flake provides a wide surface/mass ratio for smoke contact. Many variations were tried with C.A. and additives, also varying the density of the extruded mass. Contrary to early expectation the extrusion of these compositions was not easy, as the mass tended to become compacted and thus to solidify, which made it useless for a filter-tip which requires a uniform open "mesh" structure to enable easy passage of smoke, and to avoid the necessity of hard "drawing" of the air through the mass during the smoking. In the end cellulose acetate fibre was found to be the most satisfactory.

This particular project was notable in that "interference" was filed from the USA against our U.S. patent specification, and Dr. Titow went over to America to defend this in person, which he did quite successfully. For the patentee to speak in person is most unusual in the U.S. Court, and indicates the value of the patent and the efficiency with which Dr. Titow defended it. A number of British patents were filed, but these were never applied on a commercial basis.

Chip-Board

The use of plastics as bonding agents dates back to Baekeland's original ideas in the beginning of the century. As already mentioned, the war-time needs for materials stressed this possibility. We had already proved that the reconstitution of leather was not possible, but the bonding of saw-dust or wood chips was a different matter, and was a project with which we were occupied from the early forties onwards. Work in this field was by no means novel, as there were many early attempts to press out resin-bonded sawdust sheet on multi-platen presses, with

apparently little success. Our client decided to adopt another quite revolutionary technique, namely to roll out the resin/wood-chip composition, between heated metal bands. Here again an apparently straightforward problem proved to be quite complex, and again the efforts to attain a "sheet" comparable with tree-board by the proposed method was exceedingly difficult. Heating was applied by means of rectangular platens linked together much as are the "treads" in a caterpillar tractor, joined as in a tractor to form a complete "loop". Two such heating units were mounted on four drums and carried stainless steel bands, the distance between them being controlled by the position of the drums. A layer of the resin/wood chip material (usually referred to as a "carpet") was laid on the lower band and carried forward into the "nip" where it was subjected to heat and pressure essential to consolidate the loose carpet into a continuous solid sheet. The length of the traverse was so arranged that the sheet emerged from the double band pressure fully cured, and was cut transversely into desired lengths by a so-called"flying"saw. Thus sheets of any convenient length and 4 ft wide would be produced, and would be stacked at the exit end of the machine ready for further treatment such as sanding or coating. In this way it was aimed to produce by continuous working, sheets equivalent to those conventionally produced in multi-platen presses.

This project was by no means as simple as it appeared on the drawing board, since as the whole process had to be continuous, the resin/sawdust material in powder form had to be supplied regularly and continuously, and at accurately controlled thickness to the feed end of the superimposed pressing bands. Furthermore the temperature in the press itself, as also the duration of traverse, had to be such that the sheet emerged fully cured, uniform in density and at constant forward speed, ready to be cut (whilst still in forward motion) into sheets of desired length, the width of course being

fixed by the dimensions of the pressing steel bands. The problem was largely an engineering one, as far as the provision of the mechanical hardware was concerned, and to this extent Mr. Minors, and later Mr. Nicholls and Dr. Frenkel, collaborated with outside engineering specialists, particularly with reference to suitable bands (which came from America), and with the provision of bearings which had to carry the heating platens at several hundred degrees C. In normal circumstances cost alone would have ruled the project out, but fortunately it was backed by a millionaire, the late Sir Victor Sassoon, who was intrigued by the complexity of the plant and process, and who was wise enough to see a future for reconstituted wood sheet, which was not the view of the trade in general.

A small-scale plant was built in a factory in North London with our assistance, and in due course, this was scaled up to a full-size plant at Marks Tey in Essex. In all cases the chemical work was carried out at Chessington in collaboration with the manufacturers of the UF resin, and likewise the control of the process and the finished product was in our hands. As may be imagined, the project was of such complexity that development up to the final stage at Marks Tey took several years, and during this time commercial conditions changed. The raw material supply was one of some difficulty, since it was clear (almost from the start) that sawdust as such would not be available in the necessary quantity to feed the projected machine. This meant the extension of the project for the provision of wood chips from available spruce trees, and it was shown that the "geometry" of the chip played an important role. During this time fortunately the trade had become more impressed by what became known as "chip board", but equally unfortunately for our client

