

The
Life of
LUDWIG
MOND

✱
J.M.
Cohen

Methuen

The Life of LUDWIG MOND

by
J. M. COHEN



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IN the writing of this book I have had great assistance from several relatives and friends of Doctor Ludwig Mond, from several of his old servants and from some members of his companies, past and present. To all these I owe thanks, and among them to Robert Mathias, his nephew; to Mrs Brackley, his granddaughter; to Lady Gollancz; to Miss Louise Richter; to the late Mr A. W. Tangye; to Mr A. E. Wallis; to the late Mr Oliver Hall; to Mr W. Beswick; to Mr George McIntyre and to the late Mr H. C. Bainbridge, who not only talked to me about his memories of Dr Mond but allowed me to draw on his autobiography: *Twice Seven* (Routledge, 1933). Mr A. S. Irvine, Manager of the Alkali Division Information Service at Winnington, has helped me in so many ways, by his hospitality, by his jovial guidance through his company's early archives, by his own knowledge of Brunner, Mond history, by his attempts to educate me in elementary science and his correction of any technical mistakes in my typescript, that no thanks to him would be adequate. Some of his information I have incorporated in my narrative, and the rest appears separately at the end in the form of technical appendices.

Among previous publications I have made some use of *Alfred Mond: First Lord Melchett* by Hector Bolitho (Secker, 1933) and *A History of the Chemical Industry in Widnes* by D. W. F. Hardie, Ph.D. (I.C.I., 1950); also of various literature published by Imperial Chemical Industries and The Mond Nickel Company.

J. M. C.

NOTE BY MR ROBERT MATHIAS,
NEPHEW OF DR LUDWIG MOND, F.R.S.

IT is now nearly 45 years since Ludwig Mond died, and up to the time of the publication of this book no biography of him has been in existence. His sons Robert¹ and Alfred² did, in fact, suggest to his contemporaries that the story of their father's life and achievements should be written. As a result, Professor Armstrong, F.R.S., who was one of Ludwig's closest friends, undertook to write his biography. Unfortunately, soon after he started the task he died. It would now appear that I am the only one left of those who worked with Ludwig. I was closely associated with my uncle for some 20 years, first as his Secretary and Personal Assistant and then as an executive in some of the great industries created by him.

My memories of the great man are still fresh in my mind and for some years I have felt strongly that the story of his life and achievements should be told. With this in view I have been collecting and examining family letters and papers. In doing so I have been fortunate enough to have had the assistance and enthusiastic support of Ludwig's great-grandson, Julian Mond,³ who had carefully preserved all the family papers he inherited. These included much of Ludwig's personal correspondence. I have also had the wholehearted collaboration and assistance of Mr Irvine, who opened up the archives of I.C.I. to provide important additional material which, when assembled, made it possible for Mr J. M. Cohen to undertake this biography.

The story of Dr Mond is the story of a great man who started life in humble circumstances and simple middle-class surroundings, and it is my hope that his biography may prove a source of encouragement and inspiration to the younger generation.

April 1955.

¹ Sir Robert Mond, F.R.S.

² First Lord Melchett.

³ Third Lord Melchett.

FOREWORD

BY SIR ALEXANDER FLECK, K.B.E., D.SC., LL.D., F.R.S.

Chairman of Imperial Chemical Industries Ltd

THE British chemical industry, like many others, has at its foundations the pioneer efforts of determined and imaginative men. Working with what must be regarded, by modern standards, as a primitive knowledge of chemical properties and reactions and very imperfect chemical plant and equipment, they established the basic branches of the new and expanding industry.

Many failed in their efforts to transform laboratory discoveries into practical manufacture; Ludwig Mond was one who not only succeeded, but succeeded brilliantly. Good judgement combined with good fortune was the basis of the very early decision to enter into the business of ammonia soda manufacture. The author shows clearly how Ludwig Mond considered the possibility of establishing himself in several chemical processes, and how he finally chose one which was destined for success, once the manufacturing difficulties that had defeated earlier pioneers had been largely overcome by Solvay. The fact that Ludwig Mond was fortunate in his choice, however, does not detract from his insight, his imagination, and his Herculean capacity for work.

It may with truth be said that Ludwig Mond was one of the few pioneers who set out to base his chemical industrial work on modern scientific concepts and to use engineering practices of the highest possible standards. The whole of British chemical industry, indeed chemical industry the wide world over, has been stimulated and inspired by the example of accurate understanding of the physical and chemical conditions which was the basis of his technological work.

The book, as a biography, is mainly and rightly concerned with the man himself, but it could hardly avoid dealing with the growth of those parts of the heavy chemical industry with which Ludwig Mond was associated. Quite apart from the

FOREWORD

clearly-drawn portrait it provides, the book adds a most useful and interesting chapter to the history of one of the main branches of the early chemical industry.

In doing so it throws light on the progressive changes that have taken place in chemical knowledge, in methods of manufacture, in the size of firms, and in industrial relations, in which also he was a pioneer. It is indeed a far cry from the early days, when Mond's ideas were regarded as revolutionary by the business world of the time, to the normal present-day methods of management, which concern themselves to a great degree with the social well-being of employees as well as, of course, with their strict business efficiency. Nowhere is the contrast more striking than in the comparison of the initial stages of the Brunner-Mond partnership with the activities of the I.C.I., of which Brunner, Mond became a part in the merger of 1926.

It is in the belief that this volume will prove of value to those who are interested in the development of industrial philosophy that I wish it every success.



September, 1955.

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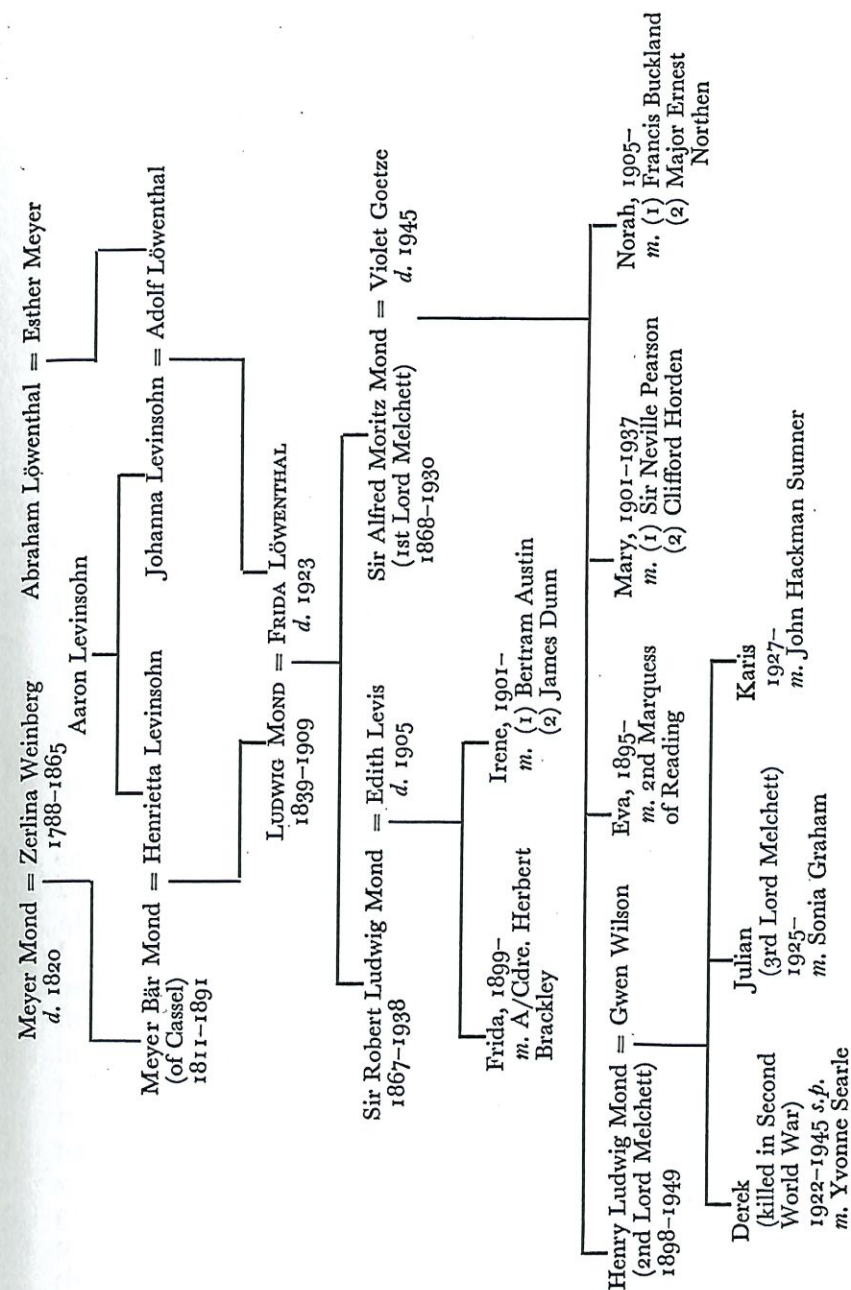
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PRELUDE

A VISIT TO 'THE HALL'

THE train standing at Platform One is the Blackpool Express, calling at Crewe, Hartford, Warrington, Preston and Wigan.'

'Crewe, Hartford, Warrington, Preston and Wigan.' It certainly must be a fast train we were going on, if it didn't even stop at Rugby. I knew all those stations well enough, surely. I was thirteen or fourteen at the time, and I had taken that journey rather often. But Hartford? Of course that couldn't be the Hertford near London. No, I hadn't heard of that place. Perhaps it was the junction for somewhere.

'What's this place Hartford?' I asked my escort, an elderly schoolmaster.

'The Capital of Old Doctor Mond's kingdom,' was his answer.

At that age I hadn't much time for cryptic statements of that sort, which let you in for saying something fatuous in reply and so getting thoroughly scored off. It would be easy enough to see what sort of place it was when we got there. But old Doctor Mond now. Who exactly was this Doctor Mond? I'd heard the name all right. Yes, there was one thing I could connect with it: some pictures I had seen at the beginning of the holidays in the National Gallery. The Mond Bequest. There was a portrait of a handsome, youngish man in a black hat against a plain green background, of a man looking away; some sort of merchant prince he might have been. But the title only called him 'a Man Unknown'. The painter was an Italian by the name of Boltraffio. Then there was the Raphael 'Crucifixion', with a golden sun and a silver-grey moon at the very top, each with a human face—one smiling, the other sour—and two angels dancing on the tiniest slips of cloud, one to the right and one to the left of the tall

cross with its long, pale Christ, who did not seem to see them. The angel on the left wore a green robe, the one on the right was in red.

The connexion between that 'Crucifixion' and the station after Crewe seemed a bit thin. But probably the man who had given those pictures to the Gallery had something to do with that part of the world. There was a Brunner, Mond, wasn't there, a firm that made soda and explosives? Perhaps it was that Mond who had his factory up there, which was important enough even for the expresses to stop at. My speculations were interrupted by the guard's whistle. Soon we were steaming past the backs of the Camden Town and Chalk Farm villas, with their dirty cream stucco and their strings of washing in the back gardens.

Hartford Station, I remember, when we came to it, was not impressive. It had one up and one down platform in a cutting that prevented your seeing the town, if town there were, and only two men with glossy brief-cases got out from a first-class carriage. Really there was nothing much to be said about the country. It was flat Cheshire land, with perhaps rather more houses scattered about it than you would expect in a purely agricultural district; and in the far distance, a few minutes back, I had caught a glimpse of some sort of works, several fields away. That was all that I learnt about the Mond kingdom on that trip.

It was many years before I bought a ticket to Hartford Station. It was at the invitation of a man I had known at Cambridge, who held a bigish job with Imperial Chemical Industries. I did not see him often, and it was always in London that we met, on occasions when he came down on business. But now he wanted me to go up to a farewell dinner that was being given for him by his friends. He was leaving the next week to take up some post for his company in South America. 'Book to Hartford Station from Euston,' he wrote. 'I'll meet you if you'll tell me when you arrive. I'm afraid I can't offer to put you up. But I'll book you a bedroom at the Hall which will suit you very well, since it is there that we are dining.'

Hartford Station had still no more than one up and one

down platform, and a diminutive siding that did not indicate much traffic. I climbed the steps from the platform, crossed the bridge, and found my friend waiting for me outside the booking-office. He was wearing a kind of light fibre helmet lettered on the front, which he had pushed to the back of his head, and far from being dressed as I expected a high-up chemist to be dressed, he wore an old pair of corduroys and a shapeless shooting jacket.

I must have looked rather hard at his helmet. It seemed out of place in that wide country road, along which straggled a few cottages with prize dahlias in their gardens and slow smoke mounting into an almost cloudless, wan autumn sky. We might have been on the extreme edge of some little market town.

'Oh, this?' he explained. 'Safety regulations. I've only slipped out of the office, you see. I'm just going to dump you at the Hall. You can have a wash and dig yourself in for an hour while I finish up, and sign my letters. Then I'll come back and stand you a drink.'

We got into the old shooting brake.

'Tell me,' I said. 'Is it your company that gets the trains to stop at this one-eyed little station?'

'Don't know, I'm sure. But they always have stopped the Blackpool express here, ever since the "Old Doctor's" time.'

'The "Old Doctor"?' I queried, with a sort of memory.

'Doctor Ludwig Mond, who put up his soda plant here at Winnington nearly eighty years ago. The Hall, where you're going to stay, was Lord Stanley of Alderley's house until Ludwig and his partner, John Brunner, bought it and built their first works in its orchard. From there it was a clear run to where we are to-day.'

'So this is the Capital of old Doctor Mond's kingdom?'

'If you like,' he answered as we turned a corner past a church that seemed still to belong to the straggling town we had been driving through ever since we left the station. 'But that's not a name any Cheshireman would recognize. "The Old Doctor", as they called him, was a Cheshireman to them, even though he was born in the town of Cassel, at that time capital of the Grand Duchy of Hesse. He's been dead more

than forty years. But you'll find he's still very much remembered in this part of the world. The Cheshiremen took a long time to accept him. At first they wouldn't work for him. But now a job at the works is something that passes from father to son.'

'He's the man who left the pictures to the National Gallery, isn't he?'

'Yes. And he founded the Davy-Faraday Research Laboratory, next to the Royal Institution. I don't think many men of his generation would have put down a good hundred thousand pounds to endow research, with no strings to it and for the benefit of any scientist who wanted to work there.'

'He must have been a millionaire at the least.'

'Perhaps he was. But that wouldn't be the right label.'

'Well, what would be then?'

'Wait till we get to the Hall, and then you may get some idea for yourself.'

'Why, does his ghost walk there?'

'Yes, I think in a sense it does. If the dead stay around whatever it was in life that they cared about most, Old Doctor Ludwig's probably still smoking his dark cigars somewhere about the place, in the spirit.'

We had left the houses of Hartford behind us, and were dropping towards an invisible river. On the left loomed a huge works whose chimneys and tall rectilinear skyline stood out against a background of autumn trees, lining the bluff which must have marked the further edge of the valley.

'Is that your works?' I asked.

'That's Wallerscote. They turn out the soda ash. Winnington itself is to the right.' I looked over a large plot of seemingly waste land with sheds dumped on it here and there, and some sizeable building work going ahead at one spot. On the far side, sure enough, loomed more of these irregular-shaped rectilinear buildings, eight or ten storeys high with great slender brick chimneys pointing up out of them, each crowned by a plume of whitish smoke. Now there were buildings standing back from both sides of the road.

'Here are the lodge gates.' There was a gap between two masses on the right, marked by a pair of iron gates, hanging

between stone posts, each crowned with a modern-looking lamp. It might have been the entrance to a park, but for the fact that the drive, if drive it was, led only towards a cliff of corrugated sheet and glass.

'That was the entrance to Lord Stanley's park. You could still drive up it to the Hall in the "Old Doctor's" time. But now the caustic plant stands square in the way. We have to go round.'

We swung past a long grey brick building in a nondescript modern style flanked by two bronze statues, which stood in front, in a little neatly trimmed garden planted with dahlias and scarlet salvia. The well-watered green of the grass and the brightness of the flowers were a surprise. For though there was none of the grime that I had expected to find so close to a huge works, there had been ever since we left the village of Hartford an oppressive colourlessness about everything. The works buildings were black and grey, and dirty concrete white. The brick of the tall chimneys was hardly pink. The sky was pale. This was a valley, I had felt, that the birds would fly across, where they would find no place to settle. And here suddenly a little planned garden came as a relief to the eye.

'The Research Lab,' explained my friend, 'with bronze statues of Doctor Ludwig Mond and Sir John Brunner. The Old Doctor's on the right.'

A stocky hirsute figure in a large high-crowned hat, swathed in a long overcoat and leaning heavily on a walking-stick, seemed to peer down from the pedestal on which he stood. His companion, on the other hand, was all movement and gesture. He appeared to be making a public speech.

We slowed up, turned off the road to the right, past more low buildings interspersed with bright flower-beds, and drew up on a wide asphalt drive in front of one of those modest black and white timbered country houses that one finds in Cheshire and in North Wales. It was long and low, apparently only two storeys high, and stood facing its own gardens with their trimmed lawns and massed dahlias, backed by massive round-domed hollybushes—and behind them by a great cliff of works building that dwarfed this well-mannered, well-tended Tudor manor-house with its careful symmetry of

criss-cross beams, if not into insignificance, at least into relative inferiority. As I got out of the car I noticed more works buildings and chimneys, rearing their heads high above the roof at the back and the side as well. Lord Stanley's Hall was entirely severed from rural surroundings by an industrialism that cared very little for its traditional peace. It lived on, I told myself, as a well-bred prisoner of mannerless modernity.

Here, as I discovered, when I came to know the Hall better, I was entirely wrong. For from that day when Ludwig Mond and John Brunner bought it on the strength of capital that they had not yet raised, Winnington Hall began to acquire a new history very much more vivid than any it had possessed as the neglected property of a family whose wide holdings left them very little time to consider this estate, especially as it was already slightly spoiled for them by the steaming little brine pans that they had let out to salt manufacturers down in the valley of the Weaver, just beyond their garden walls.

Once inside, I was introduced to several men, dressed as informally as my friend, whom we found sitting in deep chairs in the wide entrance-hall. The place, I learned, which had once been the residence of the partners, was now the club and guest-house of the senior executives of the Alkali Division of Imperial Chemical Industries.

On the table were three or four of those light fibre helmets painted with the word 'Visitor' on the front, and for the next two or three days one of them was seldom off my head. For I was taken for tour after tour of the works. The processes were simple yet baffling; the patience with which one after another of my guides endeavoured to explain them to me, almost infinite, and my own incomprehension invincible. I seemed to be led into countless hoists—which I should have called lifts—conducted along endless steel platforms overlooking giddy depths through which writhed convolutions of pipes, each one labelled and lettered; to have gazed into innumerable furnaces, through coloured glass eye-pieces which reduced the glare and enabled me to see the slowly vibrating coke burning and the clinkers shaken off at the back; to have

listened to the muffled roar of massed turbines, and inspected thousands of sacks of the finished product each marked with the down-turned crescent moon, which was Mond's sign—a play on the German meaning of his name.

The dinner to my friend was like an entertainment in a colonial station, where the customs, the slang, the jokes, even the habits of eating and drinking, were different; where the stranger was treated with boundless courtesy; where everything was done to make him forget that the Old Doctor's kingdom was another world, but where nevertheless everything referred to a past that was not his. And across that past strode the figure of this German emigrant Ludwig Mond, who with his Lancashire partner had created it all.

'So you're still working the same processes as old Mond began eighty years ago and more?' I asked.

'Yes. Of course we don't use the old donkey engines he did. I showed you the foundations of his first one that they used to call "Old Betty" beside the ammonium chloride plant yesterday, didn't I?'

I nodded. I had seen a good deal yesterday that I couldn't give a name to to-day.

'And we haven't the squads of Irish labourers shovelling the coal into the furnaces, or rolling the ammonia barrels off the barges that brought them from the Liverpool gasworks. But to all intents and purposes we're still making our soda his way.'

'So he wouldn't be lost if he were to stray back one night to see what's going on?'

'No. But why are you so interested in the "Old Doctor"?'

'I don't know. I always have a passion for knowing about the beginnings of things.'

'Well, we've got plenty of records here, and nobody's ever written about him, except about his scientific work. Why not stay up here a day or two longer, and see what you can find out? There are one or two people still around too, who worked with him and may be able to tell you something.'

Their records were copious. Family letters in English and German—the latter faded and in the old Gothic script—business letters, reports, patents, notebooks full of calculations and

rough sketch drawings of plant: everything had been preserved; everything had been filed; everything awaited the 'Old Doctor's' biographer. And there were a few old people—a retired director, a barber, a retired housekeeper—who were able to tell me something about Ludwig Mond.

THE EDUCATION OF A SCIENTIST

AARON LEVINSOHN of Cassel in the Grand Duchy of Hesse was a typical Jew of his generation. On the one hand a good Hebrew scholar, and on the other a man of commercial training, he combined a comparative prosperity in his business with a pious and moral outlook which earned him respect in his city. Born in 1772, he grew up under the influence of those French Revolutionary ideas that brought to the Jews of Germany a premature enfranchisement, which they subsequently lost on the destruction of Napoleon's empire. With the advance of the French armies the ghetto walls fell, and Jews whose ancestors had in many cases inhabited their towns for as long as the oldest families among the burgher nobility found themselves for the first time equal citizens. The belated laureate of this short-lived emancipation, Heinrich Heine, though born a quarter of a century after Aaron Levinsohn, spoke for his father's generation as well as for himself when he delivered his withering attacks on the German culture which had failed them and him, and which he viewed from the standpoint of a French citizen. For he had left his country where, with the restoration of the German princelings after 1815, the Jews were submitted once more to restrictions, often undefined, which prevented their entry into the professions and debarred them from promotion in the semi-conscripted princely armies, in which, nevertheless, second-class citizens though they were, they were still liable to serve.

But Aaron Levinsohn flourished at a time when all barriers were down; and so, in addition to his Hebrew culture and his commercial education, he acquired a wide knowledge of literature and history, a considerable curiosity about the sciences, and a large library. The old house which he bought at Cassel, on the corner of the Johannissgasse (now the Marktgassee) and the Graben, was a sixteenth-century mansion four floors high with a multitude of uneven gables, with curious beasts carved

on the projecting ends of its beams, and with its upper storeys overhanging the pavement of the street. It was one of the principal residences in the place, having originally belonged to a Chancellor of one of the early Dukes. Levinsohn himself acquired it from a well-known painter, and adapted its commodious and rambling rooms partly for the purpose of his trade and partly as a family house.

From the Johannisgasse a door led into a stockroom containing rolls of fine cloths—silks and brocades. For Aaron was purveyor to the ducal court and to the ducal theatre, for which he also designed and made the costumes, which consumed a great deal of costly material. So, although because of his divided interests Aaron Levinsohn was possibly not an outstandingly successful man of business, his enjoyment of this official monopoly guaranteed him a fair income. This, however, he earned at the cost of much rather reluctant travelling about the country to find the special cloth needed for the dressing of this or that play, of this or that court festivity. One such business mission indeed sent him to Leipzig at the height of the Napoleonic wars, where he arrived just before the great battle, during the course of which he fell ill of cholera, and had to be fetched home by his wife.

Eva Levinsohn, his wife, was even more typically the product of the Revolutionary generation than her husband. For while the new ideas served only to liberalize his fundamental Jewish orthodoxy, and he remained in the tradition of the scholar and man-of-affairs combined whom one finds, in any century, at the head of so many Jewish families in the settled communities of Western Europe, she threw herself far more wholeheartedly into the new life that was introduced by the invading armies and given a legal basis by the constitution of Napoleon's Confederation of the Rhine. When she was a young woman French was spoken almost as freely as German in the streets of Cassel, and although her family was a poor one, her father having died in her youth, she seems to have acquired a considerable education, to have read and spoken the language of the liberating invaders, to have written some poetry and to have had a considerable appreciation of the

arts. She had moreover in early life acquired a practical capability which must certainly have stood her in good stead in her marriage to her rather impractical silk merchant.

Eva and Aaron Levinsohn came of the same respectable and moderately well-to-do class of Jews who could trace their ancestry back for many generations in the same locality. Her family name of Müller, which was not a Jewish one, was said to have been bestowed on an ancestor of hers who had saved his prince from drowning in a millstream. Why the rescuer was rewarded with the name of Müller remains obscure. It was said to have been the first that came into the dripping Prince's head. The story seems slightly apocryphal, but testifies to the Müllers' sense of belonging to Cassel.

Aaron Levinsohn, on the other hand, was a comparative foreigner, coming as he did from Minden in Hanover. But there is nothing exceptional about this. For the German Jewish community was in many ways matriarchal and it was quite usual for the daughter of prosperous people to marry some less prosperous young man who had arrived on business from another town. Then, particularly if the young lady had no brother, her prospective bridegroom was offered the post of traveller or assistant in his future father-in-law's business, out of which, in due course, a dowry was paid to him, which enabled the young couple to set up their establishment, very possibly in some part of the family house.

Eva Levinsohn was a woman of character and determination, qualities which she passed on to two at least of the three daughters she bore to her husband Aaron. She had an intelligent and ironic face, whose chief feature was that commanding nose which she transmitted, together with her strong chin, to her second daughter Johanna and, without that second testimony to her strength of character, to Henrietta, her youngest. Some false curls, however, showed that for all the liberalism of her outlook she adhered to the old Jewish custom whereby women cut their hair short on marriage and thereafter wore a *scheitel* or wig, as a sign of their matronhood. But for the rest she was to the last a woman of extremely liberal opinions for her time, and one who, despite the deafness that afflicted her in old age, kept up a lively interest in everything that

went on, even to the extent of sometimes managing her daughters' and their husbands' affairs for them.

They looked back on her in after years as a proud woman who had been conscious of her own value and who had stood up to adversity with courage. The nature of this adversity is not specified in the letter written by Henrietta to Johanna, some nine years after their mother's death, in which the younger sister exhorts the elder to follow their mother's example in some adversity of her own. But whereas Johanna was probably suffering by reason of the unfaithfulness or unreliability of her mercurial husband, her mother's troubles were caused by no waywardness in hers. However, though Aaron Levinsohn was a more conscientious man than his light-hearted son-in-law, he was too little of a man of business for his family to have been always and entirely free from financial anxiety.

The Levinsohns were blessed with three daughters but no son. The eldest, Frederike, who married young, soon left for America with her family, and played no part in the life of her nephew Ludwig Mond, who as the son of Henrietta and the son-in-law of her sister Johanna was in a sense the heir to them both. Lacking a son, Aaron Levinsohn lavished an almost masculine education on his daughters. He had them taught drawing, music and languages; French and Italian were the most fashionable at the time. But he also gave them some instruction in the natural sciences, which it was not at all usual to teach to girls at that date. The local school to which they were sent was run by a Swiss pastor, who had been a pupil of the revolutionary educationalist Pestalozzi. But, not satisfied with what they could learn from their teachers, he appointed himself as a kind of supplementary tutor, taking them for walks in the hills around Cassel to stimulate their interest in nature, and getting permission to show them over near-by factories so that they should learn something about processes of manufacture. In addition, there was the ducal theatre to which in his capacity of purveyor he was a frequent visitor, and there was the ducal art collection, both in the palace and the museum, to which he had free admission. Their education was consequently a somewhat serious one,

which might in another age have started at least one of them on the road to an academic career. But all three were far more attracted by the prospect of marriage. As a result of their advanced education, nevertheless, the Levinsohn daughters had, at least, a rather better taste in literature than their friends and neighbours. Henrietta's favourite authors as a young woman were Goethe, Rousseau and Jean Paul, three authors whose theories of education she studied in order to apply them to the bringing up of Ludwig Mond and the rest of her family. It is doubtful whether, except for a little over-seriousness, she was profoundly influenced in her practice by these models, but there is more than a hint of Rousseau's mingled sententiousness and self-pity about some of her letters to her eldest son. Her elder sister Johanna, however, derived a good deal more from her father's instruction. Indeed in her middle life she showed an almost masculine grasp of business detail and manufacturing processes. Such was her mastery of these manly affairs that there were times when of all his relatives only his aunt Johanna received the young Ludwig's detailed confidences about his hopes and plans.

When Meyer Bär Mond arrived as a seventeen-year-old apprentice to Aaron Levinsohn's business, he came only from the neighbouring village of Ziegenhain. Yet the difference in social standing between a prosperous and established urban family like the Levinsohns and mere village Jews, like the Monds, was a very wide one. Meyer Bär—or Moritz as he was henceforth called—was the son of a late third marriage, which his father had contracted chiefly for the begetting of an heir who could say the *kaddish*, or funeral prayer, over his grave. Bär Meyer Mond, the father, is described in his papers as a dealer in real estate and produce, a trade whose main profits were derived from advancing money on future crops and from general huckstering among the small farmers. But the old man was dead by the time that his son came to live beneath the Levinsohns' roof, and fell under the influence of their daughters. These young ladies appear to have made some efforts to improve his education. But though a man with a clear mind and fair business abilities, Moritz was incapable of raising his interests to their level. This shortcoming caused

him to betray throughout his life a slight sense of inferiority, which expressed itself chiefly in a rather plaintive insistence that his children should show him respect. Short in stature, he was most exact in his dress, rather fussy in his manners and, since his opinions were not always treated with the seriousness he expected, somewhat over-authoritative. When Moritz came to Cassel, Henrietta, the youngest of the Levinsohn girls, was no more than twelve. In due course he fell in love with her, asked for her hand and married her when she was twenty-one and he twenty-six. Their first child died in infancy, their second, Ludwig Mond, was born two years after their marriage, on March 7th, 1839.

From a very early age the future industrialist was a consequent child, though his mother thought of him as absent-minded and remembered having to take him to school at an age when boys can normally get there on their own. Allowing for her over-anxiety, one can still share her fears for the small boy of six and a half who had to be pulled back on to the pavement by passers-by, so immersed would he be in his own thoughts. These seem from the first to have taken a severely practical turn. What became of the wool when a hole appeared in his stocking? Could God see into the cellar where the apples were stored? At nine he entered the secondary school, whose headmaster was an advanced educationalist and had recruited a good staff. Ludwig was considered a thoughtful and attentive pupil, and in the year 1848, the year of revolutions, was vociferously revolutionary in his sympathies. But in this no doubt he was no more than echoing the opinions he heard at home, since any cultivated Jewish family would be liberal in sympathy. For only under a liberal constitution could they hope to recover the equal citizenship that they had enjoyed under Napoleon. So if the young Ludwig sported a red tie and talked of the great rôle he would one day play under the Republic it was no more than the enthusiasm of a small boy who knew that his future choice of career would be restricted under the prevailing government.

But he was not content merely to voice juvenile opinions. He demanded information, and ceaselessly plagued his mother with questions about princes, constitutions and geographical

boundaries. Henrietta was more at home with ideas than with facts; and so it was to his aunt Johanna, now married and living in Cologne, that the nine-year-old student of politics wrote, as to a superior authority, to demand a thorough account of contemporary happenings and circumstances.

Aunt Hannchen, as he called her, was a far more reliable source of information on matters political than was Ludwig's mother. Her husband, Adolf Löwenthal, too, was capable of informing the future industrialist on many subjects about which his curiosity could not be satisfied at home. Adolf, as a young man, had started to study medicine, but had been forced to give up his studies after a few months owing to financial difficulties at home, which coincided with the closing of the University of Brunswick. He had next gone into a drapery business and then done his military service. But all the time he had preserved an interest in chemistry and had attended lectures when he could.

It was as a business man, however, that he had come to Cassel on the occasion of his first meeting with Johanna Levinsohn, and he remained in business during the early years of his marriage until, after a financial failure, he made use of his scientific knowledge to take up the Cologne agency for the electroplating and allied processes of the Royal Galvanoplastic Institute of Berlin. In due course he opened a galvanoplastic works in Cologne, and did moderately well, though, being something of a *bon viveur*, he always liked to cut a bigger figure than his income allowed. It was he who first stimulated the young Ludwig's scientific interests, by bringing him on one occasion a galvanic battery, and on another an edition of the chemist Liebig's letters.

The Mond family was soon increased by a sister Philippina (nicknamed Pina), two brothers in succession, Adolf and Rudolf, and finally by another sister—Mathilde. The grandfather Aaron Levinsohn, who had retired to a small apartment at the top of the family house, was by the time Ludwig knew him in feeble health. The boy's only memory of him was of an old man with a shade over his eyes and a perpetual book in his hand, who sat close to the tiled stove of his room and would sometimes, for a treat, share his snack and his glass of

madeira with him. Sometimes, too, his grandfather would tell him stories. But at storytelling no one could beat his grandmother. What is more, she taught him chess, a game he enjoyed throughout his life.

Already Ludwig was so great a controversialist that he earned himself the nickname of *Disputax* among his school-friends. He acknowledged no authority and allowed himself to be convinced only by the clearest of arguments. At thirteen he took his Barmitzvah, whereby he became a full member of the Jewish community. His parents were, like his grandparents, orthodox Jews, though very far from exclusionist in outlook. Indeed many of their friends were Gentiles. Nevertheless they would have been violently shocked if any of their children had deserted or married out of the faith to which they so loosely adhered. Ludwig therefore learned sufficient Hebrew to go through the Barmitzvah ceremony, though he rapidly became an agnostic in outlook as he grew up.

He entered the Cassel Polytechnic at fourteen—which was rather early—since he had gained a year at his secondary school through speedy class promotions. At the Polytechnic the teaching of science was particularly good. The great Robert Bunsen, who was then teaching at the University of Heidelberg, had once been on the staff, and the training indeed was superior to almost any which could be obtained in other countries at that time. In the English public and grammar schools, for instance, there was no teaching of science at all; and though a beginning had been made in the Scottish universities, no major scientific appointment was made in England until the election of Clerk-Maxwell as Professor of Experimental Physics at Cambridge in 1871—twenty-eight years later. Such instruction as was available in England was to be had from the Royal Institute or the School of Mines, or from the scientific societies in the various industrial towns. Ludwig, however, had not to look further than his own doorstep to find the best possible training for the career he was to take up, at a time when his future competitors in England were learning their trade either as apprentices in chemists' shops or working in inferior positions in the factories whose techniques they were later to improve.



Zerlina Weinberg, Ludwig Mond's paternal grandmother

When Ludwig Mond left the Polytechnic after two and a half years, he had followed courses in Higher Mathematics, Physics, Theoretical and Technical Chemistry with laboratory practice, Mineralogy and Geology, Botany and Zoology, Engineering, Architecture, Machinery and Mechanical Drawing. At the same time he was acquiring from his father's book-keeper the necessary commercial knowledge to qualify him for admission to the Cassel Merchants' Guild. But he seems to have found time also for some music lessons, for frequent visits to the theatre and perhaps for a little general reading, which his mother tried hard to encourage. It was for that reason no doubt that when Ludwig and his sister Philippina were staying with relatives his mother remarked at the end of a long letter containing injunctions to see the sights of the town, not to eat too much fruit, to wrap up warm, and to think more of the practical utility of clothes than of their smartness, 'whenever I find a beautiful passage in a book I always think of you'. But whether this testifies to a fine taste that he had already acquired or to her hopes that he would form one is not clear. She herself saw little difference. For while speaking of over-indulgence in fruit—which was unhealthy in wet weather—she expressed her confidence that she had only to say 'I wish it' for him to obey—a rather doubtful proposition in the case of a strong-willed schoolboy of fourteen.

But Henrietta Mond, despite her addiction to Rousseau, was certain that it was her duty to form her son, and even to dictate his opinions to him. For when she enjoined him further not to miss the Jesuit church in his sightseeing, she assured him, in her liberal spirit, that every way of praising, thanking and thinking of God is equally holy. Ludwig, however, was not very interested in churches or ways of praising God. He is much more likely to have paid attention to a later part of her letter in which she recommends him to see how the uncle he is visiting runs his business. 'But be very discreet,' she warned him, 'and say as little as you can. The art of listening is at least as difficult as that of speaking, and one can recognize a really well-bred man by his quietness and dignified behaviour. This applies to you too, my dear Pina,' she went on,

now addressing her daughter. Modesty was perhaps Pina's way, but it was never Ludwig's; and had his host asked him for his advice on any business matter Ludwig would have gladly given his opinion, which would have been practical—and perhaps useful.

Certainly his Cologne uncle, Adolf, treated him while he was still at the Polytechnic as an intelligent adult whose views were to be taken seriously. 'I wish that I could send you for a couple of years to the École Polytechnique in Paris,' he wrote after paying the boy most flattering compliments on his knowledge, his urge for self-improvement, his talent for analysis and his perpetual and inventive curiosity. If only Ludwig could have the run of the Academy library he would see that many of the ideas he was now thinking out had already been worked on in Paris, which was considerably more advanced in the technology of Uncle Adolf's subject than any German centre. The Paris Academy had just voted 200,000 francs for the exploitation of aluminium, which had recently been discovered by a German. The King of Prussia was said to be so excited by the new metal that he had decided to arm his cuirassiers with it.

But although his sixteen-year-old nephew might be wasting his time on problems that had already been solved abroad, Uncle Adolf only wished that Ludwig could spare a few days to come over to Cologne and talk science with him. In the meantime he sent him reports of some experiments that he had found time to do himself during the last winter. These had been frequently interrupted, but had achieved results that Ludwig would not find set out in the textbooks.

Though it is no doubt early to trace in a sixteen-year-old boy the outline of the mature man and the prophecy of his achievement, Ludwig Mond's experience seems already to have dictated the lines on which he was to develop. First, there was his liberal upbringing, which made it possible for him to think freely and untraditionally on a variety of problems. Then there was the strong chemical bias of the Cassel Polytechnic, which taught him the laboratory basis of processes, which he was often—in after life—somewhat premature in translating into full-sized plants. The gap between

the initial working out of a formula and its industrial application was, perhaps, still imperfectly understood in the Germany of Bunsen and Kolbe.

But, thirdly, and perhaps principally, he had some first-hand acquaintance with a small-scale and not very efficient business, his uncle's galvanoplastic plant at Cologne, where he not only came to look at things from an electro-technic point of view, but also learnt that the difference between a loss and a bare profit usually lay in the waste-products of any process, with which industry was so lavish in its beginnings. The chemist, the electro-technician and the sometimes rather stubborn enthusiast for waste-recovery were all present in the youth who entered the University of Marburg, the educational centre of his native duchy of Hesse, as a student of Chemistry in October 1855. The director of the Chemistry department was Professor Kolbe, second only in reputation to Bunsen of Heidelberg, whose assistant he had been, among the leading chemists of his day; and Ludwig immediately joined his class. At Marburg he boarded with a veterinary surgeon, whose rooms he discovered for himself.

On arriving in the town he found a letter from each of his parents waiting for him at the post office, full of instructions for his conduct in what his mother described as 'our Hessian Athens'. His father recommended him to a local Jewish citizen to whom he had sent a small sum of money to be drawn as required. This same Herr Weiler would instruct Ludwig as to his behaviour towards his professors, and his father would spare him all further precepts, on condition that he wrote home promptly and that his letters were more legible than the one he had sent them from the grandpaternal village of Ziegenhain, where he had stayed on the way. But from sternness his father's letter soon dissolved into pathos and ended with a plea that their affection should not be allowed to evaporate with absence. For Moritz Mond must already have seen that his sixteen-year-old son was longing to stand on his own feet and already ceasing to defer to his father as a final authority; and to him, as to his wife, obedience and affection were one.

Henrietta Mond offered much conventional advice couched

in the generalizing style of Polonius. Yet there was one observation in her letter that applied to her son Ludwig and to him alone. 'Take in everything that you hear,' she advised him. 'But don't leap to conclusions. That is a Jewish vice.' Perhaps his mother's words sank in; or, what is more likely, reflectiveness and the patient assimilation of facts were already natural to the boy. Certainly there is nothing in his letters of the time to suggest that he shared this particular vice of his people. He learnt and, for the moment, came to no premature conclusions.

A Jewish student at Marburg depended on his own personality for social success. There were undergraduate circles among whom anti-Semitism was almost obligatory though purely as a matter of snobbery; race theories were a thing of the future. Others, though far from liberal, were only prepared to accept an occasional Jew on his merits. Among these latter Ludwig Mond found himself friends, with whom he danced, skated and went on boar-hunts during this first winter away from home. Indeed several of these young men whom he met at Marburg remained intimate with him for much of his life. With some he even-kept in touch after his final settlement in England.

His mother's advice was to avoid the life of the student corps. But Ludwig was already self-reliant and had ceased to take her worries on his behalf very seriously. True, there was heavy drinking among these fraternities. But Ludwig could apparently hold his own in this respect. His mother's letters, however, contained more than mere exhortations to take his pleasures elsewhere than in the beer mug. She begged him not to become narrow, and to find acquaintances with whom he could read and discuss Goethe, Lessing and even Friedrich Engels, whose *Condition of the Working Class in England* had appeared some ten years before; and she sent him also the latest news from Paris, of the rediscovery of the true Tyrian purple, which could be manufactured out of guano and was to be tested that week before Napoleon III himself. While his father seems to have viewed his training in chemistry as a not too certain preparation for a commercial career, Henrietta Mond was already looking outside the country and to the centres of scientific discovery for a field of activity wide

enough to suit her brilliant son. Her ambition for him knew no bounds.

Her letters to him continued to mingle the soberly domestic with cultural matters and an occasional reference to science. Overshoes and an evening waistcoat arrive in the same parcel as some samples of coal to be analysed for their benzene content.

After his first enthusiasm for student life Ludwig writes that he feels very isolated and launches out into a lengthy criticism of Liebig's religious views, to receive from his mother a warning against his own too confiding nature and lack of worldly wisdom; to venture such opinions about a man of Liebig's standing in public would be extremely tactless. She did not remind him that here he had come to one of those premature conclusions against which she had warned him only a few weeks before.

At the same time she continued to watch over his reading. He was not yet ready, she thought, for Shakespeare, 'who has to be sifted before he is acceptable to us Germans. He is often too blunt and too coarse, and deep though he looked into the human heart his villains are too cruel and his female characters too fickle.' If Ludwig were to read him he should read the historical plays in their proper order. But despite her warning against the great Englishman's coarseness, she assured her son that Shakespeare is the only poet in his class. 'Be as consummate in your vocation,' she concluded, 'as he was in his, and your mother will be a happy woman.' The death of 'the best of our modern poets', Heinrich Heine, is the occasion for another maternal homily, this time on the perils of all talent that is not founded on a firm moral basis.

Look on him as an example. He was a materialist, and had no religion. He was our best poet, but light and frivolous, and an immoral and unhappy man. His uncle, on the other hand, was generally respected and deeply mourned. At his death people spoke of him as the friend of mankind. He was the famous banker, you will remember.

Moritz Mond's letters to his son were shorter. They tended to be accompanied by presents of cigars and to contain drafts

of money accompanied by strict injunctions for economy in its expenditure.

Very soon additional reasons for Ludwig's feeling of isolation became apparent. In a letter to his sister Pina he spoke of a young lady. The letter was read by his mother, who reproached him bitterly for keeping a secret from her. It appears that he had proposed marriage. She begged him to seek rather for the Philosopher's stone, or to make diamonds from coal, or to return to his old project of devising a journey to the moon. How could a young man with such far-reaching prospects for the future, who might not be able to support himself for eight years, so much as think of marriage, she asked, still less speak of it. He had matured too young, in her opinion, and that was a bad thing. She was most anxious that his father should hear nothing of this matter.

The affair blew over, and for a while Ludwig nurtured a fashionably broken heart. This did not, however, deflect him from his scientific interests. Already he was trying to find industrial applications for the chemistry he was learning in the University. His Cologne uncle was his confidant in such matters, for already his respect for his father had sunk very low. In the summer of his first year Ludwig had to make a formal apology for some unspecified wrong that he had done to Moritz Mond. This apology was accepted, though the acceptance was accompanied by a lecture. His mother at the same time was perturbed by the news that Ludwig had been wounded in a duel. She enjoined him not to seek for quarrels, but when his honour was impugned to fight bravely, advice to which she appended the offer to send him a French book, or a Walter Scott novel, to help him keep up his languages. This is the first we hear of his knowing any English.

At the end of his first year Ludwig was so well advanced as to be given a special analysis to conduct by Professor Kolbe. He had also done a piece of research on his own. He had made a bronze alloy which he hoped would be of use in his uncle Adolf's works, and for which he expected to be paid. Nothing seems to have come of this, his first invention. But his uncle, when in Munich, had met Professor Liebig and consulted him about his nephew's future. The great man had

advised that after his year at Marburg the lad should spend the next at Giessen, and a third under himself at Munich, a perambulatory process which was usual, and still is, among German students. The idea of Giessen alarmed Henrietta Mond. She had got used to Ludwig's student corps life, but Giessen was full of temptations. She preferred the idea of Heidelberg, where he would be under Professor Bunsen, though that University had recently earned her disapproval owing to some student rags which she considered too coarse to be funny.

Ludwig left Marburg at the end of the summer term of 1856 with excellent testimonials from Kolbe, and spent much of his vacation at home, reading, playing chess and practising fencing against the prospect of more duels in a University which was famous for the scars that it left on its students' faces. At Heidelberg, Bunsen was delighted with Kolbe's testimonial and readily accepted young Mond's application. So the lad moved from a provincial centre to a place of education second to none in Germany, from one excellent teacher to another, who was in addition to prove a lifelong friend.

Robert Wilhelm von Bunsen, at that time a man of forty-five, may be said to have laid the foundations of modern organic chemistry. What is more, his discoveries had been of the utmost industrial importance. His work on the waste gases from blast-furnaces, for instance, had been utilized to effect great economies in their running; and from these experiments he had elaborated methods of gas analysis which were then in general use. Then later he had gone on to the electrolysis of metals, and in the years after Ludwig Mond's departure from Heidelberg he invented the process of spectral analysis, by which he discovered the two new elements, caesium and rubidium.

In after years, Ludwig had a portrait painted of his great master. Bunsen had always refused to sit to a painter and, when asked why, offered the same excuse as for his failure to marry; that he had not the time to spare for such things. But Ludwig commissioned an artist who was equal to his problem. With the help of friends he secured a seat at the Professor's *Stammtisch*—or usual table—at his favourite café; and while Bunsen ate, drank and talked he made sketches from which

he was able to build up a portrait in his studio. This portrait Ludwig Mond took back to England, and hung in his study.

Ludwig was immediately fully occupied in Bunsen's laboratory, and very soon he was in the thick of student life too, joining the crack Rhenania corps in his second term. He proved a great expert at rapier fighting. For though he was rather broad, and therefore presented a good target to his opponent, he was remarkably quick and never tired of practising. Soon there were a considerable number of opponents' names inscribed inside the guard of his rapier, and despite the fact that his round and still beardless face remained innocent of scars, he bore some marks of his duels on his head and on his chest. His corps activities brought him many new friends. Yet his closest bond was with Eduard Hagemann, a young man who worked in the Mond business and whose father was forest ranger of the Cassel district. With Hagemann, his brothers and their father, Ludwig would ride on their tours of inspection in his vacation, sometimes in chase of the wild boar, sometimes of poachers.

At Heidelberg Bunsen directed him along a practical course and encouraged him in some experiments of his own: one for improving the poor burning qualities of the lignite which was the common fuel of Cassel's inhabitants, and another on the utilization of peat for industrial purposes: the latter a project to which he returned nearly forty years later when he investigated the possibilities of recovering ammonia from Irish peat. Both these investigations he had already begun at Marburg. Unfortunately they led to nothing.

Already Ludwig's father was restless. He was worrying about the commercial applications of the work his son was doing. Even Ludwig's mother suddenly wished that he would change over to geology. For there were, she believed, treasures slumbering in the earth, only waiting for him to discover them. It was less obvious to her that treasures were also being poured out night and day in the heavy smoke of factory chimneys and on to the waste tips of countless works, which only required the genius of a Ludwig Mond to be transformed into precious by-products.

His father was dubious about the value of scientific edu-

cation as a whole. Indeed he had been reluctant to finance these Heidelberg terms until Aunt Johanna had undertaken to bear some of the cost. So Ludwig was left in no doubt as to the sacrifices that his parents were making to keep him at the University, and he was probably seriously tempted by the offer of a post in a white-lead works, made to him towards the end of his first year there. His mother, though against this particular offer owing to the poisonous nature of the work, was nevertheless in favour of his considering a post even at that point. For an offer had just been made for his sister Pina's hand, which, had it been accepted, would have meant finding her a dowry; and this would have necessitated economies. The suitor was rejected, however, and Ludwig returned to Heidelberg in the autumn of 1857.

Before returning, however, he paid a visit to his uncle and aunt in Cologne, where he met for the first time, except for a fleeting instant some six years before, their ten-year-old daughter Frida, his future wife. In after years she would describe her cousin as he had then appeared to her, every bit the student, with his thick and curly hair sticking out from his embroidered corps cap and a shepherd's plaid over his shoulder. He arrived carrying a doll dressed as a Hessian peasant, a present for herself. But it was not a mere family visit that he had come to pay. He had worked out a plan for purchasing a share in his uncle's business, a project which he had already broached to his father. Adolf Löwenthal, however, seems at the outset not even to have inquired why his nephew was so anxious to see his account books.

Uncle has a really fine business [Ludwig reported home]. It is pleasant to run and his present turnover is not to be sniffed at. His profits are about 70 per cent and his methods of manufacture are capable of vast development. When I had looked all round, I informed Uncle and Aunt of our plan. They were both very much surprised.

They were surprised, however, not so much by Ludwig's having worked out his scheme as by his parents having agreed to it. Adolf Löwenthal discussed the whole matter with him, with more thought for the boy's future than for his

own interest, and tried to point out the superior advantages of various other branches of the chemical industry. But he had to give in to Ludwig's well-marshalled arguments and admit that (1) it would not suit his nephew to enter someone else's business, and perhaps work for years before earning anything at all; that (2) few businesses paid nearly as well as his, and that (3) to set up a factory of his own, which was the boy's eventual intention, needed far more capital than they could possibly scrape up at present. In face of such logic Uncle Adolf gave in; and it was agreed that Ludwig should leave Heidelberg and start work with him on the first of April next for a provisional three to six months. Löwenthal had supposed that his nephew would require another full year at Heidelberg to complete his theoretical training. But Ludwig explained that he was a good six months ahead of the other men in his year, since he had already decided what branch to specialize in, and they were still following the general course. He need therefore keep up nothing except his chemistry. His uncle asked him to make one exception and attend classes in logic; which seems, considering the tenor of these discussions, hardly to have been an urgent subject for study in his nephew's case.

The letter home in which Ludwig reported his negotiations shows every sign of satisfaction, but his proudest boast he reserved for the postscript. 'I have already earned my travelling expenses,' he wrote, 'by utilizing by-products which have hitherto been thrown away in considerable quantities. The process is cheap and simple; the materials now recovered are zinc sulphate and nitric acid.' Here, as when in earliest childhood he had wondered what happened to the wool from the hole in a stocking, he was hot on his characteristic pursuit of the waste-product.

His aunt and uncle were impressed, but clearly not anxious to come to an arrangement too soon. The boy was still very young and would profit greatly by working under his uncle, but it was too early for him even to talk of setting up on his own. Such was the gist of the long letter which his aunt wrote to his mother on the subject and to which his uncle appended a note, stating that he was in agreement with its contents,

but had not the time to write himself. Perhaps there was no point in his writing at any greater length. Over such important matters the Levinsohn sisters would no doubt make the arrangements without over-much reference to their husbands, as Adolf Löwenthal very well knew. Not for nothing were they the daughters of a matriarch.

Moritz Mond, however, who had apparently agreed in principle to the ideas, now changed his mind. 'To my no small surprise,' he wrote to Ludwig, 'I learned from your letter of your plans for the future, to which for reasons which I will now give you I cannot agree.' The letter, with its copious underlinings, repeated the arguments which his Uncle Adolf had tried to put up in the first place, but which he had been forced by weight of his nephew's logic to withdraw. Moritz Mond told his son that he was too young to set up in business as a partner, and too inexperienced to decide now to what branch of the chemical industry he would later devote himself. He did not, however, forbid his son's going to Cologne, nor suggest for a moment that he ought to stay at the University to take his doctorate. The inference is that he had been talked into agreeing to buy his son a share in the Löwenthal business but was now hedging. His advice that Ludwig should get some knowledge of all branches of the chemical industry was undeniably sound. Only the underlinings in his letter argue a certain discomfort, even a suspicion perhaps that his preternaturally positive son might be right in thinking that there were exceptional openings for him in his uncle's galvanoplastic line. Very few men could have suggested a new and profitable process on a mere passing visit, as Ludwig had done at Uncle Adolf's.

When the young man returned to Heidelberg for the autumn term it was with the resolution to leave at Easter. 'Surely you are not as serious as you look there!' commented his mother on receiving a tinted photograph, showing her son in his corps cap and ribbons, sitting with a very determined expression and his right hand clenched on a book.

Henrietta Mond's ambitions for Ludwig did not stop at Cologne. Business there, her sister wrote, was rather quiet. Inquiries from friends for a suitable alternative post produced

the suggestion that one might do worse than look in England. The suggestion was not taken up, though for one in Ludwig's position it had a great deal to recommend it. The English chemical industry was lagging some distance behind the German in inventiveness, if not as yet in output, and the superior scientific teaching in German universities offered him a very distinct advantage in his search for a post, once he had accustomed himself to English ways. In a German enterprise, one of her knowledgeable friends informed his mother, the proprietor was usually a trained chemist; in England he might not be, which would be greatly to Ludwig's advantage. The same friend advised her, however, that the mining branch offered even better prospects. His mother was against the mines, which she did not think would suit him. Probably she disliked the idea of his working underground. Meanwhile the Löwenthals remained silent, unwilling to back the boy against his father, and waiting for some word from Moritz himself.

Ludwig returned home to Cassel at Christmas with his mind made up, and a fresh duelling scar, this time on his nose. He would not stay to take his doctorate; whether the money to buy him a share were put up or not he thoroughly intended to go to his uncle's at Easter. In vain he tried to get Löwenthal to take a determined line. But all the answer he drew from his uncle was the disgusted statement that since his father was so much of two minds, and since even when he had an idea he could not carry it through energetically, there was nothing for it but to leave things for time to decide. He could offer no advice. But he had heard from a reliable source that the real future lay with the metallic chemist. Ludwig did not take this hint, but left Cassel before the end of the vacation to see if he could not talk his uncle over into more positive action. He failed.

Meanwhile his mother was working hard on his behalf. For her the time was always short. Even an invitation from her sister to Pina to spend the Carnival at Cologne prompted her to reflections on the theme of urgency. Of course her daughter must accept, she concluded, since at eighteen a girl had not many years before her in which to enjoy herself. She was now working diligently, therefore, on her son's behalf.

She had heard of one post for Ludwig which she had turned down as unhealthy. Then she had talked his father round into agreeing that he should go to Cologne at Easter. But now the Löwenthals were shifting their ground. Aunt Johanna wrote that he really ought to stay at Heidelberg and take his doctorate, and his uncle agreed, even to the point of offering to lend his mother the necessary money, should Moritz Mond refuse.

Henrietta Mond now appears to have suspected that her son's reasons for wishing to leave Heidelberg were not so simple as he had at first stated. She wrote, therefore, demanding an exact answer to several searching questions. Was he in debt, and if so to what extent? How soon could he take the examination and what would it cost? She asked for an immediate and frank reply to be sent to her *poste restante*, and complained of having received none to her last two letters. The facts were as she had supposed, and Ludwig did not care to commit them to paper. He was, actually, somewhat heavily in debt and he wrote hurriedly to his friend and his father's assistant, Eduard Hagemann, asking him to break the news at home. Eduard temporized. He promised to prepare the ground, but not to reveal the facts. Ludwig's mother, however, was not entirely surprised when after repeated visits to the post office she received the explanation of his silence.

Her first thought was to borrow enough to pay his debts from an old family friend, and so to keep the news from his father. But the family friend had just left the town, after helping to talk Moritz Mond over into agreeing to Ludwig's taking his doctorate. As her husband was now resigned to incurring considerable expenditure on their son's behalf she decided to show him the letter. He read it through calmly, without blenching at the amount that his son owed, but announced with some determination that he would not pay a farthing towards it. She nevertheless wrote asking her son for an exact account of his debts, in the hopes that her husband would change his mind; failing which she would have to think of another way out.

But Ludwig's mind was made up. He would not stay at the University. The debts were not his only trouble. He knew

hardly any Latin, and Latin was an obligatory subject. What was more, he did not feel that a doctorate was a necessity for the career he had in mind. Chemical manufacturers did not need to be doctors. In after years he advanced another reason for his decision: if he did proceed to the degree, he wished it to be an honorary one, granted him on the strength of his original work. In due course he attained his ambition.

Yet, but for the Latin, there was really no difficulty in his way. Money would certainly have been forthcoming to keep him at Heidelberg till May or June, which was all that was necessary. But Ludwig was determined to spend his six months at Cologne and had now decided that after that he would go to Paris. Bunsen too thought this the right course.

Meanwhile, however, there were still the debts to be settled. His nineteenth birthday came without the usual congratulatory letter from his father, in which he expected to read the news that his creditors would be paid. So on that day Ludwig settled down to pen a dignified protest at what he considered a clear case of parental neglect. But in doing so he lapsed somewhat from the over-determined adult tone in which he generally wrote about his affairs. With true adolescent bravado he began by broaching the subject of his debts, which he presumed to be the reason for his father's silence. These, he proclaimed rather grandly, he had had his reasons for keeping secret. As for his career, he was certain that he had made the right choice, and formally thanked his father for not having opposed him, for having given him, indeed, great financial assistance, although quite ignorant of the chemical industry and its possibilities. His last point was made with perhaps unnecessary bluntness, as was his further suggestion that were he now to ask for more money for his education he would run the risk of being told to go out and find himself a job in commerce: that, he wished his father to suppose, was his true reason for not staying the extra term to take his doctorate.

Having thus speciously put the anxious silk-merchant in the wrong, he allowed himself a juvenile outburst of self-pity which completed the ruin of his case. His acquaintances, he complained, had deceived him, his girl had betrayed him—

whether this is the young lady he had proposed to at Marburg or another is not clear—and his friends had forsaken him when he needed them most. Now there was nobody left but his family to whom he could turn.

The awaited birthday letter, however, arrived in the next day's post, and in it, no doubt, Moritz Mond agreed to do something about those wretched debts. For even if he had been able to stand out against his son he could never finally have withstood his wife's persuasions. Besides, he was a kind-hearted man, and only more insistent than she on the value of money because in his youth, after his own father's death, he had himself been poor. It was from the Levinsohns and not the Monds that Ludwig inherited his lifelong confidence that money would always be available when it was wanted.

Ludwig returned to spend the Easter vacation at home, while the final arrangements were made for his entry into the Löwenthal business. Uncle Adolf's letter agreeing to the proposal is a model of avuncular tact. No one would suspect from its careful phraseology that the whole subject had been bitterly disputed for the past six months. 'Concerning Ludwig,' it began, 'I am not disinclined to take him into my business for a preliminary year.' Then, after a passing mention of his distrust of university men in industry, he undertook to teach his apprentice the commercial as well as the technical side of his trade, also to instruct him in double-entry book-keeping. He further promised to put Ludwig as quickly as possible into a position in which he would no longer be a charge on his parents. One thing, however, seemed to worry him. He was most anxious for a guarantee that the young man would not be set up in business as his competitor. He had already a shrewd knowledge of his inventive nephew's qualities.

Ludwig, and, one suspects, his uncle, had got what they wanted, and the nephew moved into the Löwenthal house at Cologne, bringing with him his scientific instruments, which were set up in an attic where he could work at experiments after business hours, as his uncle himself had done at times in the past. The Löwenthals were a family of three. Their one son had died in infancy, and their only surviving child was the solemn dark-skinned little girl of ten to whom Ludwig had

THE LIFE OF LUDWIG MOND

brought the peasant doll on her birthday in the previous autumn. Frida and her mother, however, set out for Cassel almost as soon as Ludwig arrived, leaving the two men to settle down together.

But settling down was not a habit that Ludwig had yet acquired. For within a month he had come to the conclusion that there was not a great deal here for him to learn. Already in June he was discussing in letters to his mother the possibility of finding a post in one of the bigger industrial centres, Elberfeld or Crefeld. But too much writing about his affairs had its disadvantages. Another letter to his mother, complaining of loneliness, was immediately shown to his aunt, who was still staying at Cassel. Whereupon she straight away wrote off to her husband, begging him to be a friend and father to the boy, and not to overwork him. Uncle Adolf, rather amusedly perhaps, showed this letter to Ludwig, who wrote back in a fury, scolding his aunt for her interference. 'It is a principle with me,' he stated, 'that my letters are only meant for the person I address them to. If you pick hold of everything like this I shall be forced to write only about trivialities.'

Perhaps there was something to be said for getting out of the family circle as soon as possible. There was no longer any talk of his being bought a share in the Löwenthal business; and so, after a little more than three months in Cologne, he was making serious inquiries as to prospects elsewhere. At this point Moritz Mond took a hand, and once more considered giving Ludwig some capital. Perhaps it was only in his brother-in-law's business that he was so unwilling to buy his son a partnership.

The man with whom Moritz Mond got into touch over the matter was a family friend, Doctor Ludwig, the head of the first German bank to be seriously interested in industrial investment—the Bank für Handel und Industrie of Darmstadt. Doctor Ludwig was himself a geologist, who had been inspector of the salt works at Nauheim, and had some sound scientific experience. He recommended a factory at Mainz making acetic acid by the dry distillation of wood, and also producing wood-tar and lead acetate. The owner wanted a young



Moritz Mond and his wife, née Henrietta Levinsohn, Ludwig Mond's parents

chemist to take charge, and to invest some capital in this concern, so Moritz wrote to his son to know whether he was inclined and competent to fill the post. For, on the strength of Doctor Ludwig's recommendation, he was himself 'not averse to putting up the money'. The answer he received was unexpected. Ludwig had himself written to Doctor Ludwig accepting his proposal, and promising that his father would eventually provide the capital. But he had stipulated that he must get to know the works and the people before there could be any question of investment.

In the past few months his ideas for the future had completely changed. For now, he stated, he was not keen to become a partner in a business or take a director's responsibilities until he had seen something of the world. His idea was, however, that should the Mainz proposition be a good one Moritz Mond should buy a share in it on his own account, so that by working in it he, Ludwig, could indirectly repay his father the money that had been put into his education. As for things at Cologne, there is some hint of difficulties between his uncle and his aunt, and every day he is more grateful to his father's perspicacity and knowledge of men for having prevented his carrying out his crazy plan of buying a share in that concern. 'It would have ruined us both,' he concluded.

But if disillusioned with his uncle as a man of business, and far less sanguine than six months ago about the huge profits to be earned by a galvanoplastic works, Ludwig remained on very good terms with Adolf Löwenthal. Only, from now on, he was less prone to consult him on his own affairs; and soon he came to think of his uncle as, rather like his father, someone of less consequence in important matters than his womenfolk.

Through all these months during which he was working at Cologne, Ludwig was looking forward to the return of his aunt and of Frida, whom he described when she came back as 'a dear, good, understanding child, who is as fond of me as I am of her and whom I enjoy being with': which argues a somewhat rare relationship between a lad of nineteen and a child of ten. But what delighted Ludwig most were the visits he received from one Heidelberg fellow-student after

another, who would come and talk to him in the little courtyard on to which the works laboratory opened. There they would sit amidst heaps of coal, carboys of acid, broken clay cells from galvanic batteries and sacks of copper sulphate, discussing problems philosophical and scientific, arguing politics or quoting passages from Goethe at one another. Nor did he give up another favourite student pursuit. For he and his friends used to practise fencing in a long upper-storey room in the Löwenthals' house, generally used for the storing of models and half-finished work from the factory; and from under the roof the swish of rapiers could be heard downstairs in the house, to the alarm of Aunt Johanna, who feared for her windows.

Herr Werner, the proprietor of the works at Mainz recommended by Doctor Ludwig, appeared to be interested in young Mond's application. But Moritz was now growing less inclined to make any investment. His instructions to his son were that, if invited for an interview, he should take a good look round, and accept the job provided that he liked it and could have it without buying a shareholding. If he could not, he must refer the matter back to his father.

The post was apparently to be had without investment. Ludwig therefore accepted it and was just on the point of leaving to take it up when he received a letter from his father, written however by his friend Eduard Hagemann. For the day was the Jewish New Year and Moritz Mond was too observant to put pen to paper. 'Stay in Cologne over the Fast,' he commanded. 'It will create a bad impression if you demand a day's holiday the moment you arrive.' Left to himself, Ludwig would have forgotten the Fast, as he had forgotten the New Year. In his opinion the days for such archaic and unscientific survivals were coming to an end.

In mid-September he arrived to take his first post with strangers. His education was complete; he was now entering on an apprenticeship to the chemical industry, which was itself at no more than the apprentice stage in its development.

APPRENTICESHIP TO AN INDUSTRY IN ITS INFANCY

LUDWIG found two letters waiting for him when he arrived at Mainz, one from his mother wishing him success in his new job and one from his aunt dolefully reproaching him for having left heavy debts behind him in Cologne. The trouble was, she complained, that he had kept very bad company there; his friends from Heidelberg were the cause of that, and no doubt he would find others just as bad at Mainz. If he did not make a clean breast of everything she would tell the story to his mother.

Ludwig was prepared to take criticism from his aunt rather more patiently than similar complaints from home. So by return of post he explained the situation. One of his University friends had been in financial difficulties; had borrowed almost the whole of Ludwig's allowance from him and had put off repayment from week to week ever since. Various other friends also had borrowed smaller sums from him, and his plight was such that when he left he had not been able to collect enough from any of them to get his box of scientific instruments out of pawn. But he had learnt his lesson. He would not be taken in like that again. In the meantime he was just settling the last of his Heidelberg debts by the dubious process of borrowing from Eduard Hagemann. But if he were to divert some of that money to redeeming his box he would, he promised, put his first earnings towards replacing it.

Money was never a prime interest with Ludwig Mond. He always knew that it could be earned if it were needed; and when it came he cared very little about it. All that mattered was that he should be able to go ahead with whatever project he had in hand.

The Mainz project looked at first sight a very promising one. Herr Werner was a well-to-do man, but ignorant of his trade. His works were situated at Mombach, a country village

halfway between Mainz and the Rhine, and had been run by a partner, now dead, who had been the technical director. In fact the partner had started the business and it was not until two years before that, deciding to expand, he had called in Herr Werner, who had put up fresh capital. Then together they had built a new works.

But Werner had been content to remain the capitalist and had found out nothing about the processes. He was more interested in his other properties, which included two fine vineyards; and his one wish was to transfer the offices of the chemical company to Mainz, where he lived, and leave the Mombach works to a competent technical man. At present they were being run by the foreman. So delighted indeed was Herr Werner to shake off his industrial responsibilities that as soon as Ludwig arrived he introduced this nineteen-year-old chemist all around as his manager.

The processes of manufacture, as Ludwig discovered, were various but not difficult to understand. The workmen were very competent, and his responsibility was not a great one. The hours were long, however—from six in the morning to seven at night—and a small shift had to stay all night to watch the stills. He was given a room only ten minutes away, and as soon as the office was moved he would have a nice little suite. But Mombach was lonely, and after hours he would go into Mainz, where his aunt Johanna had given him introductions.

The chief trouble, however, was not the loneliness of village life after the society of Heidelberg and Cologne, but that the factory did not pay, largely, as he discovered after only a few days, because it did not produce sufficient by-products. The former partner had been making experiments for producing verdigris, which was needed as a pigment for printing textiles, but he had met with no success. So as soon as Ludwig Mond got his extra rooms, he fitted one up as a laboratory and went ahead with these verdigris experiments. In only a few days he worked out a method of manufacture for which Herr Werner's former partner had been searching in vain over several months and at considerable cost. What was more, his method was not injurious to the workmen's health and would

therefore—so he believed—probably supersede the dangerous process then in use.

On the strength of his discovery, Herr Werner pressed him to accept a contract with a share in the profits and a guaranteed minimum salary, on which he could comfortably live. All suggestions of a capital investment were now dropped. But Ludwig, being still a minor, could not enter into any agreement on his own, and wrote hastily for his father. The young chemist was most eager to fix things up quickly, not only out of his usual impatience but because samples of the new verdigris had been sent to England, where they were likely to find a market, and he wanted a share in the profits of any purchasing agreement that might be signed.

He was characteristically sanguine: his view of the factory's prospects was as rosy as his expectations from his uncle's business had been only a few months before. Profits, which now stood at the low figure of from 15 to 20 per cent, should go up to a hundred, and everything was working out as he had hoped. Indeed he calculated that in six months his share in them would put him in a position that he had not expected to attain for a good five or ten years. His father sent him his congratulations, but at the same time begged him to work hard and keep regular factory hours. He seems to have feared that success might turn his son's head between that day and the following Wednesday, on which he promised to arrive and sign the contract.

Ludwig's mother wrote off in delight that this was the first trip her husband had taken in all his life that was not for some business purpose. Ludwig must see that he enjoyed it. Perhaps he would even be able to persuade his father to take a trip up the Rhine. His aunt too, after some delay, answered his letter of explanation about his debts. She seemed relieved that he had not been offended by her criticism, but reminded him that he had not written to his uncle to thank him for getting his box out of pawn. For apparently the Hagemann money had been put to its original purpose, and Uncle Adolf had attended to the urgent matter of his nephew's scientific instruments. Not so long ago Ludwig would have confided his hopes and discussed his experiments with this considerate

uncle. But—as we have noted—his six months at Cologne had robbed him of his confidence in Adolf Löwenthal's judgement. Henceforth he never consulted him about any of his plans or schemes.

We do not know whether the timid silk-merchant took his trip up the Rhine. But he did sign a most advantageous contract for his son, which gave the young man 10 per cent of the net profits of Werner's business. Moritz Mond seems now for the first time to have been seriously impressed by Ludwig's capability, and by the respect with which he was treated at the works. He had had no idea that his son was such a practical and intelligent fellow.

Soon Ludwig had many friends in Mainz. He sang in the choral society's choir, joined a chess club, took out a theatre subscription and considered learning a musical instrument. Nor did he dress any longer in his slovenly student clothes. Such was his sartorial reformation that his mother's letters now ceased to be peppered with complaints at the way he kept his linen and at his habit of wearing his best clothes in the laboratory. Now when he went out on the firm's business he wore a top-hat, carried kid gloves, and would no doubt have looked very impressive had he not been so stocky, and had he not usually worn his hair rather too long, so that it stuck out in curls from under his silk hat. Still, from a student he had now transformed himself overnight into a young man of business.

Often his journeys for the purpose of selling his verdigris took him to dyeworks in the neighbourhood of Cologne. Then he would stay with his uncle and aunt, and take his cousin Frida out with him on his shorter trips. On such occasions, while they rode in the carriage, they would have long talks on all sorts of subjects, which, as she put it in her old age, 'furthered me much in my studies'. For a child of eleven she was preternaturally solemn and, being considered by her parents to be delicate, had long spells away from school, during which she read serious books.

Under the impact of his rapid success Ludwig now became increasingly independent, and his letters home grew rare. Indeed he seems to have had some difference with his parents

during the course of the autumn, and deliberately to have cut off correspondence. For his aunt Johanna, on the other hand, his friendship grew. So much so that when further difficulties occurred in the Löwenthal household, chiefly owing to the fact that Adolf's mother and sister had moved in, Ludwig offered his aunt and cousin house-room at Mombach, and was apparently prepared to support them out of his earnings. He even went so far as to give them travelling instructions—to go by rail to Coblenz and from there by coach—and to insist that his aunt must bring Frida with her. But the situation was not so desperate as he supposed. His aunt's letter to him had been written in an over-excited moment. She was, however, deeply touched by his offer.

Meanwhile, as the winter wore on, another difficulty arose. In a few months' time Ludwig would be due for service in the ducal army. Against this unwelcome duty his mother's first idea was to get his name struck off the citizens' register, which was possible since he no longer lived in Hesse. This would have meant, however, that he could not have returned home for any length of time without reinscribing himself and immediately laying himself open to be conscripted. Hitherto it had been legal for any young man who could afford it to purchase a substitute, but at that time a bill was before the assembly for putting an end to the practice of substitution. At this moment in his career some years of enforced idleness in a garrison town would have meant a serious interruption to Ludwig's plans. But, worse than this, if he were called up he would have to remain on the reserve until his thirtieth birthday, which would have made it illegal for him to leave his diminutive country; and this, for an ambitious young chemist, would have been an intolerable handicap. For the moment, however, Ludwig remained unperturbed. Soon he was urging his father once more to invest some money in Herr Werner's business. Moritz Mond temporized. He had not the capital readily available, was busy and would think the matter out in the New Year.

Ludwig came home for Christmas, triumphantly bringing his complete wardrobe back for his mother's inspection; and shortly after his return to Mombach he received as his reward

a variety of articles from home to beautify his room, together with a couple of books for his non-technical reading, which his mother was so anxious for him to keep up; one of them, Lewes's *Life of Goethe* in the German translation. These presents he failed to acknowledge. His mother's next letter, therefore, contained the usual reproaches. But what really worried her were the rumours of war.

It was January 1859. Napoleon III had casually remarked at a New Year's reception that to his regret his relations with Austria were not of the best, and this was taken as a sign that the Emperor intended to interfere in Italy, as indeed later in the year he did. Henrietta Mond distrusted the man and had already made up her mind that, whatever he intended, it would do Italy no good. Was he, she wondered, merely prompted by an antagonism towards Austria inherited from his uncle, the great Napoleon, or was he turning to foreign adventure because of insecurity at home? This last question has a twentieth-century ring about it. All this made her more anxious than ever that Ludwig should not be a soldier. Better emigrate to America or Australia! His aunt Frederike, she wrote, had heard great things of him even in America, and was proud. Uncle Adolf put down his success to his own early influence. It would be a pity to risk so much promise, as a soldier in some imperial squabble. Ludwig was worried too, but for a different reason. His verdigris won high praise, but it was expensive, and competitors were underselling him. Once more, the magnificent profits that he had promised himself did not seem likely to materialize. Indeed, partly owing to competition and partly to the uncertain political conditions, Herr Werner's factory was at a standstill. Ludwig was idle, which greatly depressed him. His idleness, however, can only have been relative. For whilst none of his competitors had caught up with his first, over-expensive method of producing verdigris—as he learnt from a workman whom he enticed from the most enterprising of them—he had now invented a second and cheaper process, which could not be imitated by those concerns which distilled alcohol from beet, but only by those that made it from wood, as Werner's factory did.

But the demand, particularly from the French market, was very low. In his depression Ludwig now began to worry also about the prospect of military service. It would be no joke to have his career interrupted just as it was beginning. But when his twentieth birthday came round in March, the prospect of war seemed temporarily more remote.

At this point, Moritz Mond, after a long delay, returned to the question of investment in Werner's business, and carefully marshalled his reasons for refusing: firstly that he would have to sell certain shares at a loss in order to raise the capital; secondly that Werner was a wealthy man and could himself find any additional funds that were necessary; thirdly, Ludwig had a good contract, with some time to run. The young man does not seem to have urged his father to change his mind; to be part-proprietor of a small business was now far from the height of his ambition. So, after a short visit to Cassel at Easter, he returned to deal with the two problems facing him, the matter of military service and the poor state of trade.

His mother was still pressing him to renounce his Hessian citizenship. 'I can't bear the thought of your being a soldier of such a shoddy little state,' she wrote. But the best solution really was to purchase a substitute, which was now possible, once more, the bill to forbid it having been thrown out. But war rumours were about again, and the Reserve had been called up. Moreover Herr Werner talked of closing down and turning his factory over to the War Department. But Ludwig objected. He was liable to be called up in January 1860 and did not want to go looking for a job which he could only hold for a bare six months. He insisted on the observance of his contract.

Meanwhile at home another suitor had arrived for Pina's hand, a village doctor from Schmidthof, the home of her great friend, the eldest married Hagemann daughter; and there was a great discussion as to the suitability of the match. The prospective bridegroom was, of course, a Jew. But Moritz, in his orthodoxy, was afraid that in the all-Gentile society of a little country place the couple might be tempted to lapse from their Judaism. Aunt Johanna, whose opinion counted for most, agreed with him, though perhaps less for reasons of

religion than out of snobbery. For a village Jew, like Moritz Mond himself, seemed to her a poor match for the granddaughter of such a cultured and respected couple as the deceased Levinsohns. Pina's own opinion, if she was allowed one, is not known, but the marriage did not take place.

As the summer went on Ludwig's position grew more difficult. Napoleon III invaded Italy, won the battle of Solferino and made a truce with the Austrians, by which he betrayed the cause of Italian liberty. But business continued to go downhill and Werner had definitely decided to give up at the end of the year. Now Moritz Mond was not disinclined to buy his son a substitute. His wife had paid a visit to an army captain of her acquaintance and inquired point-blank whether a Jew could possibly expect to receive a commission. The answer was that though there was nothing in the regulations to forbid it, no one could really say. It depended on the Duke, and he was well known to be an anti-Semite. Ludwig had collected the papers set in the examination for a lieutenancy. But clearly, in face of this statement, however well he did he could not hope to be accepted. Early in September therefore his father wrote that they would definitely buy him a substitute; and Ludwig then began to look for a job for the New Year.

A letter arrived almost immediately from Herr Mergler, a wood-alcohol manufacturer, in a similar line of business to Herr Werner, at Hachenberg, in Nassau. This gentleman had apparently started his works as a hobby, buying his experience—rather dearly, as he admitted in his very frank letter—as he went along. Now he would like Ludwig to come to him as an expert for a year to improve his plant for him. He asked the young man to name his salary. Moritz Mond, though slow to make up his mind, decided that Ludwig ought to accept and suggested a moderate enough sum. In the meanwhile Herr Werner, who had been ill for some weeks, died, leaving Ludwig free to go to Hachenberg three months earlier than he had expected.

Herr Mergler, however, was not prepared to pay the salary that Ludwig asked. The young chemist set out nevertheless to look at the factory, resolved to take the post if he liked it, even at the lower salary. For he was more interested in the

technical problems than in the questions of immediate money-making. Indeed at this moment his father was reproaching him once more for his unbusiness-like methods, and at the same time settling an outstanding tailor's bill for him. This, he assured his son, was the last time that he would come to his rescue in this way. What was more, Ludwig could treat the sum as a loan.

His mother also read him a lecture to prepare him for his new post. Hers, however, was on the subject of the modesty with which he must behave to Herr Mergler, with whom he would have to spend much time. He was going to live in his new employer's house, and his mother was afraid that his easy and youthful sense of superiority might annoy the elder man.

Herr Mergler made a journey to Mainz to interview his new assistant, only to find that Ludwig had already, in his impulsive optimism, left to look over his works. Satisfied, apparently, with what he saw, the young man accepted the post, returned for his luggage and, after a few days in Cassel, during which his despairing mother put his now shabby clothes into decent order, set out for Hachenberg early in November. 'He is quite a man now,' reported Henrietta Mond, who saw him after the interval with fresh eyes, 'strong and serious, but bubbling over with youthful high spirits.' Such was his frame of mind when he left to take up his post with the man whom he never afterwards referred to except as 'the crazy druggist'.

On first arriving he was enthusiastic. The village was small, but the factory offered real possibilities and was just being extended. Within a month, however, his mother could read between the lines of his letters that he was dissatisfied. Herr Mergler was a man of sixty, and too conservative to fall in with Ludwig's fresh ideas. The new assistant therefore changed his plans once more, and set about learning all the manual processes himself with a view to going to Paris and taking a workman's job, from which he intended gradually to work his way up. But these new ideas were reserved for discussion in the New Year, when he would have to return to Cassel to be present when the lots were drawn for military service. By that

time, however, he and Herr Mergler had both decided that they could not work together. The crazy druggist had been frank enough in confessing the deficiencies in his knowledge, but he was not willing to change his ways.

Ludwig Mond was drawn for service. But his father, all threats of cutting off supplies notwithstanding, put down a large sum to buy him a substitute, and the young chemist was now free to go wherever he chose. But for six months he was compelled to remain at home without a job. During this time there is no record of his activities, other than the mention of literature read with his mother. Henrietta Mond did not intend her children, whatever their other attainments, to go into the world as uncultured people, and now was her chance to remedy Ludwig's deficiencies. Her second son Adolf, a far less talented young man, who was serving a commercial apprenticeship, was—as she pointed out to his more promising brother—quite well read in the German classics.

In June 1860 Ludwig Mond was offered a post in a Le Blanc soda works at Ringenkuhl, which was very close to Cassel. He had started, almost accidentally, on what was to be the major part of his life's work: the production of one of the key chemicals required by so many branches of the rapidly developing heavy chemical industry. For soda was an essential in the manufacture of soap and glass, and was in constant demand also in textile mills, dyeworks, potteries and metallurgical works—all of which were rapidly expanding as the century progressed.

The original Le Blanc process had been invented in France by Nicolas Le Blanc, surgeon to the Duke of Orleans, between 1785 and 1790. Like so many inventions, it was the fruit of war and blockade. France's natural source for the vegetable ash used as a basis for soap was in Spain. But in most of the wars which fill the eighteenth century her coastwise trade was interrupted by British naval operations. The French manufacturer, therefore, required a domestic source for his raw material, and theoretically, at least, sea-water or natural brine seemed a suitable and blockade-free alternative to her Spanish imports of burnt seaweed. The Académie des Sciences, consequently, offered on behalf of the Government a prize of

2,400 livres for a workable method of making soda from sea-salt.

Nicolas Le Blanc was an amateur chemist, who had studied at the School of Surgery with such eminent chemists-to-be as Lavoisier, Vauquelin, Haüy and Fourcroy. Orleans himself dabbled in chemistry, and Le Blanc, with Berthollet, the Duke's physician, spent a great deal of his spare time in chemical experiments.

In 1784 he turned his attention to the manufacture of soda, and in 1790 was granted the Académie's award, though he probably never received any money. The Revolution had begun, and the Constituent Assembly passed a patent law guaranteeing inventors a fifteen-year monopoly. Le Blanc founded a company, and set up a factory on capital supplied by the Duke.

But the Duke of Orleans fell a victim to the Revolution, which in its first phase he had encouraged, and Le Blanc's factory was nationalized, Le Blanc being himself discharged without compensation. In the Napoleonic era, however, he received his factory back, though without the necessary capital to run it. His patent had now expired, and after struggling for a while to get his plant under way again, he finally committed suicide in 1806; by which date Great Britain's first plant to follow his processes, Charles Tennant's near Glasgow, had been running for two years.

The Le Blanc process made use of various techniques already described before his time, to which he added only one, the fourth stage in the total manufacture of soda. His originality was far from outstanding. But he had put together a technique which was operated under his name in the principal countries of Europe, with greater or less success, when Ludwig Mond entered that branch of the chemical industry. The first stage in the Le Blanc process was to evaporate sea-water or natural brine in order to make solid salt; the next to burn sulphur or iron pyrites to form sulphur dioxide. This gas, mixed with air and steam and using nitre or saltpetre as a catalyst, gave sulphuric acid or vitriol. The acid was then heated with the solid salt, with the result that hydrochloric acid was evolved and sodium sulphate left. At this point Le

Blanc made his great contribution. To this sodium sulphate, or saltcake, he added finely ground limestone (calcium carbonate) and coal, and furnaced the mixture. A complicated series of reactions followed, which left a heavy black ash from which the soda was extracted by solution in water, evaporation and calcination. It left behind a black sludge, consisting mainly of calcium sulphide.

Now there were heavy drawbacks to the Le Blanc system. In the first place it was extremely expensive in fuel. In the second place the hydrochloric acid gas evolved was allowed to escape to waste up the works chimneys. Being heavier than air, it descended on the countryside about the factory and rotted the leaves of the trees, killed the crops, rusted all iron tools and equipment, and ate into the stone of buildings. However, by the time that Ludwig Mond was starting his apprenticeship at Ringenkuhl—three years before the Alkali Act of 1863 made condensation of this acid obligatory in Britain—the hostility of local landowners and farmers was such that a great part of the acid was condensed in water and run to waste. At a later date chlorine was recovered from it, and about a quarter of the wasted hydrochloric acid was used for the manufacture of bleaching powder.

There still remained, however, the black sludge or alkali waste, which contained virtually all the original sulphur from the pyrites. This was already disfiguring the countryside with ugly, evil-smelling dumps on every piece of wasteland near the factory that the proprietors could buy. But, worse still from the manufacturer's point of view, this sulphur represented two-fifths of his bill for raw materials. The early Le Blanc system made one chemical and wasted two—and the value of the waste had to go into the cost of the soda.

Many chemists had been struck by this problem of the wasted sulphur, and many had tried to recover it. But up to the time when Ludwig Mond went to Ringenkuhl no one had succeeded in making the calcium sulphide in the sludge sufficiently soluble for the sulphur to be extracted.

Ludwig Mond, therefore, when he went to Ringenkuhl, was confronting problems infinitely greater than those he had met in the manufacture of verdigris. The Le Blanc process was

wasteful, and at the same time destructive of the countryside. The former factor was already of prime interest to him. There was plenty of work, therefore, awaiting him in the Ringenkuhl laboratory. For he had a great deal to learn about the Le Blanc process, which, in the course of his career, he was first to improve and then to supersede. But despite the future importance for him of the industry he was gaining his first sight of, he felt no sense of permanency at Ringenkuhl. His wages were small, and his prospects of an important post not very bright. So, within three months, although he got on extremely well with both his directors and his colleagues, he was already looking out for another opening, and his mother was once more writing round to her acquaintances, asking them to report any prospects they might hear of. There was no doubt a family conference on this matter on a certain evening in September when Ludwig marched in unexpectedly after a four-hour walk to Cassel through rain and wind, looking very smart and well built, with a little moustache that he had grown while he had been away.

New and exciting prospects now began to open before him. No sooner did his mother begin to make her inquiries than a letter arrived from Doctor Vohl of Bonn, an acquaintance of the Löwenthals of whom hitherto Ludwig had not had a high opinion. He appears to have been a teacher of science with a laboratory of his own and many private pupils. Doctor Vohl had just come back, as he said, from a journey through Bohemia and Hungary, during the course of which he had heard of a most interesting post to be filled at Alt-Orsova, on the borders of Hungary and Turkey.

Having learnt from Frau Löwenthal that her nephew was looking out for an opening, he had, without further consultation, obtained for him the invitation to travel to Orsova at the employing company's expense next spring. Their purpose was to erect a works for exploiting the local chrome iron ore, but they were already heavily engaged in other branches of the chemical industry as well. Doctor Vohl enclosed in his letter to Ludwig samples of three qualities of ore, two excellent and the third, which occurred, he said, only in small quantities, rather poorer. What was wanted in the first place was a

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thorough analysis. The next step would be to erect the works, of which Ludwig would be the manager.

Don't be alarmed [wrote the obliging Doctor]. I will lend you my support, both practical and theoretical, and I will make the journey with you when the time comes, so that I can introduce you. If you do not like the post you will have made an interesting trip at someone else's expense. What is more you will be paid for your analysis.

It seemed as if the right job had fallen from heaven.

Doctor Vohl had not been content merely to despatch the letter to Ludwig by post. He had himself taken it to Cassel, and in handing it to her, given Henrietta Mond a rosy description of affairs at Orsova. The district was marvellous, so warm and fertile indeed that the vines almost grew untended. The chemical works belonged to a noble family, who although no more than Counts, lived on an almost princely scale. They had one soda works already, and Vohl himself had just returned from putting up an oil refinery for them.

Little though she welcomed the idea of Ludwig's departure for the furthest frontiers of civilization, almost at the Iron Gates, his mother wrote begging him to forget his distrust of Vohl; which, she assured him, was no more than a youthful prejudice. For the man was very highly thought of, and he had already found many young chemists lucrative jobs. Not content with convincing Ludwig's mother, Vohl seems to have called on the Löwenthals also to win their support for his idea, and at their house, by chance, he met Moritz Mond, who had come to Cologne on business. Ludwig's father, too, was profoundly impressed by the doctor's knowledge. But Ludwig himself appears to have remained unmoved and he took several days to reply to his parents, who were urging advice upon him by every post. After a day or two, however, he came over from Ringenkuhl, and it was decided that at Christmas he should go to Cologne and from there call on Doctor Vohl at Bonn. A week later he had made his analysis of the ores and was enthusiastic. They were first class, and the thing to do was to erect a chrome alum plant immediately. This would be a very paying proposition, for very little of the



At the Löwenthals' in 1861
Back row, l. to r.: Leopold Schweich, Frida Löwenthal,
Ludwig Mond
Front row: Mr and Mrs Löwenthal

ore existed and it was in great demand, being an essential in the manufacture of yellow dyes. But Ludwig could see further into the matter than that. Since the ore was not to be found in Germany, the right course might be to erect the plant nearer home, where there were skilled workmen, rather than rely on foreign labourers and builders at faraway Orsova. He was still, he wrote, busy with the analysis, however, which was a long and complicated one; and he was also working on some interesting problems in soda production, that would involve a new process, which he expected to be very profitable, but which would require some months to perfect. So he was in no hurry to go to Hungary.

At Christmas he paid his promised visit to Cologne and was pleased to be with the Löwenthals again. Frida, who was now thirteen, was a most delightful child, as he told his mother in a naïvely enthusiastic letter home. During his stay he also paid his promised visit to Doctor Vohl, whom he found full of encouragement, and from whom he got some more information. Everything was fixed. They were to leave together immediately after Easter, and the money for the trip was already lying in a Cologne bank. First they would go to Vienna to meet Prince Kinsky, who was the owner of all the chemical plants in Orsova—he had been no more than a Count when the doctor had first spoken of him. Then they would go with him to Orsova, where Ludwig would stay, if he liked the post, not only to erect the new plant but to take over the management of all the rest, including a sizeable soda plant. It was going to be very uphill work at the start, for all the works were in a bad way. But Ludwig was confident that he would earn a nice little bit in the next few years, particularly as the Kinskys had a great number of factories of one sort and another in Hungary.

Henrietta Mond got busy. She procured him his passport well in advance and bought him a book on Hungary, which seemed to be a magnificent country and especially beautiful in the parts to which he was going. She went further, and wrote to Professor Büdinger, a Viennese acquaintance, for information about the Kinskys and Orsova. The Kinskys, he reported, had the reputation of being a high-spirited and

hot-tempered family, but fundamentally they were good-natured people and not difficult to handle. Orsova was a pleasant place in the most delightful surroundings and, as it was a garrison town, one would not be cut off there from the civilized world. There was a spa too, a mile or two away, which was frequented by the idle sons of the Austrian nobility. Of chemical works the Professor made no mention.

Ludwig left Ringenkuhl in March, and before he went the owners of the works gave a dinner in his honour. But he had very little to show for the months he had spent with them, during which he had been little more than a learner. The new process on which he was working, for recovering sulphur from the calcium sulphide waste, was still far from complete; and they could offer him no opening that might tempt him to stay. Nevertheless they wanted him to realize that they had been very satisfied with him. For this clever young man might possibly be valuable to them one day in the future.

Ludwig spent a week at home, during which he received a letter from Doctor Vohl, apologizing for a considerable silence, on the plea that he had been ill in bed for some days, but would be coming to Cassel very shortly. On April 5th he announced his arrival for the 11th; but on the 11th, when a bed had been prepared for him and friends and neighbours had called to say good-bye to Ludwig, a letter came putting the visit off again. Doctor Vohl wrote that on returning from a short trip he had found a letter from Prince Kinsky awaiting him, with the news that he would not be able to see them now for a couple of months. Vohl, nevertheless, promised to come to Cassel himself to discuss the whole matter. Ludwig was most disappointed and his mother furious. She did not believe in Doctor Vohl's excuses, and was certain that they had been made fools of. She asked her sister, therefore, to go to Bonn and pay him a visit, which Johanna Löwenthal did, and returned quite convinced of the Doctor's good faith.

Ludwig stayed at home for a few weeks more, therefore, in the expectation of leaving for Hungary in June. His mother, however, only half convinced by her sister's assurances, turned once more for information to her friend, Professor Büdinger. Ludwig meanwhile went to Cologne to say good-bye to the

Löwenthals, and there received a letter from his mother putting an end to all his hopes of making a fortune in Hungary. Büdinger had gone to Prince Kinsky himself, who told him that he had engaged no chemist and had no knowledge of Vohl. From him the Professor had gone to his general factotum, who had informed him that the Prince owned no land in Hungary, and never had done; nor did any of his family.

Far from condemning Vohl; however, as she had done over his no doubt fictitious illness, Ludwig's mother now decided that there had probably been some truth in the matter, but that it had not been as definite as the Doctor had represented it to be. His first untruth, she thought, had only been uttered out of a desire to be of service to Aunt Johanna and had brought all the rest in its train. This was a charitable view, to say the least of it, which saved Ludwig's relatives from appearing too stupid in their own eyes. But, looked at over the interval of ninety years, they seem to have been the victims of a well-contrived practical joke, which they might have suspected from the description of Orsova in Büdinger's first letter. Vohl's motives are of course inexplicable, but they may not have been unconnected with Ludwig's early contempt for him. A professor of some reputation might well resent the disrespect with which he was treated by this very clever, very intolerant young man.

Ludwig himself was surprisingly unmoved by this check to his plans. He was, in fact, very glad not to be setting out for the other end of the Austrian Empire. But the reasons for his relief were known to himself alone—or to himself and one other, for shortly before he was due to leave on his abortive expedition to Orsova, he had committed himself deeply in another direction.

Whitsun had fallen early that year, and the Löwenthals had celebrated it with a picnic to Brühl, the palace and park of the Prince Bishop of Cologne, which is about an hour down the Rhine by train. Here they had picked woodruff for the Maibowle—or wine-cup—which they drank with their meal, and although Ludwig was to leave them next day for the Turkish border everyone had been in very high spirits. When evening fell there was a dash for the train, to which extra

carriages were hastily attached to take the crowd. But the last coach, into which the Löwenthal party jumped, was quite dark, since in their hurry the railwaymen had forgotten to put in the oil-lamps. Everyone was talking and joking as they jolted home through the night; Ludwig and Frida alone were silent. Then under the cover of the train's noise Ludwig said to his cousin: 'To-morrow I shall have to leave you. Before I go I want you to promise to be my wife.' Frida put her hand in his, and bending close to his ear whispered, 'Yes.' She was thirteen and a half and still at school, but serious and grown-up beyond her years—as she explained in describing that evening in her old age. He was twenty-two, with his way still to make in the world, though without the slightest doubts about his eventual success.

His next job took him not to Orsova, but to Ehrenfeld, an outer suburb of Cologne, where Herr Weil, a family friend, was making some experiments on a semi-technical scale, for recovering ammonia and tar products from leather waste: a small-scale project, but one nevertheless that was to lead Ludwig in directions as important as those that he had sighted at Ringenkuhl. Here Ludwig lived in a country inn, where he set up his laboratory, and here on afternoons when there was no school Frida came with her parents to pay him visits, during which she would help him by folding his filter-papers, washing his glasses, boring holes in his corks and amusing herself about his laboratory, while at the same time trying to pick up some rudiments of chemistry which might later be useful to her as a works chemist's wife.

Then as they waited for some experiment to work itself out they would talk and read and spend enjoyable hours together, which were all the sweeter for the secrecy of their agreement. For a while neither had any confidant, though in a letter to his brother Adolf, the commercial apprentice, who had been taken seriously ill, Ludwig almost gave himself away.

His experiments on waste leather were going ahead; and on their results depended the future of Herr Weil's whole enterprise, which required outside capital. But whether he could get a satisfactory yield from his material or not, there was no future for Ludwig in this line, and it never occurred

to him to suggest an investment in this concern to his father. Nevertheless in the course of his laboratory work he made observations which would, he hoped, be applicable to other enterprises in the future and would, if the worse came to the worst, always earn him a livelihood. But simultaneously he was continuing his experiments on the problem of sulphur recovery in the attic of his uncle's house in Cologne, where he had installed a number of wooden hurdles on which he spread alkali waste, to oxidize in the air. These he looked after on his frequent visits. But in the intervals it was Frida's job to keep away the mice and the cats, which were attracted by the smell. With his usual premature optimism he quickly declared himself satisfied with his results, though he decided that there were variants to the process which he could try out when he had the time. But he rather rashly concluded what he had so far discovered to be already sufficient basis for practical application.

The leather-waste experiment was bound to be a short one, and within a month of its starting family letters were already full of discussion concerning Ludwig's next move. Now for the first time there was serious mention of England. One of the chemists from Ringenkuhl had been over to Cassel with news of fresh installations there, and complaints from everyone, including the director, that Ludwig had not written; and, about this time also, whether with this Ringenkuhl friend or with someone else, there had been eager talk of prospects opening up in the Manchester district.

Ludwig seemingly was taking life hard, so much so that his mother scolded him for not finding some companions of his own age, or joining a glee-club. 'You can still afford to be gay,' she wrote. 'Life smiles on you and you have no cares. You won't find it hard to earn as much money as you need. But if you find being a chemist too hard, then go into business.' But Ludwig had now two fixed objectives: the development of his sulphur-recovery process, which would lead on to further inventions, and his marriage in four or five years' time. He had set himself a definite goal, to be in an established position at the age of twenty-six; and the fact that his ambitions were taking concrete form sufficiently explained the serious look on his face that his mother complained of.

Letters from home once more contained political speculations. An attempt on the life of the King of Prussia was likely to react badly on the heads of Liberals in general and, by implication, on Jews in particular; there were hopes of a Union victory in the American Civil War. But there came also a piece of exciting family news: a little lace-bordered letter from his sister Pina announced that this time she had accepted a suitor, and was engaged to be married. Letters and congratulations were exchanged thick and fast.

Leopold Schweich, the bridegroom-to-be, was anxious for an early wedding, and the couple intended to live at Cologne. Leopold, as he looks from old family photographs, was not a very impressive young man. His wispy cavalry moustaches, on which he certainly prided himself, do not compensate for a weak chin and a rather shifty grin; nor does the rakish angle of his hat suggest quite the dashing or carefree young buck that he would have liked to appear. In a family group taken at this time all the character is in the faces of Ludwig and his aunt. He with his black beard and his assured look is leaning a little forward, for the convenience of the photographer, which gives him, as his mother complained, a slightly servile appearance at variance with 'his serious and noble expression'. Aunt Johanna's expression is neither serious nor noble. She has the confident smile of an intelligent woman who has life well under her control. Beside her Adolf Löwenthal appears rather histrionic—'like a French statesman,' his sister-in-law remarked, 'reflective but not serious'. Frida was wedged between Ludwig and Leopold Schweich. Her face was still unformed, yet it was not the face of a child. There was feeling in it, and a single-minded unselfconsciousness that was to make her the ideal companion for a man who had no room for doubts.

The news which Ludwig got from Cassel, however, was not entirely good. His brother Adolf's health was still most unsatisfactory; though he tried to lead a normal life he clearly felt every change in the temperature. But not content with this very real worry, Henrietta Mond elected to be exercised once more on the subject of Ludwig's future; she still wondered whether he ought not to go into business.

Ludwig was sparing and incommunicative in his letters home. The leather experiments had come to a successful conclusion, but the capital for developing the project could not be raised. As the autumn of 1861 wore on the next move seemed more and more difficult to decide on. Moritz Mond, with a delicate inquiry as to the state of his son's exchequer, sent an unsolicited contribution towards it. His wife wrote that chemists were men who nourished themselves all their lives on pleasant hopes. Ludwig however was not depressed. He had heard of some possibilities in Holland, he had given his first lecture to a scientific society—a talk on the Galvanic Battery to the Industry Club of Cologne—and he had decided to register his first patent, a process for the recovery of sulphur from alkali waste. For the cats and mice had been kept away from the hurdles in the Löwenthal attic long enough for him to feel certain that he had now adequately solved his problem.

Impressed with an achievement positive enough to be recorded on stamped paper, Moritz Mond, always unpredictable, volunteered to pay for the registration not only in Germany but also in France and England. Though reluctant to settle his son's debts, or support him in anything that he considered extravagant, over such matters as his military service and his patents Ludwig always found his father not only helpful in the matter of finance but resourceful—though a little over-fussy over practical details. Perhaps the chief difficulty in dealing with him was that he always liked the initiative to come from himself.