the manufacturers of platen-pressed sheet had improved their process (composition, "carpet"laying and properties) to such an extent that both as to cost and quality it was equal to anything our continuous process could offer. In spite of this our work continued and eventually the continuously-produced sheet (BARTREV) was marketed. Since in view of the complexity of the plant, and the necessary precision of the process it had little chance of a viable future, it is not surprising that it was taken over, and eventually terminated, by Airscrew Ltd., the largest manufacturers of chip-board by conventional multi-platen pressing, in this country. Although this was disappointing both for us and our client, it was inevitable that commercial viability would have the last word. At any rate we had the satisfaction of having completed a complex project which had provided us with many years of interesting work. In the course of this we gained valuable experience in the performance of thermoset compositions (mainly UF), and could give first-hand advice to users of chip-board which eventually came into favour. What is more important our client was satisfied with the work we had done, even though he did not reap the rewards he had hoped for and indeed deserved. There was for him some consolation that although the process was virtually a failure in the UK, several complete units (presses, resin and chip preparation) were sold to Iron Curtain countries, and these for a time were supervised by our experts Mr. Nicholls and Dr. Frenkel. What the ultimate fate of these machines was we do not know, but they were at any rate proof that this quite remarkable process was a practical one and capable of commercial working.

Expanded Plastics : Urea Formaldehyde

Today expanded plastics are produced world-wide in considerable volume, and it is possible to expand almost any polymer, and produce materials varying from paper-packing thickness to blocks of any desired contour. Thirty years ago the position was quite different, commercial expanded plastics materials were a rarity, and it was the basis of several projects which we received. The first quite surprisingly came to us from Pinewood Film Studios, and was for the production of artificial 'snow'. This was fairly straightforward being accomplished by the emulsification of an air frothing solution of urea formaldehyde with suitable additives leaving the foam to set. The resulting blocks were comminuted and projected through a 'blower' on to the film 'set' (notably the 'Scott' film) where the excess formaldehyde evolved made it almost impossible for the actors to survive their performance. Even so it was a pioneer effort which was quite satisfactory.

During the war a process was developed by Dr. L.R.B. Shackleton of the Fuel Research Station at Greenwich for the 'solidification' of petrol to enable it to be safely transported. This process consisted of forming an emulsion of petrol with an aqueous urea-formaldehyde resin, adding an acid catalyst and pouring the mixture into a mould where it set to a 'solid' mass. This contained over 90% by volume of petrol which could be recovered by simply crushing the mass. It was noticed that, if the petrol was allowed to evaporate, the residue was an expanded UF resin with a very fine pore structure, and strength much higher than that of the foamed UF produced by air-frothing. It was also found that the same sort of product could be obtained by using a chlorinated solvent

such as trichloroethylene, which did not present the fire hazards of petrol, but had its own associated problems such as toxicity and corrosivity. It was thought that this new form of expanded UF could have industrial application, particularly as a substitute for cork in cold storage installations since it was essentially non-flammable. A small company had been established with financial backing from N.R.D.C. to develop this.

Our first involvement with this project was very small, namely to measure the water absorption of some of the early samples. Very soon after, however, we were commissioned by N.R.D.C. to carry out a research project to improve the product to the point where it complied with quite stringent specification. This was successfully accomplished after some two years effort.

We were then invited to design, instal and operate a small production unit which was located within the factory of the British Match Co. at Bow. This plant was operated on a 3-shift 24-hour day basis for about a year, developing the process on the large scale and producing material for practical evaluation. The organisation of this operation from our headquarters at Chessington was quite a problem in logistics, and its success was due in no small measure to Mr. Redfearn.

Up to this point, almost all our work had been on material intended for thermal insulation (cork substitute) with a density around 2 - 3 lbs per cubic foot, but about this time other expanded materials began to appear, such as polystyrene, PVC and polyurethanes, and these were selling

at lower prices than could be achieved by our expanded UF, so that the viability of our product in the insulation field began to look rather poor. We turned our attention to the production of material at higher density (8 - 12 lbs per cubic foot) with the thought that this would be interesting as a non-flammable core in structural sandwich panels. Such higher density products were successfully produced and formed into sandwich panels with GRP and other 'skins', but the process proved to be uneconomic, an important factor being the low efficiency of solvent recovery which could be achieved.