Moritz's upbringing had been hard, and he was certainly not very successful as a man of business. Yet when anything seemed to him really necessary he spared neither money nor pains. It was over matters that had been subjects of family discussion that he was apt to prove difficult. He did not like to be driven. Ludwig's genuine letter of thanks for his father's latest offer touched him, and he was excited by another that followed within a week. His son had had an interview of an hour and a half with the biggest producer of soda in the district, probably the biggest in Northern Germany, Doctor Hasenclever of Aachen, who had told him that his process was good, cheap and practicable, and promised that he would

shortly put the question of its adoption before his partners. This offer particularly pleased Ludwig because sulphur was cheaper in Aachen than elsewhere, and if it were a paying proposition to treat the alkali waste there, then it would be so everywhere else. Furthermore Doctor Hasenclever talked of possibilities abroad and recommended Ludwig to register his patent in Belgium also. The young man was indeed on the point of rushing to Brussels to act on this cheering advice when his father suggested that these formalities could quite as easily be performed by an agent.

Sanguine as ever, the happy inventor was now quite certain that Hasenclever would adopt his process. Unfortunately, however, at the interview he had been unable to outline any terms, and had rather naïvely left the question of his remuneration in the great man's hands. Moritz Mond was too delighted with the turn that things were taking to chide his son for this unbusinesslike lapse. Ludwig's mother wrote, however, that, for her part, she would be more satisfied when he had made his first profits from the process; all this registration of patents did not impress her. She was to prove the truer prophet of the pair.

In December Ludwig's work at Ehrenfeld ended and he left for Cassel with his future brother-in-law, Leopold Schweich. His engagement to Frida, he decided, must still remain a secret. For while there was no reason to expect any family opposition to their eventual marriage, the young couple could hardly expect their parents to accept as fixed and definite an arrangement that seemed so premature. A girl of thirteen and a half would appear to everyone too inexperienced to make a choice, for her cousin Ludwig was, after all, the only young man she had ever met. Ludwig afterwards explained, however, that it was not his feelings for her, but hers for him, that had made him speak on that spring evening; and it looks at times from his letters as if he rather regretted having embarked on this secret relationship so early. She, on the other hand, never had any doubts, and devoted the next four years of her life singlemindedly to the task of preparing herself to be his wife. But now that his sister Pina was about to leave home Ludwig took her into his confidence. She was going to live in

Cologne, and was prepared to receive and hand on his letters to Frida. She, like any newly engaged young woman, was delighted with his news.

From Cassel Ludwig began to write a series of love-letters which continued from that time till the day of their marriage, long letters which despite the conventionality of their language do not disguise the rare maturity of this juvenile relationship. On his side the correspondence is at first delicately affectionate. He seems to combine the rôles of lover and favourite cousin, explaining his problems and preoccupations, and watching over the details of her continuing education. On her side it is at first a little naïve, perhaps a little too concerned with the distant future to take proper account of the present. But quickly it begins to reveal her growing sense of responsibility for his future and her absolutely unwavering belief in his destiny.

The language of these letters is too intimate, and too undistinguished, to be quoted for anything except the news they contain. The vocabulary of affection seems stereotyped and unreal when ceaselessly repeated in a correspondence quite devoid of literary quality; and terms of endearment translated out of a tongue as effusive as nineteenth-century German tend rather to conventionalize the love which this couple undoubtedly felt for one another. It is possible for lovers insensitively to repeat the platitudes of passion yet for their feelings to be absolutely their own. But such love-letters do not bear reading by a third person.

At Cassel there was ceaseless sewing in preparation for Pina's wedding, which was to be early in February. Ludwig was depressed, both because of his separation from Frida and of the uncertainty of his plans, and killed time by continual games of chess. Frida was for once rather the happier of the two, since she was enjoying the company of her friend Julie Stodel, a very gifted music student a year or two older than herself, who was studying composition under Ferdinand Hiller at Cologne. This young woman, who was of mixed Belgian and Spanish blood (later Mme Caruette), was to remain on close terms with Frida and Ludwig for the whole of their lives. Indeed in his will Ludwig made some provision

for her daughters, so strong was his sense of connexion with the surviving friends of his youth, and even with their descendants. At that time, however, the debt was all on Frida's side. For not only was the company of an understanding friend almost a necessity at a moment when she had put herself under excessive emotional strain, but it was to Julie Stodel that she owed her whole musical education, and the sound taste for the great composers which she preserved throughout her life.

Early in February Ludwig drove over to Ringenkuhl once more, and was delighted by the welcome he received. Everyone from the director to the workmen was pleased to see him, particularly Louis Schad, one of the works chemists, whom he had known from boyhood—another of those early friends with whom he was never entirely to lose touch. A couple of days at the soda works were sufficient to convince him that what he really wanted was to put his new process to work there. No answer had come as yet from Herr Hasenclever at Aachen, and Ludwig's easy paper calculations of the return that his invention would bring him from Germany and abroad were beginning to look a little untrustworthy. But from his visit to Ringenkuhl he brought back hopes that the management there, who already trusted and respected him, might welcome him back after his sister's wedding to install his process, if only on a small scale.

The marriage was celebrated with true German ceremony. Coinciding as it did with the Silver Wedding of the bride's parents, it was the occasion for a family reunion of formidable proportions. It began with an entertainment on the evening before, during the course of which Ludwig and his brother Adolf put on a comedy act. Dressed up as laundresses, they dilated on the advantages of living in an old-fashioned household in which the housewife took a due pride in her linen, in these days when the well-to-do were ceasing to care for such things. Ludwig appeared somewhat out of character. For it was not often that even in jest he could be found taking the side of the past against the present. Then, afterwards, there were songs and recitations, followed by a supper and dance; and early next morning the elder couple were roused by a

serenade specially composed in their honour and sung by members of their family outside their door.

The old house had seen many such celebrations in its three hundred years of existence. But this one only differed from all the rest by the fact that the wedding took place not in the church, but in the Jewish fashion in the drawing-room itself, a large corner room, with windows on both streets, in which the bridal canopy or *hupa* had been set up. After the marriage ceremony had been performed by the rabbi there followed a grand meal with toasts and celebratory recitations, one of which was composed by Ludwig; and after that there was a dance, which was led off by the bridal pair and to which many of Ludwig's school and University friends had been invited, among them a contingent who drove over from Ringenkuhl.

Within a fortnight of the wedding the director of the Ringenkuhl works had also driven over to see Ludwig, as he had expected, and an arrangement had been made between them that he should come back to them before the beginning of March, and there put his process into production on a sufficient scale for a computation of its economics to be made. During this time he was to be paid his keep and a small wage. In return for this two or three months' work the director bound himself to keep the process secret for at least five years, and at the conclusion of his experiments to present Ludwig with a complete report on the results. Furthermore, should the firm wish to adopt it exclusively for that part of Germany, they would then settle a figure of remuneration between them. With the newly married pair honeymooning in Paris, the family had time to think of Ludwig's future once more. The offer from Ringenkuhl, though so much more modest than the dreams he had indulged in when registering his patents, for the moment satisfied him, and even his father.

Frida, back in Cologne after the wedding, found the writing of letters unobserved an almost insoluble problem. Most of the day she was continuing her education at a pension for young ladies on the opposite side of the street from her home; and in the evenings it was only by subterfuge that she could procure pen and ink, and the privacy in which to address

her Ludwig. Letters were duly delivered to her by her future sister-in-law, who was now a neighbour. But her replies had to be written at night in the kitchen and in continual fear of interruption by her Mamma. She was not even able to contrive a moment in which to congratulate Ludwig on his twenty-third birthday. Such were the drawbacks of their clandestine engagement.

But as one reads Frida's very transparent outpourings one can see the immense and sustaining pleasure she took in looking forward to the future. Much of her girlhood indeed seems to have slipped by her almost unenjoyed, so intent was she on what was to follow, so impatient for the rare occasions of her meetings with her fiancé. Ludwig lectured her on the folly of thus living in the future, on refusing, for instance, to take part in the Carnival since he would not be with her. 'It would be a pity if our love were to deprive us of all pleasure in any other amusements or distractions,' he wrote. But Frida was not susceptible to such arguments, and he feared that her single-mindedness was going to overstrain her in the long years of waiting.

In the meantime things had begun well at Ringenkuhl, as he reported to his aunt in a long letter written within a month of his starting there. He had processed his alkali waste in sheds that he had adapted for the purpose, and was again perfectly satisfied with the result. The treatment, however, would have to be repeated several times, until all the available sulphur had been extracted from the waste he was treating; and this further extraction, though involving no process as complicated as the first, would require two or three months more to complete.

He went on to describe his plant in some detail, and to rejoice in his good fortune in having this opportunity of working his scheme out on a full scale. The operation was not costly in labour, he observed, beyond that of handling; and he was confident that his original estimate of the expenses of extraction would prove correct, if not a little generous. In this last hope events were to prove him, as usual, a little too sanguine. For though he had now carried out his process on a scale considerably greater than in the attic at Cologne, he

had not yet seen it in action as part of the general scheme of operations in a soda works; and had he done so he would have found that the labour cost, though it entailed no more than taking the calcium sulphide on and off the wooden racks on which it was exposed to the air, was sufficient to make his process uneconomic. But this he had still to learn.

His day at Ringenkuhl was a strenuous one, beginning at six in the morning and ending at the same hour in the evening: a twelve-hour day with an interval of an hour and a half for lunch. He shared rooms with his friend Schad in a house in the open country, though within half an hour of the works. The neighbourhood was hilly, a landscape of fruit blossom and spring greenery, and all would have been well with him but for distressing news from home of Adolf's serious illness. The boy had never gone back to his commercial apprenticeship, and now the tone in which the doctor stated that his complaint was ultimately curable suggested that in his case it might not prove to be so.

Frida, too, was now beginning to feel the strain of the engagement and of his long absence, which might soon be broken, however, by a visit to Cologne on the way to Utrecht, where possibilities for him were suddenly opening up. But she found his letters impassioned and disturbing; he was forgetting her youth. 'Please write more calmly,' she wrote, and his sister Pina (now re-nicknamed Phinchen owing to a whim of her husband's) warned him that he must write to Frida in such a way as not to excite her, and take what pleasure he could from the situation as it was.

Ludwig accepted his sister's advice, and for a while his letters were more factual and entertaining. He bantered Frida in cousinly fashion on her report from her pension, and refused to believe in her 'very good' for handicrafts until she had worked him a pair of slippers. He reported a trip to Cassel to hear Mendelssohn's 'St Paul' oratorio, and she replied by describing a magnificent rendering of Beethoven's 'Missa Solemnis' in Cologne Cathedral, with the Cardinal in purple and four priests in gold brocade, and the sun pouring through the windows to touch the effigies of the saints and bishops with gold as the populace knelt amid billows of incense.

Frida was impressed. But with a true Jewish distrust of pomp and circumstance she observed: 'Take away all this grand show and the Catholic faith would decay even faster than any other.'

Ludwig enjoyed her description of the scene in the Cathedral, which—even by modern standards—was extremely graphic for a girl of her years. If one were going to believe in the worship of a supernatural being, then the Catholic faith, he wrote, would be the one to adopt. There could be no question of a more or less reasonable religion. To follow a religion was in itself unreasonable, and the only sensible course was to believe nothing of which one was not certain. That remained Ludwig Mond's conviction almost to the end of his life, when he returned to the Jewish faith which he had long abandoned.

By the end of April the Ringenkühl experiments were complete, and Ludwig was once more looking for a new sphere of activities. The Aachen prospects had clearly failed to mature, though Hasenclever had not yet sent him a definite refusal. How the affair ended is not quite certain, but Ludwig Mond had little respect for Hasenclever thereafter.

Some time in the previous autumn, however, he had met an industrialist called Smits from Utrecht and now, in April 1862, he received a reply from the Dutchman to some letters he had written to him, which had remained unanswered since late in the previous year. The firm of Wede P. Smits & Zoon would like to discuss with Herr Mond the erection of a plant for the making of sulphur from pyrites and would welcome a visit from him at the earliest possible moment.

Adolf Löwenthal, who opened this letter before forwarding it to Ludwig, counselled a certain coolness in entertaining proposals that had been so long in coming. His nephew should state his terms, and make it clear that he had not been waiting idly all the winter for Smits to arrive at a decision. The young man took his uncle's advice, dilated on the important nature of his work at Ringenkühl, and announced that he would not be able to get away before Whitsun. If they could wait so long he would come to Utrecht at their expense, take a monthly salary while erecting the plant for them, and expect an additional bonus on leaving it in running order. It was the

letter of a man who knew what value to set on himself, and it was all the easier to write because Ludwig did not, as he wrote to his father, set any great store by people who left their correspondence unanswered for six months.

He was still confident, besides, that his sulphur patent would prove successful when applied on a large scale. He wanted also to see something of his brother Adolf, who had gone into the country in hopes of recuperation. Adolf Mond's disease appears to have been tuberculosis. Nevertheless Ludwig wrote to Cologne that there was still every hope of his recovery. His mother, however, realized that the lad was very ill indeed and had decided to take him to Kronthal, in the Taunus Hills near Frankfurt, where she would stay with him until Ludwig could relieve her. Then at Whitsun she would go back to him again; for the doctor wanted her to take a rest also. So Smits could wait till after Whitsun. But once having entered into this long-postponed correspondence Wede P. Smits & Zoon had lost no time in replying to the young chemist's letter. They wanted him to come to Utrecht immediately, then hurriedly to prepare them plans for altering their burners, and afterwards to return to supervise their working. Ludwig replied high-handedly that the alterations would have to be made under his personal supervision, but that the chief problems lay in the processing. These, he thought, could be overcome in six to eight weeks from his arrival. For he knew all the difficulties that were likely to arise: a rash claim which he was to make more than once in his life, and which this time was going to cost him his promised bonus.

For the moment, however, he excused himself on the ground that he could not possibly suspend the work he was doing: a statement which is hard to believe since he had already told his family that the Ringenkühl experiment was complete. He held out also for a higher wage than they had proposed, though he had to be content with hardly more than half the bonus he had named. He promised, however, to be in Utrecht without fail on July 10th, and insisted that Smits should be ready to begin the rebuilding on that very day. 'They made me a very small offer,' he wrote to Frida during the course of the negotiations, 'and I gave them a very straightforward

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answer. But I think they will take me on, for they seem to have great need of me.'

Ludwig's apprenticeship to his industry was now over. He was perhaps a little overcertain that he knew all the answers. But from one paragraph of his letter to Smits in which he so resolutely stated his terms one can see that behind his claims there was a real modesty.

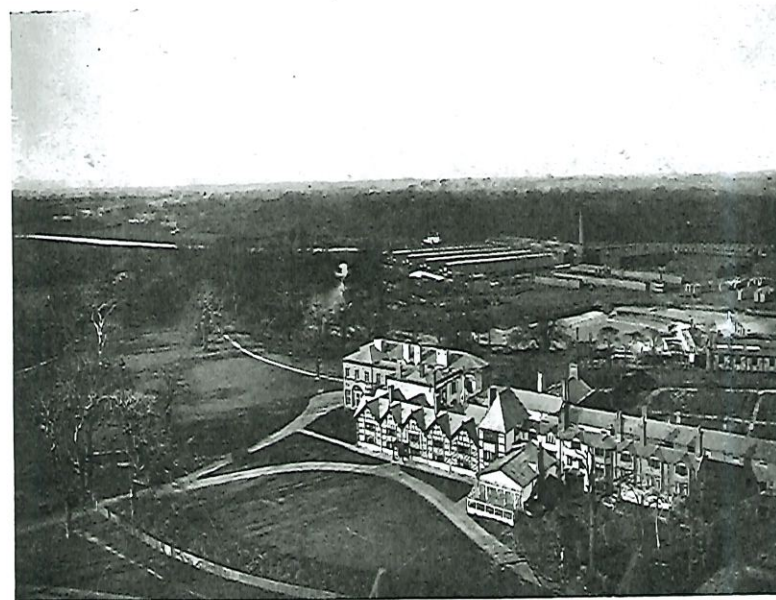
At present my time is of growing value, and when you consider that I am bringing you the lengthy experience of other men, which has cost them years of work and considerable expense, and also that you will have it in very little time and with no further expense to yourselves than the hiring of my services, you will realize that you are getting it cheap.

He knew, in fact, that it was not his own personal merits he was marketing, that his value for the present lay in the fact that he could apply the knowledge and methods of his masters Bunsen and Kolbe to an industry still in the hands of such untrained amateurs as Herr Werner of Mombach and the 'crazy druggist'.



Winnington Hall in 1866

In 1873 the castellated stucco was taken down to reveal the Tudor timbering. The girls of Miss Bell's and Miss Bradford's academy are playing cricket



Winnington Hall in 1894

The Brunners lived in the black-and-white Tudor Hall, while the Mondes lived in the Wyatt Wing behind. The pine-house jutting into the garden was for some years Ludwig Mond's private laboratory

HOLLAND OR ENGLAND?

LUDWIG departed from Ringenkuhl with some regret. For he left many friends behind, and he knew that out in the world he would probably not find so co-operative and trustworthy a team as the one he had been working with. At Kronthal he found an invalid whose daily regimen he had to supervise from the moment when he gave him his morning massage, till evening, when he rubbed him with embrocation. He found the little spa, which lies at the foot of the fir-clad Taunus, extremely boring. But he thought that his own energy and appetite had a favourable effect on his brother. His mother, on the other hand, doubted whether he was not too strenuous for the sick lad. Which perhaps he was, for all the time he was longing to be with Frida, yet worried by the obvious over-excitement that he could detect in her letters. Now it was he who begged her to set him that example of calm which had put him to shame not many months ago. They would, he promised, have a whole fortnight together in Cologne before he went to Utrecht.

Proud of the English that she was learning, she proposed on receipt of that news to kiss him on his arrival 'so dead as a doornail'. A little later in this letter she announced that she had decided to take French lessons as well with a lady who had just arrived from Paris. One can only hope that this lady's French was more reliable than the idioms of Frida's English mistress.

When Ludwig's mother at last relieved him in care of the invalid, he had just his bare fortnight left to spend at Cologne, and even this was broken by visits to Barmen and other places in search of materials for the alterations which he was going to make to the Utrecht plant. This was not very satisfactory for Frida, who had seen him only once, during the wedding festivities, since their parting in the winter. They had now been engaged for a year, and she was no more than fourteen and a half.

In Utrecht he felt that he had now really begun on his career. To the inhabitants he took an instant dislike, which when he knew them better, however, he soon modified.

The Dutch are an awful people [he wrote]. They don't skip or dance. They are as monotonous as their surroundings, as boring and silent as their own swamps. It is always the same: tea and schnaps in the morning, and in the evening schnaps and tea.

Smits and Ostermann, the partners in the concern he had come to join, did their best to make him welcome and to relieve the monotony of his life. But he decided to keep to his room and dwell on his memories of Frida, a romantic gesture somewhat at variance with his easy, sociable nature.

They had taken lodgings for him with their foreman, who lived on the outskirts of the town; and these he found pleasant. But the only amusements that he could discover in Utrecht were concerts given by a military band in a beer garden, and to these he began to go every night. The playing was good, but their repertoire a poor one. He decided to remain depressed, and he had reason. For Frida sent the most distressing letters from Cologne. Seeing him so fleetingly had made things worse for her. 'Don't think about me too much,' he counselled her. 'Besides,' he added, 'the alterations are going ahead and will be done by August.' Already Ludwig was envisaging the end of his work here and thinking of his next move. Within a fortnight of his arrival his gloom lifted, and he began to find life more amusing. His employers had introduced him into a choir, where he met a number of young people.

Frida, after a little, recovered her spirits too and returned to the task of preparing herself to be the wife of a distinguished man. In her pension or at private lessons she was working for seven hours a day, with homework that took her sometimes as much as three hours of the evening. She was oppressed by the feeling that there was so much to do and so little time left to do it in. In the year and a half before her, there were literature, mythology and history to be mastered. She did not want only the worldly semblance of education. It was nor

merely so that she could take part in conversation that she wanted knowledge. She wanted it, as she said, for living purposes. And all this must be acquired before she was sixteen. For then she would have to begin on the practical side of her education, which would fit her to be a housewife.

Ludwig also saw life stretching out before him marked with mileposts. Within the next two or three years he must learn and achieve sufficient to be able to lay the foundation stone of their life together. He was confident, however, that he was well on the way to his goal. He was being taken up by the professional men of Utrecht, and had now, thanks to his friendly employers, met his fellow chemists, doctors, engineers and everyone else whom it was worth his while for him to know. Moreover, Smits had taken him to Amsterdam, chiefly to see their sodium sulphate plant there, but he had also shown him the city. Ludwig had disliked the place, finding only an overall impression of drabness. 'These Dutch keep everything to themselves,' he commented. 'They make no display.' He was shocked, too, by the Jewish quarter with its thirty thousand 'dirty, ugly, common inhabitants, who display almost all their wares on the streets, and make the most hideous din offering them for sale'. His was the typical attitude of the well-placed, assimilated Jew to the ugly crowd still in the ghetto. What he liked at Amsterdam was the Zoo, which was said to be the biggest in the world.

Back in Utrecht at the beginning of August, he found the burner, which had been held up owing to a shortage of bricklayers, now ready. Only the chimney had still to be erected. Ludwig had introduced some new features in its construction, which he had taken from a drawing of an English burner that Smits had shown him. The partners were extremely pleased with him, not least because he had made useful suggestions for improvements in other factories belonging to them. All this he wrote to his aunt, his usual confidante in business matters, to whom he must have outlined yet more ambitious plans for the future. For in speaking of certain developments that his Dutch employers were contemplating, and that might be quite advantageous to him, he merely observed that these offered him a second string in case his other projects fell

through. He had come to like Utrecht better also, so he wrote, since he had seen Amsterdam, and he was never short of company. But this did no more than preserve him from boredom. In his imagination he had already moved on.

Three days after the completion of the burner came the news of Adolf's death. This did not come as a surprise to Ludwig. His brother had not written to him for many weeks, and he had taken this silence as a sign that the young man himself had given up hope. The family were all together at Cassel, but there was no suggestion that Ludwig should leave his work to join them. The funeral would be over before he could arrive. His aunt, indeed, was glad that he was not there and that he had now found a place in the world, since to have him at Cassel would be deeply distressing to his father, who now saw himself without a successor to take over his business from him in his old age. There was still, however, the youngest son Rudolf, who was only a boy.

Frida, according to her mother, was overworking and overstrained. Not only was she finding it hard to be separated from Ludwig, but she was also worrying about her friend Julie Stodel, whose father and new stepmother were demanding that she should leave the Cologne conservatoire and come with them to Liège. Whether Aunt Johanna suspected Ludwig's part in her daughter's trouble or not, she wrote to him about it at some length. She was thinking, she said, of sending Frida to Ostend to recuperate, for she was growing too fast. But this plan fell through. Instead Julie came to live with the Löwenthals; and with a companion of her own age, or only a little older, Frida began to take life a little less hard.

By the middle of August 1862, while the Utrecht works was not yet in production and Smit and his partner were trying to interest Ludwig in their Amsterdam plant, to which the young chemist paid another visit and where he suggested some improvements, Ludwig was already announcing his intention of visiting England. Holland was not really to his taste. For not only did he feel a foreigner there, but it did not seem to him a land of opportunity. He longed to get back to the soda industry and to put his patent into practice in a large plant. 'Are there no soda works in Holland?' his mother asked,

and 'Can't you learn some English first? It is very hard to get ahead if you don't understand the language.' Then, towards the end of her letter, conscious that nothing she could say would hold him back, she advised him, when he got to London, not to try and see the whole of the Exhibition of that year, but to concentrate on those sections that concerned his own industry. In concluding, she recommended him further to study the wise lesson that Polonius read his son Laertes, who was also bound for England, and to wind up, quoted a German proverb the truth of which Ludwig had long since learnt by experience: 'Keep your eyes open and your purse shut.'

Moritz Mond had secured his son all the introductions that he would need. He had found him a lodging, in Sidney Street, Brömpton, where he could spend a few days while visiting the Exhibition, and where German was spoken. The first thing Ludwig must do on arrival, he wrote, was to attend to the registration of his patent, which had not yet gone through in London owing to unexpected difficulties. He must be certain also to visit the uncle of a Cassel neighbour, who was in the soda industry in Liverpool, and various family connexions in both Manchester and Glasgow, who would help him with further introductions in those cities. Ludwig's father had organized his trip for him with exemplary thoroughness.

Before he could cross to England, however, Ludwig Mond had still to put the Utrecht plant into production and earn the modest bonus to which he had agreed. Early in September he wrote of having overcome the last difficulties, although it had cost him head-breaking trouble both day and night: for the plant had to be watched through the dark hours and it had broken down a great number of times. He confessed that he really did not understand what had gone wrong. But somehow the difficulties had solved themselves. A week later things were still going well, and if they continued to do so for a further fortnight he would be able to get away. His stay in Utrecht would then have lasted two whole months, and he would be overjoyed to leave the place, as he told his aunt. A day or two later things at the works seem to have been going smoothly, and with revived optimism Ludwig committed the lessons of his eight weeks sojourn to paper. His burner had

turned out very well, he wrote, and he had never seen a more practical one. But the quality of the pyrites he was treating was extremely poor. He felt, however, that he had overcome the difficulties of his inferior material. But on the day of his sailing from Rotterdam a week later he had to admit himself beaten. The pyrites could not be treated as it was, but would have to be mixed with some of better quality. As it was, sometimes he had kept his burner going for as long as forty-eight hours, but then a change in the boiler-pressure or something of the sort, which was quite unavoidable, would put the fires out. Sometimes he had worked for seventy-two hours on end, and watched every detail with his own eyes. But he had to admit that he had attempted the impossible.

Smits had at first tried to blame him for the failure, and there had been considerable argument between them, Ludwig contending that he had foreseen this possibility from the start and endeavoured to warn his employer against it, and Smits insisting that it was certainly not the pyrites that was at fault. In the end, however, he had been forced to admit that Ludwig was in the right. But he still refused to order material of better quality and though he and Ludwig parted friends he paid the young German merely the month's salary he owed him, refusing to hear of the bonus, which Ludwig admitted, strictly speaking, he had no right to claim since the plant was not working smoothly.

There is no doubt that, in common fairness, Smits should have been a little more generous, since the cause of the failure was agreed to be outside Ludwig's control, but the young man bore no malice. The letter of the agreement had been adhered to, and he did not expect more favourable treatment than that. Throughout his life, indeed, Ludwig Mond was seldom indignant even though advantage may have been taken of him, so long as no written agreement had been violated. Business, for him, was a sphere in which the only safeguard was a shrewd legal mind, capable of foreseeing all eventualities and providing for them on paper.

Nevertheless, as he went down to the boat at Rotterdam with only the equivalent of £15 in his pocket, where he had expected £50, Ludwig felt a perfect fool. 'But now I'll see

which is the greater,' he wrote, 'my idiocy or my energy.' The strain of the last weeks had not told on him, or so he felt, though a few days more of it might have done so; and he had just enough money to make a preliminary inspection of possibilities in a country which he felt confident would prove very rich in them. Certainly he was in no danger of dying through hunger and thirst, as he put it, and his way of retreat was open. In fact he had a very promising alternative still to pursue if England failed to offer what he hoped. For on his visit to Amsterdam with Smits, his employer had introduced him to a Dutch associate who owned a sulphuric acid plant, and talked of his intention of building the first Le Blanc soda works to be erected in Holland.

Although this project was not likely to mature for some months, his new Dutch acquaintance had immediately offered Ludwig the job of supervising the building and starting the production when the time came and, used though he now was to Dutch delays, he was counting heavily on this commission and on the possibility of installing his own process of sulphur recovery in the new plant. The matter, however, had reached no very concrete stage. The capital had still to be raised, and Smits, who eventually was to take an interest in it, had not yet made up his mind to do so. On leaving Holland, therefore, Ludwig had done no more than give his new Dutch acquaintance the Löwenthals' address at Cologne, so that he could be called in the moment they were ready to build.

In the meantime he was on the deck of the steamer which would bring him to London on Sunday, that legendary day of darkness and depression in the British capital, and after a day or two there he would go up by train to Manchester, within easy distance of which were some ten soda factories. His crossing was cheap but uncomfortable. For the night boat from Rotterdam carried live cattle for the London slaughterhouses. 'Now,' his mother had warned him, 'you will be leaving *terra firma*. We are all in God's hands.' 'The Englishman', she had been informed by a certain Herr Mosenthal of Cassel, who knew the country, 'does not worry about money once he has been convinced that an idea is good. But even the best paper testimonials are of no use. He won't believe in anything

unless you can give him ocular demonstration. For neither his heart nor his purse believes in what his eye does not see.'

If the English were like that they would be a people whom Ludwig Mond could respect. Furthermore, by leaving the *terra firma* of Europe behind him he was turning his back on countries where a latent anti-Semitism might always stand in the way of his advancing to the heights he so frequently envisaged. But in England things were different. Benjamin Disraeli, a Jew by birth though not by faith, had been Chancellor of the Exchequer in the last English government, and for four years now it had been possible for a Jew by religion to take his seat in Parliament. Philip Goldschmidt, indeed, the distant cousin in Manchester to whom Ludwig carried a letter of introduction, was destined to be the first Jewish Lord Mayor of that city and one day to receive a knighthood.

Ludwig arrived in London in the best of spirits. His English proved, unexpectedly, to be quite adequate for conversational purposes. For a week he paid assiduous visits to the 1862 Exhibition, which was held in a new building in Cromwell Road, South Kensington. Never, he said in after years, had he seen or learnt so much in so short a space of time. There was much new machinery, new brick-making kilns, new vessels of acid-resisting material, and for the first time Bryant & May displayed their Safety Matches. Ludwig collected addresses, advertising leaflets and information, some of which might prove useful in the next years. So busy was he that he had no time to write letters.

Manchester presented a different problem. Somewhere, and quite soon if his money was not to give out first, he would have to find an alkali manufacturer who would adopt his patent. In that city, fortunately, there was a small but very active German colony, and he was soon provided with introductions to all the most likely concerns. Furthermore, his financial anxieties were quickly relieved by his father, who opened a credit account for him at a Manchester bank. Ludwig Mond, in fact, did not begin his business life in England with the proverbial shilling. As always when his plans were well thought out and his father's advice had been taken, he had Moritz Mond behind him.

The *Schillerverein*, which was frequented by the young German colony of Manchester, had been founded three years before to celebrate the centenary of Schiller's birth, and here Ludwig found a warm welcome. Almost immediately indeed he made a friend, an unstable and mercurial engineer, Carl Pieper by name, with whom he was later to be associated and of whom, in spite of this young man's disappointing shortcomings, he grew very fond. It was a Doctor Garland, however, a Cassel man who had lived in England for some time, who proved most useful to the newcomer. Ludwig was willing to accept any opening for a start, since he knew that England was not an easy country to establish oneself in. But he felt himself to be in a strong position, for whilst chiefly anxious to have his sulphur-extraction patent exploited by a soda factory he had also another new process to offer which he had just patented in London: a process for producing nitric and nitrous acid at an intermediate stage of the soda process. Almost immediately, however, the right opening appeared. John Hutchinson, one of the biggest producers by the Le Blanc process, gave him an appointment, listened to his long explanations in broken guttural English, and made him a proposition. He would give Ludwig the three hundred a year he asked for, a sum that he considered very modest, if they could make four hundred and fifty a year by his process. Ludwig guaranteed that he could add twice as much as that to Hutchinson's profit. But, having allowed his sanguine lightning calculations to betray him into over-confidence in the past, the young chemist decided this time that he would believe in his good fortune when he saw the money.

In exactly a month from his setting foot in England, Ludwig Mond was working for Messrs John Hutchinson & Company of Widnes on the Mersey, not as their employee but as an independent though salaried scientist, at liberty to sell the rights to work his patent not only to Hutchinson's but to any of their competitors who would buy as well. None of them, however, was interested. They received him most politely, but told him that times were not good enough for anyone to embark on the capital expenditure entailed by new methods of manufacture.

In actual fact, Ludwig Mond's inventions were much less valuable in the English market than he had supposed. On the Continent sulphur was worth £12 a ton, and wages were a shilling a day. Any process, therefore, however laborious, that extracted more sulphur from the waste was liable to be rewarding. In England, on the other hand, sulphur was cheaper, being manufactured from Irish pyrites rather than imported from Sicily, and wages were higher. Mond's sulphur-recovery process, therefore, did not offer the same advantages in England as abroad. It served, however, to get him an entry into the English chemical industry which, owing to the backwardness of scientific education in this country, was badly in need of such academically trained minds as his.

When John Hutchinson, the son of a naval officer, had first come to Widnes as a young man of twenty-two, he had found it a small town, the seat of certain unimportant metal crafts and the site of a limestone quarry which cut into the Runcorn headland, a projection which narrowed the Mersey at that point. He was a young man of little practical experience, having merely served a bare year in a soda plant at St Helens, belonging to Andrew Kurtz, the German-born father of a college friend. Hutchinson's education had not been scientific, until he had attended a series of chemistry lectures in Paris where he had first met his friend Kurtz. Nevertheless on the death of Kurtz the elder, having learnt something of the Le Blanc process at St Helens, the young man decided to set up on his own, and chose Widnes for his site owing to its proximity to the Cheshire saltfields. Though technically far less inventive than many of his competitors, Hutchinson was a shrewd man of business, tenacious in bargaining and extremely clear-sighted. 'Your father was the cleverest man I have ever known,' Ludwig Mond told his daughter in after years when showing her his collection of pictures, bought with a fortune the foundation of which he owed to his early experience at Hutchinson's. 'In fact he was too clever. He saw too far ahead and missed the little things that lay between.'

The young Hutchinson's works expanded rapidly and, although rivals came to the district with greater chemical knowledge than he possessed, his was reckoned the biggest

plant thereabouts when Ludwig Mond made his preliminary inquiries fifteen years later. By this time the drawbacks of the Le Blanc process were evident to everyone who came near Widnes. For the chimneys of the soap and soda works there belched a thick smoke day and night, heavy with hydrochloric acid, which burnt the hedges, destroyed the crops and did extreme damage for many miles around in any direction the wind might carry it. The alkali waste moreover, rich with unextracted sulphur, choked the little streams that drained the marshland and polluted the Mersey itself. For every ton of soda made, approximately double its weight of *galligu*—as it was called locally—a thick and evil-smelling mud, had to be dumped on the marsh or poured out on waste land, whose purchase was always a problem to the alkali maker—and a fine source of profit to John Hutchinson, who had bought a lot of ground soon after he came to Widnes. But even when laid out on waste land, from this nauseating sludge seeped the continual odour of rotten eggs. Finally, however, the stuff dried; and even then it remained a potent menace. For it was liable to heat in the sun, catch fire and give off the irritant and corrosive gas, sulphur dioxide.

As a result of this imperfect Le Blanc process, therefore, heavy compensation had to be paid from time to time for the damage done by hydrochloric acid and in other ways; and complaints had of late been so numerous in the district that a bare two months before Ludwig Mond's arrival at Widnes a Select Committee of the House of Lords had been appointed to inquire into the deleterious effects of noxious vapours. Before this Committee in due course most of the local manufacturers were called to give evidence. They had, however, previously agreed on a common policy, which was not to fight against the passing of a safeguarding act, which they viewed as inevitable, but simply to prevent the act from being a severe one. What they combined to do was to discredit all sensational reports of damage; to reduce the charge against themselves, in fact, to one of mere nuisance.

But however good a face they put on it, however general may have been the use of those condensing towers that, as they claimed, effectually saved the atmosphere from hydrochloric

pollution, there was no denying that the Le Blanc process, as it was then being practised, made one chemical and wasted two, and that the waste was potentially noxious. It was therefore in keeping with the foresight for which Hutchinson was famous that he should take on this young German chemist. For even if the sulphur which his patent set out to save was not worth reclaiming, waste from which all the sulphur had been extracted would be harmless to health. The manufacture of by-products which so interested Ludwig might, therefore, serve the more important purpose from Hutchinson's point of view of pleasing the Alkali Inspectorate (an office that had been proposed in a draft bill about to be presented to Parliament) even though the sale of by-products might provide very little additional profit to the manufacturer. Therefore Ludwig was commissioned to install both his processes, though on scarcely more than a laboratory scale, in John Hutchinson's works. Ludwig did not delay. Within a week he had set up an experimental plant, but had then had to alter it to suit the English coal, to which he was not used. There were other things about England, too, that he found strange. He was surprised and rather annoyed to find himself held up on the Saturday because the men did not work in the afternoon; nor was he reconciled to the fact that, here, Sunday was a compulsory holiday.

He had at the outset taken lodgings at the noisy little Mersey Inn down by the waterfront, where for a while he lived at Hutchinson's expense, and here he found everything and everybody rough and strange. But he quickly struck up a friendship with Hutchinson's works chemist, Henry Brunner, the brother of his future partner, who could speak fluent German.

Henry Brunner was the eldest son of a Swiss pastor who kept a school near Liverpool, where he and his brothers had started their education. Henry had then gone to Zürich to complete his while his brothers John Tomlinson and Joseph had been pitchforked out to work as clerks in Liverpool. Then in 1861 Henry and John had both joined Hutchinson, Henry on the technical and John Tomlinson on the commercial side of the business, while Joseph stayed in Liverpool and later

became a chemical merchant and Brunner, Mond's agent. At that time Henry was not yet twenty-five—a year younger than Ludwig—while his brother was only twenty.

But though Ludwig Mond quickly found a friend he was at first as ready to complain of the English as he had been of the Dutch. Henry was typical, he wrote, of that cold and silent people. For the English were an uncomfortable race. The young man no doubt felt unhappy and isolated in this remote corner of a foreign land. He realized, however, that he had never had a better opportunity of learning than he was having at Hutchinson's, and that he would be a fool to cut it short by so much as a day. This *really* was a beginning.

Frida had now gone to Cassel to stay with her aunt, and there she spent her fifteenth birthday. 'I shall be glad when she gives up her studies, and can devote herself to domestic and feminine matters again,' Ludwig's mother wrote to him. 'Otherwise I am afraid that she will turn into a bluestocking.'

Once back in Cologne at the end of the month Frida had found herself a new friend even more given to intellectual pursuits than herself: Henriette Herz, who was to be a lifelong intimate of her and of Ludwig, spoke English, French and Italian and was very good at sketching. Her family however were of the type of village Jews whom the Löwenthals did not care to know. For her father was a horse-dealer. Therefore, though the friendship between the girls prospered, the parents remained strangers. But Frida had now no lack of company, since Julie Stodel was living in the house in Cologne and Henriette Herz was not many streets away. So in the company of friends who did not consider her thirst for knowledge as strange as did her aunt, Frida pursued her education, looking up in admiration at the accomplishments of both Julie and Harry (as they called Henriette), and following the adventures of her brilliant cousin, who had gone to England to seek the fortune on which they would one day get married.

But the long delay stretching out before her weighed on her spirits. Ludwig, too, wrote of loneliness and of his longing for her in a way that only served to make her sadder. 'We have such a long time to wait,' she wailed. 'I am so lonely and abandoned,' he replied, 'and I do not even know where you

are.' 'One does not need to be in love to be melancholy in this place,' he went on, and indulged in the usual complaints about the English fog and the bad climate.

Winter came. He had still nothing to show for his work at Widnes, nor any agreement with Hutchinson about the application of his patents. He had never worked for two months before without some positive results. A conversation with Hutchinson in December did not carry him much further forward. They came to some sort of verbal arrangement, which on top of an invitation to spend a whole Sunday at the Hutchinsons' house caused Ludwig to write home in premature triumph; but really he was no further forward.

Hutchinson was a slow and hard-headed man. He was delighted to have a pupil of Bunsen's working on his premises, but he was not impressed by anything that the young German had shown him so far. Yet Ludwig himself was confident. On account of some false information, he told his father, he had at first been doubtful as to the applicability of his sulphur-recovery process to English conditions. Now he was certain of its usefulness, and certain too that he must stay here till he reached his pecuniary objective; he must leave the country a well-to-do man.

Yet there were other moments when he set his ambition at a lower rate, when he claimed already to have achieved his main purpose. For whatever the fate of his patents, he had now seen quite a different aspect of business and manufacture from anything he had met with on the Continent, and this experience would stand him in good stead later on. He congratulated himself also on being on very good terms now with the people in Hutchinson's office and with the technical staff. In fact he was slowly teaching himself the art of patience, and learning to be satisfied with triumphs that were neither complete nor immediate. In this respect he had much to learn from Henry Brunner, he wrote early in the new year. He was now on almost intimate terms with Hutchinson's chemist, whom he considered a model of calm, though never of indifference. With calm, he saw that a great deal could be attained, and taking the will for the achievement, Ludwig now described himself as in many ways a changed man.

Perhaps he owed part of his new-won calm to the renewed exercise of his inventive powers. For by February he had worked out a new method of extracting sulphur from the *galligu* with far less cost in labour than his original scheme. It involved passing air through the waste while it was in the lixiviation vats. This obviated the labour of transferring it repeatedly from the vats to the hurdles for reoxidation, which had been a costly feature of his earlier method. These modifications he in due course embodied in a fresh patent, which he registered in the following autumn. But by that time he had grown disillusioned with patents. 'It is quite well known in England,' he wrote, 'that out of a hundred apparently excellent registered ideas, scarcely one is both practical and valuable.'

But there was another cause contributing to his growing peace of mind: the alternative possibilities he had been working for were opening up in Holland. Smits' friends who had been contemplating the erection of a Le Blanc soda plant had, after a lengthy correspondence, accepted Ludwig's proposals of terms, and were now anxious for him to erect and start their works for them. The project was, however, a somewhat far-distant one, as the partners were not yet in agreement, even as to a site for these works. But this was not the only interesting news from Holland. Ludwig learnt from the same letter that Smits himself had now taken his advice and mixed better material with the pyrites he was using. The plant that Ludwig had erected for him was consequently working well; and had he not made such a precipitate bolt for England the young chemist would by now have received his modest bonus. This last tantalizing item of news did not upset him unduly. He was more interested in future prospects than in past losses. What he complained of was the snail's pace at which things were going ahead in England. He was on excellent terms with everybody from the director downwards, but no one did anything to hurry on his projects.

A letter from Aunt Johanna was disquieting. First she strongly advised him against rushing to Holland which, despite his new-found calm, had been his first intention on hearing favourable news from that quarter. Secondly she had

discovered his correspondence with Frida. Her reproaches for the harm he was doing by thus interfering with her daughter's peaceful development were well deserved. Time and again his letters rose to a pitch of emotion that was far greater than a child of Frida's years should have been asked to share. Her mother had often unhappily wondered why the child was so silent and so self-absorbed, and why she was so secretive, even with her own mother. No one suggested that Ludwig should not keep up a correspondence with her, and help her mother with the task of her spiritual upbringing. But his letters were not only foolish and childish; they were most upsetting to Frida. Still what was done was done. Now he must try to steer the relationship into more peaceful waters, so that gradually she could come to show his letters to her mother. It was important for the moment, however, that Frida should not know that her secret was discovered, and Aunt Johanna went so far as to give Ludwig a convenient address to which he could send his reply. She did not want her husband to have any idea of what was going on. It was the custom of the Levinsohn daughters to keep their husbands in the dark.

Ludwig's reply was not an easy one to write. It opened with a display of emotionalism which did him little credit. He confessed that he had often blamed himself for speaking too soon. Yet had he not made Frida a declaration he feared that the results for her would have been even worse. When he had been with them in the previous spring he had been conscious that she was no longer a child. Indeed he doubted whether she had ever really been a child at all. All the same it was a source of great regret to him that their relationship had developed so prematurely.

I had not been with you long [he declared, referring now to his stay in their house eighteen months ago], before I knew that she was passionately in love with me, and this through no fault of mine, and I saw with each week that passed that my silence was doing her far, far more harm than would the pacifying certainty of my love. Perhaps I was wrong, but I assure you that even though I had decided to marry Frida, if I could win her love, when she was no more than nine [he had first seen her on her

tenth birthday] and though I loved her with all the passion of which I am capable when she was thirteen, never a word would have passed my lips if I had not thought it necessary for her that I should speak.

His excuses may have seemed to his aunt a little specious. They were, however, based on a sound judgement of affairs. Though nine years older in years, and in intelligence immeasurably her superior, emotionally Ludwig had been considerably less mature than his future wife even when she was no more than thirteen. When he wrote of her as now considerably the more sensible of the two he was entirely right.

Aunt Johanna's reply was reassuring. If there was anyone in the world whom she would choose for her daughter to marry it was her nephew. But for the present he must, for Frida's sake, moderate the tone of his letters. Nor if he took a trip to Holland must he come on to Cologne without first hearing from her how his doing so might affect Frida. In fact, his aunt now shared his secret with him, and invited him henceforth to watch with her, like some second presiding deity, over her daughter's future development. One thing, she insisted, was essential: Frida must know nothing of her complicity; this would make it easier to conceal the state of things from her husband and Ludwig's parents.

His uncle, she said, was now leading his own life to a greater extent than ever, and hardly appeared any more except at table. She would, therefore, as the women of her family had always done, take the responsibility entirely upon herself. One cannot help suspecting that the turn events had taken was really very much to her taste. She and Ludwig had always been in one another's especial confidence, and this secret only bound them closer together. The chief sufferer under the new dispensation might have been Frida, who was now to be brooded over by an over-fond mamma and fiancé in collusion. Fortunately her mind was too independent for her to be much affected, and she continued to educate herself for her future destiny, even to the extent of following the scientific journals and keeping Ludwig posted with any news which might interest him. She and her friend Julie Stodel went so far as

to make him a translation of a French account of the discovery of a new element, thallium.

Meanwhile at Widnes things were not going fast; work on Ludwig's projects was liable to be suspended in favour of anything else that required doing in the factory. He had however dug himself into English life. Early in the new year he left his noisy inn down by the waterfront and took rooms inland, on higher ground and away from the fogs that clung to the river, in the still unspoilt village of Appleton. Here he was joined by a strange fellow-protégé of Hutchinson's, a young Mexican who was being trained to take over the management of a pyrites mine in Spain. Ludwig's task, which he entered into with enthusiasm, was to teach the young man sufficient practical chemistry, which he had to do in French, their only common language. The Mexican had received a good theoretical training in the École Centrale in Paris but his knowledge had grown rather rusty in the years that followed when, having gambled away an inherited fortune, he had taken a variety of jobs, wandering over half Europe, sailing the Atlantic as a common sailor and working as a bootblack in New York before fetching up in this foggy corner of Lancashire.

It argues considerable unconventionality in John Hutchinson that he should have had at his works at the same time such a strangely assorted pair of foreigners as an ambitious and inventive young German Jew and a reckless rolling stone from the New World. But since he was himself not of provincial stock but the son of a naval officer, and since he had himself received some of his education abroad, his outlook was very much wider than that of his competitors or of Widnes society in general.

Ludwig took a liking to his pupil Gonzalez. He admired him for his confident good looks, and respected him for refusing to turn to his rich relations now that he was, comparatively speaking, on the rocks. It was with the envy of the man of foresight for the reckless adventurer that he recorded his penniless friend's story in his letters home. Gonzalez was a married man, but had left his wife behind in France, to live with her parents. Ludwig admired his pupil also for his sound

practical qualities. 'I have never met a young man with more energy and endurance,' he wrote to Frida. The quality about Ludwig that most impressed the young Mexican was his directness. He concluded his first long letter from Spain in which, after thanking his tutor for all his kindness, he described the primitive state of the country and its vast mineral wealth in sentences that almost apologized for their warmth. 'Je sais que vous détestez la flatterie,' he wrote, 'et comme je désire que vous me laissiez votre bonne amitié, je finis en vous souhaitant bonne chance et surtout bonne santé.'

Ludwig's health remained good, especially now that he was living out of the poisonous mists of the industrial lowlands, but he continued to be out of luck. Sulphur fetched only a quarter of its price two years before at Ringenkuhl, and he was uncertain whether with land and timber at their present cost it would pay to put up a sulphur-recovery plant at all. Nevertheless he was working on some improvements to his process. But these, as he ruefully recorded, had to be tried out, and for the moment he could see no prospect of that. Moreover he was disillusioned about the whole business of patents and inventions. As for his second string, his nitric acid manufacture, he was delayed by the absence of Henry Brunner, who, as Ludwig explained in a letter to his mother, had hurt his eye and had not been at the works for a fortnight. Moreover, a little before this, a cast iron still, which had been specially manufactured for this process, had exploded. Now a wrought iron one had been brought in to replace it, but experiments were held up until Henry's return to work. In fact the nitric acid experiment went no further. For all that, Ludwig was optimistic.

I would not attach great importance [he wrote] to the failure of one expectation and still less would I be worried about my future, which seems to me more assured now, after the valuable experiences I have had here, than if I had made a large sum of money in Germany and not come here at all.

He was extremely pleased with his progress both as a man and a technician.

My life here is very simple [he wrote after summing up the causes for the failure of his hopes]. I spend the whole day in the factory, most of it in the laboratory. In the evenings I usually stay in my rooms, with a young man from the office who lives in the same house. Sometimes I go out to visit some people, the factory doctor or a young German who is over here teaching, or some young men from the works—that is the chemist and his brother—with whom I am on very friendly terms. Sometimes too these people come to see me. We drink tea, play whist, talk and sing. I have not been to Manchester for some time, because the journey is rather expensive, but last Sunday I was in Liverpool, visiting the Brunners.

The correspondence between Ludwig and Frida now ran at a more modest emotional pitch, though he seemed frequently to get worked up at not receiving a letter from her on the day that he had expected it. She wrote a great deal about her friend Julie's difficulties with her father and of the attempts by the Löwenthals and their circle to get her friend concert engagements in Germany and Holland. Frida, too, had played in public, though only at her pension, where she appeared in blue satin with powdered hair to perform at the piano and speak an introduction to Haydn's Toy Symphony.

Ludwig continued to report failure. His hopes were now centred on the Dutch soda factory, but he declined to fix them too firmly even on that, and declared that if those plans fell through he was ready to go out and get another job of some sort here in England. He had now worked out his new and improved process for sulphur recovery, but had so far only been able to try it out under laboratory conditions. The verbal agreement that he had made with Hutchinson seemed to be leading to nothing, and Ludwig had more than half decided to move on. His hopes of being independent at twenty-five were receding. The only really successful invention that he had made, he told Frida, was a two-lensed glass that he had set up to magnify her photograph. 'We are not a family that has ever made money,' his mother wrote consolingly, 'though I should have liked you to make a pile with your patents if only to impress your father.' Then at the end of her

long letter she commented on the cruel suppression of the Polish rebellion against Russia. 'Can you believe that we are living in the nineteenth century?' she asked. 'The Thirty Years war was no more dreadful.' How little did she foresee the horrors that the twentieth had in store, for the descendants of her own friends and relatives, amongst others.

Her letter was written to congratulate Ludwig on his twenty-fourth birthday, an occasion of which Frida took advantage to join issue with Goethe, who speaks in one of his poems of the pleasures of living apart. 'It may have been all right for him,' she naively protested, 'but it is not so for us. I should like to be with you.' She sent him at the same time as this unofficial letter her official birthday greetings, which were sufficiently formal to have been shown to her mother. For Frau Löwenthal had still said nothing to her daughter about her discovery, and her subsequent correspondence with Ludwig. Frida spoke in her private letter of a concert that she had heard in the Gürzenich, Cologne's principal concert hall, at which they had played Beethoven's violin concerto and one of his symphonies, part of a Cherubini Mass, an aria from *Don Giovanni* and one from Weber's *Oberon*. She was enthusiastic for Beethoven.

Ludwig replied to her private communication, exhorting patience. He had enjoyed himself at a birthday party given for him by his English friends, and he had even managed to reply to the toast in his honour by making a speech in English. The party had gone on till 3 a.m. He had then spent the week-end in Manchester, where he had visited his engineer friend Pieper and his cousins the Goldschmidts. He was hoping to go back to Manchester the next day to see the illuminations in honour of the Prince of Wales' marriage to Princess Alexandra of Denmark.

As spring progressed Ludwig grew more and more anxious to leave England. Once he planned a trip to Belgium with the intention of coming on to see Frida at Cologne, only to abandon the idea since he would be compelled in the end to return to England, and it would be better to establish himself there now than to come back in a few months' time to do so. His general prospects seemed rather less bright. The Dutch

company still could not make up their minds, and unofficially he heard that Hutchinson was disappointed with his patents and had lost interest in them. Frida, for all her anxiety to see him, advised him at all costs to stay. 'We have borne separation for so long now. We must and will go on bearing it still longer,' she wrote. 'England is the land for you.'

Frida's parents had decided that she should leave her Cologne pension in the summer, since eight to ten hours' work a day was overtiring her. First, they wanted her to spend some weeks in complete idleness, then to take some private lessons and to start on the most important subject in a girl's education, the study of housekeeping. All this Frida accepted, but afterwards, she declared, Ludwig himself must teach her English. He approved of the whole plan; for much though he would like his wife to be a complete dictionary and encyclopedia of ancient and modern learning—as he put it—who would spare him the trouble of looking things up, he would rather take a little trouble himself if it would spare her headaches. 'I am no longer a schoolgirl,' she proclaimed at the end of a subsequent letter in which she offered him her sound and disinterested advice. One wonders if she ever had been one.

Meanwhile Ludwig's father also sent him advice, which almost amounted to a letter of instructions. He should, of course, on coming to England have got himself a well-paid job and let the matter of his patents and their working take second place, he announced—as ever, wise after the event—for it is more important to get a wage than to go out after a fortune. 'I may not know much about chemistry,' he went on, foreseeing his son's inevitable reply to this sententiousness. 'But I do know that it is not so easy to get ahead in the world as young men think. When I was your age . . .'

It was all distressingly predictable. The course that his father recommended to Ludwig was to go to Leeds to consult a friend of his and then to Newcastle, a large centre of the chemical industry where there were also soda works. After that he ought to go to Amsterdam and interview the Dutch directors, whose decision had been delayed by the illness of his old associate Smits—who now proved to be its guiding spirit. Then if no result could be obtained there he should come

home, taking care not to spend too much on the way, for money was harder to make than to spend.

This was a return to the tone his father had used to him before he came to England; and sensible though Moritz Mond's advice seemed, Ludwig knew that really this not very successful silk-merchant was as short-sighted as before. Besides, the results that he was getting from his laboratory experiments were excellent, better than ever. Now there really was something to show Hutchinson, if only he would pay attention. But a letter written by Richard Powell, Hutchinson's second-in-command, when Ludwig pressed for an interview, categorically stated that what had really interested them had been the nitric acid process, which had unfortunately failed, and that they had now no time to go into the matter of sulphur recovery. Nevertheless Ludwig could see Mr Hutchinson for a few minutes on the following Sunday, before he left for London. At that meeting Hutchinson merely promised to deal with Ludwig on his return, if he would wait. Ludwig answered that this depended on how long he would be away. Satisfied that the proprietor's absence would be short Ludwig awaited his return. But on the day that Hutchinson was expected back Richard Powell told Ludwig that the boss was overworked and could not attend to any further business.

But the young German persisted, and ten days later Hutchinson not only gave him an interview, but agreed to put his sulphur-recovery process into large-scale operation.

I have at last brought the thing to perfection [he wrote to Frida]. I have always had it dangling before my eyes, and now I am certain of its great financial practicability under all circumstances. I do not believe that I shall strike any difficulties now. For I have already worked the process on a considerable scale.

Speedily his hopes of success were soaring. But this time he was not so confident that he would make a large sum of money. He was in fact not certain whether his patent would hold; whether indeed it did not conflict with patents already existing. But this, he claimed, putting a bold face on it, was to

him a secondary matter. He had never believed in the bottom of his heart that he would make a fortune by his invention.

From this it would appear that Mr Hutchinson, although at last willing to exploit Ludwig Mond's brains, had no intention of letting the young man grow rich at what he considered his expense. For in Hutchinson's view the profits derived from experiments conducted in his own factory ought rightfully to accrue to him: and in this belief he was no doubt at one with the average British manufacturer of his day, to whom patents were an academic subject and the scientist merely a works chemist, entirely at the command of his employer, and consequently a man not justified in demanding a reward for any useful improvements he might make, since these would be based on his experience in the works in which he served. Ludwig was, of course, in a slightly different position since he was only at Widnes in a voluntary, or semi-voluntary capacity. Nevertheless the secret of Hutchinson's reluctance to negotiate with the young German chemist undoubtedly lies in his unwillingness to pay a royalty on a process which had been perfected in his works, with no outlay by Ludwig. He did not care to buy what he considered to be his own.

In fact Ludwig's boast that he had finally come to an arrangement with Hutchinson was premature. True, the proprietor had once more agreed verbally to work the new process on a major scale and had ordered the necessary machinery. But, as he had put it, this was no more than a promise to adhere to their original arrangement, which was in itself vague enough. Indeed Ludwig did not think it worth the expenditure of £30 to register the patent on his improved process, since he now decided that he could not expect Hutchinson or any other Englishman to pay him any large sum for his services in the matter. From Belgium there was some hope of getting a better reward, since the patent law there was more favourable to the inventor. Meanwhile it was almost impossible to get a further interview with the boss. For Hutchinson rushed off to London, came back to Widnes for a few days and then departed to take the cure at Bad Ems.

So whilst Ludwig and his parents were exchanging congratulatory letters the matter was really very far from settled.

Indeed almost the only thing that had happened had been that Ludwig had considerably abated his expectations of profit from his discovery, which certainly made it much more likely that Hutchinson would eventually adopt it. Actually Ludwig's position was now rather more uncertain than before, since he had been taken on at Widnes only to work out his two processes, one of which was now perfected and the other abandoned.

His life for the present, however, was a very pleasant one. For he was completely his own master, was on the best of terms with the staff, and knew that the foremen and workmen would do anything they possibly could for him, since he had rather expensively purchased their goodwill by his generosity in the local pubs. Moreover, small though his volunteer's wage was, he was able to live comfortably and within his means. He had in fact got used to the English way of life. He found plenty of quiet amusement with his new friends, and congratulated himself once more that whether he was making money or not he was gaining the most valuable experience.

In May he was nursing his Manchester friend, Carl Pieper, who was recovering from a serious illness, and for whom he had taken a room in his own lodgings at Appleton. For all Pieper's instability, Ludwig felt more affection for him than for his more reserved, if more dependable, English colleagues. They had besides a common language. In this same month, when he had still no hope of seeing Frida until the slow-moving Dutch should come to a decision, the suggestion came from a relative who knew of their engagement that her parents should now be told. Frida was against it, but Ludwig much less so. Rather disingenuously he assured her that she need expect no opposition from her mother, who would say that she had known all along but had kept it to herself. He was not certain, however, whether her somewhat distant relations with her mother would be any easier for the confession and advised her to wait until he could come to Cologne and they could make a declaration together.

They had now been engaged for two years. At Whitsun Frida visited Brühl, the scene of their betrothal picnic, and felt like weeping because he was not there, since—as she wrote

—she always missed him most in the country. He, on the other hand, went that day with a party to a local beauty spot, an old ruin that had been transformed into an inn, and danced until the early hours of the next morning. Whitsun, he said, is the only time in the year when every Englishman goes out into the country, and there is dancing in the inns every night of the week. Such was the shortness of a workman's summer holiday in 1863.

In June Ludwig's hopes began to rise towards their former giddy heights. The new machinery was almost ready for delivery, and he now felt that perhaps it would be worth his while to take out a further patent. Furthermore Pieper was nearly better, and the Dutch had broken a long silence. Smits wrote that they were at last about to sign an agreement to put up the works, and invited Ludwig to come to Holland at their expense and discuss the proposition on the spot. This fell in with the young chemist's own wishes. For in Hutchinson's absence Powell was allowing every sort of unnecessary delay, and there was nothing to be done now that the preliminary small-scale experiments were absolutely complete, except wait for the erection of the new plant. Once this was working his process would no longer be a secret from anyone. It was therefore advisable to visit Hutchinson at Ems, where he had plenty of leisure, and get a more definite agreement with him about its exploitation before it was too late. Moreover, as he told his parents, he was very much looking forward to seeing them. For it was almost a year since he had left Cassel. But he had not let anything of that sort influence his decision to accept Smits' invitation. 'For,' as he somewhat sententiously remarked, 'matters of sentiment end where business begins. I have learnt that very thoroughly here in England.' Frida, with only half the details of his plans before her, firmly advised him not to come merely because he wanted to see her.

Richard Powell made no difficulties about Ludwig's departure. He was glad to have him away whilst the new machinery was finally being installed. So, after sundry small delays from the Dutch, Ludwig eventually arrived in Utrecht on July 13th, after ten months' absence from the Continent.

The contract with the firm of Smits & de Wolf was quickly signed. For the equivalent of a bare £15 a month with a bonus of something over £200 to be paid him when the work was completed and production had been going for three months, Ludwig undertook to produce a fixed quantity of sulphate, hydrochloric acid, soda ash of specified qualities, soda crystals, chloride of lime, sulphuric acid and sulphur—this last by the use of his own patents on which he would receive a royalty—from an equally fixed quantity of pyrites, salt, chalk or limestone and manganese dioxide, all of equally fixed qualities, also of so much quicklime. The choice of apparatus and arrangement of buildings, as well as the selection and hire of labour, were to be in Ludwig's hands, and the directors undertook that the erection of the plant and all ancillary work should go forward without delay. Further, although Ludwig would enter their employment on September 1st, he was to be master of his own time, which would allow him at any moment to return to England to safeguard his interests there.

The terms do not appear very liberal. It is difficult to imagine any expert called in to erect a factory to-day contenting himself with even four times the salary which Ludwig accepted from Smits & de Wolf; nor can one imagine any factory designer waiting till a works had been running for three months before receiving a bonus, even if it were ten times as great as the sum to which Ludwig agreed. The whole proceeding amply confirms the view that Ludwig himself took from the moment when he tried to persuade his father to buy him a share in his Löwenthal uncle's electro-plating business. There was no future, he could plainly see, in working for any employer. It was better indeed to remain independent and collect royalties on inventions than to take a salary. In this he had been opposed all along by his father, who saw in a job at so much a month a security that no young man could afford to dispense with. Certainly if all his experience could earn him so little, and that so impermanently, Ludwig was justified in his independent attitude. A fixed job with Hutchinson, for instance, would never have allowed him to marry. In the mid-nineteenth century few men who were not employers could expect to enjoy middle-class incomes.

Ludwig paid a rapid visit to Cologne, where he impressed everyone by his anglicized appearance. He had had a haircut in Manchester, and had shaved off his beard. From Cologne he went to Cassel, duly visited Mr Hutchinson at Bad Ems, returned to Utrecht to sign his contract and was back in England at the beginning of August. There everything was as he had left it. Hutchinson was back, the whole place was in a bustle and everybody too tired in the evenings for the little festivities which Ludwig tried to introduce. As a result of his meeting with the proprietor and strenuous efforts since his return he had now control over the working of his own project, which he expected would begin in two or three days' time. It was in his power therefore to go straight ahead and complete his work in England before leaving for Holland.

At the end of August Frida left her pension, after considerable protests from the staff and pupils, who crossed the road in a body to reason with her mother. Her final appearance was at the end-of-term concert at which she once more played and recited. Immediately the term was over her mother fell and damaged her foot, and Frida's long-promised holiday was once more postponed. Nor was she prepared to take a rest. Already she was arranging lessons for herself for the autumn.

Autumn set in early and Ludwig reported his first fire in that 'poetical institution', the English fireplace, at a time when the grapes were still ripening on the Rhine, a sad comment on the Lancashire climate. Carl Pieper had left the country, and Ludwig missed him. He was hoping to be away himself within a few weeks. But Hutchinson had now gone to America and would not be back till the end of October, and Ludwig wanted to wait for his return. For despite his Ems visit he had still extracted no more definite agreement from this hard-bargaining industrialist. The new sulphur-recovery process was now, however, patented and Ludwig was as ever quite confident of his eventual success, but—as he wrote to his aunt—no longer ready to raise a great shout each time things went in his favour.

The final result was not in doubt; it was a question of time, and for the moment Richard Powell stood in his way, a man whom it was not easy to convince because he did not care for

Ludwig to be successful. Now that things seemed to be going this way, Hutchinson's second-in-command was taking a personal interest in his process and suggesting improvements in the machinery, which Ludwig had to accept since in Hutchinson's absence there was no appeal. All this was making for further delays. Meanwhile building operations were beginning in Holland, and it was doubtful whether he would be able to stay in England long enough to come to the long postponed agreement. 'I am really heartily tired of England,' he wrote to Frida and at the end of October he left, still in hopes that he could reach a speedy arrangement with Hutchinson, but still far from having done so.

Indeed their last interview had been a stormy one. For Hutchinson at last came out in the open and protested against Ludwig's registration of his last patent, since the invention had been made in his works and at his expense. He even threatened to start a legal action. Ludwig, however, knew that he was right in law and held his ground. Hutchinson then said that he would like to make a friendly settlement. He offered to stand half the patent costs and in return either take the sole rights to the process for Lancashire, Cheshire and Wales or share the total rights for the British Isles. Remembering—though Hutchinson had forgotten—that he had offered him the first alternative at the beginning, Ludwig agreed to accept one of these proposals and asked for time to decide which. If only Hutchinson were not so well known to be a slippery customer the obvious course would be to go into complete partnership with him, Ludwig wrote to his aunt. For not only would they together sell their rights in other districts at a good price, but Hutchinson's own works were paying extremely well, and Ludwig would, under such an arrangement, be entitled to a share in the profits. His idea was to write from Holland for a draft agreement and see how honest Hutchinson's terms would be. For whatever his reputation with his competitors and his employees, he had never acted in anything but a friendly and trustworthy way to Ludwig. 'Besides,' his letter to his aunt concluded, 'I would leave the drawing up of the agreement to a competent lawyer.' But again it was not going to prove as easy as he supposed.

CHAPTER 4

UTRECHT AND FARNWORTH

ON his way from Widnes Ludwig had spent a couple of days at Newcastle-on-Tyne, which was a centre of soda production of almost equal importance to the district in which he had so far been working. Here he had visited all the important works, and explained his latest process. This won him an interested hearing, and left him with the impression that his ideas were far more marketable than Hutchinson and Powell had led him to suppose. He had offered the rights of his invention for the district at £5,000, and had been surprised to find two of the Newcastle companies prepared to negotiate at that figure, which effectually convinced him that it was really too low. Furthermore, none of the men he had approached had doubted the originality of his discovery, which he had himself begun to question since he had been dealing with Hutchinson. The Lancashireman would indeed have been well advised to clinch matters with Ludwig before allowing him to wander away and gain a revised impression of his value to other industrialists.

His family were of a divided mind. His aunt agreed with Ludwig's policy of temporizing, and waiting for Hutchinson to send a draft agreement. His father, on the other hand, was all for the prompt acceptance of the Lancashireman's offer, and for Ludwig's immediately drafting his own terms, a course which, as his son clearly saw, would play into Hutchinson's hands, since it would enable him to take advantage of any loose phraseology in a document which the young man would have to draw up in a language not his own. But Ludwig, backed by his aunt, and with or without the assistance of a clever lawyer, was now more than a match for John Hutchinson.

From the vantage point of Utrecht he saw that to accept the Lancashireman's offer of a partnership over the whole British Isles was worth the risk, though it meant gambling for

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double stakes. If the worse came to the worst and Hutchinson did not play fair, Ludwig would be losing money which in fact he had never possessed; and so, as he saw it, he would be no worse off. On the other hand merely to grant his former boss the right to work his process under royalty would leave him with the task of himself finding other firms willing to exploit his patent in other localities. His best asset, too, when trying to convince these other firms would be to show them the process running in the Widnes works, a proof that would be made twice as convincing by Hutchinson if he were to have a half share in the royalties which any new exploiters would pay. Ludwig was not, as he said, looking for a fortune. But if he was going to risk his hypothetical riches on a gamble he was anxious to have his family's agreement to his doing so, since, as he saw it, it was they who would eventually benefit were he to make money. Always he saw himself as potentially the sole breadwinner of the family. For Uncle Adolf was growing no more reliable with age, and Moritz Mond's business was neither brisk nor profitable. There remained, therefore, himself and Leopold Schweich as the only props for the future of the elder Mond and Löwenthal generation, and Schweich was almost as unreliable as Uncle Adolf, though a far better man of business. Moreover, his own affairs, the export of jewellery, took him away on trips to Russia, which would almost inevitably prevent his being at hand at a crisis.

In taking this view of the future Ludwig was, in fact, not far wrong; and it was not only his parents' generation but his nephews and nieces as well who were later to look to him for help. Even Leopold Schweich's own children, though their father was not a poor man, received more help and encouragement from their uncle than from him. Indeed when Ludwig Mond eventually made a fortune he made money for his whole family as well, for each one of them had a small amount of capital invested, in his or her name, in the Brunner, Mond venture.

Ludwig's reception in Holland made up for all the disappointments and delays he had suffered. Work was already well advanced to plans that he had sent out from England. His employers welcomed him, his friends were delighted to

see him, and after a few days in a hotel he settled into the pleasantest of private lodgings, with a view over the canal, which made a bend in front of the house, to a large garden on the other side, beyond which stood two windmills. From his window he could watch the barges going past at a leisurely pace, which seemed to him to contrast delightfully with the bustle of England, where everything hurried so fast towards its goal, the moneybags, that no one lived in the moment at all. The moments just slipped by. But if he was glad to return to the more sober pace of continental living he brought to it a new love of domesticity that he had acquired in England; he enjoyed entertaining his friends, he enjoyed brewing tea and coffee in his heavily overfurnished rooms, just as he had done for the Brunners and his other Widnes colleagues at Appleton. He was interested, too, in the details of comfortable living. The Dutch, he was glad to find, did not use a tea urn but brought a chafing dish in with the boiling kettle to keep the water hot. This, he found, was some sort of substitute for the English open fire.

He had arrived just in time for the national holiday celebrating the fiftieth anniversary of Holland's liberation from Napoleon, and his new principals took his entertainment in hand. They invited him to concerts, operas and oratorios; they introduced him into cafés, beer-houses and oyster-bars: business was for the moment a secondary consideration. It was a delightful change after vegetating in England to strut about in an orange cockade and swathed in an orange scarf, taking wine with all and sundry in celebration of Holland's freedom; and it was impressive to find that all alike, rich and poor, decorated their houses and came out into the streets to demonstrate.

It seemed to him, as a natural republican, very childish that they should put so much trust in a single man and his royal house and show so little reliance on themselves as a people. But despite his liberalism he could not help seeing that England and Holland, the two nations that were most liberally governed, were at the same time the most conservative and the most monarchical. He could not fail to contrast this universal rejoicing with the cold reception which the King



Ernest Solvay, aged 46 years, with his wife, father, and Armand Solvay

of Prussia had received when he had visited Cologne the previous autumn to inspect the newly completed Cathedral. Not a cap had been raised, not a cigar removed from any citizen's lips. At Elberfeld the shops had been deliberately shut when he passed through. Frida had given him a graphic account of the day.

His projected visit to her at Cologne had perforce to be postponed. He could not leave Utrecht while the building was going forward, and now they would have to wait till Christmas. But being at present almost on German soil, in a town where German wine was drunk and German music played, he no longer felt so far away from her. Moreover his prospects now seemed to him to be set fair. He had heard from Hutchinson, who definitely accepted his terms for a partnership and promised to send the draft agreement immediately for him to approve.

If it affords you any reassurance [he wrote to Frida, who had been worrying on his account], I can now offer you the absolute certainty that I shall earn enough in the next two years to found a factory which will bring us in a yearly income as large as the joint possessions of both our parents. I would not have written all this to you [he added] if I did not think that you had caught a bit of your mother's complaint of self-torture.

He had himself, he declared, got beyond that and was willing to let things take their course, since he knew how little one could really hurry them on. At least he was not utterly dependent on either of his present projects. The future, he felt, was assured.

Meanwhile, however, an explosion in the works had temporarily deprived him of the sight of one eye, and somewhat held up his plans; and it was with an eye-shade that he paid his long-promised Christmas visit to his fiancée. The time had now come to break the half-open secret of their engagement, which was duly revealed to his not entirely unsuspecting aunt in Cologne, and then, on the last day of his subsequent visit to Cassel, to his mother, who had guessed the truth long ago, at the time of Pina's wedding. Was it though, she asked her sister, a serious affection in Frida's case? For Ludwig

was the first man she had ever noticed, and he was, his mother boasted, attractive to all the girls. The best thing to do, she thought, was to let things take their course and on no account to inform her husband on account of his 'hypochondriachal character', by which she meant, no doubt, his habitual anxious pessimism. She was herself delighted.

On his way back to Utrecht Ludwig stopped at Brussels, and on his return found everything as he had left it. There had been quarrels among the management, but on the surface all was peace. From his window he now had a view of the canal under ice and thronged with skaters. How damp and evil-smelling would the mists be at this time of year on Merseyside! Frida at home was taking sewing lessons, and after hemming a complete sheet groaned to her friend Henriette that she would far rather be learning Greek. For then one could read Homer, but now though red in the face with the effort they had nothing more exciting to go on to than another sheet.

The New Year found Ludwig impatiently expecting a letter from Widnes with the promised agreement. Things were going splendidly at Utrecht, where sulphur was being recovered most successfully by his method, and where now the main buildings of the factory were being erected to plans that Ludwig had prepared long ago. With Hutchinson, however, things were once more at a standstill. The draft agreement had arrived, but Ludwig could not accept its terms. Hutchinson claimed the right to work the patent in his own factory free of royalty and wanted Ludwig to take similar rights for any factory he might erect, as compensation. Ludwig held out for a royalty payment by Hutchinson, and was prepared to break off negotiations altogether if Hutchinson would not give way.

The real difficulty was that Ludwig suspected the Lancashireman of trying to cheat him, and very bluntly committed his suspicions to paper. This nettled Hutchinson, who still could not reconcile himself to paying a royalty on a process largely invented in his own works. The correspondence dribbled on, with Powell, who wrote the letters, clearly fighting hard to prevent Ludwig's gaining any advantage. But Ludwig held the patent, and without his consent the process could

not be worked. What was more, so long as the negotiations were by letter only, he could hold his own. Face to face, he knew that Hutchinson could get the better of him, for he had a wider vision, a quicker grasp and the advantage that the conversation would be in his own language. But in correspondence Ludwig had plenty of time to consider each move, and was very unlikely to make a blunder.

Early in March he snatched a few days more in Cologne. Work was heavy at Utrecht, and it had been weeks before he could get away. In his duel with Hutchinson he had gained a point. The Lancashireman consented to pay the royalty on the working of the patent in his own factory. But Ludwig held out over other matters, and refused to be frightened when Powell informed him that a rival concern was said now to be working a sulphur-recovery process, which might be a violation of Ludwig's patent. Utrecht was in fête again, this time for the Jubilee of the Burgomaster. The streets were decorated, the factory closed, and Ludwig, who had been taking singing lessons, joined the procession with the choir of which he was a member.

March and April flowed by and the lovers' letters were full only of Shakespeare. Frida had seen a famous actor in *Richard III*, and Ludwig joined her in excitable admiration of Shakespeare's art. She had hoped that he would be able to come to Cologne for Easter. He could not, but planned to spend a week on the Rhine, where she would be staying, at Whitsun. It would be the first time in the three years of their engagement that they would share a day or two together on their own. Holidays at Utrecht were merely a nuisance that held up his work, he protested just before Easter. But his subsequent account of the way in which he had spent the week-end hardly bore him out. His brother-in-law had been staying with him, and though Leopold was a good fellow they had very little in common. He had however impressed his guest by the good table that he kept, and tried to do him the honours of the town. He had even attempted to play billiards, a game at which, owing to his damaged eye, he was not very proficient. But on this occasion, to his great surprise, he had actually won a match. And that had not been the end of the

season's festivities. He had sung and played the piano and drunk Geneva and bitters round all the cafés in Utrecht. On Easter Monday, however, he had reverted to his sober habits and gone to the empty office to finish some drawings.

Frida was working hard also. She could already read Italian and was sufficiently proficient in English to have translated several fragments of Ossian. With visits to the theatre and museums, with drawing and music lessons, with reading and sewing, she was now most strenuously preparing herself for marriage. 'What is man,' she asked, 'if he is spiritually dead?' It was a question to which she did not expect to discover the answer in person. The discussion of Shakespeare concluded, she initiated a new one on *Faust*, of which she had seen a performance, and from there she returned to *Hamlet*. But she felt that she was wasting her time. Books did not satisfy her, and not only did she miss Ludwig, but Julie too. For her friend had at last left the Löwenthals' house to join her father. Ludwig replied to her new burst of pessimism by a statement of his own attitude to life, which was something more than a casual utterance. Indeed he summed up the philosophy that was to be his throughout his life when he wrote: 'Our activity acquires an aim as soon as we work for others, and every task becomes easy once we undertake it in this spirit.'

To improve processes of manufacture, to save the wastage of material and the poisoning of the air with offensive waste-products was, as he saw it, a service to mankind; and like the other pioneers of his age, he considered the providing of work and wages by men of initiative who erected factories, risked capital and themselves devoted long hours and the predominant attention of years to their businesses, something more than a mere means of gaining positions of power and wealth. To be brief, he believed that such enterprises conferred a true benefit on society. It would be impossible to appreciate Ludwig Mond's life-work if one did not understand that in improving the Le Blanc system of soda manufacture, in eventually introducing a better method in its stead, and again in later years, when his life's work might seem to have been done, in launching the Mond nickel process on

the world, he felt himself to be doing work as important and as beneficial as when out of the money he made he founded the Davy-Faraday Laboratory and at his death bequeathed his great collection of pictures to the nation. Ludwig Mond sincerely believed that the application of science to industry would bring wealth and peace to mankind; nor had he the faintest suspicion of the deadly use to which the discoveries of his generation would be turned by their sons, their grandsons and great-grandsons.

With Whitsun approaching, Ludwig had sudden news that his friend Carl Pieper, from whom he had been expecting a visit, had decided to get married. 'I can't see why a man should wait until he is a Croesus or a minister of state before he takes a wife,' he wrote to Frida. 'It does young people no harm to battle for their existence.' This was perhaps the first time that he had said so clearly that he would marry her at the first possible moment, whether his patents were taken up or not. Hutchinson was still making difficulties, and in hopes of wearing him down Ludwig merely reiterated his claims.

Meanwhile Frida's doctor was urging her parents to send her into the country. The strain of the long engagement was telling on her. She had had some inflammation of the glands during the past winter, and had narrowly escaped an operation. Now her future mother-in-law had come to Cologne, and Ludwig was most anxious for her to break down her reserve. 'My mother is at heart much more enthusiastic, idealistic and affectionate than we are,' he wrote encouragingly. But Frida found it easier to explore a smelting works and give him an exact and poetic description of the new system being worked there than to make contact with her aunt. 'Why haven't you seen much of her?' Ludwig asked in the same letter in which he rejoiced at her interest in industrial processes, and at her ability to see them from an aesthetic angle, to which owing to practical considerations he was himself blind. It was as well, he said, that she should view them in that way since they were to pass the greater part of their lives amidst reeking chimneys, glowing ovens, belching flames and powerful, grimy workmen.

The projected Rhineland holiday was postponed and Ludwig

came for a week to Cologne. On returning to Utrecht he found a letter awaiting him from Hutchinson, which he described as extremely friendly, almost affectionate. 'There is really no intention on our part to *get as much as possible out of you,*' it read. The letter to which it came as an answer must have been rather less temperate.

Frida was still hoping to get away, and Ludwig to find an opportunity of business to be done in Germany which would allow him to join her for a short holiday. Her friend Julie, however, was trying to persuade her to come to Liège, a course to which Ludwig took strong exception. For her health's sake she *must* go into the country. 'I feel very sorry for your girl-friends when I think that they have their whole lives in front of them in which they won't have you!' he wrote. He more than suspected that they merely made use of her as a confidante, and that the feelings they expressed for her were not friendship but disguised egotism. He was planning to get an invitation to Holland for her from the wife of one of his directors. Frida admitted that he was right about her friends. Henriette was writing miserably from the country imploring her to come, but she summed the situation up frivolously by quoting from Heine:

Glaub' nicht, dass ich mich erschiesse,
So schlimm auch die Sachen stehen.
Das alles, meine Süsse,
Ist mir schon einmal geschehen.*

'Man, that masterpiece of creation,' she wrote, 'is a creature of habit.'

He was now hoping to get away in June, for the complete factory was due to go into production in mid-July; and for the moment he was far too busy to be taken up with his future plans. Nevertheless he found time to hear some music, to sing, even to take piano lessons, though his fingers were stiff from lack of practice, and to enjoy at least a sight of the country. For he had acquired in the months at Utrecht a sense of security. His chances of actually taking a holiday, however;

* Do not imagine that I shall shoot myself though things may be bad indeed. This has all happened to me before, my sweet!

receded as the days passed. At best he would be able to spend an evening or two at Honnef, on the Rhine, or in Cologne, wherever Frida might be, but he would have to take journeys each day to the industrial towns near by to buy coal and interview workmen. For, the soda process being new to Holland, there were no skilled workmen to be found there. But not only were things moving fast in Holland. There was good news, too, from England. Hutchinson seemed to be giving in still further, and now asked Ludwig to name the sum per ton of sulphur produced in his works that he would require as royalty. If there was no catch in this, concluded Ludwig, he was now getting his way completely.

Suddenly, however, he received a check to his plans from a most unexpected quarter. Frida, who had suddenly gone to Königswinter, on the Rhine, to join Henriette, wrote that she could not return to Cologne to meet him. She hoped that he would join her where she was. He replied a little hurt at this *impossibility*, but glad that at last she was in the country. He was ready to leave on Friday to recruit his labour, and after a week in Oberhausen and Duisburg would arrive in Königswinter the following week-end. It was July, but the weather on the Rhine was more like November. In such moments as were fine they picked the cherries from the dripping trees. But it was good to be together, and indoors they read and talked and tried their French and English on one another. A journey up the stream to Coblenz had to be postponed.

Ludwig returned to Utrecht to find various things held up by his absence. The sulphuric acid plant was ready to start up, but the chief part of the factory was still awaiting earthenware vats, which had been ordered early but were still not ready. This delay, however, could be turned to his advantage. For it would give him a chance to go over to England and see Hutchinson. As he took his first look round the almost completed works on his return, he felt a real thrill of pride in his achievement. Everything, from the buildings and the great machinery to the shovels and wheelbarrows, was of his design and choosing. Everything harmonized and was beautiful, he told Frida, because it was made for its purpose;

otherwise he had paid no special attention to external appearances. Yet it had all turned out so well, and after spending three sleepless nights on the job, he could finally proclaim also that everything was working satisfactorily.

The factory had only been going a week, and yet from the way it looked it might have been running smoothly for ten years. Now there were four subsidiary plants to finish. Only the sulphuric acid plant, which it had not been possible to plan entirely beforehand, had proved a disappointment. In fact it had occasioned the company a considerable loss.

Negotiations with Hutchinson once more went forward slowly. The note urging him to fix a royalty was interpreted by Ludwig as more conciliatory than in fact it was. When he suggested £1 5s. a ton for himself, Powell pointed out that this meant a total payment of twice that amount, since Hutchinson and he were taking half shares, and that the sulphur produced would, under such conditions, be unsaleable. He suggested that Ludwig should once more meet Mr Hutchinson, who was again at Ems, and discuss the matter. But Hutchinson had in fact left Ems, and Ludwig failed to catch him at Brussels. Early in August therefore, the young German chemist was at Widnes again, but in the certainty of getting his own way this time without great trouble or delay. For the Utrecht works were already turning out 15 per cent more than he had contracted for. That should convince the Englishman that he had some results to show.

A night spent on the way with Carl Pieper and his wife made Ludwig even more eager to marry, and an apparent victory over Hutchinson, who accepted his terms without demur, made him confident that the day of his wedding was now not far off. For by one of his characteristic lightning calculations he reached the sudden conclusion that his income would almost immediately be £2,000 a year. Invigorated by this fresh burst of optimism, he declared that his English trip had been most enjoyable. He had been delighted to see his old friends at Widnes once more, and he had been pleased and flattered by the reception he had received from Hutchinson and Powell. But he was in fact not much nearer his goal than when he left Utrecht.

Another flying visit to Germany to recruit labour for the Dutch works enabled Ludwig again to stay for a day or two at Cologne. Now his mother was urging him to invite his father to Utrecht and show him the factory. But Ludwig preferred to wait till the whole plant was working, and this, owing to the delays in the sulphuric acid production, would not be till October.

Moritz Mond, at this juncture, was presenting his son with something of a problem. For although rumours of the engagement had already reached Cassel, the old man still remained in the dark; and this general reluctance to let him into the secret was producing awkward situations. Indeed when Henrietta Mond invited her niece to stay—which was surely the most natural thing in the world—Frida wrote off in a flurry for Ludwig's advice, which was to find some excuse for refusing, since it would be difficult for her to behave in front of her future father-in-law as if nothing were in the wind. His plan was to wait a little and then take Frida to Cassel himself. But in the interval he intended his father to stay for a few days with the Löwenthals on his way to inspect the Utrecht factory. Then he would see Frida in her natural surroundings, and would be more likely to accept her in that way than if he were suddenly to meet her again after a long interval, as his future daughter-in-law.

The reason for this careful humouring of this hypochondriacal little man's foibles was a patriarchal one. As head of the family, Moritz Mond must be persuaded to give his free and willing consent to the marriage. Neither Ludwig nor Frida set any store by the Jewish religion, yet the idea that their wedding should only have the grudging assent of the bridegroom's father was unthinkable. Racial custom was a stronger tyrant than any religious orthodoxy. With half his mind, however, Ludwig knew that all these contrivings were really unnecessary. 'Why should I write so much about matters that are not really so important?' he asked, after making a careful rehearsal to Frida of these schemes to win his father's absolute approval. 'Really he will be pleased anyhow'; which was true enough. For Moritz Mond had never opposed his son in any but his wildest projects, and then with no great

resolution. Yet there was the picture of the Jewish patriarch, so much more compelling at times than the diminutive and worried figure of Moritz Mond, of the stern head of family without whose consent no plan could go forward; and there were moments when the real and imaginary father became confused in Ludwig's otherwise shrewd brain.

Meanwhile Frida continued with her scheme of self-education. Now she had begun to read Byron, whom she enjoyed, though she was distressed at his habit of killing off his heroes early in the poem. No sooner did she feel sympathy for one of them, she complained, than his creator destroyed him. At the same time she and her friend Harry Herz were at work on a translation of Dickens's *Christmas Carol*.

Ludwig was overwhelmed with work at Utrecht. His subsidiary plants were now producing sodium sulphate and hydrochloric acid. But though his workmen, particularly the Germans, were hard-working and efficient, they were not used to his factory or his methods, and he was perpetually having to clear up difficulties. This he found tiresome, since he did not like to be kept continuously down to details, which left him no time for any relaxation. Unexpected accidents occurred also. One of his high-level water tanks collapsed as soon as it was filled. But whether the fault lay in the design or the construction it is impossible to say. He had promised to come to Cologne as soon as the whole plant was working, but so imperative was it now that he should be continuously on the spot that he moved out of his rooms with the view over the canal into others nearer the works in order to be at hand at the shortest notice.

One day, however, he snatched a bare half an hour to meet Carl Pieper who was passing through by train, and the two young men briefly moralized on the change that the last eighteen months had brought them both. For it was no longer ago than that that Ludwig's father had written to him when Hutchinson suspended work on his project: 'Try to get a job in England, and if you don't find anything within a week come home'; and in those same weeks Carl had been out of work also. Indeed, very shortly afterwards he had fallen ill again into the bargain. But they had both strenuously per-

sisted along the lines they had mapped out for themselves, and now both had an assured living. For they had both had opportunities of proving themselves.

So invigorated was Ludwig by their few minutes on the platform that on his return he succeeded in getting a big pump to work, which had given no water since its installation. Indeed, it had not stopped pumping since, as he wrote a day or two later. So although his working hours were now from eight in the morning until midnight or one o'clock, and although minor difficulties continued to occur, he was in the best of spirits. For a few days, indeed, he had to take complete responsibility for everything, both the partners being away. Smits, in fact, had gone to England where he was shown over Hutchinson's works; and on his return he paid Ludwig the compliment of saying that if the Englishmen really wanted to learn something, they ought to come to Utrecht. But a little later Ludwig received an even greater tribute to his achievement: his father at last announced that he was reconciled to his choice of profession.

Once during November Ludwig managed to pay a brief visit to Cologne, where he found Frida far less depressed and nostalgic than usual. She had begun to attend various series of lectures on such assorted subjects as astronomy and early German poetry; and although she found a deplorable lack of seriousness in such of her friends as also took these courses, there was always Henriette, who was as solemnly intellectual as herself, with whom she could discuss her interests and to whom she could air her feeling of superiority.

To have Ludwig so near was both delightful and tantalizing. For although he expected to become freer once the factory was completely working, he was in December shorter of time than ever. Moreover, another accident to his eye, which had been splashed with caustic soda, rendered everything a great deal more difficult. In fact he could hardly snatch a moment to write a letter. A single freezing night and the neglect of the necessary precautions by careless workmen was almost enough to stop the works altogether, and cause the most serious financial loss.

Ludwig even feared that he would not be able to get away.

at Christmas. For though he had now taken on an assistant, a Doctor Bacharach, who was the son of family friends, he was not yet prepared, as he was in later years, to leave any responsibility to others. So Frida, not for the first or the last time, had to ask him *not to come*, so as to spare him the distress of announcing to her that he really could not. For she saw with pride how necessary he was in Holland, since he had still to nurse his works through their first Dutch winter. 'You see how sensible I am!' she concluded. 'If only I had less imagination and more understanding!' she exclaimed as she summed up her character on her sixteenth birthday. 'But now I am on the way towards realism.' One sign of her progress was, in her opinion, that she could no longer appreciate Bulwer Lytton, but enjoyed Dickens. In fact she could read few novels. To be in tune with them one had to take an exaggerative view of life, she proclaimed. She could not therefore bear the mystery stories of Eugène Sue; on the other hand she was delighted with Goethe's *Italian Journey*.

At last Ludwig was ready to show his father the factory, and whilst he was in Utrecht to break to him the news of his intended marriage. Yet at the last moment, when Moritz was staying with her in Cologne, his aunt begged him to postpone the revelation. His father was so unsuspecting, she wrote, and would be so hurt that everyone, his wife included, had been keeping this news from him for so long that it would be better for her nephew to let him go back in ignorance, and reveal the secret only when he himself went to Cassel, as he intended to in February. But Ludwig preferred to talk to his father then, and found him not at all resentful at having been kept in the dark for so long. Indeed, after reading his son a conventional lecture on the dangers of early marriage, he meekly accepted the inevitable; and having now considerable respect for Ludwig, under the shadow of whose factory this revelation took place, he made no real opposition. Of course Ludwig was acting contrary to all sound business principles, and Moritz Mond was convinced that he was wrong. But now there was no more to be said about it.

'He won't want to discuss the matter with you,' Ludwig wrote to his aunt, who was expecting and somewhat dreading

a second visit from her brother-in-law on his way home. 'For of course he takes a long time to digest anything,' Ludwig had his own plans now completely mapped out.

I have now decided to leave everything as it is till I have worked here for another two or three months [he wrote], and have received my bonus for the erection of the factory. Then I shall not take long to decide whether to settle here for some time or to move on at the end of this year. As soon as I am clear about that I shall send out cards to my friends with no more ado, and inform them of my engagement. With people who have never made a decision in their lives [he went on, returning uneasily to the subject of his father], one has to act summarily, and I am pretty sure that really he'll be best pleased if I go ahead without referring to him too much. I have always had to treat him in this way over all matters without exception, and as you see he is now quite content.

For the first time Ludwig's assessment of a situation was quite correct, and his plans for the future conceived with absolute realism. The Utrecht factory was the first creation of his maturity, and it was at the point when it began to work that one sees him finally throw aside the last vestiges of adolescent fantasy. Henceforth, from his twenty-sixth year, his imagination and his creative powers worked in unison.

A letter from Hutchinson enclosing a draft of the contract in its revised form threw that whole matter back almost to the beginning. As Ludwig had feared, it was framed entirely to suit the Englishman's interests. What was more, Powell had made no progress with the experimental plant that he had offered to erect months before. Negotiations had now been protracted over almost two years and had hardly advanced at all. Ludwig wrote a most intemperate reply. But he realized, all the same, that if he could bear still more haggling correspondence he would in the end secure, if no fortune, at least a favourable agreement.

Towards the end of March, however, John Hutchinson died at the age of forty of tuberculosis, a family complaint that had been hurried on, no doubt, by the chemical-laden atmosphere in which he worked. In the last months of his

life he had been beset by financial anxieties; for the American civil war had cut off one of the principal export markets for British soda.

As Hutchinson's eldest son was a child, the firm was now administered by three trustees, and managed by Ludwig's old enemy Richard Powell. He, however, did not prove so indifferent to the sulphur-recovery process as might have been expected, since the rival method being worked by Crosfields, a firm of competitors, was apparently proving a success. Crosfield's method had, in all probability, been taught them by one of Ludwig's workmen who had joined their staff, and filed his own patent. In the long run it was unsuccessful.

Ludwig now entered into the correspondence in earnest, dividing his evenings almost equally between drafting his answers to England and practising the piano. A letter from John Brunner reminded him that there was at least one man in Widnes who would be willing to co-operate with him rather more effectively than Powell.

Ludwig had, however, decided to stay at Utrecht for the present, and in June discovered a house in which some rooms would shortly be vacant, a house with beautiful views over the canal and within a minute or two of the works. He and Frida had decided to marry in the New Year: all that was necessary was to talk to Moritz Mond once more. No one else would oppose them, and his opposition, though still, despite everything, to be expected, would be no more than formal and cautionary. Yet the closeness of Jewish family life so held them all that marriage with even the mildest of opposition from the bridegroom's father was unthinkable.

Ludwig was now eager for Frida to see the place in which she was going to live, and so much did his principals value their young German expert that Frau Ostermann, the mother-in-law of Smits and herself a large shareholder in the new works, promptly sent her an invitation to stay. The Ostermann family consisted of three young daughters, the half-sisters of Smits' wife, and they lived the very quiet life of a well-to-do Dutch family, which, in Ludwig's opinion, made their house most suitable for a young lady whose engagement had not yet been publicly announced.

After some questioning from Cologne about what might be the reactions at Cassel, the Löwenthals agreed to Frida's coming, and Ludwig sent careful instructions about the clothes she should bring: 'a silk coat and also a woollen one for evenings, or else a shawl as it becomes very cool after sunset'. For social events he thought that a black silk dress would be sufficient. All his friends were looking forward to meeting her; and as it was not usual in Holland to announce an engagement until just before the wedding there would be no awkwardness about their relationship.

Frida found that Ludwig was a very popular figure with the Ostermanns, who seem quickly to have overcome her shyness. For soon she was playing music and reading Molière with the daughters in the long hours that Ludwig was in the works. One evening a ball was given in her honour and she danced all the dances. Ludwig wrote the most enthusiastic account of her visit to his aunt. He had been quite delighted to find how gaily and easily she mixed with the company. 'The life here suits her well,' he wrote; 'and she is better and livelier than at Cologne.' It was a little naïve of him, perhaps, to suppose that the cause of this lay in the Dutch climate. In November the formal announcement of the engagement was sent out, and Moritz Mond, about whose feelings everyone had been so worried, was not upset, at least at the time.

In Widnes, too, things were now moving forward so fast that Ludwig was ready to go over at any moment. Powell had resigned the management in October and had been succeeded by Henry Brunner, who wrote to know the exact position in regard to the patent, as Major Cross, the representative of the shareholders, wanted to try the process at last on a large scale, and no one could find any note of Ludwig's correspondence with Powell. So the newly affianced chemist once more began to compute the profits he would soon be drawing from England. For Brunner was already beginning the necessary alterations to the plant and was hoping that Ludwig would come over in the spring to superintend the beginning of work on his process.

Frida returned to Cologne for her last winter of cultural and domestic preparations, during which the most exciting

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event that she reported, in letters concerned chiefly with the prospects of marriage, was a symphony concert at the Gürzenich conducted by the revolutionary composer Johannes Brahms. He had played the E flat major piano concerto of Beethoven, and conducted his own Serenade in six parts, which had taken more than an hour. She was not enthusiastic for this new composer, however, nor was the rest of the audience.

He has a very clever touch [she wrote]. You would suppose that he would be note-perfect, and yet in spite of all his self-assertion, I have never heard so many mistakes or such inaccurate playing. His composition was endlessly long; it has individual beauties but they are reminiscent of the Pastoral Symphony. . . . It was only out of respect for Hiller, the conductor, that there were not catcalls.

Brunner was writing the most friendly letters from England. Building was progressing; Major Cross was one of the pleasantest men he had ever met, very businesslike and yet very considerate and kind; and all the details still at issue could be settled over a cigar in the spring. This was a change of tone indeed. What was more, things were going on a great deal better at the works than in the last days of Hutchinson or in Powell's time.

Ludwig was warmly welcomed at Widnes when he arrived in March. As he sat in his old room in the original hotel on Merseyside where he had stayed on his first arrival in England, he could easily have thought himself back a couple of years, were it not for the changes that had taken place *with* him and *in* him. With the backing of Cross and Brunner, and provided with introductions from Hutchinson's, he once more visited Newcastle to call on the Tyneside soda works. Many of them, he found, were only waiting to see the Widnes factory working his patent to install it themselves. He refused to place his hopes too high, however.

Here in England he found many of his old bachelor friends married; among them Schad, the Marburg scientist with whom he had worked at Ringenkuhl and who had now settled in Lancashire, and John Brunner. But his father was,



Edward Milner

One of the first directors of Brunner, Mond & Co., Ltd, 1881. In 1872 he drove Mond and Brunner over to see his Salt Works at Anderton and, on that trip, Winnington Hall and Park was discovered



Charles Holland
Mond's and Brunner's sleeping
partner, 1872



John Crosfield
First Chairman of Brunner, Mond
& Co., Ltd., 1881

unfortunately, once more withholding his formal consent, on the plea that though Ludwig had a good enough post he had no security and no capital. The old man was working himself into one of his usual states of anxiety; so upset was he indeed that he was not well enough to make his annual visit to Leipzig Fair. The family doctor, however, took the sensible line of telling him that he would never be well so long as he went on worrying about his son's marriage, and that, if only for his health's sake, he had better give his final consent. This he did in a characteristically roundabout way, by yielding not to Ludwig or his mother but to the arguments of his daughter Phinchen, who came specially from Cologne to reason with him. In the meantime the Danish war, which neither the Löwenthals nor the Mondes were prepared to take as more than a barbarous interruption to what should be an age of liberal prosperity, had led to a much greater conflict between Prussia and Austria. Ludwig's mother took the matter personally. She could not imagine anyone more obstinate than Bismarck, she said, except her own husband on the subject of his son's marriage.

In May troop-trains were passing through Cassel, trade was at a standstill, and Henrietta Mond was sending her son the list of respectable tradesmen in the town who had gone bankrupt owing to the resulting slump. Her husband, naturally, having recovered from his alarm over his son's rash determination to get married, was plunged into fresh abysses of apprehension. His wife, on the other hand, was full of practical advice as to Ludwig's best means of avoiding recall and mobilization. The Duke of Hesse was frightened, however, and for a while it seemed possible that war would not actually come to Cassel.

To the Mondes, apart from Ludwig's possible participation, the prospect of a Prussian invasion was rather to be welcomed than feared, since it would sweep away the petty restrictions of this small principality. Moreover, only under Prussia would a strong Germany be possible; and fundamentally, despite their liberalism, they were German nationalists. Ludwig on the whole shared their opinion. But he was not as much concerned about the war as they, and beyond offering his parents

a refuge in Utrecht, should things get really bad, hardly mentioned it in his letters. Holland was quiet enough, he had a business trip to make in Belgium, he was in touch with a large soda works in France whose owners were coming to see his process at work, and he was receiving regular reports from Henry Brunner of progress at Widnes. His wedding, which he had tentatively hoped would take place in July, was now fixed for October. He was not perturbed, and his parents' anxieties died down. For the Prussian occupation of Cassel, when it came, did not prove very disturbing. The invaders were polite and quiet enough, opened the Museum and the Picture Gallery to all free of charge, and replaced the seats in the Friedrichsplatz. In August peace was signed, and Moritz Mond's doctor recommended him to take a trip to Spa to restore his nerves. But, to quote his wife, he was too miserly to go.

Meanwhile Ludwig was finding time to purchase the furniture for his married home. He bought everything according to his own taste, consulted his aunt and future mother-in-law when his choice was made, and finally congratulated himself on not having spent a penny too much. A last-moment suggestion from Cologne that it might be convenient to put off the wedding a little longer met with a determined refusal from him. He could not afford to be away from Utrecht late in October as the works correspondence clerk had fixed his wedding for the end of the month, and both men could not be absent at once.