Plastics in Building

In spite of the fact that from Baekeland's time it had been hoped to use the then available polymers as bonding agents for structural purposes, 'the trade' refused to give them fair trial, and preferred to continue to use the long-tried metals, wood and ceramics. World War II showed that plastics had many structural possibilities, so much so that during the war the Ministry of Works thought the use of plastics in building construction sufficiently important to set up a committee to consider the possibilities and make recommendations for the future. Their report was published in 1944 by the Stationery Office under the title of 'Plastics, Post-War Building Studies No. 3'. Experience has since proved that many of the recommendations were very realistic, although progress towards their implementation was slow, since it was considered that there were many more worthwhile applications for the supplies of plastics then available than for building purposes.

Contrary to this defeatist trend our laboratories had faith in the future of plastics, if wisely applied, for many building applications, and we found clients who shared our ideas, with the result that we carried out feasibility studies for specific applications. Among the earliest of these was the use of extruded PVC for rainwater guttering, and also for cold water pipe systems. (In this connection it may be noted that our laboratories have the largest independent testing station for the long-term pressure testing of pipes in the United Kingdom). Early failures in these applications were largely due to the fact that manufacturers slavishly copied the design of conventional metal materials, for which plastics as such were impractical. We were involved in the design, production and testing of some of the earliest rainwater fittings, which gave us interesting projects and a valuable footing in the building trade. As the production improved so our interest and industrial connections became more extensive. As already recorded, we were associated with the production of bonded sheet (chip-board) from the early use of this material, although our connection was more specifically with novel plant for sheet production.

Success of plastics as bonding agents gave rise to their wider exploration, and this was particularly the case in the bonding of glass fibres or 'GRP' as it became known in the trade. This again was an area in which we were associated from the start, and our work embraced not only the production of resins, but of glass fibres suitable for the production of laminates, and thence to the actual laminated products themselves. Much of our work involved the testing of products for specific purposes, and of an ever-increasing size. The most outstanding example of this was the large-scale testing by Mr. Berry of reinforced plastics panels for prestige buildings, typically the Covent

Garden Flower Market roof and the International Telephone Exchange, Mondial House

The Covent Garden Flower Market roof consisted of 800 moulded GRP units, and the principal units were 3 metres square and $1\frac{1}{2}$ metres deep in the form of a bucket. There were no British Standard tests for this type of application and so Yarsleys, in consultation with the Building Research Establishment, developed a number of simulated service tests in order to gauge the suitability of the design, material and process for the particular application.

The tests which were performed included wind loading tests simulating a wind speed of 85 miles per hour; snow loading simulating 300 mm depth of snow; impact tests simulating a man falling on to the panel (and also bricks and other vandalism); calculations of heat flow and solar radiation; weather and water-tightness tests on roof panel joints to ensure they would be watertight. This test simulated a rain fall of 175 mm an hour for 10 minutes accompanied by a 30 mile per hour wind. These tests indicated that the roof should be suitable for its intended service. Similar tests were carried out on the panel for Mondial House. These panels were 3 metres high, $1\frac{1}{2}$ metres wide and 1 metre deep. In addition to this, Yarsleys developed a practical fire performance test in which a 40,000 BTU/minute flame (approximately 900 kilowatts) was lit under the bottom corner of the panel, and observations made in order to determine whether the flames would spread quickly up the face of the panel. This test showed that there would be no undue spread of flame, and the test has now been adopted by many Government agencies as the standard test for this type of panel.

At the time of writing, Yarsleys are investigating the performance of raised modular floors for computer rooms and offices, in an endeavour to develop for the Property Services Agency of the Department of the Environment, a purchasing and performance specification for these materials. Once again, all the properties listed above are being examined, and it is hoped that the work could form a basis for a British Standard in due course.

In addition to these more major projects in building, our laboratories were engaged in the day-to-day testing of moulded units, including strangley enough the testing to a B.S. specification of literally hundreds of toilet seats. Our testing work on all types of building products extended when our fire testing units were installed at Ashtead, since the fire risk of plastics had been one of the early objections to their use in many areas of building.