The ceremony took place at the Löwenthals' house in Cologne, and friends and relatives arrived from many parts of Germany. But perhaps because he felt that it would upset him too much, Moritz Mond did not attend his son's wedding. His alarms and anxieties had prevented his seeing Frida since the announcement of the engagement. The couple, however, promised to call at Cassel on the way back from their honeymoon to receive his blessing. The ceremony was conducted by a Rabbi, and the dinner that followed was so excellent that neither Adolf Löwenthal nor Leopold Schweich, the two *bon viveurs* of the family, found any cause for complaint. Then, after a sight-seeing tour which took in Heidelberg, Dresden

and Saxon Switzerland, the young Monds, after passing through Cassel, arrived in Utrecht less than a fortnight after their wedding.

The winter was a quiet one, with Frida serving her apprenticeship to married life in a set of rooms furnished by Ludwig and under the maternal eye of Frau Ostermann, who acted as her guide in all her domestic difficulties. Her mastery of Dutch, her piano lessons and her delight in greeting her husband on his return from the factory alternate in her letters to her mother with business details. The housekeeping was costing them exactly as much as Ludwig had budgeted for; she had found a laundress who did not use soda, far less chloride of lime: a strange recommendation from the wife of a chemical manufacturer. By the beginning of the New Year of 1867 she was pregnant, and Ludwig had suddenly decided that Utrecht did not offer him sufficient scope. In February he brusquely wrote to his parents-in-law that he would be bringing Frida to stay with them for a few weeks while he made a journey to England. Not till he arrived did he tell them that he was leaving Holland for good.

The immediate purpose of Ludwig Mond's English trip was to see Messrs Tennant of Glasgow, who had become extremely interested in his process since they were in trouble with the local magistrates, who insisted on their rendering the residues from their soda plant harmless. Ludwig, however, also took the occasion of this visit to meet the Chief Inspector under the Alkalis Act and to explain his method of sulphur reclamation to him. This official was encouraging, and held out hopes that he would report in favour of its compulsory adoption in all cases of pollution. In the meantime Tennant were compelled to introduce it and, flushed with his success, and with the feeling that the forces of progress were finally on his side, Ludwig was now certain that other works would rapidly follow their lead.

He decided, therefore, to settle near Widnes, and wrote curtly to his aunt that he was now coming to fetch Frida away. His letter was answered by an indignant protest at his high-handedness. Surely, his mother-in-law pleaded, it would be better for her to stay with her parents until the child was

born. But though she began by accusing Ludwig of treating his wife like a chattel, she ended by listing the essentials that would have to be bought for the new establishment: 'a bed for yourself, one for the maid, and also a bed for the nurse or wet-nurse. I do not know whether these women in England sleep on the sofa.' That a wet-nurse would be required was taken for granted, since women of the middle class were far too delicate to nurse their children. So with the aid of Mrs Brunner and Mrs Schad all the necessary purchases were effected, and Frida arrived after a fine day or two of holiday at Dover, where Ludwig had imaginatively halted the journey to give her a rest. On her way she had spent a wet Sunday morning in London, which gave her an effective introduction to the capital.

The house to which Ludwig Mond brought his young wife was at Farnworth, on high ground about half an hour from the works and close to the village of Appleton, where many of his friends lived and where he had himself had his bachelor rooms. It was a not very large family house called 'The Hollies', and stood a little back from the road. The front door was in the centre with a debased Georgian fanlight over it, while on either side were the windows of the principal rooms. Above were three tall bedroom windows and to the back and sides sprawled the offices and stables, which were approached by a drive at the side. From the front 'The Hollies' had a certain very English dignity, but for the rest it was a shapeless brick agglomeration which suggested, like so many houses of its date, that its architect had been interested in very little except the front elevation. But its situation was beautiful.

I only need to open the window [wrote Frida to her mother], and fields and meadows lie before me, with Appleton in the middle with its friendly church. Further back is Widnes with its innumerable chimneys and its background of blue-veiled hills, whose shapes are most beautiful. I love it here.

But there were beauties closer at hand. Behind 'The Hollies' lay a garden full of fruit trees. 'One cannot see the leaves on

the trees for the fruit,' Frida reported to her mother in another part of this letter, which is a catalogue of Farnworth's charms. They had a paddock, and had tossed their own hay; they would probably buy a pony and trap, and the Brunners were delightfully welcoming. Very soon her English improved sufficiently for her to make some acquaintances in the district, who came to visit her during Ludwig's occasional absences. For he was frequently calling on different manufacturers who might be interested in his process.

On paper his income from royalties on it seemed likely soon to run into some thousands a year, and frequently he counted over his anticipated receipts. But for the moment very little was coming in. Living at Farnworth, however, was extremely cheap, and expenses seldom outran Ludwig's carefully computed budget.

On September 9th, 1867, Frida bore a son to whom they gave the name of Robert Ludwig. Immediately Frida's mother, who had been disappointed at not being invited over for the confinement, wrote insisting that her daughter was of too excitable a temperament to nurse the child, and quoting some doctor to the effect that a mother should be a fortnight in bed, a fortnight on the bed and a fortnight round the bed after childbirth. But not only had Frida contrived to have her child without an influx of relatives from Germany; she also nursed him herself, and within a month was making arrangements to leave for a stay of some weeks in Glasgow, where Ludwig had to superintend the erection of some plant for Tennant. What was there for her to do if she remained alone at Farnworth? she wrote in reply to her mother's protests. She had soon grown tired of her English acquaintances, who had little education and narrow interests. They were interested in absolutely nothing except gossip and social precedence. Frida liked England well enough, but she did not care for provincial company. Fortunately there was one possible friend, a widow who kept a local boarding school, who, though considerably older than herself, did share some of her tastes.

In January of the New Year, 1868, the Mondes were in Glasgow. Robert fortunately was a good child, and it was possible for them to settle into lodgings quite comfortably. By

now various manufacturers were adopting the sulphur-recovery process, and things were going very much in Ludwig's favour. Everyone indeed was highly delighted, except his father, who complained at some length that he did not like the way in which his son drew up his contracts; they put too much trust in the other party. The immediate trouble, however, was not over-generous contracts but a trade slump, which reduced several of the Widnes manufacturers to working only three days a week during that winter. In November Ludwig Mond received a cheque for only £34 11s. 6d. for a quarter's royalties on Hutchinson's output of sulphur, whereas he had been counting on receiving quite a thousand in a full year. Nevertheless the future looked bright.

Glasgow proved unfriendly. 'The English say, "My house is my castle,"' complained Frida to her mother-in-law, 'but they ought to add: "And I lock myself up in it."' Her letters were full of general information and comment. She took a pessimistic view of the Fenian troubles, expatiated on the organization of the Presbyterian Church, and theorized on the differences between the English and the Scots. 'The Scots are an independent, proud people,' she observed, 'and are considered false by the English.' Both nations seemed to her to pay too little attention to the care and upbringing of their children.

This observation naturally led her round to the subject of her own healthy, rosy-cheeked Robert. Though he was still only a few months old she had doggedly decided that it would be a good thing to talk to him sometimes in English. This would help Ludwig and herself to master the language, and at the same time give the child some knowledge of it during the time of their residence, which she thought of as no more than one stage in Ludwig's career. For herself, she was confident that she had surmounted the principal difficulties, and was now anxious to study the 'finesse and character of the language' as she wrote to her mother.

Their stay in Great Britain seemed then likely to last no longer than it would take Ludwig to sell the rights to his process. He did not yet even suspect that the main work of his life would be devoted to the English chemical industry. Yet after his return to Farnworth he began to take an interest in

English politics. For in the summer of '68 he so far identified himself with the country of his sojourn as to attend the meeting at which Gladstone was adopted as parliamentary candidate for South Lancashire. It was natural that a continental liberal should move straight into the orbit of the English Liberal party.

That summer Ludwig's surviving younger brother Rudolf, who had been working in his father's business, suddenly died, leaving him now as the sole member of the family on whom his parents, as well as his parents-in-law, could rely in their old age. But as things were going in these months, none of them had much to fear for the future. Hutchinson's were using the sulphur-recovery process throughout their works; Muspratts, also of Widnes, had adopted it; and it was also in operation both in Newcastle and in Bristol. In August Ludwig Mond read a paper before the British Association, which met that year at Norwich, 'On the Manufacture of Sulphur from Alkali Waste in Great Britain'. Frida was nervous on his behalf. 'I should not like you to overhurry your lecture,' she wrote. 'One does not have such an opportunity every day. Do not overstrain yourself, and take an effervescent powder before the lecture. I will do the same, and perhaps the result will be mutual.'

One can only speculate on the impact of this volcanic foreigner on this staid British assembly. That he had a matter of first-class importance to communicate would obviously win him a hearing. But neither in his manner, his dress, nor his appearance had he yet made any concessions to English taste. He had once in his dandyish youth shaved off his beard, but now he had grown it again, in continental fashion, only to frame his face; his chin was shaved. He wore his bushy black hair long at the back, and parted it in the middle. But so thickly did it grow that the parting was almost invisible. The face that looked out from this frame of black hair was all intelligence. It is difficult to imagine it in repose except in sleep. His eyes were dark and, as a result of the two accidents in his youth, the left one seemed at that time a little strained. It is perhaps this, but perhaps only the brightness of the photographer's lamp, that gives him in a photograph of this

epoch a rather fixed look, as if he were anxious to catch whoever might be talking to him off his guard.

But not only was this stocky little foreigner with a guttural accent remarkable for his looks. His dress, too, was by English standards eccentric. His black wideawake hat with its high crown, of a type that he wore throughout his life, was in the tradition of the continental intellectual. Actually it was made for him to his own specification by a Liverpool hatter. Such a hat some French poet might have worn, when making a heroic gesture on the barricades of 1830 or 1848. It was the visible counterpart of his surprising statement that he was at heart a socialist, which considerably frightened his neighbours at Widnes. But despite his mother's recommendation that he should read Engels on the *Condition of the English Working Class*, this did not mean that he was in any way a follower of the dogmatic socialists. By his socialism Ludwig Mond meant simply his anxiety for the welfare of the people who worked for him, and his belief that successful private enterprise could—and must—raise the living standards of its employees.

Such statements, made at gatherings of local industrialists, would leave some of the less intelligent among his friends and colleagues perturbed. For they had seen Ludwig Mond making determined efforts to win the respect and to gain the confidence of the men who erected his plant and operated his processes. He would drink with them in the pubs, and over their beer teach them to play chess. He found the English working man, despite his insistence that his Saturday afternoons and his Sundays must remain free, on the whole a more reliable and efficient worker than those he had known at Ringenkuhl and Utrecht. But at no time did his 'socialism' blind him to the difference in function between the responsible heads of a concern and their employees. For beneath his wideawake poetical hat he wore a long black overcoat, of a cut that he clung to also throughout his life; and this had origins of a different and contrasting kind. It was the distinguishing garment of the small Jewish merchant of any town from Cologne to Kiev; the garment of the pious orthodox father of a family whose thoughts are divided between the letter of the law and lightning calculations of profit and loss.

With such a mixed psychological heritage as was expressed even in his clothes, Ludwig Mond must have appeared a formidable stranger to the learned gentlemen assembled in Norwich. 'It must be very interesting for him to meet so many famous men,' wrote Frida to her mother. It must have been equally interesting to them to meet a man who was already so much of a force in his industry. Although his lecture was delivered only on the last day of the session and the discussion of it was consequently cut short, it earned Ludwig the acquaintance and respect of Professor Frankland, the leading chemist in the country. The text of it, moreover, was printed in the technical press. 'I have made some very interesting acquaintances,' he wrote to Frida, 'who promise to be helpful in their way.' Perhaps better than anyone else this pupil of Bunsen and Kolbe realized in what way the pure scientists could assist industry.

At the end of October, when Robert was less than fourteen months old, Frida gave birth to another son, Alfred, the future first Lord Melchett. 'Robert', reported his father, 'is extraordinarily pleased with the baby.' His own position, despite his short tenure of it, was assured. It was the younger brother, whose birth had been the more difficult, who had to fight for his position in his parents'—and particularly in his father's—affection. At Christmas Frida's mother paid her first visit to Farnworth and was much impressed with these 'small Englishmen'. 'Children here become lively more quickly, but they are also much more restless than with us, where they are more tied up,' she reported. She found the Monds living very much to themselves. John Brunner and his wife were close friends, and his brother Henry, who had recently married also and with whom Ludwig was so closely associated at Hutchinson's, was an intimate too, though to a lesser extent. But with the exception of her middle-aged schoolmistress Frida had still found no woman who shared her interests. Still Frau Löwenthal found 'peace and equanimity' at Farnworth, and as soon as Ludwig had his pony and trap, she could see that they would have the additional advantage of being as near to everything as if they lived in the suburbs of Liverpool.

Early in 1869 Ludwig was again on the Continent, chiefly

in France, where various works were negotiating with him for the rights of his process. 'To-day one is no longer wedded to one place but to the world,' he complained, 'one lives on the railway; and young people, especially, are unable to speak of a definite domicile.' He found it hard to be away from his family, but this roving life really suited him. For in after years, when they could easily have stayed in one place, he and Frida together would move in just this way from London to Paris, to Cologne, Switzerland and Rome, accompanied by a host of relatives, dependants, secretaries and maids, and in constant communication not only with continental scientists and men of business, but also with the works in England.

In the meantime Ludwig had evolved a new process supplementary to that of sulphur reclamation. He now proposed to use the desulphurized residues from the alkali waste to replace part of the limestone used at an earlier stage in the Le Blanc process. Although the idea was not absolutely new, since a Bristol firm was already operating a similar process, he took a patent out for this improvement. But it is probable that it was not applied at all widely outside the Hutchinson works. Once the manufacture of caustic soda from Le Blanc ash by the lime-soda process became widespread—as it did in the late sixties—the chalk precipitated in this process was generally used in preference to the less pure desulphurized waste.

In May, when both Ludwig Mond and Henry Brunner were called to give evidence before the River Pollution Commission, which sat at Widnes, the former rather grandly stated that the wholesale use of his sulphur-recovery process would save almost a quarter of a million pounds a year, which were expended on Sicilian sulphur. The Commission, naturally, reported in favour of the Mond methods, and Ludwig now knew that sooner or later it was bound to be universally adopted. If some works were still holding back it was in order to take advantage of the experience of others and to have the benefit of any improvements which might be made in the process as a result of early experiments.

In July Moritz Mond found a fresh cause for alarm, for he read in his paper a report that the total abolition of patent

rights was being proposed in England. His son, however, reassured him. 'The mere idea has called forth a storm of indignation in the Liberal Press,' he wrote, 'and the present rulers of England, the workmen, stand like one man for the maintenance of patents.' This, after the second Reform Bill, which still did not produce household suffrage, was certainly an extreme estimate of working-class power. For even though it had just received added strength from the new voters in the boroughs, many of whom could be counted as 'working men', the strength of the Liberal party was still largely middle-class. Ludwig Mond's estimate of conditions in the country of his temporary adoption was still slightly unreliable.

In August he and Frida took their children for their first English seaside holiday. They went into rooms at Beaumaris, in Anglesey, where to Frida's disappointment, they made no friends. 'If I were to be here for as long as the mountains opposite,' she wrote, with her eyes on the mainland range extending from Penmaenmawr to Carnedd Dafydd, the Glyders and Snowdon, 'I doubt if I should make any even then. The English are a nation of hermits. Even the nursemaids do not talk to one another, and that says a lot.' She did not perhaps take into account how strange and foreign she and her family must have appeared; nor how forbidding, perhaps, with her high intellectual standards, she would have seemed to the other mothers from Liverpool or Manchester who sat with their children on the shore and watched the yachts sailing in the estuary under the shadow of that unfriendly range. She took the children across to Bangor to have their photographs taken, but found that the best camera there required a fifteen-second exposure. She postponed the photographing therefore until after the holiday, when they found a man at Warrington with an apparatus which took the pictures in a tenth to a quarter of a second. 'But it was two and a half hours,' she reported indignantly to her mother, 'before anything reasonable came out.' She was clearly at the stage through which so many of her race and nation have passed, of finding the English annoyingly inefficient. It was an attitude that no doubt contributed to her Beaumaris loneliness, but one that she lived to slough off.

She had now got used to speaking only English, and would have done so to Ludwig also if he had not objected. He mixed the two languages indiscriminately at this period. A business memorandum or a note of clothing to be packed or purchased, scribbled on the blank sheet of a letter, would slip indifferently from English into German and back: 4 shirts, 1 Leibbinde (belly-band), 1 Unterhose (pants), 1 nightshirt, 1 Vorhemd (starched shirt-front), 4 cuffs, etc., is to be found scribbled on the back of a royalty account from Hutchinson's of this date. But English, as Frida protests somewhat apologetically in recording Ludwig's preference for his mother tongue, is so much more convenient a language than German. Moreover, Robert could not speak any German as yet, though she hoped to teach him some. Soon, however, both children spoke better German than English, a state of things that was to be a handicap to the perfect mastery of what proved to be their native language.

In the winter of 1869-70, her third in England, Frida was still complaining of the dullness of her female neighbours, whom she found so drab, uneducated and plain. But, as she boasted to her mother, she got on better with the men. She was now reading *Jane Eyre*, *Shirley* and various novels by Dickens; also one or two by George Sand, which gave her some practice in French. One cannot feel that she often read anything for the mere pleasure of it. Most things for her, at this time, seem to have served a somewhat earnest purpose of self-improvement. She was suddenly aware, for instance, of the importance of the *Origin of Species*, which she found to be in so much demand that she could not get it from the biggest lending library in London—probable Mudie's—even ten years after its publication. 'For me there is nothing horrible in the idea of being descended from apes,' she wrote. 'On the contrary, I see the great progress we have made since our forefathers'—the remark of a woman eminently suitable to be a scientist's wife but hardly cut out for social success in a country district of South Lancashire. But there was a solution for the problem of her loneliness. Her girlhood friend Henriette Herz, with whom she had shared so much, was invited to live more or less permanently as her companion. This seemed in no way

to inconvenience Ludwig, who though before marriage rather critical of his wife's friends accepted them freely thereafter. Miss Herz indeed soon proved as close a friend to him as to Frida. He enjoyed her habits of philosophical speculation, encouraged her in her writing of unsuccessful novels, and supported her in the difficulties that subsequently arose in her family. She was, in a sense, the complement to the more practical and less imaginative Frida, and the friendship of the two Monds and Miss Herz remained stimulating to all three till the day of Ludwig's death.

In May 1870, in the certainty that a Rivers Pollution Act would be passed as a result of the Commission's findings, Ludwig and his partners at Hutchinson's made the proposal that a company should be formed among the alkali manufacturers of England to take over the management of his patents for their mutual profit, and to purchase a half interest in them. The letter outlining the advantages of such a move set out the high figures of profit that could be expected from the granting of licences over the seven years that his principal patent had still to run. But it ended by revealing the very modest figure of the earnings to date. The income from royalties and from the sale of licences for the year ending March 31st had amounted to no more than £2,100. Despite Ludwig Mond's revolutionary impact on his trade his fortune had still to be made.

The time for such co-operative action among rival manufacturers was, however, premature. Perhaps the whole idea was in advance of the cut-throat capitalist epoch in which it was proposed. Ludwig, standing outside competitive interests, was able to think in terms of the industry as a whole, whereas the owners of various works could consider only the profits of their own enterprises, which had usually no more capital than they required for their own expansion. To him the formation of such a company would have meant a large sum of money and freedom to devote himself to some new field of action, perhaps on the Continent. However, although five concerns were now recovering sulphur in his way, the proposal to form a company fell flat; and with the outbreak of the Franco-Prussian war that summer, business again fell off.

The Mond's sympathies with Prussia were outspoken, Frida's especially. 'Historical justice,' she opined, 'which has constantly nipped the wantonness of nations in the bud, will not fail. In any case the Latin peoples are declining and the Germanic peoples rising.' She accepted a neatly mechanistic view of history, and looked forward to a further bout of such wars in which Germany in her turn would be attacked by the 'Barbarian of the Steppes'. Ludwig, on the other hand, with his eye on the immediate present, noticed with satisfaction the general sympathy for Prussia among Englishmen at large. He was, however, less wholeheartedly partisan than his wife, since he had business friends in France who were working his process and for whose families he felt some anxiety. There was also Julie Stodel, Frida's old friend, and her stepmother, who were possibly still in Paris.

1871 was a crucial year in Ludwig Mond's career. It was clear now that the proposed company would never be floated; and despite Major Cross of Hutchinson's optimistic forecasts, despite the coming Rivers Pollution Act, there was, he decided, no hope of really great developments from his patents. He would clearly have to set up on his own account; and whether in Britain or Germany, was still not clear. On the one hand his mother-in-law, who had been on another visit to Appleton, deplored Frida's loneliness in England. Furthermore Ludwig had been approached by a German company about to set up the manufacture of fertilizers from waste leather by the process on which he had worked in Cologne many years ago for Herr Weil. The advantages of England, on the other hand, were plain. Particularly at the time of the Paris commune, he was impressed by the moderation of the English labouring class. Not only had they no sympathy with the violence of their French brothers, but they were not inclined to political action at all. Even when industrial disputes arose, he noted, the workers were hostile to agitators and quite ready to re-establish reasonable relations with their employers once a settlement had been reached. But he saw other advantages also in setting up business in England. If he remained in the country, he would be able to safeguard his sulphur-recovery interests at the same time; furthermore he could

become a British citizen by residence in the summer of 1872.

There were other factors of even greater weight. Philip Goldschmidt, who had been his first friend in Manchester, had some floating capital and had inquired of him for a likely field for investment. While at the same time John Brunner, who had been Hutchinson's office manager and was now the cashier, had suggested that they should set up some enterprise together.

John Brunner, he realized, was the right man. His brother Henry, with whom Ludwig was now working in close co-operation, being an engineer, to some extent duplicated his own talents. But John was a commercial brain, pure and simple, and it was a man of this sort that Ludwig needed. So, with a possible partner and a possible source of capital, and with a revival in the demand for soda following on the end of the Franco-Prussian war, there was everything to be said for his remaining in England.

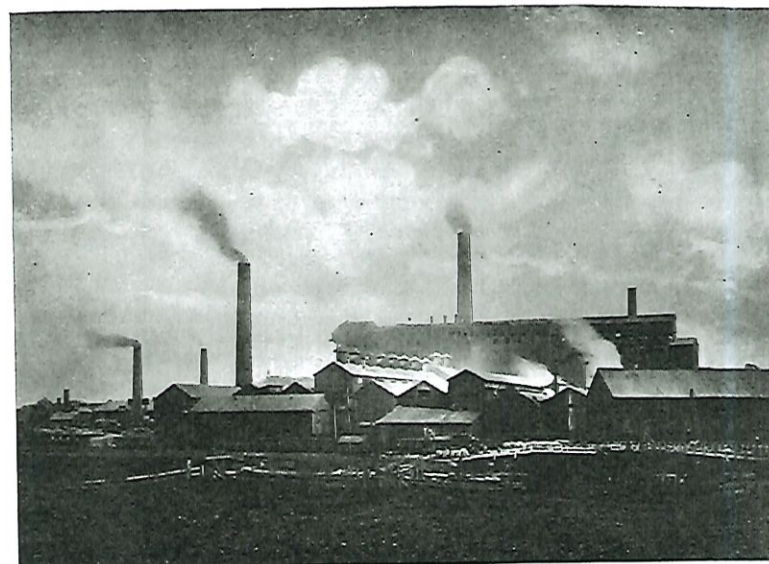
Ludwig, moreover, was not nearly so dissatisfied with English society as was his wife. In the early days of his stay at Appleton he had got to know many people in the neighbourhood, and now that he was established there he was the leading spirit in a discussion club on serious, almost German lines. The 'Qu'est-ce-que-c'est Club' held its first meeting on January 26th, 1870. Its members included two or three of the younger chemical manufacturers in the district, the headmaster of the local grammar school, his eventual successor, the two Brunners and Ludwig Mond. The purpose of the club was to discuss at its fortnightly meetings the meanings of such familiar abstract nouns as 'morality', 'virtue', 'art', 'poetry', 'justice', 'vulgarity', 'science', 'natural law', etc. Meetings were held at the houses of its members, each in rotation, and the session, which opened at eight o'clock, was required to conclude at 10.30. One rule was that a definition for each word had to be agreed before the next was debated. Also each member was required for some formal reason hard to imagine to put forward his suggestions under a pseudonym. Ludwig's was 'Unverzagt' (undaunted), John Brunner's 'Onward and Upward', Henry Brunner's was 'Nemo' and

the future headmaster's most fittingly 'Palmarum qui meruit ferat'.

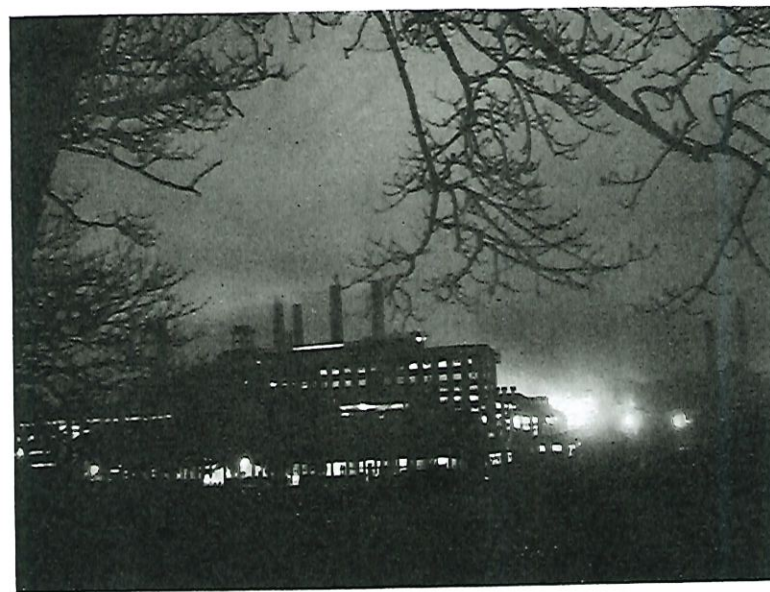
At the first meeting of this 'Qu'est-ce-que-c'est Club' only the word 'beauty' was attempted. Later, however, towards the end of the Club's fourteen months of existence, it proved possible to define several at each meeting. Many of these suggestions, briefly though they are recorded in the club's old minute book, throw considerable light on the characters and enthusiasms of the members proposing them. Ludwig's own definition of science as 'systematized experience' does not perhaps make too far-reaching a claim for the pursuit to which he had dedicated himself. His view of morality, on the other hand, as the opinion of the majority on right and wrong—a definition modified during the course of discussion to 'the majority of educated people'—reduces the whole question of ethics to one of informed opinion. Faith, in his opinion, is 'the faculty by which certain people are persuaded to consider as true what they do not know'. Civilization had for him no spiritual content. It was no more than 'the development of the intellectual and moral qualities of nations'.

None of the members of this serious and convivial club can have been much more or less than thirty, but there was a great deal besides their comparative youth that they shared in common, as can be deduced from the record of their debates. All of them trusted implicitly in the powers of logic and believed that all problems could be solved by them; all were certain of the efficacy of education, and of the rightness of majority judgements so long as the majority was educated. They did not discuss progress, but took it for granted; they did not discuss war or poverty, nationalism or greed, because although their meetings took place at the time of a major war they believed that such events would soon be things of the past. The 'Qu'est-ce-que-c'est Club' was the expression of a buoyant optimism, not unjustified so far as the careers of any of its members were concerned, for they were all to rise to important positions, industrial or scholastic, but a little over-certain, on the other hand, of the boundless future in store for humanity.

By the summer of 1871 Ludwig Mond had decided to set



Winnington Works in 1884
Eleven years after its foundation. The first plant was in the second shed from the right



Winnington Works to-day

up a chemical works in England. His first project had been to manufacture fertilizers near London. He also considered the idea of making ammonium sulphate from gasworks liquor; and in the previous year he had taken out a patent for chlorine manufacture. He had, in fact, many more interests in mind than his sulphur-recovery process to which he had devoted his last few years. But this had quickly given place to a scheme for the manufacture of alkali and bleaching powder, and he had made a proposition to Philip Goldschmidt, to whom he now turned for the necessary capital. But Goldschmidt was in no hurry with his reply, and for once Ludwig Mond was prepared to wait. For he had just heard of 'some discoveries relative to soda manufacture which will probably bring about a revolution in this business'—as he wrote to his mother-in-law—and he wanted to know more about the truth of these rumours before committing himself and John Brunner to any definite line of action. Nothing came of this inquiry.

Early in 1872, therefore, he planned a journey in Belgium, partly to explore possibilities for his sulphur-reclamation process and partly to investigate a story, which had been told him by M. Merle, a French manufacturer who was working his sulphur patents. According to Merle a revolutionary alternative to the Le Blanc soda process had been worked out by the firm of Solvay near Charleroi.

Now the ammonia-soda alternative had long been known on a laboratory scale, but no attempt that had been made to apply it on an industrial basis had proved successful, and Solvay had taken out no patent in England, as he would have done if he had really perfected an alternative process to that of Le Blanc. All the same, if there were anything in the Frenchman's story, it would be to Ludwig's advantage to know of it. For to set up a new form of manufacture would be the most profitable course imaginable, since as a trained chemist he would be better equipped than any competitor to make a success of it.

This project for setting up a new concern, however, was already arousing paternal protests. The vision of his son establishing himself on borrowed capital filled Moritz Mond with alarm. 'The man who is your friend to-day is your enemy

to-morrow when finance is at stake,' he proclaimed. But Ludwig reassured him. In England it was possible to set up business in a modest way, for units in the chemical industry were not so large as in Germany. Three thousand pounds, and the improvement in trading conditions that seemed to be on the way, would be enough to earn him and his partner fifteen hundred pounds profit in their first year, he believed. For himself, he was investing no more than £600. Everything, however, depended on their choosing the right branch of the industry. Of course, he assured his father, both he and Frida would have preferred to set up in Germany: he had no wish to be stuck for ever to this place (Widnes). But next year he would have British nationality; and there was a great deal to be said in favour of that. But not everyone agreed with him. Frida's mother, on a fresh visit, commiserated with her daughter on being tied to this unintellectual country, with its cold, foggy climate, its stiff, one-sided people and its high prices. However, she was too shrewd a woman to press her son-in-law to alter his decision. She saw that soda was in very short supply and that nowhere except in England could a new chemical business be founded on so small a capital.

So early in April, after some preliminary correspondence, Ludwig left for Brussels to meet Solvay and examine the workings of the new process. For a year now he had been making inquiries about all sorts of industrial possibilities all over the Continent; for a year now he had been sending out propositions that read like schoolboys' problems, to all manner of manufacturers and suppliers. 'It is intended to build a chemical plant near Widnes for the manufacture of 5,000 tons of saltcake and 1,250 tons of bleaching powder per year. A capital of £10,000 would suffice for the purpose . . .' Taking manufacturing prices, selling prices, cost of transport and everything else into account he would then arrive at the figure of possible profit, to which he hoped his correspondent would agree. Alternatively he would send some such categorical question to a foreign scientist as: 'I would like to know in which of the larger Dutch towns the ammonia liquor from the gasworks is not yet being utilized.' And on the strength of the answer a number of rough calculations on the back of an

envelope would lead him to some fresh proposition on the lines of the bleaching-powder project. But so far not one of these sums had worked out right. Either the capital required was too great, or there would be difficulties with patents, or the demand was too small, or the cost of production too high to be competitive. But here, when he saw Solvay's process, he knew in a moment that he had found what he wanted. Gone was all fear that the absence of sulphur waste from the ammonia-soda process, which used neither sulphur nor pyrites, was a threat to his own living. His patents could take their chance now. He was on to something much bigger.

The beginnings of Solvay's process for soda manufacture lay almost as far back in the past as the origins of the Le Blanc method. In fact, as Ernest Solvay himself put it, 'Never before was the industrial realization of any process attempted so frequently and for such a long period of time as that for making ammonia-soda.' On a laboratory scale the first experiments in the making of soda from concentrated solutions of salt saturated with ammonia had been made by the French engineer and physicist Augustin Jean Fresnel in 1811. The process was simpler and far less wasteful than the Le Blanc method, and furthermore it left no poisonous waste-products. Serious attempts had been made already in England by two manufacturers working at Whitechapel to apply it on a commercial scale, and various patents had been taken out between theirs of 1838 and one by the Widnes manufacturer William Gossage in 1854; but no satisfactory plant had as yet been devised for working this rival process, the successful application of which seemed likely to knock out the Le Blanc manufacturers for good. But Solvay had been working the ammonia-soda process with limited success for nine years already at Couillet, near Charleroi, before he made the final adaptation of his plant which sent Ludwig Mond on his visit of inspection.

On first meeting M. Ernest Solvay in Brussels, Ludwig was somewhat taken aback. The Belgian was a decent, intelligent fellow, but no business man. What was more, he was reluctant to disclose those essential figures which would enable Ludwig to make one of his lightning calculations. The Belgian seemed very eager to grant Mond a licence, but could not be pinned

down and was vague about terms. So Ludwig Mond set off to pay various calls in Germany including visits to his parents and parents-in-law, promising to come back in a week's time, when he hoped that Solvay would bring him a definite proposition. In point of fact he already knew what this would be, nor had he any doubts about his own decision. Even with only half the requisite information he was able to make a preliminary calculation of costs and profits; and Solvay's figures, when he finally disclosed them, corresponded almost exactly to Ludwig's inspired guesswork; the wages were rather higher and the fuel consumption considerably lower than he had supposed, but the overall picture corresponded to his expectations.

On returning to Brussels he found Solvay communicative and even more eager than before to come to terms. So, after making a preliminary offer of five shillings a ton royalty on his output of soda, Ludwig set out to view the factory and to meet Solvay's partners.

Immediately on arriving at Couillet he formed a most optimistic view of the new process's future and, although himself almost without capital, began to outline a future collaboration on the very largest scale. He wanted something far more comprehensive, in fact, than a mere agreement for the exploitation of certain patents; he proposed a complete exchange of the details of all research and freedom for each party to visit the other's works at will.

His optimism swept the Solvays off their feet and the agreement which he drew up with them was so comprehensive that it can justifiably be called one of the earliest examples of international industrial co-operation.

I have been here since yesterday morning [Ludwig wrote to John Brunner on April 23rd, 1872], and have closely and thoroughly examined the works and books of the Company. I am perfectly satisfied and you may consider this business as concluded. . . . Should any difficulty unexpectedly arise about details I shall simply stick to my conditions, and even depart and leave the details for settlement by correspondence, as I have now the Co. completely in hand.

He had undertaken to set up his works within a year and to have them in production within two. During this time Solvay was to grant no licence in England except on terms considerably less favourable than those he had granted to Ludwig Mond. But when the two years had expired and the new firm was on its feet, he would be practically free to make such other arrangements in England as he liked. Ludwig Mond returned to Widnes therefore with a flying start in the exploitation of the ammonia-soda process. It remained to raise the necessary capital, to find a site to erect the works and to get them into production: no small problem for two men with little money and hardly sufficient influence to attract the backing they needed for this unorthodox venture.

CHAPTER 5

WINNINGTON HALL

LUDWIG MOND's lightning calculations were promising enough. Assuming that in 1873 a ton of 56 per cent soda ash would fetch £10 10s. at Liverpool it could be delivered at the cost of £7 1s. 4d. manufactured by the ammonia-soda process, and this included 8s. royalty (for Solvay's partners had forced Ludwig to raise his offer from 5s.). On the other hand the Le Blanc manufacturers could not produce it under £9 1s. 10d. The advantages were obvious enough. But Philip Goldschmidt, who only a short while ago had been eager to back any venture of Ludwig's, was not convinced. He raised a number of technical objections, which were speedily and peremptorily answered, but within a few weeks he wrote curtly to say that he was not prepared to back the project.

The new scheme was bigger than the old; Ludwig now talked of £15,000 capital, a sum which he reduced by a full third, however, as the summer wore on and capital proved difficult to raise. Nevertheless, whilst John Brunner continued to hunt up any wealthy men with whom he could get in touch his partner undertook the equally difficult task of clearing Solvay's patents, not only in London, but in various continental countries. There were, he discovered, other patents covering an ammonia-soda process, including those of James Young, a wealthy Scotsman, one of which seemed to Ludwig of the greatest importance since it would have enabled him to make ordinary washing-soda crystals directly from his process. He endeavoured to get a licence from Young for working this patent, but offended the Scotsman by his handling of the draft agreement. Young had already announced that his son was to devote his life to establishing the Young version of Solvay's processes. Things, however, did not turn out that way.

Within a few weeks of Ludwig's return from Belgium yet one more patent was registered by one William Weldon which duplicated one of Solvay's claims. It cost Ludwig seven guineas

WINNINGTON HALL

to lodge an objection to this, and it would no doubt have greatly annoyed him to learn that Weldon's process was chemically impossible in the usual conditions of the ammonia-soda process.

*Cost of a Ton of Soda Ash 56% made by
Le Blanc's process at Widnes Solvay's process at Winsford
Capital required for a make of 60 tons weekly*

<u>£ 13,500</u>		<u>£ 10,000</u>	
<i>Cost per Ton.</i>			
17 1/2 lbs. Pyrites @ 5s. per ton	£ 1-10-9	1 1/2 lbs. Sulphuric Ammonia	at £ 28 p. ton £ 1-10-0
29 - Salt	8 1/2 - 12-8	40 - Salt in Brine @ . .	1-0-0
1/2 - Nitrate of Soda @ 13 -	6-6	39 - Slack	7 1/2 - 15-8
88 - Slack	8 1/2 - 1-15-2	44 - Limestone	4 1/2 - 8-10
35 - Limestone	6 1/2 - 11-4	5 1/2 - Coke	2 1/2 - 5-9
Wages	1-12-0	Wages	15-0-0
Repairs of Plant	14-0-0	Repairs of Plant	11-0-0
Packages	18-0-0	Packages	1-2-0
General Expenses	16-0-0	General Expenses	8-0-0
Depreciation 10%	9-0-0	Depreciation 10%	6-8-0
Freight to Liverpool	2-0-0	Freight to Liverpool	3-0-0
<u>£ 9-7-0</u>		<u>£ 6-10-11</u>	
<i>At Works buying Salt at £ 10-5-0</i>		<i>Royalty</i>	
<i>At the best situated works in Newcastle about £ 9-15-0</i>		<u>£ 6-18-11</u>	

A COMPARISON OF THE COST OF SODA BY THE LE BLANC PROCESS AT WIDNES AND THE SOLVAY PROCESS AT WINSFORD, 1872

This is one of many in Mond's handwriting. The sale price was 2 1/2d. per degree per hundredweight, or £10 10s. a ton for 56% Na₂O = 96% sodium carbonate.

This was a moment when improved methods of soda manufacture were interesting more and more producers. Solvay's had just declared a dividend of 100 per cent. The demand for soda was growing rapidly and everything depended on Brunner and Mond getting in first with their Solvay process.

The question of a site for the new works did not at first exercise the partners greatly. The Cheshire saltfields were

clearly the most favourable district, for there the brine was to be had in plenty, and could be piped direct to the works. For there was no need in Solvay's process for it to be converted first into solid salt. In addition, limestone, the second raw material required, was within easy reach in the Derbyshire quarries. The ammonia would come by rail or water from the Midlands or from Liverpool. So a site was needed with access to road and rail and with a frontage to the canalized river Weaver, which communicated with the Mersey. That was self-evident. So Ludwig quickly got in touch with a Cheshire salt manufacturer of German origin, Hermann Falk, from whom he hoped to lease the necessary land at Winsford.

The leasing of land, however, proved much more difficult than he had supposed. The first time that the two partners took the train to Winsford station, just short of Crewe, they returned with no progress made. Falk was accommodating enough, and he knew the district inside out. For not only had he been Chairman of the Salt Chamber of Commerce for the past seven years, but recently had been made a trustee of the Weaver Navigation also. 'Surely the devil is worshipped in Cheshire,' wrote Ludwig to his future partner, 'if all is true that is said about him.' But rents were higher than either of the partners had expected, and John Brunner was against building a works on someone else's land. They made a number of abortive inquiries, however, in the next few weeks, from Lord Delamere among others, whom they found prepared to go to any extreme to prevent a soda works being erected near his mansion of Vale Royal. Various other local landowners shared his view. It was bad enough to have brine pans in the district, but a soda factory would be something considerably worse. Ludwig pointed out to Lord Delamere's agent that he could erect his works on Falk's land in any case, and that he would then be nearer Vale Royal than if he were to build on the plot of his Lordship's own land that he wanted. His Lordship was not persuaded by this argument.

Their failure to find a site at Winsford, and the possibility of Lord Delamere's preventing their building even on Falk's land, part of which was held on lease from him, left the

partners almost defeated. They continued to correspond with one old gentleman in the Isle of Man, who seemed disposed to lease them a plot that might have suited them. For the moment, however, despite a long interchange of letters, he did not yet seem to have realized the purpose for which they wanted his land. So Ludwig Mond, this time alone, once more took the train for Cheshire, but this time got out a station earlier than on previous trips. On his way from Hartford, the stop before Winsford, he ran straight into his friend Falk who, in his fear of losing a valuable tenant, offered him yet another plot of his land, and remained with him all day until the trap came to take him back to the station. The day seemed to have been wasted. But already Ludwig Mond was thinking of possibilities further down the river, where Lord Stanley of Alderley was the principal landowner.

Strolling down the Weaver towpath towards Winnington a week or two before, he and Brunner had enjoyed the wide views over the low-lying parkland of Lord Stanley's estates. Here the river and the new cut formed between them an island, and in the meadow-land separating the walled gardens of Winnington Hall from the water they had glimpsed a site better than any offered them by Falk, or refused them by Lord Delamere. Falk had talked of building them a line of railway for their own use. But here they would be sufficiently near the main Cheshire lines to require no more than sidings. It was hot July weather, and the mist lay over the park, curling more thickly along the edges of the water. From out of the mist, over the grey-pink walls of the garden, rose the bulk of Winnington Hall, in part a Georgian building, in part an older structure covered in greyish stucco. The smoke rose from no more than a single chimney; the house seemed deserted. In the stables and outhouses there seemed to be little activity.

But the vision of factory towers in those river-meadows faded. It seemed hardly credible that Lord Stanley would prove any more amenable than Lord Delamere, if it came to a question of selling his land for industrial plant to be set up under his windows. Yet almost under his windows and on his own land there were already salt-pans smoking. Squat chimneys already defaced the meadows a little above his

garden. This was brine-land. Moreover Lord Stanley's family had not lived at Winnington Hall for twenty years, and until recently the house had been let to Miss Bell and a partner, who ran a ladies' academy, to which Ruskin, Burne-Jones and the Hallés had been frequent visitors. But now the two ladies had moved their school and, although their tenancy continued, the place was almost empty. Two years before the whole estate of 627 acres had been offered for sale by auction, but had been withdrawn for lack of bidders. Ludwig coveted that meadow-land, and cautiously he began to make his inquiries. He had detected sinkages in the road on the way to Winnington Bridge, which connected Hartford with the main road on the far side of the Weaver. Perhaps the extraction of brine from the lower levels rendered the ground unsafe for building. However, he was reassured by local surveyors.

On his way over to Belgium for a further conference with Solvay Ludwig made tentative inquiries from his Lordship's London solicitors for so much land as he wanted. At first they seemed to make no difficulties, and from his hotel at Ostend Ludwig sent his partner the draft of a letter, which he asked him to draw up and despatch, making a formal offer proportionate to the figure of twenty thousand pounds, which his Lordship was asking for his whole property. Ludwig had reason to believe that Lord Stanley was short of money and would accept, particularly when assured that the ammonia-soda process produced none of the noxious fumes or waste matter for which the Le Blanc works were notorious.

He was wrong, however; Lord Stanley insisted on selling all or nothing, and in his park, adjoining his mansion, lay the best site in all England for the factory which Ludwig Mond wanted to build. Brine, road, railway and the canalized river: all were there.

The purpose of Ludwig's second visit to Couillet was to negotiate for the capital he needed with Solvay's, who now seemed willing to participate in a limited company for the exploitation of their patents in England. For since none of Brunner's acquaintances could be persuaded to come in, Ludwig realized the difficulty of finding a sleeping partner for a proposition in which neither of the working directors

would have much capital at stake. The Solvays themselves were amenable enough, but their shareholders objected; and though Ludwig was sufficiently persuasive, even in his broken French, to talk everyone over when he was in Belgium, negotiations broke down the moment he left. By September, however, Brunner was in touch with some new connexions in England.

Meanwhile, confident that any land bought could be mortgaged for three-quarters of its purchase price, the partners continued their dealings with Lord Stanley. He was their only hope, for they had learnt that Falk definitely could not let them his land without Lord Delamere's permission, and their correspondence with the Isle of Man petered out when the old gentleman finally realized that his land was wanted for development. Then, poor though he was, he refused point-blank.

By November so difficult had the situation become that the partners advertised in *The Times* for a gentleman with capital, and Ludwig was scaling down his own way of life in order to bring in every penny that he could. He had even decided to mortgage his sulphur-recovery patents, for whatever lump sum they would raise.

So drastically did he reduce his expenditure indeed that he even cut down subscriptions to various societies to which he belonged, and abruptly ceased his small loans to his father-in-law, whose business was going on the rocks and who had already sunk so low as to be borrowing £30 at a time from his son-in-law without much hope of repaying him.

Ludwig worked over his preliminary estimates for setting up the factory once more, and decided that it could be done for the very reduced sum of £7,600, which left hardly a penny over for contingencies. Not only was he tired of fruitlessly pursuing possible sleeping partners, but he very much grudged sharing his profits with anyone who would not be working with him. Indeed, before the end of November he and John Brunner had decided to start absolutely on their own, and to set about purchasing their land immediately. But three days after they had come to this decision the right man turned up.

Charles Holland was a Civil Engineer of Manchester, a

man whose advice both partners would value and who was prepared to loan them £5,000 at 5 per cent with the right to a third of the profits up to a maximum of 25 per cent of his capital. Brunner put up £4,000 and Ludwig himself no more than £1,000, and the partners agreed to limit their drawings to £10 each a week. They were now ready to build.

Meanwhile Lord Stanley's solicitors were procrastinating, and in his fear that they might be treating with another purchaser, Ludwig offered, in addition, to take a lease of the Hall which would be unlettable if works were erected in its grounds. Lord Stanley at a personal interview inclined to agree to this, but his trustees insisted on an outright sale. Ludwig protested that he and his partners had not the necessary capital, but Holland was encouraging. He had seen over the Winnington estate, realized its value, and was anxious to buy. As an immediate asset, there was valuable timber in the park, and a local carpenter assured Ludwig that the value of the lead on the Hall roof alone was sufficient to cover the cost of the place's demolition. In March, therefore, they bought the whole estate for the remarkably low sum of £16,108, which was only a few pounds more than their offer. The land was already mortgaged for £12,000 and, taking into account the value of the timber, the partners were now nicely placed, providing only that the works could be put up speedily, and would show an immediate profit.

Already they had a Mr Horrocks, of whom Ludwig thought most highly, preparing a lay-out for their buildings, and estimates for equipment were working out well within their figure. By the end of April Ludwig Mond had taken up quarters at an inn in the nearby town of Northwich and had begun work on the estate. His sole equipment was one office desk sent down to him from Widnes by his partner. The first thing was to find gravel for the concrete and to dispose of the timber. On May 12th, 1873, he wrote for the first time on notepaper headed: Brunner, Mond & Co. Manufacturers of Carbonate of Soda (Pure Soda Ash), Winnington Park, Northwich.

His last weeks at Farnworth were marked by an incident, characteristic of the practical helpfulness for which the Mond

afterwards became famous. A neighbouring cottager who had been earning a little extra money laundering and charring for Frida was woefully deploring their approaching departure. Ludwig, returning from Northwich for a couple of days, looked in to see the woman.

'Well, what are you going to do now that we are going away?' he asked.

'Trust in God, I suppose,' replied the woman, who was, like everyone else, very much afraid of this gruff foreigner.

'Nonsense, you won't have to do that,' replied Ludwig, who had never done so himself. 'You can take in washing.'

And when he learnt that she had no adequate washhouse he set about designing her one with the same care that he had just been applying to his works lay-out. The washhouse was built, provided with a new copper, and left to her as a parting present from her former employers.

The old Hall on the demolition of which Ludwig Mond had at first resolved was a timbered structure of Tudor date which had been stucco-faced in the early nineteenth century and crowned with toy-fort crenellations. But on to this had been added in the eighteenth century an L-shaped sandstone wing designed by the fashionable architect James Wyatt. The place had been inhabited by the Stanley family for little more than twenty years, and in the last little while, since the departure of Miss Bell's academy, the structure had been allowed to deteriorate. The gardens, however, were still well kept up, and there were small greenhouses and a most impressive poultry house for 600 hens, with accommodation also for the keeper and his family. But the interior and decorations of the house were extremely shabby; for the Stanleys had never spent much money on it. Indeed the only room that retained dignity and character was the Octagon drawing-room in the Wyatt wing, a well-proportioned apartment remarkable for its Chinoiserie wallpaper and for its marble fireplace inlaid with Wedgwood medallions above the grate.

In the condition in which the partners found it, the Hall struck them at first as dark and depressing, a place only fit for demolition. Fortunately John Brunner was forced by circumstances to revise his opinion. Ludwig had the offer of

a house in the neighbourhood, but the Brunners, however, could find no accommodation at all. John therefore took another look at the house they had unwillingly purchased, and decided that if the repairs could be done at a reasonable price the old Hall would be worth saving to live in. Ludwig was doubtful; deterioration seemed to have gone too far. But the local builder, who was putting up the factory building behind the house, undertook the work; and on removing the flaking stucco revealed the typical black-and-white timbered house that stands to-day. It was then decided that the Monds should take over the Georgian wing, and that the stables, coachman's house and outbuildings could be adapted for various purposes connected with the works. Thus the chiefs of the new firm would be living on the job.

At first they sat on opposite sides of the double desk, and the office was the old harness-room. Later a cowshed became the clerks' room, and a loft above was used as the drawing office. The foreman was lodged over the coach-house, and rooms were given to other employees above the stables. Even the rooms in the poultry house were in time transformed into a villa for the works manager.

John Brunner, however, found that he had taken on more than he bargained for; for beautiful though he saw the newly bared timbering to be it was riddled with worm and dry-rot. Indeed, it proved necessary in the end to gut the two upper storeys, and to build in their stead a new first floor, making use of such of the timber and panelling as was sound. It was not till some months after the Monds had moved into the Wyatt wing that the Brunners were able to transfer themselves to their new quarters, the adaptation of which had proved most costly.

Meanwhile Ludwig, living in the Angel Hotel, Northwich, supervised the erection of the works, and scanned the columns of all the local papers for second-hand factory equipment. A couple of boilers were located in a small Lancashire town, but their owner was an habitual drunkard and difficult to deal with; the stationmaster at Northwich station had to be implored to handle awkward parcels quickly; and all the time a close watch had to be kept on the partners' narrow bank

balance for fear that the payment of some small account might produce an overdraft. For though the mortgage on Winnington Park had proved even a little larger than the vendor's solicitors had led Ludwig to expect, rather more than the company's complete capital was now sunk in freehold property. Holland was, however, a wealthy man, who had great confidence in the project, and he helped his partners over more than one minor crisis. Yet each time he had to be persuaded afresh. Neither Brunner nor Mond could see more than a few days ahead at any moment.

Frida could expect no more congenial society in aristocratic Cheshire than in the Lancashire she was leaving. The aristocracy, 'with whom', as her mother wrote home to Cologne, 'one would naturally have no social intercourse', were divided from them by religion if by nothing else, while the local salt manufacturers—the only middle-class inhabitants of the district—were neither educated nor sociable. 'Like most people in England,' reported Frau Löwenthal, 'they are artisans who have worked their way up. This is all very uncomfortable for a woman. . . .'

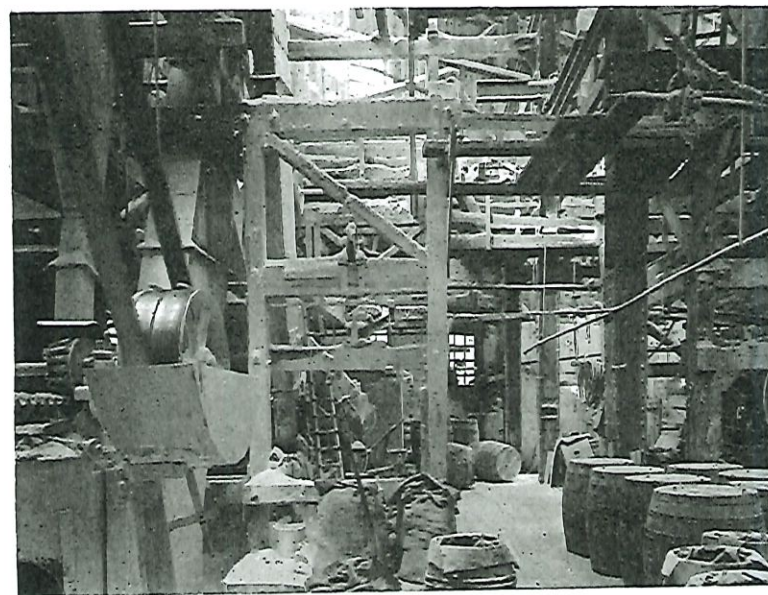
But Frida did not find it so. For company she had Miss Herz, and her friend Mrs Brunner would be living in the other wing of the great house. Moreover she would be taking part in Ludwig's great enterprise, a prospect which meant far more to her than that of making new and amusing acquaintances. She immediately threw herself into the task of economizing, of making the furniture of the moderate-sized house at Farnworth do service in the huge rooms of the Wyatt wing. But she was not greatly tempted towards extravagance on such things, for she considered English furniture both tasteless and much too expensive.

Now she renounced luxuries and elegant clothes, as well. But these had never meant a great deal to her, and anyhow she would be leading a very quiet life at Winnington and would have no opportunity to wear pretty dresses even if she bought them. Besides, there were compensations, the huge walled fruit garden outside her windows, the vegetable gardens and the Park, which was still beautifully timbered despite the fellings. True, the gardens were now overlooked by the works

rising in the meadows on the river-bank. But for the present they were well kept up by the old gardener, who had stayed on with the new owners; and every morning of that first summer at Winnington there were flowers and fruit in plenty brought to the kitchen door. The large rooms pleased her also, though not so much as they did the children who rushed about the underfurnished expanse of their new home, and out into the gardens and the Park.

Prospects seemed good. The works were expected to be in production in September, and the price of soda remained high. Moreover, the cost of the building had worked out at only a hundred pounds more than Ludwig's original estimate. The repairs to the old Hall, however, had eaten up an unexpected £2,000. Still, the financial margin was wide enough, providing that immediate and profitable sales could be made. But it was December before the first smoke rose from the works chimney, and there was no hope of production before the New Year. Many things had gone wrong. Working almost ceaselessly, Ludwig had trouble both with workmen and suppliers. He had brought a few men from Widnes, but for the most part he had to depend on Irish labourers, who proved lazy and inefficient. For the Cheshiremen would not work for him; they had seen the devastation that soda plants had created in Lancashire and resented the intrusion of this foreigner with his odd black hat, his curious coat and his legendary fits of temper.

The local landowners proved equally difficult. Several of them were obviously waiting their opportunity to prosecute Brunner and Mond under the Alkali Act, and their Inspector of Nuisances made such statements about the poisonous nature of the process that Ludwig had to silence him with a writ for libel. But greater than any labour trouble or than the neighbours' hostility was a difficulty that Ludwig had not foreseen at the outset. Although Solvay had advanced much further towards solving the problems of producing soda in the new way than any of his predecessors, he had not yet attained an absolutely dependable process. Nevertheless Ludwig had confidently begun by building a copy of his Couillet plant. But, as he speedily found out, this type of manufacturing was



Part of the Ash-shed sixty years ago



The Ash-shed to-day

more complicated than anything he had yet met, even in those difficult days when he was setting up the Utrecht plant for Smits. Despite the fact that Solvay sent over his own foreman to start production and paid a visit himself somewhat later, the process was in fact too new for there to be any hard-and-fast remedies for the difficulties that occurred. The apparatus was complicated. The plant, though extensive, had to run as a single whole. A stoppage anywhere brought the whole works to a standstill, and then suddenly all the men were idle and raw materials began to pile up.

From December 1873 till September 1874 a series of unforeseeable disasters kept the plant in and out of production. In John Brunner's words, 'Everything that could break down did break down, and everything that could burst did burst.'

Though Ludwig's bedroom was only a few yards from the works and though the sound of the engines working the night shift can never have been out of his ears, he slept or watched many nights through on the cat-walk above the engines, and when he slept at the Hall was frequently awoken by the ringing of a bell which he had had hung over his window so that he could be roused in an emergency. Frida complained that she seldom talked to him except at meal times. First the blowing engine broke down. It was poorly designed and much too lightly constructed for the gas-pressure they were using. Again and again they renewed the parts, attempting meanwhile to run on one cylinder of their two-cylinder engine.

Ludwig was almost ill with fatigue, but even so he congratulated himself on having learnt a great deal from his troubles. Cash, however, was running short and he made a fresh attempt to sell his sulphur patents for France, the only certain source of income he now had. He tried also to borrow £1,500 from a German cousin, and rather rashly promised that his father would back the bill.

The manufacturer of the blowing engine was of course responsible for its defects, but it cost Brunner and Mond a lawsuit to get their eventual compensation of £1,500. No sooner were their engine difficulties over, however, than there were a series of boiler explosions. On the occasion of the worst, Ludwig was, as usual, roused in the night, and he and

Frida bandaged the scalded workmen with strips of the sheets torn from their bed; one man died. Soon it was clear that the boilers were defective also. So a locomotive was hired to provide steam, and after some time production was once more resumed. Such was the effect on Ludwig, however, of this fatal accident that for many years afterwards he refused to employ steam pressures of above 100 lb. in his works or to allow steel pipes over 2 inches in diameter to be installed. These restrictions stood in the way of many improvements.

But there were, in addition, many difficulties inherent in Solvay's process itself. The raw materials were necessarily impure, and all operations had to take place inside closed, pressure-tight vessels to avoid loss of ammonia. Various sorts of caking and corrosion were liable, therefore, to take place in the tubes, pipes and boilers, particularly since the Weaver water they were using contained salt that had overflowed from workings higher up-stream.

The apparatus [as Ludwig wrote some time later to a German chemical manufacturer who inquired about his results] is most complicated; the whole plant is essentially one single unit connected by four pipelines and hundreds of cocks which come to a standstill on the slightest disturbance or blockage. Two years ago I started my technical training all over again.

The works had to be watched night and day. Lowery, the foreman, a Widnes man, was an excellent fellow in an emergency, but careless in the routine running of the plant. At one crisis, which arose when Ludwig was on the Continent, Brunner wrote that he would have to be sacked on Ludwig's return. But despite Lowery's shortcomings neither of the partners cared to be without him, and he worked for them for the rest of his life. Indeed, in the early days, it was with relief that they noted no especial calamities when he went away for a fortnight's holiday.

A great deal, too, depended on the works chemist, who had little time for research but was continuously occupied with urgent jobs of analysis. Here Ludwig himself, though already anxious to devote himself to fundamental improvements in

the process and to expand the works, had always to retain control. The actual chemist, a Mr Mebus, whom he had sent for from Germany at the very beginning, was a man of the same training as himself. But some of the junior chemists whom he recruited later in England were far less rigorously schooled than these pupils of Kolbe and Bunsen. John I. Watts, who had worked with him from about 1877 and rose to be a director of Brunner, Mond, tells a story that reveals the 'old man's' method of tackling an emergency problem. Three of his assistants once reported to him that a certain boiler employed for heating brine was constantly getting stopped up with sand. Ludwig Mond expressed surprise and accompanied the three to view it. He was shown the sand, and listened for a short time to the various theories propounded to explain how it came into the brine shaft. Then he suddenly turned to one and said: 'Bring me some hydrochloric acid.' When this was brought he poured it over the 'sand', and this promptly dissolved with free evolution of carbon dioxide, which proved it to be chalk. Turning to the assistants, he said: 'Now where is your sand? You are a nice lot of chemists.'

Many who worked with him felt that he knew the answer to a problem before he worked it out. But rule of thumb never satisfied him. He had not only to have absolutely scientific tests performed on everything, but he even required an account of every irregularity in the results. It was often, he said, from the exception rather than from the normal occurrence that one learnt most. As a taskmaster he was most exacting. Being himself indefatigable, he never recognized any limits to what he could ask of a man.

When he first came to England, he had been annoyed that men could not be asked to work on Saturday afternoon or Sunday, if need be. He would never grudge his own time to a problem. Again, he would never accept the excuse that an employee had done his best. 'Heaven help the man who does his best and fails,' he would say. 'For then there's no hope for him, and I have no use for him.' Yet there were certain men for whom he made exceptions; and chief among them his old friend Charles Pieper, whom he employed as his patent agent

in Germany, who answered no letters, offered little help when his advice was sought, and even on one occasion clearly tried to go behind his back and make some direct agreement with Solvay for himself at Ludwig's expense.

Towards his employees Ludwig Mond was deliberately gruff and carefully cultivated a reputation for a short temper. There was an often quoted occasion on which he had interrupted a stroll through the Park with Frida and Miss Herz and the discussion of some philosophical subject, to storm at a workman whom he had caught off his job. Having apparently lost his temper, he however returned after a couple of minutes to his wife and friend to resume the conversation exactly where he had left off. His attitude was a mixture of the benevolent and the peremptory. Having seen a man fall from a scaffold, he rushed to give assistance. Finding that the man was uninjured, he ordered him curtly back to his work. His was the impatience of a man whose brain operates more swiftly than his neighbour's; he enjoyed discussion, though he did not care for contradiction. But what he could not forgive was a failure to keep up with his processes of thought. To be 'slow at the uptake' was for him an unforgivable sin. For himself he was always in advance of the moment, planning the profits and expansions that the next years might bring, and intent on the further problems raised by the ones in hand. For him the present was no more than a jumping-off board into the future.

The Winnington household presented a strangely un-English face to the world. Gone were all Frida's early enthusiasms for England. She now thoroughly disapproved of English upbringing, of English education. The children spoke only German at home, and were in charge of a governess from Bremen, who gave them a serious and thorough German schooling, which ran to a strict timetable throughout the day. Books and playthings were sent from Germany, and Ludwig even found a line or two to spare at the end of a letter to some foreign correspondent to arrange for the buying of, and payment for, special Froebel toys. The children's books were selected with equal care; all must be severely practical and must treat of the wonders of nature; myth and supernatural content

were firmly eschewed. The Bible was undesirable reading since it brought forward so many instances of cruelty. Frida objected strongly, for instance, to the story of Joseph. How could her dear children understand, she wrote to her mother, 'that brothers could be so cruel to one another' or that they could 'give such grief or tell such lies to an old father'. The Bible must not come into the hands of Robert and Alfred, she decided, and therefore her mother must search for the right kind of books for them in the Cologne bookshops. This for two small boys of seven and eight who were eventually to go to English public schools and to occupy positions in English industry was an unfortunate start.

Ludwig's relations with his sons, as with his workmen, were a mixture of the kindly and the exacting. What he wanted of them was the incessant question, 'How does it work?' Then he or Frida would embark on a tireless series of explanations. Meal times were an opportunity for self-improvement. 'May I have some sugar for my porridge?' 'Yes, if you tell me where it comes from,' is a recorded sample from a Winnington breakfast conversation.

But in the children's own concerns Ludwig was not interested. Robert did not suffer under this treatment; he was a quiet and persistent child, endowed with a curiosity that won his father's approval. Moreover, he was neat in his handling of things and later of apparatus, and did not question the German way of life that prevailed at home. Alfred, on the other hand, was a more imaginative child, gauche, clumsy and inconsequent. Frida made much of his little ideas as to the way the flowers grow, and admired the persistence with which he would take a knock and go on with what he was doing. But there was a lack of sympathy between him and his father, which later developed into open and mutual impatience, and was not bridged until in his later life Ludwig found that both his sons were equally indispensable to him.

For the present the boys ran wild about the Park and works in such free time as they were allowed, rushing around, according to the old gardener, like a couple of young monkeys. The works with their endless pipes and furnaces, their stairs and galleries, excited them. They would steal the men's dinners

and hide them, or pelt the office boy with turf. They would fill their straw hats with lime and ride their donkeys far beyond the bounds set for them by their mother. Alfred would find a pump and turn on the steam to see how strong it would blow. All these stories were remembered and recounted years afterwards to Hector Bolitho, when he came to write Alfred's biography. But if there was one thing, everyone told him, that brought the boys to order it was the smell of their father's black cigar, which could be caught by the least sensitive nose the moment he entered the works.

The two boys' high spirits were the product of boredom. They had no companions, and Alfred, at least, was very conscious of the fact. On one occasion the Brunner boys, who were considerably older than they, tried to teach them cricket, to the tolerant amusement of their grandmother Löwenthal, who was at Winnington on a visit. But relations with the Brunners were not close. For the first Mrs Brunner, who had been Frida's friend, had died within a few months of their coming to Winnington, and John had shortly afterwards married his housekeeper, a most respectable doctor's daughter, of whom Frida, nevertheless, did not approve.

But the Wyatt wing was continually full of resident or visiting foreigners: Mebus, the works chemist; another chemist called Merkel who came from Germany to teach the young Mond, and later took a post in the firm's laboratory, which led him to high position; experts from Solvay's; German scientists on the look-out for employment in England; and with them a small English minority, consisting of Brunner during the early months of his bereavement, and Lowery the foreman, who lived above the coach-house but came in to meals. There was a babel of conversation in French, German and English.

Over this large and ill-assorted household Frida presided, with the support of Miss Herz; and soon she was joined by her mother who came for a prolonged stay whilst the feckless Adolf Löwenthal underwent a series of financial crises at home. Ludwig's consignments of English banknotes, cut in two for precaution and the parts sent by successive posts, had quickly to be resumed. But Adolf's self-pitying letters,

addressed to his wife but clearly intended for his son-in-law's eyes, showed patently enough that bankruptcy could not be warded off by such hand-to-mouth assistance. Ludwig read his father-in-law a lecture on the necessity of pulling himself together and going out after fresh business. But Adolf was too old a *bon viveur* to take much notice, and generally failed to answer his letters. Nor did he always acknowledge the money he received, but immediately spent it on day-to-day living and then wrote for more. In the midst of the greatest difficulties at Winnington, therefore, Ludwig had to take charge of the Löwenthals' affairs and, working through various German acquaintances, none of whom he trusted, to dole out sufficient for his father-in-law to live on, and at the same time to rescue enough from the wreck of the electro-plating business to support him in retirement.

In the midst of this Johanna Löwenthal returned home and, on rejoining her husband, began to display a will of her own, rejected the idea of retirement to Wiesbaden, and started speculating with the funds her son-in-law provided; only to complain, when he rather curtly told her to stop, that he was no longer kind to her and that their only relationship now was through Frida. Ludwig seems at this point to have lost faith in both his brothers-in-law—for his younger sister Mathilde was now married also—and to have seen himself in real earnest as the sole means of support of all his relatives. His father's business, in which Ludwig had never had much confidence, seemed now to be failing, too, and at much the same time as the Löwenthals were falling on to his hands, he was proposing to Moritz Mond, 'as one business man to another', that he should retire and place his capital with Brunner, Mond's, where he would receive very fair interest. He did not conceal from the old man, however, the fact that this would be very much to his own advantage, too, since it would enhance his credit with his associates, both of whom had more capital in the business than he.

The choice of John Brunner as his partner had proved a sound one. Primarily a business man, John, nevertheless, learnt a great deal about the technique of production, and even made sound technical suggestions. Indeed, on one

occasion, early in the company's history, when Ludwig was on holiday in Switzerland, he almost begged his technical partner to stay a little longer so that he could master a particular problem that Ludwig had always dealt with himself—that of the loss of ammonia. But the chief decisions were always Ludwig's, and there were even occasions when Brunner confessed that he had himself no opinion to offer and left everything to Ludwig Mond. He was, however, a great stabilizing influence, a man who was far less carried away by the problems and anxieties of the moment than was the more temperamental Ludwig. John Brunner was a family man, and a keen gardener; and where Ludwig would take his worries home with him and, smoking cigar after cigar, pace with them restlessly up and down his study till late into the night, his partner knew how to relax, and complained of no worse troubles than lumbago, which frayed his temper. But, as he once wrote, that did no harm, since it made people dance to his piping quickly. Moreover, he cured himself of his complaint, by a strenuous week-end's lawn tennis.

Brunner's part was to buy the raw materials and sell the finished soda. This sent him travelling round the Northern towns in the early days of the firm. But he quickly fixed up sufficient contracts to absorb all that could be produced, since for a long time the output was not high. In the first instance, however, contracts were not easy to secure since Brunner, Mond were producing soda ash of greater purity than the Le Blanc manufacturers, and customers had to be convinced that it was really to their advantage to receive their material free of impurities. They were in the habit of measuring it by the bucketful and of using just as many buckets of the new soda as of the old. So they could not see how they were better off. Mond's solution was to present each new customer with a new and smaller bucket. But, even when these contracts were fixed, two years after starting, at Winnington, Brunner, Mond were sending out under their new sign of the downward crescent—a play on the name of Mond—no more than 2,500 tons of soda a year. The American market was the most lucrative and they concentrated on that, but it was so overstocked owing to unsettled political conditions that on one occasion

in their early days the partners rejoiced that a vessel had gone down in the Atlantic with a cargo of theirs fully insured; for this would relieve the congested American stocks a little. The American situation was, however, much improved when Brunner went over himself in search of orders and when the change in taste from bitter beer to lager caused a lively demand for bicarbonate from the brewers.

The introduction of the Solvay process did not for a long time have any great effect on the works making soda in the old Le Blanc way. For one thing the Le Blanc manufacturers were producing, as by-products, hydrochloric acid, bleaching powder and other chemicals which could not be manufactured by the ammonia-soda process. Therefore, they could survive, as Ludwig himself saw, by concentrating on their by-products; by turning themselves into chlorine factories, pure and simple, and disposing of their alkali for what it would fetch. The Le Blanc system, thought Ludwig, would always supply the bulk demand for the crude product, while the pure ammonia-soda would take up the margin—a good and growing one—between that and the full demands of the market.

Then, too, Winnington's early difficulties were well known at Widnes. Widnes had no greater belief in ammonia-soda now than it had had in so many other ammonia plants that had worked for a few months and then collapsed. The Le Blanc manufacturers sat back and watched for Brunner, Mond to collapse in their turn.

But though they might not fear competition at home, the Le Blanc manufacturers were badly hit by the closing of export markets as a result of the erection of the ammonia-soda plants abroad. Solvay himself opened up in America; and various manufacturers in France, Germany, Austria and Russia, relying on Ludwig Mond's advice and experience, built works in their own countries to exploit the Solvay-Mond methods. So by 1883 the ammonia-soda process accounted for nearly a quarter of the world's soda production, and many of the export fields were closed to the Le Blanc manufacturers by home industries. With growing prosperity, however, the demand for such goods as soap, textiles, and glass, that used soda in their processes, steadily increased, so

even these old-fashioned businesses managed to struggle on, largely as bleaching-powder works, and did not finally give up this line of business till after the First World War.

Brunner and Mond, having got into production in mid-1874, a full nine months after the scheduled time, lost a good five pounds a ton on the soda manufactured in their first year, but struggled through with help from their bankers, Messrs Parr's of Warrington, and their sleeping partner, Charles Holland, and with constant worries about the payment of the week's wages, to break even in the next year. In 1876, however, they made sufficient profit to pay off most of their debts, and were then free to turn their attention to the possibility of manufacturing by-products. This happy state of things the partners celebrated by raising their weekly drawings from £10 to £30. As usual Ludwig was planning well ahead of the time. Already in 1875, with the corner hardly turned, he was thinking of enlarging the works next year and reporting to his relatives in Germany that he had already got the necessary funds. These extensions, which practically doubled the plant, were working in the spring of 1877, by which time Ludwig had leapt ahead again and, following his old bent, was considering the utilization of waste. By 1879 he was already planning the formation of a limited company with a capital of £600,000 to replace the partnership: a scheme that was carried out a couple of years later; and in 1880 Brunner, Mond continued their programme of expansion by taking over a small and unsuccessful plant at Sandbach which had been attempting to work Solvay's patents in competition with them.

The history of the Sandbach works had been a pathetic one. James Richards, a Manchester chemist, had been approached by John Brunner at the inception but, after a lot of shilly-shallying, had been unable to find the capital which Charles Holland had later put up. A few months afterwards, however, some money being available, Richards had gone to Solvay and taken out a licence to work his process independently. By Solvay's agreement with Mond any other concessionaire was compelled to pay a royalty of twenty shillings per ton against Brunner, Mond's eight shillings. Starting

with this handicap, Richards and his partners struggled on for two years, and then appointed Ludwig Mond to manage their works for them at the salary of a thousand a year, Richards remaining on as the chemist. By this arrangement Brunner and Mond took a twelve-shilling royalty from the Sandbach works and, at the same time, exacted an agreement from Richards to sell them his works as soon as they had sufficient capital to buy them. In the meanwhile the partners agreed to stand half the losses on the plant in return for half the profits, when they made any. But Sandbach gave Ludwig perpetual trouble. Frequently he would drive over, stride through the works, and then, too worried and tired to return to Winnington, take a bedroom at the local inn, throw the mattress on the floor, and at any time of the day or night, lie down to ponder his problem. Then when he had reached a conclusion he would replace the mattress on the bed, return to the works, give his orders and drive post-haste back to Winnington. But if Sandbach was an unsatisfactory plant from the beginning, it was at the same time a useful training ground for the young men Ludwig was beginning to engage for his expansions.

1881 was a triumphal year for him, for with the floating of a limited company, he was at last free to return to the task of research. 'We are no longer making chemicals, we are making money,' he had complained as the balance sheets improved.

Now he was free to apply himself once more to his prime interests, from which he had had to withhold himself for the last ten years. Back in his laboratory, he saw two main problems to be solved, one of which, in fact, remained insoluble on any but a small scale to the end, but the pursuit of which led Ludwig to major discoveries he had not envisaged when he began his experiments. The first was to find a cheap and certain source for the ammonia used by the Solvay process, which was now being purchased and transported from the Liverpool gasworks. For this there were three possibilities. It might be produced from bones and waste leather, in the way that had given it its original name of spirits of hartshorn; and about these methods Ludwig already knew a great deal

through his association with Herr Weil in his early days at Cologne.

It might, on the other hand, be distilled direct from coal, or in a more revolutionary way it might be derived from the nitrogen of the air, supposing that this could be made to combine economically with hydrogen. This last and most attractive method Ludwig Mond actually worked out to a point where it had to be abandoned owing to the difficulty of making thin retorts which would stand the very high temperature of $1,400^{\circ}$ C. required. But the second, though leading to no large-scale change in the methods of ammonia production, proved almost more important, though for other reasons. For from the burning of low-grade coal in a mixture of air and steam a valuable gas was manufactured which was marketable for its own sake as a smokeless fuel that could be utilized for power and the heating of furnaces, etc. From these experiments was born Mond Gas or Power Gas, which was in due course developed by a separate company. As a method of cheapening ammonia, this second alternative proved hardly more fruitful than the others. Yet it gave birth to a highly valuable alternative fuel, and at the same time struck the first blow in what proved to be an unsuccessful battle to turn the Black Country green again, which was Ludwig Mond's open ambition. For a gas-run factory would pollute the air far less than the coal-burning chimneys of the existing furnaces.

Ludwig Mond's second principal problem proved in the long run even less soluble than the first. Always an enemy of waste, he could not bear to see the chlorine from the brine he drew up from beneath his lands cast out into the river in the form of calcium chloride; or to rent land on which to dump the solid waste. His aim, to which he devoted money and labour in vain, was to produce bleaching powder from it which would compete with that of the Le Blanc manufacturers. This again led him to very important, though indirect, results. For by the chance discovery of nickel carbonyl during experiments on the chlorine problem, Ludwig some years later gave his name to yet another process, the Mond nickel process, the exploitation of which was to his late

maturity what the building of Brunner, Mond & Co. had been to his middle years.

The flotation of the limited company in 1881 enabled the life managing directors, Ludwig Mond and John Brunner, almost to double the size of their works. But new buildings and increased output formed only a part of their programme of expansion. They were now in the position to embark on a scheme of research, which Ludwig had long desired to do, and to recruit trained scientific staff on a scale that would have seemed a wasteful extravagance to their Le Blanc competitors.

The new company, whilst leaving all the power in the hands of the former working partners, elected an outside chairman, the soap manufacturer John Crosfield, whose firm was a considerable consumer of their soda.

Their sleeping partner C. M. Holland had, of course, a seat on the board, as had Edward Milner, who had been a small salt manufacturer when Brunner and Mond came to Cheshire, who had helped them to find a site, even driving them about the country in his trap, and who had joined them at the beginning as a brine expert. Very quickly, however, he had taken on additional responsibilities; and it was he whom Ludwig sent in the first place to manage the unsuccessful Sandbach plant.

Milner was a man of patience, tact and kindness, who could calm Ludwig in his furies and atone for the frequent gaucheries of the impetuous John Brunner. Almost as valuable a collaborator was John I. Watts, who was not immediately rewarded with a seat on the board. He was a Manchester Quaker of good education, a dapper, rather reflective figure whose sensitive face and curled moustaches make him a somewhat unexpected figure in the earliest works photographs. Like Milner, he must have provided an element of stability and good breeding very valuable to the company in its early years. He had found it difficult at the inception, however, to convince Ludwig Mond of his worth. Approaching him for a post, he had been told that the works employed none but German-trained chemists, and it had only been by offering to work for nothing until he had proved his worth that Watts had secured an appointment. Soon Ludwig realized this positive Englishman's

value and Watts worked for the company all his life. He survived indeed to write his late chief's obituary for the Chemical Society. It was he, also, who compiled the history of the company's first fifty years, for the anniversary of 1923.

Now, a new generation was being recruited, of men who had never worked for any other employer. Ludwig had admired the practical ability of Professor Roscoe, ever since he had first met him at Norwich on the occasion of his address to the British Association on his process of sulphur recovery. As the works expanded, therefore, he encouraged Roscoe, who was teaching at Owens College, Manchester, to send him his pupils. Now, for the first time, because of Watts's success Ludwig was satisfied to take English-trained young men, among them several who, in their maturity, rose to fill positions of great importance in the British chemical industry. This did not prevent his continuing to invite key men from the Continent; and it was perhaps on his German-speaking assistants that he relied most heavily. Henry Schellhaas, for instance, a large untidy German, remained responsible throughout his chief's life for every extension or alteration to the company's plant; between him and Ludwig there was a constant interchange of sketch plans and blueprints, which kept them in the most intimate collaboration. The firm's tendency, however, was to choose for their new openings North Country science graduates, often of strict, sometimes of teetotal, upbringing, and to transfer the most promising of them from scientific to executive posts at an early date. But the future of their other recruits, of those without scientific training, was often planned with equal care. It was said of F. W. Brock, who rose to be the company's secretary, that he was marked out for this position some years before the company was formed, in the year 1876, when he was taken on as a fourteen-year-old office boy.

So far as the workmen were concerned, Ludwig Mond was prone to say that he had outgrown the 'socialist-comradely' ideals that he had fostered when he first came to England. At the beginning he had idealized the British working man, but now he felt that he had been let down in the early days at Winnington and Sandbach. Henceforth all the responsi-

bility and all the authority must rest with him. But he did passionately care about the improvement of working conditions, and in a time when strikes were bitterly contested and often cruelly broken, he carefully cultivated goodwill and co-operation between master and man. In 1884 a week's holiday with pay was granted to every man who had lost fewer than ten days, or shifts, in the previous year except for reasons of illness; a concession far in advance of its time. In later years Ludwig doubled the week's pay, in order to encourage his workmen to go away for the holiday, which he knew they could not afford if they were to receive no more than their pay packet for a single working week. This revolutionary innovation became the accepted practice and remained in force until, only a year or two ago, Brunner, Mond's successor, Imperial Chemical Industries, extended the holiday to a fortnight without the corresponding increase in holiday pay.

Conditions of employment were steadily improved with the early success of the company and at the instance of the board itself. The hours of a shiftman, for instance, were reduced between 1874 and 1889 from 84 to 56 per week, and rates of pay rose in proportion. In 1892 the old two-shift system was abolished and the three-shift system substituted. This put an end to the almost intolerable overworking of the key staff. Such advances were, of course, only practicable on the basis of successful trading. The profits were large enough to allow of big dividends, and consequently there was something over for the betterment of conditions. But the ultimate responsibility for this happy state of affairs rested largely with the inventive powers and industry of one man. It was at no small cost to himself that Ludwig Mond had earned the right to say as he strolled along the still rural Weaver bank after his dinner: 'And this is the great Babylon which I have built.'

A portrait of the dreaded 'Old Man' as he appeared in 1886 at the age of forty-six is provided by A. W. Tangye, at that time a young half-trained student of Roscoe's in search of a job:

He was only some 5 feet 8 inches in height and stooped forward slightly, a rather fearsome figure, with magnificently developed chest and arms. He was just in from a

tour of the works, and wearing a black shapeless hat with a broad brim, both hat and coat much covered with white dust. From under the brim of this hat a much tortured and disfigured left eye (damaged with caustic in a Dutch works) first met me, and then a heavily bearded face with a powerful racial nose. His moustache and beard were rough black hair, rather aggressive, and he was smoking a dark cigar. The right eye was very powerful and searching. The whole head seemed very powerful in proportion to the body.

He met me with a remarkably amiable smile, and took me into a small neighbouring office. He at once commented on my youthfulness and very short period of College training. He strongly recommended a further two years training in a German University. I replied that my father would sooner see me go to Hell than Germany. This amused and, I think, pleased him. He then questioned me as to how much I was taught at Owen's about the ammonia-soda process, and was decidedly pleased to learn how little was known about it. My repetition of Roscoe's remark to Watson Smith ('We really must pay some attention to this process at Northwich') amused him.

It was not long, however, before Ludwig grew to be on considerably closer terms with Professor Roscoe. As for the young man Tangye, he was taken on as a learner and sent to Sandbach at £1 a week. After a long and successful career with Brunner, Mond's he retired from a directorship in 1926, on the formation of the I.C.I. combine. His memories and records of the past have been a considerable help in the writing of this book.

Mr Tangye seems to have been one of the few, even among the highest ranks in Brunner, Mond, to have overcome his fear of the 'Old Man' and his rages. There were moments at which even John Watts was afraid of his chief's outbursts. A particular instance of this occurred at a moment when Watts and a fellow chemist had taken out a patent for some discoveries made by them at Sandbach, and awaited Ludwig Mond's comments on their presumption. Ludwig had been in their position himself when he had been working for Hutchinson, where he had had to answer the proprietor's



The Monds in the eighties
L. to r.: Robert, Alfred, Adolf Löwenthal, Mrs Löwenthal, Frida Mond, Ludwig Mond

claim that any discoveries made in his works must automatically be his to exploit. But that did not guarantee that the 'Old Man' would take this registration calmly. On this occasion, however, Ludwig Mond dismissed the matter lightly. He merely mentioned the name of a French scientist who had to his knowledge made the same discovery many years before. Watts's conscience nevertheless troubled him for some time after this threat of a dispute, which in fact never took place.

Although Ludwig Mond was by the middle eighties taking on English-trained scientists, men of continental origin or education, like Schellhaas, still suited him best, and in the works photographs of that time there usually stand out among the bluff and bearded Northerners one or two men pronouncedly German in dress and features, some of whom, indeed, like Ludwig himself, never grew acclimatized to their adopted country. But of all the men of foreign extraction whom he employed none was closer in his confidence or none more anxious to assimilate himself to English ways than J. G. Jarmay, a Hungarian by birth and a favourite pupil of Roscoe's, who collaborated with Ludwig in the research of the eighties and was afterwards knighted for his services to the Ministry of Munitions in the First World War.

In contrast to his principal Jarmay became extremely English in his appearance and his ways, and while working at Winnington rode regularly to hounds, to the considerable indignation of some of his colleagues, to whom this seemed presumptuous in a scientist. But if Jarmay adopted a protective colouring which was almost too perfect for its purpose, Karl Merkel, by contrast, who had first come as a tutor to the Mond boys, but had soon been given an important post in the laboratory, remained a continental to the end. From his appearance in early works photographs he would appear to have been something of a lady-killer with his drooping black moustaches and his heavy dark eyes. He was a man with some of the brilliance of his master, and left the company to reorganize the soap works of Brunner, Mond's first chairman, John Crosfield, who begged Ludwig to be allowed to take him away. An Italian type, 'with no trace of the Hun', as a colleague remarked of him at the time of the First War, he

made a great success at Crosfield's, afterwards came to London, and was active throughout the War in his efforts on behalf of the German prisoners, for whom he worked in the hopes that there would be no ill-feeling when it was all over. Of all Ludwig Mond's protégés in his first years, Merkel was almost the only one to make an independent career for himself; the rest stayed with the firm, and attained positions of greater importance as its rapid expansion went on.

The community at Winnington was from the first a close one. The town of Northwich, a mile and a half away, could not provide accommodation for the growing numbers of workmen, and by the end of the seventies houses were being erected in Winnington Park. In the years after the formation of the company more and more dwellings were put up by Brunner, Mond, and streets were laid out which were named after the pioneers of the process by which their inhabitants lived. In addition a co-operative store was started. At the same time, the executive and scientific staff built or rented small country houses for themselves in the district, and passed them on from one to another, as transfers and promotions dictated. Brunner and Mond, in fact, found themselves at the head of a patriarchal community; a state of things that exactly suited Ludwig's nature. First to his workmen, but not for many years to his staff, he became a respected, almost a beloved figure, the hero of legendary and largely unhistorical anecdotes, such as that in which he was said to have taken off his coat to fight a difficult Irish labourer, and in this way to have reduced him to obedience.

The patriarchal spirit of the early days had, however, its disadvantages for the Winnington community, on such an occasion as that on which one official, with or without Ludwig Mond's knowledge, was sent by another to interfere with a love affair of yet a third, who took the matter very badly, but was tactfully sent off on a foreign mission by the company, from which he returned with an enhanced reputation. This subordination of the private to the business life was, however, probably typical of the times.

Ludwig Mond's patriarchalism was also expressed in another way: by his concern for his German relatives. At his

mother's death in 1878, the responsibility for his father fell upon his hands. The old man stayed on in the old Cassel house and, growing meaner and more careful with the years, refused even his son's presents; which had therefore to be made by subterfuge, as on the occasion when Moritz Mond's doctor recommended him to drink better wine. The patient, however, refused to spend any more with his wine-merchant. Ludwig, however, carefully arranged that a better brand should be supplied and himself undertook to pay the difference. Whereupon Moritz Mond, appreciating the finer quality of his new supply and seeing no change in the price he paid, wrote triumphantly to Ludwig that it was absurd for anyone to talk of his buying more expensive stuff, for the wine he was now drinking was the best in the world and it was no dearer than the last lot.

Ludwig's parents-in-law also looked to him for their well-being, and he was already guiding the scientific education of his nephew Emil Schweich, whose mother—his sister Phinchen—had died and whose father was frequently away on business tours. In addition he acted as guardian to the children of his younger sister, Mathilde Mathias. What is more, in due course both Emil and his sister, and one of the Mathias sons, Robert, were to join him in England. He offered the two young men business positions, once they had proved their capability.

His own sons, who had started at a weekly boarding school not far from Winnington, run by a German, were now sent to Cheltenham College, where the Brunner boys were already at school. It was an unfortunate choice for boys who still remained as thoroughly un-English as the Monds. Robert was clever and was not gnawed by self-distaste; what he was, he was, German accent and all. But Alfred felt his anomalous position most cruelly. A Jew by race, he knew nothing of the Jewish religion. Confronted with Christian dogmas which offended his sense of logic, he argued with his housemaster, who had not read Darwin and considered the boy irreverent. Taught German by a master who knew the language far less well than he, he took the German prizes but despised the school teaching, of which he thought this was a fair sample.

With no more knowledge of games than he had got from the Brunner boys in Winnington Park, he persistently and clumsily tried to learn football, practising his kicking by the hour, and longing to be English like his school-fellows. His sole talent was for essay-writing, in which he gave his disorderly imagination free play; and it is said that he was always prepared to write other boys' essays if they would do his ordinary school-work for him. At home Robert's relations with his parents were as easy as ever, Alfred's just as difficult. The younger son found one confidante, however, in his mother's friend Miss Herz. Only she knew how much he loathed the easy cosmopolitanism of his home, which suited his elder brother so well.

CHAPTER 6

'THE POPLARS'

IN 1881 Ludwig Mond was appointed one of four honorary secretaries of the newly formed Society of Chemical Industry, which had begun as a club in Widnes, but which was now expanding into a nation-wide organization, intended to give the industry some sort of corporate unity. It was, perhaps, this first taste of public activity which suggested to him that it was time for him to leave his remote corner of Cheshire and take a house in London. There he would be in closer touch with various other scientific bodies and would no doubt be able to play some part in their affairs.

For Frida and Miss Herz, too, life at Winnington was becoming increasingly constricting. The works and workers' housing now covered a great part of the Park and gardens, although the view out of the front windows was not yet cut off by the glass and iron cliff of the caustic plant, which now overtops the Hall. John Brunner was tied to the place, for he had begun to interest himself in the public life of the county, to busy himself with the building of schools, to sit on the local education committee and to think of running for Parliament. But Ludwig Mond now felt free. Research could be pursued wherever there was a laboratory, and wherever Ludwig Mond went he immediately built one for himself. So in 1884 he and Frida took a house in Park Crescent, London, while they looked for a suitable place to buy.

To suit Ludwig it must have large rooms, for he expected to entertain on a considerable scale; it must also be near Euston Station, since he would frequently need to run up to Winnington, where the Wyatt wing was to be kept for him. There must also be outhouses which he could transform into his laboratory, and the structure must be dry enough for valuable pictures to be hung on the walls, for he had decided to collect Italian paintings. All these conditions were fulfilled by 'The Poplars', Avenue Road, St John's Wood, a mansion in the ornate French style, lying back from a quiet road north

of Regent's Park, with gardens that ran down to the boundary of another open space, Primrose Hill.

The house, which dated from about 1840, had formerly been occupied by some exiled French nobility. Its rooms were large, and behind it was a lawn, suitable for garden parties, upon which stood a huge chestnut tree. There were also stables, in which a laboratory could be built. For Ludwig preferred to hire a carriage and horses, rather than keep one of his own. But even 'The Poplars' in time proved too small for Ludwig's manifold activities, and a few years later the next-door house was bought to be used as an office for his gas and nickel companies. But in the beginning he had room enough here to work and to receive scientists, many of them from abroad, with whom he kept up a lively interchange of ideas.

The house was run luxuriously, though without ostentation, and was large enough for guests to lead a life almost independent of their hosts. The domestic details were entrusted to a housekeeper, though always under the closest supervision of Frida Mond, who did not allow her intellectual interests to deflect her from the duties of a housewife, for which she had so carefully trained herself in her last years in Cologne. To her servants, many of whom she brought down with her from Cheshire, she appeared kindly and patient, and always more approachable than her somewhat enigmatic husband, whose tempers were legendary, yet who never behaved with anything but consideration in his home. He spoke to his servants very little; while his wife was always willing to dilate on the subject of the pictures or china or other knick-knacks of her own collection with the same earnest wish to improve these raw young women's minds as she had always shown towards her own children.

She and Miss Herz would invite artists to the house as freely as Ludwig filled it with scientists; and frequently there would be singing and piano- or violin-playing after dinner. The house was at its fullest on Sunday afternoons when the Monds were formally at home. At 'The Poplars' Robert and Alfred were always free to entertain their strangely contrasted circles of friends.

In the year that the Monds moved to London, Robert left Cheltenham and entered Peterhouse, Cambridge, to read the first part of the Natural Sciences Tripos. Ludwig had planned for his eldest son an education which would put him in the position to continue his father's work. From Cambridge, after two years, Robert went on, without taking his degree, to the Zürich Polytechnic High School, then spent a year at Edinburgh University under professors whom Ludwig respected, before going to Glasgow as assistant to Sir William Thomson, afterwards Lord Kelvin, a frequent visitor at 'The Poplars'. At this point, after an education in four universities extending over some five years, he was, in his father's opinion, ready to continue his research at Winnington itself.

So close a conformity to the parental pattern might suggest a young man of little character. But Robert Mond was not a one-sided scientist. He had a great love and knowledge of music, was a competent singer and at times got into company that was not welcomed at Avenue Road. He was, however, content to follow the line his father had mapped out for him and, though tempted by pure science, reconciled himself for a while to following the applied branches in which his father led.

Alfred, on the other hand, lumbered on at Cheltenham, where the Brunner boys stole all the honours, departing in the glory of prefecthood and games-captainship while he seemed to have acclimatized himself no better to English ways in the five years since he left his preparatory school in Cheshire. Cambridge, however, gave him a great release. Already he had glimpsed the way that he was to follow. From Miss Herz, his first confidante, he began to turn in his Winnington holidays to his father's partner, John Brunner, a man as successful as his father and yet firmly anchored in English life. John Brunner was at that moment about to go into politics, a career which tempted Alfred also.

On a holiday in Germany some years before, he had been asked by his German cousins what he meant to be when he left school. 'I am going to be Prime Minister,' he replied, boldly jumping all the intermediate stages. To his father he was now more explicit. 'I am going into politics,' he

announced. 'What party?' asked Ludwig. 'Liberal,' replied Alfred, who had become used to sparing his words when talking to this parent who could so quickly pick up a loose statement. 'Why?' inquired Ludwig. 'Because I have examined all the parties and I find that there are less clever men among the Liberals than among the others.' It was a good enough reply to prevent further inquiries, but it was a long way from the truth. In 1885 John Brunner had been elected Member for the newly formed Northwich division of Cheshire, only to lose his seat in the following year on the issue of Mr Gladstone's first Home Rule Bill. He got in again, however, at a bye-election in the following year and held the seat till 1910. Brunner was a Radical and an anti-Imperialist, but Ludwig, despite his own youthful Radicalism, despite his early enthusiasm for Mr Gladstone in his first married years at Widnes, had refused to appear on his partner's election platform and was an emphatic opponent of Home Rule.

Ludwig's political views were not pronounced, but they had certainly grown less advanced with the years. At the end of his life he spoke of himself as a Conservative. True, his experiences as an employer had left him a passionate believer in reforms, but in reforms conferred from above rather than seized from below; with political or economic agitation he had no sympathy. It was necessary therefore for Alfred to conceal his Liberal convictions from his father, though even at that date they were far to the right of John Brunner's. Indeed Alfred was, in the end, while still a Liberal, to apply Ludwig's own belief in class co-operation on a national scale. His was the Liberalism of the first National Insurance Bill of 1910, of which he was a fervent supporter.

Ludwig had always been in touch with the men he employed. The very nature of his work had demanded it. The erection of an experimental plant of the kind he first built in Holland; the numerous structural alterations, all demanding the closest co-operation between builder, workman and inventor; the strenuous beginnings at Winnington: all brought him close to the most resourceful section first of the German—for he had to bring his workers from Germany to Holland—and then of the British working class. 'Don't call me Sir,'

he would protest at Winnington. 'I am not a gentleman, I am a workman.' But he was a workman with a special function that he did not forget. He was the workman who had built the works; without him and his kind it could not continue.

Brunner's was the Liberalism of the North Country industrialist who sees his interests overridden by those of the landowner and the farmer. His partner's was of the continental variety, psychologically egalitarian, strong in its faith in the government of law and in its support of authority against abuses by any section of the community. His first acceptance of the Alkali Acts with all their implications demonstrated his belief that workmen of his sort had nothing to fear either from above or below. He respected the strength of the men he employed. Asked to give a prize for a bicycle race at the works sports, he inquired the cost of a bicycle. 'Twenty pounds,' was the answer. 'All my men cannot buy a bicycle,' he answered, 'but they've all got feet. I shall give the prize, but they shall run for it.' And he made them all start from scratch.

With his Liberalism still unformed in his brain but with his ambitions orientated, Alfred followed his brother from Cheltenham to Cambridge. Cambridge put him on his feet, and at the same time drew him nearer his father. The company into which he drifted at St John's was made up largely of medical students, agnostic, speculative and fervent believers in the eventual triumph of scientific thought over faith of all kinds. With them the type of argument he had overheard at Winnington, the clear thought that Alfred had learnt to imitate, were immediately successful. For the first time he was in the company of people who appreciated him. He was not an attractive man. Indeed, he was so slovenly as to earn for himself the ironical nickname of 'Beau Mond'. He sat up half the night talking, he played endless poker and at the end of three years summed up the academic results of his Cambridge life in a telegram of one word—Ploughed.

But Alfred had learnt to think, to express himself; to find words, learnt under the exacting mental discipline of Ludwig Mond, for the intangibles that he and his friends so enjoyed discussing. And one summer evening, walking with his father

beside the Cam and listening to the nightingales that have now long since deserted the Backs, for the first time in his life he drew near to his father. Ludwig had been moved to talk of his own youth and the friends of his Heidelberg days. It was a short moment only, but several times afterwards, when father and son had relapsed into their usual estrangement, Ludwig would remark: 'I should like to hear the nightingales in Cambridge now.' Alfred had read the *Science Tripos* and failed. He was free to turn to law and politics. The works would have no need of him, it seemed. But Ludwig was too much of a patriarch to permit either of his sons to move permanently out of his orbit.

Life at 'The Poplars' continued in the tradition that Frida and Miss Herz had begun already at Winnington. Ever since the firm had been on its feet they had filled the Wyatt wing with company that they would find for themselves on their occasional visits to London. The composer Max Bruch and his wife had been tempted North for a long stay, during which there was music every evening, and every facility was given to him for working at his opera by day. Artists, some almost unknown, whom Miss Herz had met in some London studio, were invited to Winnington on the pretext of painting Ludwig and Frida. There is record of one who departed after many weeks of generous hospitality, having failed to catch the likeness of either, but leaving behind him a passable portrait of Miss Herz.

Ludwig was interested in the technique of painting; sometimes, too, he would sing for the benefit of his musical visitors in his bass voice that had remained unpractised since his bachelor days. His favourite song was Schumann's setting of Heine's 'Two Grenadiers', but he remembered his student songs too and still enjoyed part-singing. When he could be persuaded to relax, it was clear that none of his youthful enthusiasm was dead. But it was stimulated in particular by another acquaintance of Miss Herz's, who influenced him in a direction in which he was now ready to travel. For with a large fortune which he had amassed almost inadvertently when more concerned with chemicals than with money, he was now in the position to develop any interest that struck his fancy. Brunner

had gone into politics, Ludwig had his laboratory, but long years of work had told on him. He required some other, additional interest.

Professor Jean Paul Richter had come from Germany with a young wife and commissions to catalogue the art collections of two noble lords, also that in the Dulwich Gallery. Professional art historians were rare in England at that time; he began to contribute to the art journals; his book on the Ravenna mosaics confirmed his reputation; and soon he was an acknowledged authority whose opinion was valued even by the National Gallery authorities. Frida was introduced to him in London; Miss Herz came down to study under him for six months, and soon he was borne off with his complete family of children—for Frida made nothing of wholesale entertaining—to stay for some weeks at Winnington. She was a wonderful hostess.

This was in 1883, the year before the Monds moved South, when Professor Richter was just completing his massive edition of Leonardo da Vinci's notebooks. The art historian impressed Ludwig immediately. With his keen eye for talent in any field, he not only recognized Richter's qualities, but saw a way of employing them. Some chance—or perhaps calculated—remark of Mrs Richter's about the bareness of the Winnington walls set him thinking of collecting some pictures and employing his art historian friend to choose and buy them for him. For he had no intention of indulging his own taste; he had never embarked without expert guidance on any venture he did not understand. So when the Richters left after a very comfortable stay the highlight of which had been a charade party at which the ladies had dressed up, Frida as an Egyptian lady and Miss Herz as a nun, the art historian departed with a wealthy client in tow.

On his next visit, when the London move was already decided on, Richter and Ludwig drew up the terms of his commission; every picture bought must be worthy of a place in a public gallery. There were no limits set to the amount the Professor might spend on his client's behalf. Indeed the first two pictures which were hung at 'The Poplars' were among those finally left by Ludwig Mond to the National Gallery.