Films and Film Coating

Since my early experience had been based on the manufacture of film, it was natural that we should apply our knowledge of this rather unknown technique if possible. We could not of course afford even a small-scale film casting machine, so that our film samples were prepared on a simple sheet glass 'flat-bed' machine. This work was taken over by Mr. Fontana (who had worked with me when the film casting (band and wheel) machines were installed with our assistance at the Brantham Works of the British Xylonite Company), and later by Mr. Cheetham.

We also laid out a full-scale band casting machine at Salford, Manchester which was installed and operated by Mr. Fontana. This was designed primarily for casting 3 mil film for tape (sound) recording.

Thin Films

Active work on the development of thin polymeric films by solution casting techniques was commenced by YRL in 1953, initially under a commission from the Ministry of Supply. The first samples of micron thickness films were prepared by allowing dilute polymer solutions to spread onto either a mercury or water surface, and subsequently evaporating the solvent. Recovery of the sample films prepared in this way was difficult and the need to prepare larger samples led to the development of semi-continuous casting techniques, with the deposition of dilute polymer solutions onto polymer film substrates, which were initially drawn under a casting head by hand.

A first attempt to mechanise the process came with the realisation of the influence of application and drying parameters on film quality, thickness and uniformity, and a prototype casting machine was built to enable the preparation of thin films in 5" width and in continuous lengths up to 200'. Development of the prototype casting machine and units to enable stripping and slitting of thin films followed, and the thin-film casting process thus developed proceeded continuously until 1974 (when the unit was unfortunately destroyed in a fire). By this time the process had reached a level of sophistication to enable the preparation of high quality, uniform thickness, pin-hole free films,

generally in the thickness range of 1 - 6 micron, cast as single or multiple layers, not necessarily from the same material, but also from a variety of soluble polymers and copolymers. Although the process was primarily developed for the preparation of free, self-supporting thin films, it is also a precision coating process enabling the deposition of uniform coatings which may range upwards from a fraction of a micron in thickness.

Development of Cartographic Films

An example of a project which was carried from a laboratory development study to a commercial production scale was concerned with the development and preparation of dimensionally stable cartographic films (in 1960). The project started as a small feasibility study to examine the problems of combining the favourable properties of polyester films, which could not be printed or dyed satisfactorily, with other films which would accept multi-colour printing and draughted images. The combination of experience in adhesive bonding of polyester film and film casting soon produced several prototype compositions and the promise shown by these was such as to encourage further development. Variations of the laminate system, as single and double-sided coatings, in clear and matt finish, were prepared, optimised and thoroughly tested on a laboratory scale, and considerations given to production of the materials. As there was no commercial casting machine adequately equipped to apply the four solution coatings of the process, the client

commissioned us to design and build a full-scale unit to operate at 52" coating width, without (as we had advised) building an intermediate-sized machine. The challenge both on the polymer and engineering side was accepted and the project, which had started as a £100 feasibility study, became the largest ever undertaken by YRL, up to that time. The project finally engaged a team of seventeen chemists, technologists and engineers for eighteen months in attending to all aspects of the design, construction, servicing and commissioning of the film plant unit built. This consisted of a 60' x 10' x 6' casting machine for applying and drying four coatings simultaneously, at a casting speed of 3 - 20'/minute, in which there was 400' of film being processed at any one time, together with all ancillary equipment for heating, air conditioning, extraction and bulk solution preparation etc.

Artificial Dielectric Radar Lenses

Another project involving the use of film and also adhesives, expanded plastics, GRP, and engineering expertise, came to us in an interesting way from A.S.R.E. We were asked in the first instance, if we could develop adhesives of low electrical loss for bonding copper to polystyrene film and expanded polystyrene. The adhesives were required to progress a novel development concept on artificial dielectric radar lenses involving the use of small copper discs 3/32"

in diameter, to refract radar waves. Ideally these discs were required to be supported in free space in layers about 1/10" apart, each layer being composed of discs 1 thou thick, 3/32" in diameter, spaced 7 thou apart, in a regular hexagonal pattern. The nearest approach to the ideal but impractical construction was to bond the copper discs to a low loss polystyrene film, and to use low density expanded polystyrene as spacer material as being the closest material to air dielectrically.