They were the 'Madonna and Child holding a Rose' by Sodoma and Fra Bartolomeo's 'Holy Family'. After this brilliant initial purchase Richter left for Italy, where he had not travelled before and where a number of Renaissance pictures were coming into the market. Settling first at Verona and then at Venice, he began to buy Veroneses and other paintings of the Venetian school, to be packed and sent to England. It was a time when prices, though considerably higher than those that the Prince Consort had paid for his pioneer collection of Primitives, had not reached the astronomical heights to which they were driven by Duveen and his American clientèle. Italian treasures were well within the reach of the German art historian backed by the profits of the ammonia-soda process.

It was not long before the Mondes themselves travelled South also. To Frida as a tireless Goethe enthusiast the land where the lemon trees flower had a natural lure. For three winters in succession they stayed in Florence; in the fourth, that of 1889, they pushed on to Rome. His Italian journeys did not represent any sort of temporary retirement on Ludwig's part. Telegrams passed backwards and forwards between his hotel and the works; a secretary was installed in his suite and members of the firm were often sent out to him to discuss important decisions; also, as it seemed to some of them, in order that their own horizons should be widened.

Mr Tangye, who had never been out of Britain before, was sent out to Rome in the winter of '91 to bring certain reports and samples, only to find when he arrived that, apart from a few hours' work in the morning, little was expected of him except that he should enjoy himself and see the city. By this time Ludwig Mond felt free to stay away for the whole of the winter months. He had already set up an establishment in the Italian capital, and was entertaining there as freely as he would in the spring and autumn in London. The company that visited him was largely Italian and partly scientific, partly artistic. He himself, with the years, attained a certain fluency in Italian; Frida and Miss Herz, on the other hand, came to talk the language well, and to mix freely in Italian society.

Not far from the top of the Spanish Steps, in the centre of

Rome, stood a derelict Palazzo, which had been built by the painter Zuccari on the profits he had made from a journey to England to paint Queen Elizabeth and her court. It was a wedge-shaped building on the sharp corner of the Via Gregoriana and the Via Sistina, and from its balcony, which overhung the main entrance, as well as from its upper windows, it offered a wide view over the city to the dome of St Peter's. The Mondes saw it on their walks about the city and, dilapidated though the place was, took the lease. The work of renovation began. Now Richter must find more pictures to cover the walls of this house too; and soon all the principal rooms were hung with Italian paintings, all of which fulfilled Ludwig's original instructions to Richter that everything he bought must be worthy of a public gallery. In addition there were fine pieces of Renaissance furniture to be found: cassoni, many drawered cabinets, and a magnificently painted spinet of the eighteenth century—now in the Fitzwilliam Museum at Cambridge—on which Frida loved to play.

Miss Herz, in addition, under the original influence of Richter, was making a collection of art books, which form the nucleus of the art library at present housed in the Palazzo under the title of the Herz Foundation. The pictures likewise have remained in Rome, and so choice were they that the finest of all, the Filippo Lippi, which came to London for the Italian Exhibition at the Royal Academy, was at one time 'borrowed' by Mussolini himself to decorate his study in the Palazzo Venezia.

Here, shortly before the war, Ludwig's grandson, the second Lord Melchett, was granted an audience with the Duce during which he had pleasure in congratulating him on the resemblance of his taste to his own grandfather's, since he had selected old Ludwig's favourite picture out of all the contents of the Roman galleries to hang in his own room. The Duce is said to have been a little taken aback by what was not intended to be a malicious remark. After Mussolini's fall the Filippo Lippi was returned to public view.

The Palazzo Zuccari was at first leased and then bought in Miss Herz's name. But the large music room, the pictures and

furniture, were all of Ludwig Mond's buying, and here he gathered round him a circle that he owed in part to his own scientific eminence and in part to his wife's and Miss Herz's patronage of the arts. Among the visitors to the Palazzo were d'Annunzio, Siegfried Wagner and Eleonora Duse, who were attracted less by extravagant hospitality—for the Monds were not lavish in display—than by the evident appreciation shown by this foreign scientist and his household for achievement in the arts. It was the tribute of a family that had made its fortune in a coarser way, and yet which remembered the middle-class respect for culture that had prevailed in the Cassel and Cologne of their youth.

The Monds were cosmopolitans with their roots still in the German *Aufklärungszeit*, in the days of the short-lived Jewish emancipation that had followed the Napoleonic standards. One evening in particular seemed to sum up the whole of their cultural heritage, an evening on which they assembled an orchestra in the music room of the Palazzo, to play a concert of certain lesser known works of Bach which they had never heard. It expressed everything, perhaps, that had gone to their making, except their Jewish origins, which in this second *Aufklärungszeit* it was perfectly possible to forget. Perfectly possible for all except perhaps for their son Alfred, a Wagnerian but no lover of Bach, who coming out to Rome to recover from pneumonia contracted at Edinburgh, was painfully aware of so much beauty from which he seemed to be shut out by his clumsiness and his Jewish features. He felt his own defects so strongly that he vowed he would never marry.

Under the impetus of the original flotation, the development of Brunner, Mond continued unhindered. In the year of Ludwig's removal to London the capital of the company was almost trebled. A works photograph of 1888 shows Ludwig, now bald but with as bushy a black beard as ever, sitting with his short legs thrust aggressively forward beside a fiercely leonine John Brunner, on the further side of whom sits the mild and relaxed Edward Milner. It is an interesting group which reveals all the contrasts between Cheshireman and German, between Jew and Quaker, between scientist and engineer, which were resolved by a common devotion to a

major industrial project. The dapper Merkel from Stuttgart, with his brooding, almost Mediterranean, good looks, and beside him Watts with the sweeping moustaches and somewhat lackadaisical air; the stocky Herbert Humphrey, Ludwig's future collaborator on the Gas Producer plant; Lowery, the first foreman of the works, so reliable in emergency, so careless over the details of everyday maintenance; Henry Schellhaas, with an untidy, rabbinical air and already putting on flesh; Tangye sitting on the ground with tousled hair and short powerful limbs, like a watchdog ready to spring: all are there among the sixty or seventy clerical, scientific and maintenance staff, standing or sitting grouped outside the heavily curtained windows of the Wyatt wing.

When that works photograph was taken the output of ammonia-soda was a hundred times greater than it had been in the company's first year; and with their fresh capital Brunner, Mond had bought more land from Lord Stanley further along the Weaver. They had also been compelled to purchase a tract of sunken marshland on the river itself as a dumping ground for their works refuse. For though the waste from ammonia-soda was innocuous when compared with the Le Blanc sludge which had been tipped about Widnes a quarter of a century before, it was nevertheless bulky and unsightly.

Developments were tremendous. In that year the firm had begun the manufacture of soda crystals, which had hitherto only been produced from Le Blanc soda. In addition to this washing soda, the experimental work on which had been done at Sandbach, Brunner, Mond were now making a refined sodium bicarbonate, under patents taken out by Mond and Jarmay, and in addition to that, caustic soda. In 1887 ammonium chloride was produced by a refrigeration process for several purposes, one of which was the manufacture of bleaching powder, the Le Blanc manufacturers' most valuable product on which their process was kept alive.

Other methods of working the ammonia-soda process had recently been tried by various companies in other parts of Cheshire. None of them, however, was thriving, and one at Middlewich was soon taken over by Brunner, Mond. Not

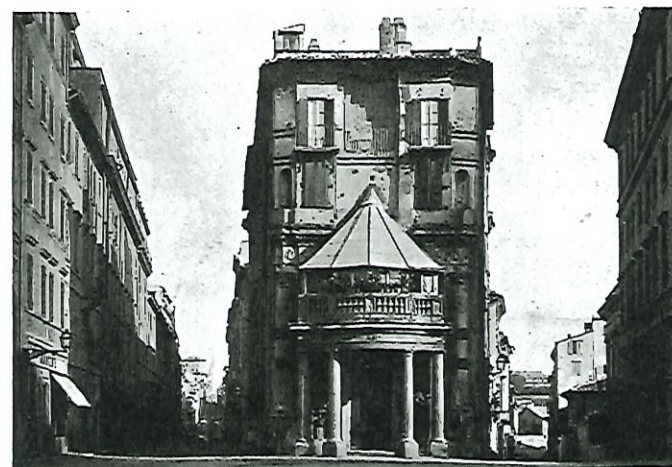
THE LIFE OF LUDWIG MOND

very long afterwards yet another nearby competitor was bought up and dismantled. In addition, moreover, to their Cheshire extensions the firm had opened a factory at Silver-town, in the London area, to supply the South with soda crystals and caustic soda. The proposal to start manufacturing outside the Cheshire area led to heavy opposition. The cost of rail freightage for the bulky soda crystals was high, and Ludwig Mond was strongly in favour of sending down the soda ash and adding the water near to the markets. John Brunner and others, however, opposed the decentralization of production. After a long argument, however, Ludwig won his point.

The Le Blanc manufacturers' only reply to this ceaseless expansion by their rivals was to rationalize; and in 1890 the United Alkali Company was formed to buy up the surviving works, to close the least efficient and concentrate production in the most up-to-date. Later they themselves built an ammonia-soda plant at Fleetwood, thus reading their own funeral service over what had been for so long a most thriving branch of the chemical industry.

Meanwhile the pulse of the huge Brunner, Mond concern continued to beat at the bottom of 'The Poplars' garden. Ludwig Mond had taken on as his personal assistant a pupil of the leading scientist, Viktor Meyer, the young Austrian, Carl Langer. Though still located in the stables where it had first started, this laboratory remained the chief Mond research station. Now with his son Robert, with Langer and with a German scientist, Friedrich Quincke, Ludwig Mond pursued his old search for methods of recovering valuable chemicals from fuels, ores and waste-products. The principal achievement of this new spell of research was the Mond nickel process which was the product of a line of research into certain problems that arose out of utilization of Power Gas.

The production of Mond Gas, which was obtained by burning coal at low temperatures in a mixture of air and steam, had already been developed on a practical scale at Winnington, where a large plant had been working this patent for some time. This gas, after yielding the ammonia needed for Mond's soda process, produced a gas of low calorific value, but capable of heating furnaces and working gas engines.



The Mond homes

1. The old house in Cassel
2. The Hollies, Farnworth
3. The Poplars, Avenue Road, Regents Park
4. The Palazzo Zuccari, Rome

The public launching of this Power Gas system was not undertaken by the Winnington firm but was sponsored by a company independent of Brunner, Mond—The Power Gas Corporation—which designed, manufactured and sold the equipment and also granted licences for the process in somewhat the same way as Ludwig Mond had done. The new gas had at first met with a cool reception from steel manufacturers and strong opposition, as a rival, from the town-gas industries.

Ludwig's statements that his gas could be generally employed in manufacture met with strong criticism from iron makers, who said that, owing to its low calorific value, it could never be used for making steel. With characteristic energy Ludwig immediately built a Siemens steel furnace at Winnington and made steel there for some weeks, inviting the steel makers to come and see it. Only then some steel makers in Scotland and in England erected Power Gas plants under licence to similar designs, prepared by Mr E. J. Duff, Chief Engineer of the United Alkali Company, who, with his firm, linked up their fortunes with The Power Gas Corporation, which was thus able to supply and build complete Mond Gas plants.

Ultimately, to help The Power Gas Corporation to widen its scope, Mond granted to the company the free use of his foreign patents as well as the British rights and this led to the extension of the Mond Gas principle in many countries overseas.

One important pioneer undertaking which might be looked upon as the first British gas grid was promoted by Mond at the turn of last century and statutory powers were obtained for a company, in which Ludwig was directly interested, for piping Mond Gas over an industrial area then called the Black Country. This first effort to break through entrenched town-gas interests was met with hostility. The gas undertakings in South Staffordshire sent eighteen learned counsel and several expert witnesses to prove the impracticability of the scheme and to safeguard their own rights. However, the advocates and witnesses in favour of the scheme were also distinguished and powerful men, including eminent scientists such as Lord

Kelvin, Sir James Dewar, Sir Richard Threlfall and Sir Frederick Bramwell. In the end the South Staffordshire Mond Gas Bill was passed by Parliament.

One shining factor in the situation to-day is that the old breach between town-gas and 'Power Gas' has been healed. 'Power Gas' serves the gas industry to-day and sells its gasification plants to town-gas companies to a degree once hardly thought to be possible.

This outstanding achievement has proved the value of the Mond Gas principle, for it has continued and expanded its services over half a century and it is now part of the nationalized gas undertaking. It has supplied gas for thousands of industrial furnaces requiring clean gas, particularly for metallurgical heat treatment. This includes malleable iron products which require a reducing flame, formerly produced by smoky fires. Mond Gas was clean and it served many purposes such as pumping for mine drainage, ceramics and glassware.

The fact that from the Staffordshire gas plant Mond Gas has been supplied for half a century to hundreds of works without interruption, through many miles of pipes, without storage plant, at the rate of millions of cubic feet of gas daily, in an area honeycombed with colliery workings, created an object lesson. It also illustrated a wider policy for the industry by overstepping barriers and rivalries which restricted development.

Ludwig Mond undoubtedly took an unduly optimistic view of his gas for power production. 'This paper', he said in 1900 during the discussion of his lieutenant Herbert A. Humphrey's lecture on 'Power Gas and Large Gas Engines for Central Electricity Stations', 'fitly closes the century of steam, and fitly inaugurates the century of Power Gas.' Here he was premature, for the steam engine forged ahead, and his Power Gas had to fight heavy opposition. The same thing said fifty years later would not have seemed so rash, in the days of the Power Gas turbine and the piping of low-grade gas made direct in the mine. However, The Power Gas Corporation ran into an early sea of trouble. It was eventually rescued, however, by Alfred Mond and by Mr W. Beswick, a young man whom

Ludwig's political son had met during an election campaign and brought down to London.

Perhaps the thought which led Ludwig Mond to the discovery of Mond Gas continued to work on in his mind and experiments were made for the development of a gas battery to turn gas directly into electricity without the intermediate stages of gas engines and generators. This was for the Victorian scientist a problem equivalent to the making of the philosopher's stone.

Ludwig's second principal problem, the costly one of bleach manufacture, had been carried one stage forward by the production of ammonium chloride, which has already been noted among the advances made by Brunner, Mond in the years following the company's first expansion. But the method was expensive, and experiments for its improvement, going hand in hand with those for the gas battery, were occupying 'The Poplars' laboratory in that vital autumn of 1888, when other and unexpected developments took place.

The gas battery was an old dream of the electro-chemist. The first cell was constructed by Mr Justice Grove in 1839. But Ludwig Mond's present purpose was to build a dry battery in which producer gas took the place of hydrogen. The difficulty was that the carbon monoxide and hydrocarbons in the gas destroyed the absorptive power of the platinum black coated electrode. Their removal, however, was possible if the gas were first passed over finely divided nickel at a temperature of 400° C., when it was converted into solid carbon and carbon dioxide. Ludwig and his fellow scientists had got so far with their investigations when discoveries involving nickel and carbon monoxide arising from this their ammonium chloride problem deflected their attention from the gas battery altogether.

One important factor holding up the production of cheap chlorine and bleaching powder from the ammonium chloride of the ammonia-soda process was the speedy deterioration of the nickel valves, and also the pellets of nickel oxide and china clay, employed in the decomposition of ammonium chloride. This deterioration was found to be the fault of the so-called inert gas used to blow the last of the ammonia out of the pipes,

which gas contained oxides of carbon. Therefore Mond and Langer set up an apparatus in 'The Poplars' laboratory to investigate this problem and, as a preliminary experiment, carbon monoxide was passed over finely divided nickel at a series of different temperatures over several days, during which, in order to keep the poisonous gas out of the laboratory, it was caught as it escaped and burned in a Bunsen burner. These tests were started up afresh each day, the experiment being discontinued in the evening, and the nickel being allowed to get cold.

One evening, however, in October 1889, the assistant who usually remained behind to close down the experiment had gone home early, and Langer himself was waiting for the flame to die down and the last of the carbon monoxide to be burnt, before locking up. It was the first time he had done so, and he was quite unprepared for what he saw. For as the apparatus cooled to about 150° , to his great surprise he saw the flame of the burner grow luminous, and increase in brightness until the temperature fell below 100° . Furthermore, from its normal blue it had turned a greenish yellow. At this point he called Ludwig Mond in to witness the phenomenon. At first the explanation seemed to be that there were some impurities in the materials. The sulphuric acid perhaps contained some arsenic, which was burning in the form of arsenic trihydride. But when Langer heated the glass tube through which the gas passed to the burner, a bright—not a dull—metallic mirror formed on the glass. A cold porcelain plate was held in the flame. The deposit that formed on it was clearly not arsenic but nickel.

This explained the disintegration of the nickel valves and pills during the manufacture of chlorine, and it led Mond and Langer to the discovery that nickel combines with carbon monoxide to form a tetracarbonyl, which is a colourless liquid boiling at 43° and solidifying at 25° to form needle-shaped crystals. But before Ludwig Mond could communicate his discovery to the *Journal of the Chemical Society* two further years' work were necessary, during which he and his team experimented with other metals and discovered also that iron makes two different carbonyls when treated in the same way but

under different conditions. The importance of this discovery of the carbonyls, which in the words of Lord Kelvin had given wings to the heavy metals, was that it made possible the extraction of nickel from the poorer ores. The distance between this laboratory discovery, however, and its commercial application was almost as long and difficult as that between the first working of Solvay's process and the flotation of Brunner, Mond & Co.

Ludwig Mond's discoveries and their large-scale application were beginning to bring him the rewards of public recognition. Hitherto his chief activities had been in connexion with the Society of Chemical Industry, of which he had twice been president, and of which he was for years Foreign Correspondent. He was also a fellow of the Chemical Society, and served as its vice-president, but when offered the presidency declined on the excuse of ill-health. He was active in Manchester, as a governor of Owens College, and later as a member of the University Court.

From that first paper at Norwich which had caused Frida to suffer pains of anticipation on his behalf, he had gone on to address a variety of public bodies on the subject of his various discoveries. As an impromptu speaker he was nervous, and he remained off the platform whenever he could. When he read a paper, however, he was not only cogent but philosophically venturesome. His treatment of the theme 'Necessity is the Mother of Invention' in his presidential address to the Society of Chemical Industry in 1889 shows that he was well aware of the long-term implications of the work he was doing.

If this has been the case in the past [he said in reference to that worn adage], I think it is no longer so in our days, since science has made us acquainted with the correlation of forces, teaching us what amount of energy we utilize, and how much we waste in our various methods for attaining certain objects, and indicating to us where, and in what direction, and how far, improvement is possible; and since the increase in our knowledge of the properties of matter enables us to form an opinion beforehand as to the substances we have available for obtaining a desired result, we can now foresee, in most cases, in what direction

progress in technology will move, and in consequence the inventor is now frequently in advance of the wants of his time. He may even create new wants, to my mind a distinct step in the development of human culture. It can then no longer be stated that Necessity is the mother of Invention; but I think it may truly be said that the steady methodical investigation of natural phenomena is the father of industrial progress.

Certainly invention since his day has produced new necessities. At the moment when he spoke those words the armaments race had not yet begun, nor had the advertising profession developed to the point of making men conscious of their lack of objects that hitherto they had easily done without. Ludwig Mond was thinking of the scientist as a man who could foresee and manufacture all that was needed for a better life. This filling of wants almost before the public was conscious of feeling them would, as he saw it, raise the standard of living, provide fresh incentives to more work and invention, and so lead into an era of peaceful trade and prosperity, which was the future that he and his generation expected.

Ludwig Mond was an optimist. He believed in what he had spent his life doing, and would have done his work with equal enthusiasm had its rewards been less. But had he known what misuse was to be made of the products of the scientist's laboratory, he would certainly have despaired, as he did when the exploding boiler scalded a man to death in the early days of Winnington, and as he did later when gas poisoning occurred at Clydach. In the first case he refused to allow any more high steam pressures to be used in his works; in the second he almost decided to close his nickel refinery down and return the shareholders their money. He was only deterred from this course by his sons, who saw that the trouble need never recur. Ludwig Mond was before everything a humanitarian.

In 1891, after the publication of his two papers on the carbonyls, Ludwig Mond was elected Fellow of the Royal Society, a rare honour for an industrialist, and in the next year he was made a Doctor of Science (*honoris causa*) of the University of Padua. The Italians' example was followed four years after that by his own University of Heidelberg, where he

had not stayed to take his degree, preferring as he put it at the time, or somewhat later, to wait until they gave him his doctorate on the strength of his work. Now he had attained his dearest wish.

Indeed, at the age of fifty-five Doctor Ludwig Mond appeared to have achieved everything that was within his grasp, everything to which he had looked forward as a distant aim in the days of his youth. Not only was he an acknowledged scientist, but he had gained acknowledgement in his own way, by the industrial path rather than in the laboratories of pure science. Moreover he had won a position of authority in a foreign land, a land in which no distinctions were made between Jew and Gentile. What was more, he had made life pleasant for his wife, his sons, and his nephews and nieces who were grouped around him. The Monds of Avenue Road and the Palazzo Zuccari were now well-known for their hospitality, their interests and their influence in many directions. Nevertheless they remained intellectually isolated, a family with a multitude of acquaintances but few intimate friends. The combination of the Doctor, as he now came to be called, a serious conversationalist who ignored or overrode any frivolous talk that might arise at his table, and his wife whose grasp of fact and theory was almost as thorough as his, though a little relieved by the contrast of Miss Herz, who was not entirely free from a sense of fun, tended to keep visitors at a formal distance. A meal at 'The Poplars' might be something of an ordeal. The house, which was heavily overfurnished in the mingled French and Italian style that was the fashion of the time, tended to turn any party into a somewhat formal occasion.

Frida Mond drew her guests from among struggling authors, musicians and painters; Alfred Sutro, the dramatist, Maurice Hewlett, in the years before his novels became successful, Arthur Symonds, a poet whose work did not sell in proportion to his reputation, and Israel Gollancz, a young scholar whom she backed over many years, were favourites with whom she would conduct learned argument from which Ludwig did not mind being excluded. He had little time for reading, and was too restless to apply himself to the study of anything that did

not bear on the problems of the moment. Frida, on the other hand, with her prodigious memory, had acquired a knowledge of Shakespeare as great as the knowledge of Goethe that she had gained as a girl. Without ever neglecting the details of her household, which she ruled with meticulous care for detail, she spared a great deal of time for reading, and not only kept abreast with Shakespearian scholarship but also followed up any interests then being pursued by her sons or her friends. Just as in her girlhood she had mastered sufficient science to keep Ludwig posted with news clipped from any periodicals he might have missed, so now she kept abreast of developments in a variety of fields; a practice which she pursued to the very last years of her life when, although she had been confined to her room for some years, she was able to discuss the subject of aeronautical engineering with the young pioneer of civil aviation, Herbert Brackley, who was engaged to her eldest grand-daughter. Frida Mond, in fact, conducted an intellectual existence on her own account, though not to the neglect of her household or her sons.

Among the acquaintances made during the early years of the Palazzo Zuccari was Sigismund Goetze, a young English painter, a protégé of the classical Pre-Raphaelite Alma Tadema, who came out with a letter of introduction, casually given him by a London friend. The Goetzes were a commercial family of German extraction, though English for several generations, who kept up a rather un-English enthusiasm for the arts, similar to that of the Monds. Their ancestors had been emigrant craftsmen, but the father was a coffee-broker in Mincing Lane and the mother, though not a professional pianist, had played at Philharmonic concerts when a girl. Unlike the Monds, however, they were not Jews; and unlike them also they were light-hearted, attractive, good-looking and, perhaps, like so many of the visitors to 'The Poplars' and the Palazzo, they were in the first place dazzled by the apparently limitless spending in which this serious family indulged.

The acquaintance, however, ripened. Back in London, Sigismund brought his fair and handsome sister Violet to Avenue Road. There were tennis parties. She sang, she

charmed the old gentleman, she made him laugh, she argued with him and refused to be snubbed, and as she did so she captivated first the susceptible Robert and then the shy and awkward Alfred, who was now following that 'sterile and uncreative occupation' as he called it, the Law. He had tried after coming down from Cambridge to work for his father at Winnington, but the experiment had lasted only a few weeks. Ludwig was quite reconciled, however, to his younger son's legal studies. For he needed an expert in patent law for the various ambitious schemes he now had in view. But Alfred did not care to confine himself to so narrow a field nor, having asserted his independence of his father by leaving Winnington, to surrender it again by becoming his expert on patents. His eyes were still fixed on a political career, and Violet Goetze with her charm, her social ambition and her agile mind was just the woman who could help him to it. Moreover he was deeply in love with her.

Soon the Goetzes were constant members of the Monds' entourage. They went up to Winnington, and Violet, after one look across the garden at the works, pulled down the blind. Not content with this, she told her future father-in-law what she had done. He was cross with her. 'The Works are my life's work,' he protested, 'and your bread and butter.' But Violet Goetze was irrepressible. She and her brother stand out from a large family photograph of Monds and Brunners, taken outside the Wyatt wing that spring, as visitants from another world, Sigismund leaning gracefully against the wall behind the rest, and Violet with her flimsy parasol in the front row, a strange and fashionable contrast to the well-upholstered sobriety of the second Mrs Brunner, of Miss Herz and Frida Mond.

Alfred Mond was slow to propose. He was twenty-four, and still deeply dissatisfied with himself, his appearance and his clumsy manners. He was gruff, with all his father's downright-ness but none of his cogency, none of his superb belief in his own judgement. Robert and Alfred followed the Goetzes to the South of France. At the Casino Alfred gambled and Violet stood behind him picking the numbers. 'That's right,' remarked a fellow gambler, 'follow your wife's advice.' On the

day before he left for Rome he told her of his love, but still had not the courage to propose. They had walked down the avenue on a carpet of fallen mimosa blossom. From the Palazzo Zuccari, perhaps after consulting his father, Alfred sent a letter of proposal. From her answer fell a bunch of pressed mimosa. 'I am going to marry the most beautiful woman in the world,' he told his grandfather Löwenthal, whom he visited in Cologne on his return journey. 'Everybody envies me,' he wrote to Violet. 'But how are you going to defend your action in marrying me?'

Alfred was earning very little from his practice. One could never tell with Ludwig what he would regard as necessary expenses in his sons, and what he would consider extravagance. At the University both had spent their allowances freely on books and drawings, according to their tastes, and had then to be supplied with small sums of money, or sometimes with actual parcels of food, by their worried mother. But when it came to the matter of setting a son and a daughter-in-law up in life, Ludwig had none of the closeness of his own father. Things had to be done in the style befitting a Mond; and though his daughter-in-law brought no dowry a house in Lowndes Square was furnished in the best of Edwardian taste, a contrast with its plain paint and mahogany, to the patterned wallpapers and ornate bric-à-brac of 'The Poplars'.

The Alfred Mond, despite the bridegroom's professed atheism, were married in church, and from All Saints, Hamilton Terrace, started on a social career which was to bring him to Cabinet rank and to the House of Lords, and her to an active life as hostess and organizer. The first effect of his marriage on Alfred was to send him back with renewed vigour to patent law. Soon his father was consulting him at all moments, convenient and inconvenient, of the day and night on matters concerning his projects. Doctor Mond was a tireless worker, but given to dozing in the afternoon. Then before dinner he would pick up his plans and schedules and send to fetch his sons or anyone else who was working with him at the time, for what might prove to be a discussion lasting far into the night.

Alfred had no defence from such summonses. He had no

clients, but purported in his Inner Temple chambers to be writing a book on patent law. Violet, however, made a journey to 'The Poplars' to protest to the 'Old Man' about her husband's frequent absences. Amenable to her, as he always was to a pretty young woman, he consented to monopolize his son rather less in future; and it was agreed when she left him that she could count more regularly on Alfred's company on future evenings. What is more, little by little Ludwig came to keep his word. His elder son, however, had no such protection. For he was still living at home, and was even more important to his father in consequence of his scientific training than the less practical Alfred, who was an expert in one field only.

Doctor Mond's real loss was the growing distance between himself and John Brunner, whose preoccupation with public life made him reluctant to undertake any further industrial ventures. The nickel discoveries came on Ludwig at a stage in his life when he was eager to repeat the triumphs of sulphur recovery and the ammonia-soda process. Mere production held no charms for him; money-making was an automatic and uninteresting pursuit. What fascinated him was the building up of new industries, the translation into steel and brick, gas and steam, main products and by-products, of the little sums and equations and formulae that he would still jot down on the backs of envelopes or on the pages of his notebooks. 'If a factory with an output of fifty tons a day costs so much to build, consumes so much coal, etc.' The working out of such sums on an industrial scale was worth more to him than any political achievements; and now he had to find fresh partners. Who were better fitted to work beside him than his own sons?

Robert Mond had gone from Sir William Thomson's Glasgow laboratory to Winnington. There for two years he studied various electro-chemical processes and the patents governing them. Then as a works chemist he turned his attention to the recovery of chlorine. Always pure science tempted him; always he kept his attention firmly directed on the practical problem. From the recovery of chlorine and ammonia he turned to the manufacture of pure zinc and chlorine, to the mercury cell and to his father's electrolytic zinc-chlorine process. While he lived at Winnington, he had

every comfort, and in his ample holidays came down to London, or to Rome and joined the family parties at the Palazzo Zuccari.

His father was generous but at the same time restrictive. Forgetting how he himself had hunted with his friend Hagemann, the forest ranger's son, he objected to his sons riding to hounds; it was no part of a scientist's life to ape the gentleman in that way. Robert, and Alfred on occasion, had consequently to keep their hunters out of their father's sight and to ride with the Cheshire pack by subterfuge. Neither was a good horseman, and both would come back to Winnington tired, wan and sometimes the worse for a fall. The servants had then to keep the secret of the young gentlemen's plight from their father. But for both the young men these stolen pleasures seemed worth while.

Robert quickly proved himself a laboratory man with little liking for actual works practice. Nevertheless when the company took over the leases of a number of abandoned lead zinc mines in North Wales it was he who opened them up and equipped them. After this, however, he was brought down to 'The Poplars' to work on the problems which afterwards led to the discovery of the carbonyls. Here he took little credit for what he did. Far quieter than his brother, he was content to leave the glory to his father and to the jealous Doctor Langer. In later life, in private conversation, he would admit that the discovery of the carbonyls was largely his work, but protest that it would hardly have been worth the unpleasantness of a dispute to assert his claim. He was not, however, self-effacing in every respect. Among his colleagues at Winnington he had the reputation for being wild and 'artistic'; and he was credited with having got himself into several scrapes from which his father, with the aid of other members of the family, had had to extricate him. There were stories of extravagant ladies, whose favours had cost him large sums. He was apparently not always the quiet, considerate, chess-playing musician of whom they had come to be fond.

He was thirty-one before he married a woman of whom his parents approved far more unreservedly than they had of Violet Goetze. Edith Levis was the daughter of a Jewish family

whose anglicization had gone a step or two further than that of the Monds. Robert had met her some years before, but had been snubbed when he called on her somewhat overbearing elder sister. His wife was an orphan, who had spent a great many years in Paris, studying art and listening to music, a young woman to whom many young men had addressed poems in German protesting their everlasting devotion in accents strongly reminiscent of Heine. The Levises were a Manchester family of rubber importers, who were allied with the von Fleischls (later Fletchers), with the Hechts and other families of Jewish trader-princes.

Edith herself was a Christian convert; her cousins, uncles and aunts, all people who had drifted further from the synagogue than from their German origins. For German was a second language with them all; and though they had reached the stage of taking for the season, or even purchasing, landed estates in Surrey, Kent and as far afield as Scotland, their house-parties consisted still of their own kind; they remained a still unassimilated enclave in a Gentile society, from which they were divided by their love for music, their German habit of family celebrations for which humorous verse was still manufactured in the mother tongue, and by a certain uneasy sardonic humour which jarred on their neighbours.

To the solid Victorian man of business it was natural that a man should either be an artist or a commercialist. The Hechts, von Fleischls and Levises, and to some extent the Monds themselves, endeavoured to be both. As artists, they were perhaps no more than appreciative patrons; as men of business they were both creative and successful. The Goetzes on the other hand, lacking the Jewish flair for business, had the culture without the means of indulging it. This was a difference that forcibly struck Ludwig and Frida Mond. Their new daughter-in-law did not look to them for support.

The house of Mr and Mrs Robert Mond in Berkeley Square was furnished, like Mr and Mrs Alfred Mond's, in impeccable mahogany varied with a piece or two of antique French furniture, the cult for which was to last only a few more years. Both his house and Alfred's were in the height of fashionable taste. Neither of them, however, had the individuality of 'The

Poplars', with its priceless Italian masters hung on embossed leather wallpapers, with its old family portraits, its over-carved and over-fringed furniture, its enormous set of red and gold Bohemian glass, specially manufactured for the King of Naples and bought by Ludwig at a sale in Italy. 'The Poplars' with its hideous medallioned garden front, looking on to its giant chestnut, with its acres of garden, with its butler and footmen, its secretaries and electric brougham, had a character that could not be rivalled by any more carefully decorated and more central mansion in Mayfair or St James's.

With his sons established, though in no real sense departed from the paternal house, Ludwig had still nephews and nieces and even unrelated protégés to manœuvre and fit to his interests, to benefit and control. In 1891 his father died in Cassel, an old man and still stubbornly preserving his independence of his wealthy son. Moritz Mond had retired from business a few years before, after receiving a very good offer for the old family house. Unknown to him the purchaser was his son, Ludwig, who arranged also for a very nice home for the old man and his housekeeper at Wilhelmhohe. Such kindnesses as Ludwig did him had to be performed by subterfuge even to the last.

A couple of years later Adolf Löwenthal died also, in the spa of Wiesbaden to which Ludwig had in the end persuaded his parents-in-law to retire, leaving his wife, Ludwig's first confidante and now a querulous old woman depending on her sons-in-law, to survive him by no more than a year or two. But Doctor Mond had also dependants of his own and his sons' generation. His sister Mathilde Mathias had lost her husband at an early age, and Ludwig was acting as guardian to her children; while his other nephew and niece, the son and daughter of his widowed brother-in-law Leopold Schweich, also looked to him as a guide.

Emil Schweich, his late sister Phinchen's eldest child, had admired him from over the Channel ever since the foundation of the Winnington factory. Ludwig had directed his education and, when he was old enough, brought him over to work as manager of the coke ovens and gas plant at Winnington. But after five years there the young Emil grew restive and left for

Jamaica to run a project for the extraction of dyes from log-wood. In this he was successful, and he returned to float a company in which his cousins bought shares and in which eventually his uncle and his father participated. Now, with his reputation enhanced, he came to play a larger part in Ludwig Mond's various ventures.

Emil Schweich, who later changed his name to Mond, had none of the brilliance of his cousins. He was a far safer man, a conventional man of business, who earned his cousin Robert's affectionate scorn for his perpetual anxieties over every trade setback and his renewed buoyancy each time the market recovered. Robert and Alfred had inherited their father's disregard for mere money-making. Both at various times in their lives heavily overspent on their favourite projects; both had their moments of skating close to insolvency. Both were confident, however, that with so much behind them the worst could never happen; and it never did.

The short and immaculate Emil had none of their abandon. As a director of Brunner, Mond's, he had the merit of acting as link between his uncle and the growing executive staff, many of whom went in awe of the 'Old Man', whom they seldom saw. On the family side Emil drew the links tighter by marrying Mrs Alfred Mond's sister Angela Goetze: and these same links were pulled even closer still when her artist brother Sigismund, through whom the connexion had originally been formed, married Emil's sister Constance Schweich, who lived almost as a daughter at 'The Poplars'.

Ludwig's German relatives provided him with yet another right-hand man. After serving in the German army, which he found infinitely displeasing, his nephew Robert Mathias, the son of his sister Mathilde, who had now remarried, turned to his uncle for advice and a job. 'I don't employ people merely because they are my relatives,' said Ludwig, 'but there is a problem that I should like to see solved. Great quantities of our soda are exported to India, Burma and to China; I should welcome a report on the use it is put to, also on the natural alkalis which are used by the natives for washing and the making of soap.' A meeting with Sir John Brunner was arranged, at which Robert Mathias informed him that his

uncle had suggested no salary for him since he did not think that so young a man could send reports useful to the Company. The Doctor's nephew was then hastily equipped for a Far Eastern journey.

Mathias sent regular reports and on his return suggested that Brunner, Mond & Co. should open their own offices and godowns in India and China, which they did. He received a cheque for £1,000 and all his expenses. Ludwig Mond then engaged him as his personal private secretary and for some years Robert formed part of the great Mond entourage. A man with a delightful sense of the ridiculous, and an imperfect mastery of the English language, he provided a gay contrast to the serious company at 'The Poplars'.

Ludwig's sense of responsibility caused him to watch over details of every kind in his relatives' lives. He carefully drew up a marriage settlement for his sister on her second marriage and set her second husband up in business; he protected the interests of his niece Thérèse Mathias when she married a gentleman, half-German, half-Arab, who was a representative of a German Bank in Egypt; he attended to the affairs of numerous first and second cousins, Goldschmidts, Katzes and Levys, who wrote to him from Germany at crises in their commercial existence. To all he was equally helpful; with all he was equally insistent that his advice should be followed to the letter if his financial help was expected, and with all of them he kept in such close touch that when the Hitler persecutions began twenty-four years after his death his surviving son Robert was able to bring two entire families to England and establish them there. Ludwig and Frida preserved complete genealogies of their families over many generations.

But not only were Mond relatives watched over. The complicated and unsatisfactory fortunes of Henriette Herz's relatives were followed with the same peremptory interest. One of her brothers was rescued from bankruptcy, and his student son's fees paid at a Polytechnic selected by Ludwig, so that the boy's education should not be interrupted by these family troubles. The town of Cassel was also the recipient of Doctor Mond's benevolence. For at his father's death he endowed its various Jewish charities in the old man's memory.



The Brunners and the Monds, 1898
Outside the Orangery at Winnington Hall during celebrations to mark the 25th Anniversary of the foundation of
Winnington Works

Front row, l. to r.: Miss Stodel, Mrs A. Mond, Miss Hertz, Dr Ludwig Mond, Mrs Mond, Lady Brunner, Sir John Brunner, Bart, Mrs J. F. L. Brunner, Mrs Broadbent, Miss Brunner, (unidentified)
Standing, l. to r.: Miss Nordlinger, Mr A. Mond, Mr E. Schweich, Miss Schweich, Miss E. Lewis, Mr R. Mond, Mr S. Goetze, Miss Mathias, Mr R. Brunner, Mr J. F. L. Brunner, Mr Broadbent, Mr Godfrey Brunner

Ludwig and Frida, however, were gradually turning away from Germany. To an old student-friend who had written to him out of the blue to ask for a loan, Ludwig wrote some three years after coming to London:

Even the enormous metropolis is no compensation for the old country. However great the advantage of position and fortune may be the feeling is that of a stranger in a foreign country. Relations with people brought up with different language, literary tastes and prejudices always remain formal and can never create true bonds of friendship. I have now been resident in Great Britain for 25 years. If my children were not of English birth and education, I might contemplate going back to Germany. I try to make up for this by travelling on the Continent, especially in the South (Italy). . . .

But despite this protestation to his old Korpsbruder, Ludwig's attachment was not to the Prussianized Germany of that day. The Germany in which his roots were sunk had been killed by Bismarck. German visitors to 'The Poplars' were rapidly outnumbered by Italians whose acquaintance he had made at the Palazzo Zuccari. Such Germans as came to Avenue Road were scientists, artists or Jewish connexions.

The younger Mond's went further in their anti-Prussianism than either of their parents. In Alfred's case this was to be explained by his wish, ever since childhood, to become absolutely English. In Robert's case it was rather a fastidious distaste for the abrupt manners and the argumentative insistence that he found in the Germans he met; later all his affection was reserved for France. But though both sons had made up their minds in youth that the average German was a barbarian, German still remained the language of their family festivities. As in the case of the Levises, humorous poems recited on birthdays were invariably in German, though the monstrous confections that served as birthday cakes were invariably the masterpieces of a French chef. Still, gradually Italy was taking the place of Germany in the Mond family's affections.

An excellent picture of Doctor Ludwig Mond's appearance and manner at this time is provided by the man who later

became his secretary, in succession to his nephew Robert Mathias, Alberto Cerasoli, who had been invited as a student of engineering by Miss Herz to the Villa Barberini, the former summer residence of the Popes overlooking the lake of Albano, where the Mondes were staying in the spring of 1892.

He was then in his 53rd year [he writes of his future principal], a noble and commanding figure, his eyes remarkably keen and scrutinizing, his figure ever moving and revealing an exuberant vigour. I had never seen such a *man* before, and I must say that I have never seen his equal since. He looked at my eyes for a few seconds, then apparently satisfied by this examination he asked me a series of questions about my studies, about the school organization in Italy, entering into the most minute details of how the various branches of science were taught, etc. I could see that he was a man to whom every side of human activity was intensely interesting, that he would see and scrutinize everything for himself.

Cerasoli was impressed by Ludwig Mond's direct manner of ascertaining the factual truth about anything that occupied his attention, and his disregard for what other people considered difficulties. The boy went over to England for some engineering experience, called at 'The Poplars' and found the 'Old Man' working at high pressure, surrounded by his sons, secretaries, chemists and engineers. He was himself, he ruefully concluded, an outsider. But Ludwig Mond had already taken his measure. Cerasoli returned to Rome, took his examinations, and then returned to England. After a few weeks he asked Ludwig Mond for a job, and was promptly sent up to Winnington, where he spent four years—a dull place, as he concluded, which was only lit up for him by Doctor Mond's occasional visits to superintend the erection of the new caustic soda and electrolytic zinc plants which were being put up by his old friend and chief engineer Henry Schellhaas.

Doctor Mond was the life and commanding spirit of the great Winnington works [Cerasoli continues]. His presence there was made manifest to everybody when in the morning the bell of the works was rung instead of the usual

steam whistle. At the ringing of that bell everyone was animated by a new spirit . . . no one of the 4,000 employees was to be seen for a moment away from his allotted task.

An emotion, which was part fear and part respect for this astonishing little man's achievement, animated the whole place. Ludwig Mond would move quickly followed by his entourage with plans, working drawings and schedules from place to place in the works. Each office would post a boy at some vantage point to watch for his arrival. But whatever he said, whatever decisions were reached, whatever rebukes administered, his voice was never raised, his guttural tones never rang out, to be overheard in any adjoining office. Then, the inspection concluded, the Doctor would return to the Wyatt wing, where the chiefs would be entertained to a dinner ordered and watched over by Frida, if she had come up with him on this occasion, or otherwise by the housekeeper. When the table was cleared a conference would begin, which would very probably continue until late into the night.

Sir John Brunner's visits were very different. With a ringing voice that echoed through the offices, or could be heard above the noise of the works, he would greet an old employee, ask news of another and relate an anecdote about a third. He was a master of the sometimes ill-timed theatrical gesture, and it was told of him that on one occasion when he had discovered the clerks working late into the evening, trying to trace a small discrepancy that was holding up the balancing of a ledger, he had dramatically sent the office boy home, and taken a seat on his stool. Then the great man had got down to the books, which had once been his concern, and had not got up till late, with the error still undiscovered.

There was respect for John Brunner. But he was a public figure about whom there were no mysteries. Ludwig Mond, on the other hand, was a legend in his own lifetime. Already apocryphal tales were told of his spectacular fits of anger, during one of which, in his early years, he was said to have thrown his broad-brimmed black hat on the ground and stamped on it. There was another story, according to which he had once sat on a brine tap for hours on end, at a time before the works had their own brine shafts, to prevent a local

salt manufacturer from drawing off the whole supply. The scene of this exploit would still be pointed out to the inquiring visitor.

In 1898 the company celebrated the twenty-fifth anniversary of the foundation of the Winnington works, and in honour of this event there were a series of entertainments lasting over several days. On June 7th the directors gave a dinner to MM. Ernest and Alfred Solvay and several other visitors from Belgium. All the pioneers of ammonia-soda were present in one room of the Wyatt wing. Then the next day a dinner was given at the Central Hall, Northwich, to some two hundred old servants of the company, present-day staff and foremen. This was followed one day later by a fête held in what remained of Winnington Park to all the workmen with their wives and children. This fête was arranged, on a speedy decision of Ludwig's, in a bare fortnight. 12,000 were present, and there was a gift for every child of a bag of sweets and a special souvenir mug bearing the portraits of the founders. The day began with the cutting of the first sod for a Recreation Club which Sir John Brunner and Doctor Mond were presenting to their workmen. Jubilees were in the air in 1898, and here some of Queen Victoria's subjects did not fall behind the Queen herself in the staging of theirs.

In his speech of reply to the thanks voiced by his men, Doctor Mond said that he felt strong and well enough to remain at the helm of the ship for another twenty-five years. He was now fifty-nine, and if he hoped to remain an active head of Brunner, Mond for only half that time the moment had now come to cut down his work. He was, however, in those very months, undertaking responsibilities which would double it. If soda was the making of Ludwig Mond, nickel hastened his death.

CHAPTER 7

NICKEL

THE discovery of the nickel carbonyl, as has been said, led Doctor Mond, Robert and Langer to undertake a series of experiments to discover what other metals combined with carbon monoxide in this way; they were more concerned with the new class of carbonyl compound than with its implications for nickel. The paper communicated by Doctor Mond to the Chemical Society did no more than record the manner of the discovery. Yet almost simultaneously he applied for a patent covering 'The Manufacture of Nickel'.

But, as he knew from his youth, of all the patents taken out only a very small number are really applicable to production; and as his knowledge then stood he was in no condition actually to embark on nickel manufacture. Here there was no Solvay with an experimental factory already at work. If he were to develop this new line he must start from the beginning. But this, in the inception, he had no intention of doing. He was, when the initial discovery was made, a man of forty-nine with an immense income from his own company. At best he could hope to add something to this company's fortunes or his own by taking a royalty on this new method of refining nickel, should it prove practicable. But even this was in the future.

His paper to the British Association in 1891 carried the sub-title 'and its Application in Arts and Manufactures'. But this was hardly justified by the bare final statement that 'these processes open up a wide perspective of useful application, considering the many valuable properties of nickel, especially its power of resisting atmospheric and other chemical influences'.

But the importance of nickel far outsoared such humble uses. A paper by Riley, the manager of a British firm which manufactured nickel on a small scale, had put the metal forward as the ideal toughener for steel, and though the idea had

not been taken up by the British Admiralty it was already known that the Americans were adopting it for the manufacture of armoured plate. Furthermore, though this opened up a far more restricted field of utility, nickel was recommended in many quarters as a substitute for the weighty and bulky copper coinage against which there was much agitation in several countries.

The future of nickel indeed was almost certain, and already the Canadian High Commissioner was canvassing the great European steel producers on behalf of his country's infant nickel industry. But it was doubtful whether the Canadian ores, in which the metal was found in combination with copper, could ever compete with the supplies which were then being drawn from Bohemia and New Caledonia. What Doctor Mond saw was a huge potential demand for nickel, and large deposits of ore without the means of easily and cheaply converting them to the metallic form, or to a form suitable for large-scale industrial use. What he did not know was that parallel experiments to his own by Colonel Thompson of the Orford Copper Company of Canada, then only in their development stage, would also succeed in revolutionizing the extraction processes, and separating the copper and the nickel on a successful and commercial scale.

Perhaps Doctor Mond had not even heard of the Orford experiments. Certainly he did not know, in the initial stages, that his was only one of two possible methods, and that the other was not only capable of making use of the Canadian ores, but had already the backing of the nickel interests in Canada. Moreover in the matter of cost there was little to choose between the two methods. It was not this time as it had been with Solvay and Le Blanc, the question of replacing an obsolete process by a new one. Of the two competing new developments, Doctor Mond's and Orford's, each might prove equally effective. But his, having the smaller backing, started with less prospect of success. Ludwig Mond started on his second great venture with the odds against him.

Having turned away from the general subject of the carbonyls, which was further pursued, however, by his son Robert, Doctor Mond worked out what he considered a

practicable method of refining nickel and offered it first to one after another of the English steel manufacturers and then to three concerns engaged in nickel refining. None of them was willing to take it up. This was a challenge to the man who had carried Solvay's ammonia-soda process through to success to repeat his achievement in middle life. He asked his partner, Sir John Brunner, to come in with him again on this new venture. But Sir John was immersed in politics. He made a tentative offer to join Doctor Mond, however, in return for a half-share in the profits. But his old partner had already promised Langer a considerable interest, and the half-share was not available. Sir John Brunner was perhaps glad to have this excuse for refusing to come back into business.

In 1892, therefore, Ludwig and Langer began to put up an experimental plant in a wooden shed on the premises of Henry Wiggin at Smethwick. This reproduced on a large scale the pilot plant which was already working at Avenue Road. Again there were days and nights of watching, of which Doctor Mond took his share. But the bulk of the experimental work at Smethwick was perforce left to Langer, who took something under three years to solve the chief production problems. His main achievement was to develop a method of recovering the bulk of the copper from the Canadian nickel-copper ores, leaving a residue from which the nickel could be extracted by the Mond carbonyl process, and from which could be recovered all the precious metals—iridium, platinum, palladium, gold and silver—contained in the ores. So it was that theirs became in every way an alternative to the still unpublicized Orford method, which wasted the by-products.

Mond's special problem was that of ore supplies, for the best process could be of no use to him if the supplies of ore were not available. He had still not resolved to embark on the mining or refining of nickel himself, but he engaged Doctor Mohr, a German mining engineer who had been general manager of the Rio Tinto mines in Spain, and sent him on a world tour of inspection to find deposits of nickel ores. Wiggin's own sources of supply were various, and their output of nickel by their own 'wet' process small.

Doctor Mond set out to be methodical. His expert Doctor Mohr's first journey was to see a mine in Silesia; but it was too small and its ore of too low a grade. Furthermore its owners tried to deceive him about its yield. Other possibilities in the Andes were ruled out by their inaccessibility. Norway and Griqualand, Greece and Madagascar were thought of but rejected. North America was the next choice, and Doctor Mohr went to Canada, where for the last twenty-five years several companies, the chief of which were the Orford and the Canadian Copper Company, had been working. In addition numerous prospectors had taken out licences in various parts of the country where there were unworked surface showings.

Mohr's report was exhaustive, but not on the whole encouraging. He found the Canadian nickel industry depressed. Increased production in the expectation of swift developments in nickel steel had led to the piling up of matte. For not only had the adoption of nickel steel hung fire, but such demand as there was for nickel was still largely supplied from France, where the New Caledonian ores were smelted and refined. This might have reacted in Doctor Mond's favour, now that he had worked out a way of separating the nickel from the copper which would put the Canadian supplies on an equal footing with those from the Pacific. But Mohr also brought news that Orford's had perfected their own method, of which Doctor Mond had not known in the inception.