Following a short study, adhesives satisfying the basic requirements were developed and tested and approved by the client who then asked if we could undertake a radar lens development programme, which had not previously been feasible in the absence of suitable adhesives. The programme that followed lasted four years and involved the design, construction and use of a machine to prepare copper/polystyrene "Mosaic", the study and preparation of high temperature-resistant expanded polystyrene copolymer, the preparation of all materials for and the construction of prototype compound and plano-convex radar lenses, together with epoxy resin/glass radomes in 18", (2 off), 27" (3 off) and 72" (2 off), diameters and all relevant testing. This was efficiently accomplished by Mr. Cheetham and his team.

Dental and Other Prostheses

Among the earliest and more personal applications of plastics was their use in the production of dentures, and we became mainly associated with this work when they were supplied on National Health demand. This not surprisingly resulted in a fall in the price of the material used which was methyl methacrylate monomer, which until then was an ICI monopoly in this country. One of the early problems we faced was the production of this monomer by the pyrolysis of "scrap" polymer. This had to be free from impurities to give products of the required high quality, which was not so easy as had at first been anticipated. This project was another of Mr. Cheetham's responsibilities, and he took the process to the production of the actual denture and dentine. As the use of these "MMA" dentures extended, the requirements to meet the needs of the dental mechanics became more exacting. Not only had the monomer to be free from impurity, but the "dough" produced from the mixture of polymer monomer and catalyst had to have a precise doughing and setting time, and of course the necessary mechanical properties which normal use demands. Important among the physical requirements of the polymer were "bead" size and uniformity. The material specification was even more stringent when the polymer was used for the production of dentines (teeth) to give a strong and homogeneous denture. This project continued for several years until a product eventually met the exacting requirements of the dental fraternity.

An extension of this work was the production of dental fillings for repairing natural teeth. Here suitable polymers were used with admixed catalysts to give rapid curing when the cavity in the tooth had been

prepared. In this case the difficulty was a personal one, as the setting of the filling in the cavity involved a considerable exotherm, which the patient had to endure for a limited time. Thus speed of curing had to be combined with a dough time sufficient to enable the dentist to shape and trim the filling in the cavity, which was by no means an easy combination of properties in the polymer composition.

A further dental project involved us in the development of a dental impression compound used to make a rapid but very accurate impression of the mouth from which the acrylic dentures are ultimately produced. Like so many of our early projects, we were required to match existing commercial products without infringing patented formulae. Mr. Shelton spent some 2 years on this assignment, and was eventually successful in meeting all the specified parameters, indeed with a 'bonus' in that the pH of the final mix was such that, when the 'hardener' was added the mix progressively changed colour from blue to pink giving an indication of when mixing was complete. Acting as a guinea pig, Mr. Shelton literally swallowed many of his experiments which failed to set in the mouth. These compounds, based on insolubilising a soluble alginate and filler, had to meet a very stringent specification, - a setting time of not more than four minutes in the mouth, with very low exotherm, and the ability to make a very detailed cast of the mouth free from pin-holes etc. They were also required to have as low a shrinkage rate as possible after removal from the mouth in order that a plaster replica could be cast from them within a reasonable working time.

The development of plastics artificial limbs was a project in which we became involved in 1960, in conjunction with units and companies associated with the fitting of limbs at Roehampton Hospital. Although some preliminary development of plastics artificial limbs had been undertaken previously, there was no satisfactory means of construction which competed with the then conventional 'tin-legs', which were custom built from formed aluminium tubes by highly skilled teams of craftsmen. We were commissioned to study the whole process of fitting artificial limbs and to develop materials and processes for the custom fabrication of above-knee (A/K) and below-knee (B/K) artificial limbs. We were fortunate in this work to have Group Captain (now Sir) Douglas Bader as a model for testing out our prototype limb units.

Hot-Melt and Coating Compositions

Hot-melt adhesives were among the earliest projects with which we had to deal, and of these the most interesting was the apparently simple problem of attaching the cork disc to the crown cork in beer bottles. As was frequently customary, we carried out laboratory-scale trials to develop a composition which would meet the client's need, before this was submitted for his machine trials. Again this was a case that something which appeared straightforward, proved indeed elusively difficult, since it entailed the application to the centre of the cork disc a measured quantity of polymer composition at the required temperature, and the individual quantities had to keep pace with the rate at which the crown caps were applied to the bottles.

When we had developed a composition which appeared to meet the need, it was decided to transfer a full-scale capping machine from the client's works to our laboratory, so that we could carry out further tests without detriment to works' production. This was one instance where it was fortunate that we had space available as the machine was large, and to maintain the normal speed of throughput of the bottles large quantities of the adhesive were needed,which we were also able to supply, using our large Werner Pfleiderer mixer. Simple as this project appeared, it provided us with laboratory and plant-scale work for a number of years.

Plastics are applied as coating compositions in a variety of ways, and our laboratories have been associated with most of these in the earlier stages of their development. This was particularly true in

the case of emulsion paints, in which plastics are dispersed in water as an emulsion very much resembling natural rubber latex. On evaporation or absorption of the water on the coated surface, the fine particles of plastics remain and form a continuous film. Emulsion paints are particularly suited to application by feed rollers, and as such have proved invaluable to the home decorator, where they have certainly effected a revolution.

Reference has already been made to the application of finely comminuted plastics by flame spraying techniques, and in this connection we were associated with the early work on the Schori gun. Our work related specifically to the coating with "Thiokol" of metal ammunition containers for a Government contract, which requires a tough scratch-resistant coating, suitable for military purposes. We explored a range of thermoplastics for application by the Schori method, but few of these showed much advantage over the conventional processes. We also did a certain amount of pioneer work on the application of thermoplastics by the fluidised bed method. This we applied to PVC, nylon, fluorocarbons, cellulose acetate, acetate butyrate, and epoxies which were available at the time. Here again, although excellent results were obtained in some cases, little overall advance could be claimed, and our work was rather on a quality comparative basis than a novel development.

Physical Testing

By comparison with organic and technological projects, physical testing was pedestrian, since it entailed the repetitive determination of properties of materials and products by methods which at the time were relatively basic and simple. We obtained one contract which ran for many years relating to the certification testing of vapour (fuel evaporation) seals for oil container tanks conforming to the Chicago Bridge patents. The seal material consisted of a glass fibre fabric reinforced with a mixture of 'Thiokol' and 'Neoprene'. Samples of every roll were taken on site by Mr. Ives, and were not issued for use by the client until we had certified that they were to specification. As this was a costly material the rejection of a faulty roll represented a considerable cost loss, but it stressed the importance which was being attached to physical testing per se.

Another quite basic project which we did for the ERA, was the investigation of electrical tracking. This was one of the early defects, especially in phenolics, and it limited the application of plastics in many cases. For this reason the cause and prevention of tracking in plastics compositions was of considerable commercial importance.

Physical testing in the sense of quality control became a matter of routine practice, and as it increased so we acquired even more sophisticated apparatus to ensure greater speed and accuracy of application. Our first real break-through came when we received AID approval as a Part III Test House, which opened the door to new work and general recognition.

Another significant step forward which enhanced our authenticity was the appointment of members of our staff as representatives on BSI committees. In the past this had been the monopoly of manufacturers, Government bodies and users' associations. Mr. Ives chaired TIB/14 for a number of years, and was an ISO delegate at Hamburg, Lisbon and Bucharest, and our invitation to join PLC/17 (and subsequently other committees) marked our acceptance as a substantial voice in independent testing, alongside with RAPRA etc. This included membership of several official bodies by Mr. Riley and Mr. Mead, and at a later date I was the first Chairman of Panel 6 of the British Calibration Service dealing with thermal measurement. All this involved a considerable amount of time for which we received no direct remuneration, but we established our recognition as a test house of standing, and this gave us "bread-and-butter" work in the testing of materials and products which increased in importance as the need for quality control in plastics was recognised. Very much the same applies in the work we did to assist in the establishment of the Agrément Board, which issues certificates of quality for materials and products, and their expected life.

The examination of thermal properties, in one way or another, occupied much of our early attention, and this was particularly so in the case of thermal conductivity to which reference is made later. Since one of the disadvantages of plastics had been their flammability, we established a limited test section for this purpose first at Ashtead, and more recently an elaborate and comprehensive layout at YTEC, Redhill, covering the requirements of a number of official specifications. This filled a gap which was inadequately covered by the Government testing

establishment. Our ability to cover fire testing has grown with the need, and has added considerably to our acceptance as a comprehensive "test house", and an activity which is lucrative and has considerable potential.

A comprehensive survey of testing methods, with the title of "Handbook of Plastics Test Methods" by Messrs. Ives, Mead and Riley, has been accepted as a standard work on the subject, and was valuable publicity for our establishment.

Thermal Conductivity

Work on thermal conductivity was centred initially at Chessington and then at Ashtead within Yarsley Testing Laboratories, and was mainly controlled by Mr. M. Riley. It is of interest to note that as in a number of instances in the past, what was work of considerable and lasting proportions arose from a single and relatively simple initial enquiry. In this case we were asked to undertake a programme involving the thermal conductivity of woven glass textiles. With the assistance of the National Physical Laboratory we set up the appropriate equipment for high temperature measurements, and then began a long and very profitable collaboration with this national organisation.

In a short time we added low temperature equipment, and later extended our range to cover materials between -196°C and 1000°C. With the closure of the NPL thermal conductivity department about 1967, we acquired some of their surplus equipment, notably in the fields of

metallic thermal conductivity and thermal transmittance. Whilst this was of material advantage to us, it was a loss to the country as a whole, since it meant that for a period of ten years, when energy conservation was of mounting concern in most countries, the UK had to exist without an official laboratory covering this subject.

For some years the Yarsley Laboratories continued to expand their facilities for internal determinations, and eventually began to construct apparatus for sale as the demand arose. Eventually we exported units to China, India, Singapore and Europe, and it is particularly gratifying that between 1978 and 1979 we were able to supply the NPL with several sets of apparatus, and so assisted them in setting up a facility as part of the British Calibration Service. In this way we can claim some small part in nurturing the 'art' of thermal conductivity during a difficult transition period, and to have assisted the NPL with some experience of our own, thereby repaying in some small measure the assistance they had given to us in the early days.

Our interest in thermal conductivity naturally brought us into active contact with the British Calibration Service to which I have already referred. Apart from my Chairmanship of Panel 6, Mr. Riley served on special working parties, as did other members of the staff. We hope shortly to become one of the first British independent laboratories to gain approval in this very specialised field of thermal conductivity measurement.

Engineering

Our function in the engineering field has changed over the years, and at one time it was a very important factor in our work involving both design and construction as described in an earlier section of this narrative. Our most ambitious production was the four-sided, film coating machine, which was built in sections at Chessington (owing to space limitations) and then erected and adjusted on the client's site.

Eventually our work mainly developed into the production of special test units to cover applications which arose from current laboratory work, notably that of the production of pipes of various types and dimensions. Thus for and from our own laboratory needs we were able to meet the needs of other users, some of them our own clients. This work again was divided between Chessington and Ashtead and was throughout under the general direction of Mr. R. Bradley. Some of the units became virtually of standard production, and some of them, together with special 'one-off' units, were exported. Brief reference may be made here to the more standard units we produced which conformed to various standard specifications.

(a) Resistance to Impact Tester - for unplasticized PVC pipe to comply with the requirements of Appendix F of BS 3505:68. This came basically in two forms, (1) being hand operated and covering a range from ¾" to 12" pipe (2) a more sophisticated Tester covering 6" to 24" pipe, power operated with raising and lowering mechanisms, rebounding and catching device etc.

(b) Long Term Pressure Testing Rig - for unplasticized PVC pipe to comply with BS 4728 and ISO R.1167.

These are multi station rigs normally covering about twelve samples. Basically consisting of a console which houses constant pressure source, accumulators, pressure gauges, valves etc. This is then linked by suitable pipework to a sample conditioning tank electrically heated.

(c) Falling Weight Impact Tester - for film or sheet materials to comply with BS 2782 : 306B and C.

This is a sample Impact Tester and can be used with either a spherical ended weight or a dart.

(d) Low Temperature Brittleness Tester - for determining the brittleness temperatures of plastics to ASTM D.746.

This consists of quite conventional apparatus, e.g. Heated Water Bath, Sample Cutter, Sample Holder etc.