Of all the properties which he had seen, Mohr pronounced only one to be really suitable and of lasting importance; this was in the Sudbury district of Northern Ontario, and most of it was held by the Canadian Copper Company. A lesser man than Ludwig Mond would have given in, and sold his patents for whatever they would fetch to one of the Canadian companies. But he firmly believed in the future expansion of the demand for nickel and in the value of his own process, which he was convinced would prove cheaper to work than Orford's.

In 1895, describing 'The History of My Process of Nickel Extraction', he stated his firm belief in his eventual success,

and in doing so made the boast that his alone was a purely chemical process.

Of late years [he protested] there has been a tendency to take chemical operations out of the hands of the chemist and to thrust them into those of the electrician, in the belief that the simplest way of obtaining a chemical change consists in the pulling apart of a chemical compound by electrical energy, and subsequently putting its constituents together again in the forms that are desired.

This seemed to Ludwig Mond in itself wrong. He was rooted in the age of chemistry, pure and simple; and he felt that there was some virtue inherent in a purely chemical method over and above that of one in which resort was made to strong-arm electrical methods, though he was himself interested in the electrolytic refining of zinc and copper. Winnington was in fact turning out the purest zinc on the market, though in small quantities.

His confidence in the superiority of his method was not shared by either of the Canadian companies with which he conducted protracted negotiations for the sale of his patents. Colonel Thompson of the Orford Copper Company was approached by Wiggin in 1896 and said that he was interested. It was he who had worked out the Orford method of separating the copper from the nickel, and he was now producing pure nickel by an electrolytic process at a refinery in New Jersey. Negotiations with him dragged on, and achieved no results. Doctor Mond then approached the Canadian company, who had no refinery of their own and sent their matte to Colonel Thompson for refining. There was some agitation in Canada at the time against the export of unrefined nickel, which seemed likely to work in Doctor Mond's favour. But after two years of discussions his process was rejected for a second time on the excuse that his claims were not substantiated.

This was, perhaps, only a bargaining device. The Canadian company was confident that they held the trump cards: a virtual monopoly of the available nickel deposits. But Doctor Mond took their refusal at its face value, and sent Langer and

Mohr on a second prospecting trip. Five years had elapsed since Mohr's first visit to Canada, and very little had changed in the meantime. Returning to the Sudbury district, they reported favourably on some properties held by a prospector by the name of Ricardo McConnell and certain of his friends. These would yield the minimum supplies of ore fixed by Doctor Mond, at a figure sufficient to provide a thousand tons of refined nickel a year. At this point he finally broke off negotiations with the Canadian company and, still without any capital except his own, resolved both to mine and to refine for himself.

This decision came as a surprise to his wife, his family and his associates. For only a few months before he had talked of leaving the enterprise to younger men. He had said this to the Rothschilds also, whom he had met in Paris in the previous spring, when he had tried to persuade them to take a licence to work his patents. 'I am too old to start a new industry,' he had stated. But the Rothschilds were interested in the French nickel company, which owned the New Caledonian mines, and refused. Doctor Mond was now resolved to go ahead himself. But before any mining could be done it would be necessary to open up the backwoods country in which McConnell's concession lay. Mohr estimated the probable yield at 200,000 tons; a mining engineer called in for a second opinion divided this figure by half, but the actual quantity of extractable ore proved to be four times that of Mohr's estimate.

McConnell was invited to London to negotiate with Doctor Mond, but by the time he arrived Ludwig had moved on to Rome. After some preliminary discussions with Alfred Mond in London the Canadian was therefore invited on to join the party at the Palazzo Zuccari. His reactions to the international society he found there are not recorded. But the negotiations were completed, and he returned to clear the backwoods he had sold, on behalf of their purchaser. Everything remained to be done. Plans and designs had to be made and discussed. The site for the smelting plant had to be decided upon; roads made; the position of the villages for the workmen's houses chosen; an aerial tramway from the mine to the smelter erected and water power had to be developed. More-

over exploration work and diamond drilling on a large scale had to be carried out in order to find the best position for the shafts for the two mines that it was decided to open up.

The nickel ores of Canada were discovered as early as 1856, but the region was then inaccessible and forbidding. However, in 1883 the Canadian Pacific Railway came that way, and a cutting revealed an extensive ore-body near Sudbury. Nowadays the extent of the deposit is so carefully mapped that its general shape—a long, thin, nickel-ore bowl filled with geological rubbish—is well known. When McConnell did his prospecting, he had little to guide him except norite outcrops and his prospector's hunches.

Norite—an igneous rock—had been found to be associated with the nickel ores and had been used as an indication of their presence. But prospector's hunches and a partly-fortuitous association were not enough for Ludwig: he wanted scientific proof that nickel was there before he went to the expense of diamond drilling to prove the deposits.

On his return from Norway, Doctor Mohr had brought with him Gudbrand Henriksen, a Government Inspector of Mines, to report personally to Doctor Mond at Rome. His reports about future prospects in Norway were disappointing, but his knowledge of prospecting techniques was most encouraging. For he knew the Swedish method of finding iron ore deposits by their effect in the mass on local disturbances in the earth's magnetic field. And though magnetite—the Swedish ore—was the well-known lodestone that had for centuries been used for compass needles and was strongly magnetic, on theoretical grounds pyrrhotite—the Sudbury nickel ore—should at least show some local effects on the compass, particularly on the dipping needle. So without more ado Gudbrand Henriksen was appointed pioneer in the now refined and invaluable technique of magnetic surveying and packed off to Canada in the middle of 1899.

For the next two years Henriksen experimented, mapped and, at Doctor Mond's behest, measured the electrical conductivity of supposed ore-bodies without coming to any definite conclusion whether the magnetic field or McConnell's

hunches gave the better prospect of success. However, results were not uninteresting, though there was some difficulty of interpretation. H. W. Hickson—Doctor Mond's technical representative in Canada—wrote in early 1901: 'The magnetic survey over this point shows great variation and resembles a storm-centre as plotted by the weather bureau,' but by the middle of the year, two Swedish experts—Karl Köjer and Erik Nyström—had also been engaged for the magnetic survey and Doctor Mohr, writing from Victoria Street as General Manager of the Mond Nickel Co., could say 'we have discussed the Magnetic Survey of the Garson property with Mr Köjer, who recommends the cutting of trial trenches . . . in the ore-bodies indicated by the Magnetic Surveys'.

McConnell went ahead with plans to get men, plant and camp equipment to the spot before the spring thaws held up communications. While the snow lasted sledge transport was practicable; but, in the absence of roads, transport by horse wagon over the rough ground was extremely difficult. By the end of June 1899, McConnell had cut and partially graded seven miles of wagon road, built and equipped accommodation for eighty-five persons, including a laboratory, a storehouse and a blacksmith's forge, sunk two shafts each over fifty feet deep, bored nine hundred feet by diamond drill, dealt with contractors, corresponded with lawyers and undertaken negotiations with the often elusive owners of additional properties which Doctor Mond wanted to purchase.

Now the Canadian Copper Company no longer stood in his way. When they saw that the Mond project was definitely going forward, they consented to sell him their eighth interest in a second property, the controlling interest in which belonged to McConnell. Purchases and development had by May 1899 cost Ludwig Mond some \$320,000, which in the event of his failure to float a company would have to be found out of his own fortune. But in addition to this expenditure, he was even now planning a smelting plant to be erected in Canada and a refinery for which a site would have to be found in the region of Swansea. For this part of South Wales combined the advantages of convenient port facilities and nearness to the anthracite coal deposits.

This time Ludwig Mond stayed at home, awaiting a report from Langer, Mohr, and his son Robert, who were driving about the district in a landau, looking for a suitable site. Twenty-six years before he and John Brunner had tramped the Weaver valley on a similar quest. Now, equally indomitable in his spirit, he was too tired a man to undertake the search for himself. Yet, though he might be longing for the repose of Rome or the South of France, he was still capable of tremendous bouts of work. A visit to Winnington would exhaust many of his younger executives before it would tell on the 'Old Man'. At 'The Poplars' too there would be all-day conferences over plans, drawings and alterations to plant, all of which would be drawn up by Schellhaas at Winnington and then submitted to the Doctor.

There was one occasion, when some such scheme was under consideration, that has been described by Robert Mond's sister-in-law, then an eighteen-year-old girl who had been invited to join a party which was just about to start for Winnington. When she arrived at Avenue Road about midday Ludwig and the two sons were deep in a discussion which had lasted all the morning. Every available surface in Doctor Mond's study was covered with huge plans and blueprints. The gentlemen did not break off for lunch, and in the early afternoon, the ladies getting nervous that they would miss the train at Euston, a footman was sent to knock at the study door and announce that time was short. Ludwig Mond hardly looked up from his papers. 'Send to Euston,' he said gruffly, 'and order me a special train for later this afternoon.'

In the brougham on the way to the station the discussion continued. The plans were half-folded, but still turned over at intervals, much to the ladies' discomfort, in the restricted space of the carriage. Once the party was in the train, the private carriage which was always reserved for Doctor Mond was overspread with the same plans and papers. Tea was served, but there was nowhere to put the tray down. At last Frida decided to interfere. Insisting that her husband had had nothing to eat since breakfast, she demanded that one corner of the table be cleared and ordered him to drink a cup of tea. She watched him, indeed, until he had finished it. This

was the younger Miss Levis's first introduction to the Mond's; it was one that she did not forget.

A site for the nickel refinery was found at Clydach, near Swansea; and once more Ludwig Mond bought an estate with a park and mansion. But this time it was Doctor Langer who was to live in the mansion, and it was Mrs Langer who cut the first turves on the new site in February 1900. But the responsibility for the design of the works to be erected was Ludwig Mond's, and much of the preliminary planning was done at Winnington. In this refinery the experiment which had brought such surprising results almost twelve years before was to be repeated on a continuous and monster scale.

The difficulties of promoting a company to take over Ludwig Mond's nickel interests were great. His first thought after finally breaking off negotiations with the Canadian Copper Company was to raise the capital he required privately through a South African mining concern. These people sent their own expert engineer to calculate the probable ore reserves in the Sudbury mines, and he reported that they had been greatly overestimated. By this time the younger men around Doctor Mond, particularly his secretary and nephew Robert Mathias, were advocating a direct approach to the public. But Doctor Mond knew little about the workings of the Stock Exchange, and was not easily persuaded.

It was not until the summer of 1899 that he felt free to plan his first visit to Canada, where he hoped to take part in some of the final negotiations with property owners and contractors. The first half of the year had been an extremely exhausting one for him. In addition to his long-distance supervision of the whole Canadian project, and his efforts to find capital for it, he had been making frequent visits not only to Winnington but to Clydach, where Doctor Langer was preparing for the erection of the refinery. But this was not all. His stay at Rome in the previous winter had been cut short. Residence at the Palazzo Zuccari, indeed, had hardly been a holiday, for often the whole day was spent in routine business, so heavy was the correspondence arising from the reports that daily reached him from his various concerns. It was not only nickel that claimed his attention. There was his white-

lead project, about which something will be said hereafter; there were alterations to plant at Winnington, and there were investigations into various electrolytic processes, on which experiments were going on at Winnington under the direction of Doctor Heinrich Hirz, another of Doctor Mond's German protégés; and there were also such cheerful occasions as the Garden Party at 'The Poplars' given for the Royal Society in the June of that year. Only a few days in March spent alone with Frida at Naples gave him a complete rest from his manifold activities.

Once back in London, he had to deal with the expansion of his Producer Gas interests, which involved the erection of two large plants, one at Winnington, the other in Birmingham. In the summer he took a house at Shanklin, Isle of Wight, and carried his work there with him. The early autumn of 1899 was cold, and he began to feel exhausted. Nevertheless he decided to visit Canada, and a few days at sea gave him fresh energy for the work to be done there.

When he arrived, he found that a railway saloon car had been placed at his disposal by the President of the Canadian Pacific Railway, to be used as his hotel during the whole of his trip. He had brought his son Robert and Doctor Mohr with him, and he immediately embarked on a fatiguing six weeks of constant travelling and interviews. He was faced with more discouraging reports from his mining experts on the probable yields of the Victoria mine. It was suggested that his company did not yet own sufficient mining property to put it on a sound business footing. He had consequently to authorize the purchase of another deposit and the taking of an option on yet one more.

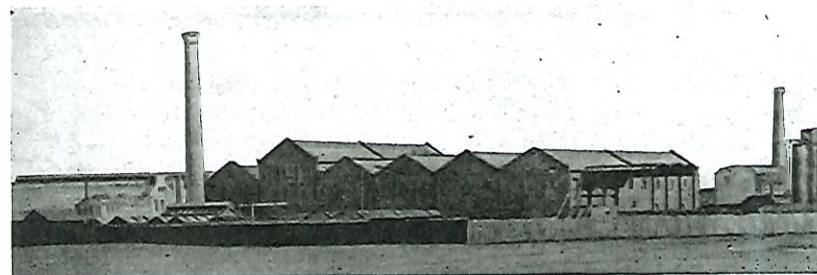
When Doctor Mond's saloon pulled up at the Victoria Mine Halt late one afternoon, Ludwig, complete with his broad black hat and long dust-coat, appeared at the door and shouted out in his still deep and powerful voice for a porter. The small party greeting him and Robert Mond on the platform swung round in surprise and Hiram Hickson, the mine manager, who was busy shaking hands all round, hurried up to see what was wrong.

Nothing was wrong, explained Ludwig, a trifle testily; he

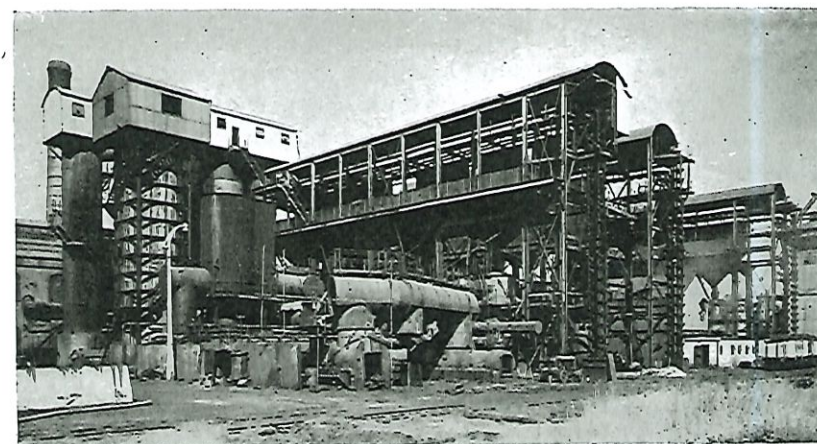
just wanted a porter for his big trunk which was very heavy. Hickson, without another word, went round to the luggage van and swung the huge trunk on to his shoulders, explaining, as he came back to Ludwig, that they didn't happen to keep porters at the halt. Then, with as courtly a bow as he could manage in the circumstances, he turned off and led the way to his newly built house.

Once there, the warmth and the rest cheered Ludwig and he began to look about him, admiring the wooden-frame house that was so comfortable and so suitable and yet so different from the solidity of the comfort to which he had been used. But there was one thing solid that caught his eye and pleased him—a huge monolithic fireplace hewn out of granite. The inquisitive Ludwig who had once asked what became of the wool when a hole appeared in a stocking suddenly sprang alive. How did so big a mass of rock get there . . . perhaps his host had carried that, too, on his back from the station? But the reply that he got was not one that he expected: the rock had been there since the ice age that left it. At first it had seemed an irritating obstacle to Hickson when he had been sitting his home. But, with a forthrightness that delighted Ludwig, he had made up his mind to use what Nature had so conveniently provided. So his masons dressed it roughly into a hearth and mantelpiece, and his carpenters had built his house to suit his fireplace.

But all the buildings of Sudbury could not afford Ludwig so warm and gracious a welcome. For one day the party came back, wet, worn out and cold, from a rough ride round the outcrops. As they rattled into Sudbury, they took refuge in the hotel and went into the bar, elbowing their way through the miners and drillers who thronged the room, to find seats in a quiet corner. Ludwig Mond, deep in discussion with Hickson, kept on his great black hat which he had pushed to the back of his head. But these discussions were rudely interrupted by the barman, who bellowed across the din: 'Remove your hat, sir! Can't you see there's a lady present.' Ludwig, taken aback, quickly slipped his hat off with a smiled apology. The forthright and burly Hickson, however, was having no affront to his guest, so put his own hat on and continued the



The Brimsdown Lead Works in 1905



The South Staffordshire Mond Gas Works

conversation. Finally, to the barman's insistent demands for its removal he replied, quite disarmingly, that he could not see anything wrong with his hat. Ludwig was getting uneasy, as he had a hatred of trouble. But the barman, realizing for the first time who his visitors were, became all smiles, apologies and charm.

Doctor Mond returned to England exhausted, and was compelled immediately to travel up to Winnington, to approve the alterations to be made to the plant at Lostock Gralam, near Northwich, which had been taken over by Brunner, Mond from a company that had failed to make a success of soda manufacture by a variant of the Solvay process. A day or two before Christmas he left with his family for Paris, to return in the new year looking better. But the fact that his looks were by now a subject of comment to his Italian secretary Alberto Cerasoli and his closest collaborators was a bad sign. He was by the turn of the century seriously overstraining himself. He had never been a good sleeper, and now he was suffering from spells of insomnia. His preoccupation with business never stopped, and during the night he would enter in a memorandum book, which he kept beside his bed, details of the matters with which he wished to deal in the morning.

On his return to England he prepared to set out for a late visit to Rome, but here he took no holiday. Evening drives in the Campagna and strolls on the Pincio with his friends, Doctor Cannizzaro and others of Italy's leading scientists, were things of the past. The Palazzo Zuccari that winter was no more than one huge office. There were final negotiations for the purchase of the additional mining deposits, final plans for the Canadian refinery and for the works at Clydach, the construction of which was begun in February 1900, and in addition, there were negotiations for the erection of the Mond Gas plant at Dudley Port, besides the taking out of new patents. Doctor Mond scarcely spared himself the time to attend a couple of concerts.

On returning to London he continued his programme of unrelenting work, never stopping until late into the night and not breaking off even on Sundays. It was a way of life that was sure to end in disaster, but the Doctor possessed the

energy to lead it, with occasional short breaks to gather strength, until the winter of 1902.

The Mond Nickel Company was formed in September 1900 and the shares offered on the Stock Exchange in May of the next year. Doctor Mond had asked for £600,000, and the subscription list was closed next day, heavily oversubscribed. Almost double the capital had been offered by an investing public to whom the name of Ludwig Mond spelt success and profits. The profits, however, were slow in coming. Doctor Mond himself was touchingly surprised by the power of his name to impress. For the business, the properties and about seventy patents, he received £325,000, more than four-fifths of which he had already spent out of his own pocket or on overdrafts from Parr's Bank personally guaranteed. The organization was at first almost a family concern. Ludwig Mond was chairman, his two sons directors and his nephew, Robert Mathias, the secretary. This last appointment he was reluctant to make, since he was always in two minds about using his influence for the benefit of his relatives. But Mr Mathias, who had first been his private secretary, had proved his value in the flotation of the company, for which he had taken the chief responsibility. He was rewarded, therefore, with the secretarial post, which carried with it the salary of no more than £400 a year.

The Victoria mine was ready for operation early in 1901, and later in the year the copper-nickel matte began to flow from the smelter. Work on the Clydach site, however, was held up. The plant and equipment were entirely novel, and this led to unavoidable delays of various sorts by the contractors. No nickel was produced until the spring of 1902.

The spring and summer of 1900 saw a continuation of Doctor Mond's almost deliberate overtaxing of his strength. Returning hurriedly from Rome with only his secretary, he moved feverishly during the hot months between Winnington, Clydach and London. The flotation of the Nickel Company was now only one of two major preoccupations, the second of which was the erection of a plant for his white-lead works at Brimsdown; and in addition to these he was faced in the

autumn with the re-erection of his Gas Producer plant at Winnington, which had been destroyed by fire.

Up to then white lead was produced by the old Dutch process, primitive beyond belief. The process vessels were crocks of some quart capacity, with a false bottom in the lower third. This bottom was filled with vinegar, while the top two-thirds was filled with strips of lead sheeting, carefully coiled, or hung from cross-bars at regular intervals. A layer of these crocks would be placed on the floor of a shed and surrounded up to the rims with fresh dung or spent tan-bark, and that layer covered with planking to act as a base for the next layer, and to keep the dung out of the pots. When the shed was full it would be left to heat up and react for two or three months.

The first action of the dung or spent tan-bark is to heat up, as it does in a garden compost heap. This evaporates the vinegar, the acetic acid of which attacks the lead to form various acetates. The carbon dioxide gas from the decomposition of the dung then attacks the lead acetate, forming a basic carbonate—white lead—while the acetic acid thus liberated converts further lead to acetate. How soon the white lead would be ready was a question that could only be decided by long experience: from the outside the metal might look thoroughly corroded, whereas only a thin layer might have been formed; if the carbonation was too prolonged, the white lead lost covering power. Once the foreman decided that conversion had gone far enough, the stack—which might contain many tons of white lead—was carefully broken down and the product first ground and sieved free from unchanged lead, then washed to remove any lead acetate, and finally dried. But in the garnering, and in the grinding and drying, a dust was formed which had a disastrous effect on the health of the workers.

The misery which its manufacture brought in its train—painter's colic, wrist-drop, general paralysis, blindness, depression, and suicide—to Ludwig far outweighed white lead's advantages to mankind. It was with interest, therefore, that he read one day of a new process patented by Professor Gustave Bischof. This was a neat and precise chemical process

and, as he quickly saw, could be made by adequate design quite dust-free and almost entirely innocuous.

The Bischof process, Ludwig at once saw, was a chemical process after his own heart. Its raw material was litharge—a readily obtainable lead oxide. This litharge was reduced with water-gas to form the black suboxide of lead. The black suboxide was then transferred to a blunger—something like a dough-mixer—where it was damped and oxidized with atmospheric air, to form lead hydroxide. From the blungers the hydroxide went to mixers where it was made into a slurry with water containing a little acetic acid, and carbonated with carbon dioxide from the air-blow of the water-gas plant. When carbonation had transformed the slurry of lead hydroxide into white lead, the slurry was filter-pressed and the water driven out of the filter-cake with linseed oil. This gave a white-lead paint ready for packing direct, untouched by human hand. Further, there was little or no dust with its attendant toxic risks.

Ludwig Mond picked on this process and called Professor Bischof for interview. The interview ended with Ludwig taking up the process more or less as a hobby, and as a relaxation from the more serious affairs of the Mond Nickel Company. This hobby proved a costly one—not from the point of view of money, which hardly affected Ludwig's fortune, but because of the inroads that it made on his health. For the process took many years to get on to a commercial footing and used far more of Ludwig's time and patience than he had bargained for; and that at a time when he could ill afford the additional demands on his constitution.

The pilot plant for the Brimsdown Lead Co. was set up at Willesden and Ludwig Mond engaged staff for it. And thither Professor Bischof repaired to work out the techniques of the process and the size and design of the apparatus required. Then the Professor would come to 'The Poplars' to report and to ask Ludwig's advice. Ludwig was then so busy that the only time he could spare was at week-ends. Much to Frida's and her family's annoyance, therefore, Bischof often appeared during the sacred English ritual of Sunday tea on the terrace. Ludwig would greet him heartily and, forgetting his family

and the great crowd of visitors, would lumber off with him to his study to look over Bischof's drawings and reports, issuing pithy comments, or scrawling untidily in pencil over the flowsheets and plant layouts.

As a research chemist at the salary of one hundred a year, he took on a young man who, like Mr Tangye, has recorded his first interview with the great industrialist and described the almost clairvoyant skill with which Doctor Mond solved the difficulties of production.

H. C. Bainbridge had comparatively little knowledge of chemistry when he was engaged by the Doctor as an assistant to Bischof. In fact when on his first day Bischof instructed him to analyse a sample of the Producer Gas on which the works were run, he had never made a gas analysis in his life, and had to talk himself out of his difficulty. But though he knew very little science he was a judge of men. From the first moment when the Doctor called in his electric brougham to announce that he had appointed this lad to the job and at the same time come to take him immediately to Willesden, young Bainbridge was impressed. On the drive, Doctor Mond sat beside him in the carriage, smoking his cigar and saying nothing.

When Dr Mond, massive from the head downwards, massive in hat, massive in mind, in face and body and heart too [Bainbridge wrote in his late middle age], came in his electric brougham to take me away, the game was up. I really hadn't a chance. At breakfast I was anything, but by lunchtime I was a fully fledged research chemist.

Ludwig Mond could convince a lad, if only temporarily, that it was his destiny to be a chemist, and young Bainbridge, despite his lack of chemical education, quickly learnt the principles of the white-lead process. He found that Bischof was in a mess. The difficulty was that his new process was almost as unpredictable as the old one. Sometimes a hundredweight, half a hundredweight, a quarter of a hundredweight of white lead overflowed the commercial standard kegs, and at other times it only half filled them. There were troubles, too, with the combination of linseed oil with the wet white-lead

cake as it came from the filter presses. Bischof worked extravagantly, and was often difficult to control.

But Doctor Mond relied on the ignorant young man he had appointed. He asked him to discover the cause of the difficulty, and young Bainbridge, with a preconceived answer in his head, produced a series of results, 75 per cent of which seemed to support his theory.

Cock-a-hoop, he set off for 'The Poplars' with the results of three months' work under his arm. Doctor Mond rejected his three-quarter proof, and sent him back for another three months to work out the reasons for that 25 per cent of cases that contradicted his theory. As a result a white lead was produced 50 per cent better in covering power than the standard product. Unfortunately it was not so easy for the painter to apply.

Naturally enough, there was prejudice against the new product. The covering power was called in question and there were many differences of opinion over this. Bischof devised an ingenious test to determine its efficacy; this consisted in painting exact weights of the various white leads on pieces of sized cardboard ruled with black lines. Little more than a glance was then necessary to show which of the paints obscured the black lines best.

Bainbridge became expert in this and in similar tests, and throws a further light on Ludwig's appreciation of the physical skills that he himself did not possess:

If his brain could master mine at every turn [wrote Bainbridge], in one respect I had the advantage over him. I had more brains in my hands than he.

When we had made a lead 50 per cent better in covering power than any other, we had to prove it to those who might be likely to buy it. At Dr Mond's instruction, I went off one day to the Home Office Laboratory, the head of which at the time was Dr Dupré. 'I have seen your panels,' Dr Mond told me, 'but these you have painted in your own laboratory using samples of paste chosen by yourself. Now you are going to Dr Dupré's laboratory and you will give him a sample of our lead and he will have others with which to compare it. He will put all these samples in front of you, and you won't know which is which, and then,

before him and his assistants, you will paint your panels and you and he will compare the results. I am making this quite clear because the experiments are purely manipulative—they depend primarily on the evenness of the coat you put on each and on the quickness with which you paint to avoid adsorption of oil in the wood. In a word they depend on the skill of your hand. Can you rely on this? I do not want to say too much, but very largely the whole future of the undertakings hangs on your panels.'

There may have been occasions, such as when accidents happened owing to carelessness, when Dr Mond thundered out what he had to say, but, if there were, I never witnessed them. Indeed, I sometimes marvelled at his composure. I have heard him, after a quarter of an hour's consideration, give instructions for thousands of pounds' worth of new machinery and apparatus to be thrown away as scrap. 'You have failed to note some essential condition in the experimental stage, that is all,' he would say, and he would say it without a murmur of complaint or censure, when, if I had been him, I should have lost my temper. But, calm as he was, his awe-inspiring personality diffused supreme authority and sometimes struck young men with confusion. It needed some nerve to merely meet him and take his instructions without losing one's head. I think it was the fact that Dr Mond could not paint those panels himself which gave me the assurance I needed. Anyway, when I sallied forth with my hardwood panels, eight inches by two, my paint brushes, and my sample, I felt like David setting out to slay the whole White Lead Caucus with one blow. And I did it.

That afternoon we proved, if I remember right, that ours was 75 per cent better than any white lead on the market and the results of that test are docketed in the Home Office Laboratory pigeon-holes to-day.

Undeterred by the losses he had made at Willesden, where expensive apparatus had had to be scrapped overnight, Ludwig Mond now sent his young protégé for a tour of England, to inspect the vegetation in the neighbourhood of every lead works in the kingdom. For the plot on which he was anxious to build a plant for Bischof was surrounded by market gardens, and before going ahead he wanted to be certain that

the fumes would not damage the vegetables as they grew. Bainbridge was given a roving commission and his expenses, and it was up to him not only to watch the smoke from factory chimneys, but to mark its trail and then run down and take specimens of the shrubs or grasses on to which it had blown. Furthermore, he was without any introduction to get an interview with the owner of each factory and elicit what information he could from him. He reported to Doctor Mond at the end of some enjoyable months that there would not be the least danger in his building a plant at Brimsdown.

This assignment, on top of Bainbridge's very useful service at Willesden, in the course of which he would himself descend into the vats to clean them when no workman would do so, would no doubt have earned the young man a valuable post in one of the Mond organizations. But unfortunately he had himself contracted the lead poisoning, the danger of which it was Doctor Bischof's claim to have abolished. So young Bainbridge took his next job in a healthier industry and became the London agent for the Russian jeweller Faberge. It is a curious fact that his reports to Ludwig Mond were for the most part written for him by an impecunious friend with a fluent style, one Frederick Rolfe, who afterwards wrote some extravagant novels under his assumed title of Frederick, Baron Corvo.

The pilot plant at Willesden had demonstrated that excellent white lead could be produced by Bischof's process at a cost no higher than that made by the Dutch process. Further, it was discovered at a time when the public conscience had been pricked to such an extent by the tragedies of the lead trade that by 1895 lead poisoning had become a notifiable disease, and four years later employment conditions in the white-lead and similar trades were rigidly fixed by law. The Board of Trade, however, so far recognized the innocuous nature of the Bischof process that the works were specifically exempted from statutory control.

--Ludwig now thought that the time had come for existing manufacturers to take up his process—but in vain. Vested interests and innate conservatism weighed the scales against the process, so Ludwig himself floated the Brimsdown White

Lead Co. John Brunner, the eldest son of his old partner, was chairman, and Robert Mathias, his nephew, a director, with H. A. Humphrey as the works manager.

It was several years before the Company became even a moderate commercial success, by which time substantial contracts from the Admiralty and other large users assured the future of their sales. The works continued in successful production, however, for a couple of decades, until rationalization and the formation of the Associated White Lead Co. ended the Mond interests in the concern.

Almost the only sample of Bischof's product still in existence is in St Paul's Cathedral. Ludwig Mond was at the time friendly with the painter Holman Hunt, whose 'Light of the World', which had been presented to Keble College, was the masterpiece of his youth. But the picture had caused Holman Hunt great grief. For when, some thirty years after it was painted, it was brought to London for exhibition, the surface was found to be in a lamentable condition. At Oxford it had been hung too near to some hot-water pipes. The painter, therefore, had been commissioned to restore his picture at great expense. But he was still not satisfied either with its condition or with its inaccessibility to the public. He decided, therefore, at the age of seventy, to paint a replica and impose conditions on its sale that would prevent its being hung in any but a public place. He still feared, nevertheless, that the same accident that had befallen the Keble version might happen to the second picture. The trouble, he knew, arose from defective priming. Ludwig Mond and he had very often discussed the chemistry of paints, a subject in which Holman Hunt was particularly interested in an epoch when most artists were beginning to neglect it. The majority of his contemporaries, indeed, were content to buy what they supposed to be standardized pigments from a colour-shop: a carelessness which has ruined the tones of many Impressionist and Post-Impressionist paintings. Holman Hunt, however, mixed his own colours; and Doctor Mond, as a chemist and an amateur of the arts, was able at times to help him with advice as to raw materials. It was to Doctor Mond, therefore, that Holman Hunt turned in his dilemma, and a small jar

of Bischof's White Lead was promptly despatched from Willesden to the artist's studio.

Holman Hunt approved of the material, and a special keg was prepared for him. The picture was painted, bought by the Rt Hon. Charles Booth, exhibited in various places, and finally hung in the Cathedral where its groundwork is, perhaps, the only monument to ten years of abortive work and considerable loss of capital by Doctor Mond.

The Bischof process displays a weakness in the approach to technological problems that was common to industrial chemists of Ludwig Mond's time. They tended to take their problems out of the laboratory at far too early a stage, and to set up machinery for large- or medium-scale production on the basis of no more than the establishment of a formula. His sulphur recovery had been taken straight from the attic of the Löwenthals' house at Cologne, to be offered as a practicable process to the leading Le Blanc manufacturers of four countries. Smits' Le Blanc works at Utrecht had been laid out regardless of the effects of winter weather, which held up production, and no tests had been made on the type of pyrites used preliminary to the buying of supplies. The delays and disasters of the early days at Winnington had arisen largely through the indiscriminate buying of standard apparatus unsuitable for the rigorous demands of a process that had not yet had time to settle down into economical production. Science was viewed at that time as a theoretical discipline, which should play the same part in an industrialist's education as the Latin and Greek he studied for his degree in a parson's. His practical training began, according to the half-formulated Victorian belief, at the moment when he attached himself to a particular branch, and applied himself to the problems of that branch at a manufacturing level.

The insufficiency of education of this kind was clear to Ludwig Mond from his own experience. For his nickel experiments he was employing foreign academic scientists, and the field of their research was for a long time only the converted stables behind his own house. The German academic scientist was, in his opinion, still the best-trained man in the world. But in Germany the climate of opinion had changed since

the time when his own masters Bunsen and Kolbe, with whom he remained in touch till the last, had interested themselves in problems of industrial application. A training in pure science was now considered a prerequisite to any post in industry, and the Professors were confining themselves to theory and education.

It was this early training in pure science that Ludwig Mond had missed. Halfway through his Heidelberg time he had decided what branch he was going to follow, and specialized accordingly. But from his first meetings with Professor Roscoe and Professor Frankland at Norwich, he had begun to interest himself in problems of pure research. He had encouraged his son Robert to work under Sir William Thomson, the future Lord Kelvin. But after 1891, when he was elected a Fellow of the Royal Society, he was brought even nearer to academic scientific circles.

He was by now quite certain that apprenticeship to an industry, or even courses of technological study in special laboratories or institutions, could never make a successful industrial chemist. This he stated in a speech at the opening of the Schorlemmer Laboratory for Organic Chemistry at Manchester in May 1895, in which he advised the students to give all their attention to the study of pure science without any thought for immediate practical results. His own generation had been too quick to lay down their textbooks, and translate what they had learnt into terms of works chimneys and waste tips.

Opportunities for pure research were not sufficient, nor were there laboratories available for the work which was waiting to be done. Ludwig Mond decided, therefore, to repay the honour done to him, an industrialist of foreign birth, on his election to the Royal Society, by erecting and endowing a laboratory, the establishment of which had been recommended as long ago as 1843, when the foundation of a school of practical chemistry at the Royal Institution had been proposed, but rejected owing to lack of space.

I have felt that the need for such a laboratory [said Ludwig Mond to the assembled members of the Royal Society on the occasion of his formal offer of this gift, on

July 2nd, 1894] has become greater and greater since the work of the scientific investigator has become more and more subtle and exact, and in consequence requires instruments of precision and a variety of facilities which a private laboratory can only very rarely command; and surely this need exists nowhere to a greater extent than in England, and nowhere can such a laboratory be expected to bear more abundant fruit than in the country which possesses such an unrivalled record of great scientific researches, and amongst which the laboratories of the Royal Institution stand foremost.

For the purpose of this foundation, which he named after two of England's greatest scientists, the Davy-Faraday Laboratory, Ludwig Mond had bought the house adjoining the Institution's premises in Albemarle Street, Piccadilly, once Lord Albemarle's town mansion, the principal rooms of which were suitable for a library, and the upper and lower floors for conversion into a number of small laboratories, each of which could be separately equipped for individual works of research.

So many research workers were eager to avail themselves of the Davy-Faraday foundation that, generous though the gift was, it still did not meet the need that existed for the national encouragement of science, as Norman Lockyer, the astronomer and a friend of Doctor Mond's, pointed out in his article in *Nature*, acknowledging it. For many industrial firms on the Continent, as he pointed out, possessed research laboratories still larger than those about to be established.

Not content merely to present a building, Doctor Mond equipped it with the most up-to-date apparatus, prior to the selection of which he sent his son Robert on a world-tour of inspection of the laboratories of Europe and the United States. The cost of this gift to the country of his adoption was £45,000, and he added to this an endowment of a further £62,000. In doing so, he made the purpose of this foundation perfectly clear; he wished to make it possible for scientists of any nation to pursue their researches inexpensively in London, and he hoped by this means to attract first-class men.

The first to take advantage of the Davy-Faraday foundation was his own friend Sir James Dewar, who moved into the flat

in the upper storey of the Royal Institution and in the laboratory below pursued his researches into the liquefaction of air and of hydrogen, for the pursuit of which Doctor Mond made a series of further grants. These pursuits of Sir James Dewar quickly filled up a great deal of the available accommodation, and eventually prevented the laboratory's being used for the international purposes which its founder had envisaged. But Sir James persisted, and at a later date Robert Mond resigned from the board of management to protest against what he viewed as the violation of his father's wishes.

By another timely endowment Doctor Mond was able to simplify a task which was becoming increasingly tiresome to scientific workers. The quantity of technical publications had vastly grown since the day when he had himself been kept abreast of contemporary developments by means of newspaper cuttings, or translations made for him by Frida, her friends or her mother. Now he had again and again to remind his assistants that they must find out all that had been done and written in the field in which they were working or they might toilfully elaborate and patent a process that had been tested and abandoned years before. He gave a further £14,000, therefore, to the Royal Society to defray the cost of the regular compilation of a catalogue of international scientific literature, to be available for general consultation. His were not benefactions made out of ostentation; they were the results of Ludwig Mond's own experience as a scientist, and he applied as much thought to the details of their use as he would do to minutiae of any of his own enterprises.

Great as was Ludwig Mond's fortune it was only at moments such as this that he stood out as a very rich man. For the rest he appeared to those who knew him rather as a man of taste and knowledge than as one who was in the first place a millionaire. He had never felt tempted to move into Park Lane and emulate the Sassoons, the Barings or the Rothschilds; he had no country estate, kept no racing stable and no yacht. He aspired to no seat in the House of Lords. Indeed, when the question of a peerage was unofficially raised he replied that such honours were not for foreigners like himself; he was content to have earned himself a Fellowship of the Royal Society.

But if Ludwig Mond did not strike a stranger at first sight as a rich man, in the way that a Joel or a Barnato might, it was quickly obvious that he had surrounded himself with precious things, and that these belonged to him, as of right. It is true that the pictures Richter had bought for him hung in no specially built gallery, but merely on the walls of the living rooms at 'The Poplars'. But this showed no under-assessment of their beauty; rather it proved that he loved to have them about him in his daily life. His small Titian of the Virgin and Child grew dearer to him as his eyesight grew weaker with old age; and frequently he would stop his habitual march up and down the room to gaze closely and affectionately into its quiet depths. These pictures were his, because he loved them. Money had come to him through his efforts to make things, to cheapen manufacture, to save waste; and he had spent his money in this way, on acquiring possessions that he valued.

The flotation of the Mond Nickel Company left both his sons free to pursue their own ways. Both held directorships in their father's companies; both were available for consultation at any juncture. But it was clear that neither Winnington nor Clydach could absorb the interests of these two ambitious men whose talents in some ways stretched beyond their father's. Robert continued with the investigation of the carbonyls, and undertook various researches in collaboration with his father's assistants. But a sudden illness in 1902 made it necessary for him to spend the next three winters in Egypt, and he was quickly seized with a passion for Egyptology. Almost on his first arrival he provided money for the repair of a royal tomb; and very soon he had bought the concession to excavate the Theban cemetery, which he held for twenty years, and which he surrendered to the University of Liverpool only when Egyptian legislation made it necessary for him to hold it not privately but as the nominee of a scientific society. He himself took part in the digging of tombs in the company of the leading Egyptologists, whose work he financed, and for the purposes of recording their finds he perfected one of the earliest processes of colour photography. This passion of his was perhaps no more than an extension of his interest in the arts

that he had acquired during the collection of his father's pictures. He himself had made a more modest collection of Old Master drawings, the first of which had been bought out of his student allowance in his days at Cambridge and in Edinburgh. Now to these were added antiquities, Egyptian, Greek, Etruscan and Chinese, selected rather for their beauty than for their purely historical interest. Ludwig Mond watched the beginnings of these new interests in his eldest son with patience. Egyptologists and others of Robert's new friends would be invited to the giant garden parties at 'The Poplars'. Ludwig knew that Robert remained at his side even though his approach to industry remained that of the pure scientist and man of culture that he was.

The tradition of the Levinsohns was still strong in the ageing industrialist. It did not seem to him wrong that the money one generation had amassed should be spent by the next on pursuits that could bring no financial advantage. Many a wealthy industrialist has wished to make gentlemen of his sons. But the conception of a rise in class did not occur to Ludwig Mond. He had been content in the past to describe himself as a workman, and for a workman there was always the possibility of becoming a master. To become a master meant for him additional responsibilities and an additional income; it did not involve a change in cultural outlook. For a workman, of the sort that he had been, had not been cut off from the things of the spirit: from music, reading and pictures. To become a nobleman, a landowner, involved a far greater change, which was, to Ludwig's mind, impossible for a Jew with a continental liberal background; nor was such a change of status much to be sighed after. For with his patriarchal influence, his pictures, his palace at Rome, his house in London and the works at Winnington, Doctor Mond had all that he, or any nobleman, could desire.

With his son Alfred's ambitions the 'Old Man' had, on the whole, less sympathy than with Robert's. He proclaimed himself now a Conservative, and his younger son had decided to stand for Parliament in the Liberal interest. No sooner had he got his father's neglected financial arrangements into some sort of order than he was elected treasurer of the Free Trade

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Union. In 1900 he stood for Salford, and failed to win the seat. Backed by his wife, however, he had fought the election well. Himself anxious, and dreading each public speech he had to make, he found in her a woman of charm and organizing ability, who was almost capable of fighting the election single-handed. Intellectually Alfred Mond was bold; he declared himself in principle against the Boer War, though he admitted that once started, it had now got to be fought to the finish. He attacked the selfishness of the South African mining magnates, however, and came out also as a Temperance Reformer. His Liberalism was, nevertheless, of a very moderate nature, as it had been even in the days when he found Sir John Brunner's arguments too radical for him. It was a Liberalism, however, that was to get him into Parliament in the landslide of 1906, and to win him the backing of David Lloyd George, at that time a more resolute opponent of the war than he.

Alfred's political career, his talk about the necessity for efficiency and thoroughness in the running of the country, aroused no great enthusiasm in the ageing industrialist. Alfred's Liberal friends were welcomed, of course, just as were Robert's Egyptologists, at the garden parties at 'The Poplars'. But it did not occur to Ludwig that his younger son was merely proposing to apply on a national scale some of the innovations that he had introduced at Winnington. The Popular Budgets, Housing and Factory Acts, Health Insurance, Unemployment Insurance and extension of the franchise: all these measures which were discussed between Alfred and his friends should have appealed to the old pioneer of shorter hours, holidays with pay and good housing, who was also the founder of the Co-operative store in the Solvay Road. Ludwig Mond was glad to see his son cutting a figure in the world. But it did not seem to him that seats in Parliament were more valuable than seats on the boards of his own companies, which his sons possessed already. Alfred had, however, given him a male heir; Robert was the father of two daughters.

The flotation of the Mond Nickel Company gave Doctor Mond no respite in his activity. In August 1900 he had taken a short holiday in Switzerland, from which he hastily returned



The Mond Nickel Refinery at Clydach, near Swansea



The Victoria Mine, Sudbury

on receiving news of the disastrous fire in the gas plant at Winnington. Throughout the autumn he was making hurried visits to the Wyatt wing, where plans for the rebuilding were laid before him. At 'The Poplars' his study remained, as ever, covered with plans and estimates. The smelting works at the Victoria mines at Denison in Ontario had to be pored over: Ludwig wanted to put in a Bessemer plant to produce an 80 per cent copper-nickel matte and the Canadians wanted a 20 per cent matte. On top of all this, conflicting reports of the ore reserves at Denison had to be resolved, and his pioneer technique of magnetic traverses was producing maps that only served to make confusion worse confounded: for Ludwig and his staff in London had not then sufficient experience to be able to interpret the voluminous magnetic data sent over from Canada by their two Norwegian surveyors.

The study at 'The Poplars' was a bustle of practical activity: in the laboratory in the old stables a serener atmosphere prevailed, where a series of experiments in an entirely different field was being carried out. Here, under the direction of Doctor Shields, whom he had put in charge as Doctor Langer's successor, investigations of a more theoretical nature into the flame temperatures of various gases, burnt in air and in oxygen, on the rate of diffusion of gases and on the iron carbonyls were occupying the remainder of Doctor Mond's attention. He felt too tired to leave England, but reluctant to stay in London through the cold and fogs of December. He migrated, therefore, to the Lansdowne Grove Hotel at Bath which he found an even more convenient centre than London for journeys to Clydach, to Winnington, to Dudley Port and even back to 'The Poplars'.

But at Christmas itself he gave himself up to the pleasures of a family party. There were his sons and their wives, his nephews, his nieces, Miss Herz and a Goldschmidt niece, Sir James and Lady Dewar, Arthur Symons and his wife. There was hardly any room in the hotel for other guests; and so much was the place given over to the Mond party that the Doctor sent for his own French chef from 'The Poplars' to superintend the meals and add those touches that were beyond the talents of the capable Bath cooks. The Frenchman's

especial creation was a gigantic and elaborate Christmas cake, of the kind that he habitually made for the Christmas parties in Rome. The Doctor also procured a large Christmas tree, from beneath which Christmas presents were dispensed, according to the German fashion, on Christmas Eve, at a party for which a band and a party of carol singers were engaged.

But if these were his permanent guests others came and went during the holiday. His secretary Cerasoli made several visits; engineers and other experts came over with plans for the Mond Gas Company's plant, and he had a visit from Norman (afterwards Sir Norman) Lockyer, with whom he enjoyed great dinner and after-dinner discussions on Space, Time, the Stars and the Nature of the Universe. It was on such occasions that Miss Herz, too, was at her best. For in conversation like this the boundaries of science seemed to expand and to leave room for wonder, and it was at that frontier that the Doctor's mind met hers.

Doctor Mond's speculative mind ranged in other directions as well on that holiday. He had never before had leisure to look at the city's Roman remains. But after a single inspection of the Baths, his mind turned rapidly away from history into its usual scientific channels. When, he demanded, had the most recent analysis been made of the thermal gases and waters of the spring. One of his chemists and his secretary were commissioned to find out, and they could only report that the Romans had been the last people to take much interest in the matter, and that they had no doubt their own scientific methods of testing, which had now been forgotten.

This rather dubious statement did not satisfy Doctor Mond. He asked Sir James Dewar, therefore, who was fortunately a member of his party, to make a proper analysis, and undertook to pay the expenses. Sir James had recently discovered the existence of helium, and had since then been working at the Davy-Faraday Laboratory on the problems of liquid air. But he was readily persuaded to turn his attention to this comparatively simple matter. The authorities of the spa readily gave their permission, and the Roman bath was then roofed over with canvas, and a gasholder placed over the top to collect the hot gases. But before this could be done consider-

able scaffolding had to be erected. The experiment took quite a time to carry out. But in due course cylinders of compressed gas were sent up to the Davy-Faraday Laboratory where the analysis was made, and various rare gases were discovered in the waters, including small quantities of helium itself. In addition the degree of the water's radio-activity was determined. This, certainly the first scientific analysis of the Bath waters since Roman times, and probably the first in their history, cost between five and six thousand pounds.

It was not till mid-February that Doctor Mond, with his departure for Rome, interrupted an almost continuous rush of work, which had gone on, wherever he was, for almost two entire years. Yet even during the couple of months that he spent at the Palazzo Zuccari there were several visitors from England and from Canada with whom he spent long hours in his study. But here in Rome for the first time for these two years he did the round of the museums and the art exhibitions, attended the concerts of the Bach Society, which he himself sponsored, walked on the Pincio, drove into the Campagna and entertained his Italian friends, who were such a delight to him. Perhaps he was beginning to mellow now. Once he had said, when reminded of one of his projects that had not succeeded: 'I hate my failures.' Now, when speaking of the gas battery, and his enormously expensive attempts to make chlorine from the waste chloride of the ammonia-soda process, he would say, almost with a grin: 'I have enjoyed my little failures.'

Neither relaxation nor mellowing, however, were enough to restore his physical health. For some months, his secretary and all those who knew him best had been commenting on his tired appearance. A return to London plunged him immediately into the business of yet another company formation. It was time now for his Producer Gas interests to be brought together under a single head.

It was necessary, too, to arrange for Central London offices for all his three companies, a measure that he had hitherto opposed. He worked on through the spring and at an increasing tempo in the early summer, in order that he might get away to Switzerland in August for a few weeks' rest. This he

did, and here once more he was able to break off the train of his activities. There was still a great deal of resilience in him, and the walks and drives he took in the hills around Disentis gave him the strength to work on at the old pressure for yet another eighteen months.

At Disentis he was joined by his son Robert and his daughter-in-law, who accompanied him to Berlin to attend the wedding of his niece, Fräulein Mathias, to her Egyptian banker. It was a match that gave him great anxiety, owing to the entirely different origin and upbringing of the pair. But, assuming his usual patriarchal responsibility, he made all the arrangements for the wedding, and in order to be present paid his first visit to the Prussian capital for many years. It left him with no regrets that he had chosen to work in England. Increasingly as the years went on he grew to distrust the new rulers of Germany. His partiality during the war of 1870 had turned to open dislike by the time of the Kaiser's telegram to President Kruger. Ludwig Mond shared none of his son Alfred's scruples on the subject of the Boer War.

Back in London, Ludwig was once more sucked back by his manifold interests. Everything had to be attended to at top speed, since he had decided to take another trip to Canada in November. The Victoria mine had begun to yield ore in February, and by August copper-nickel matte had begun to pile up at the smelter. The Clydach refinery, however, was still not completed, and it was not for another six months that the first nickel and the first copper sulphate were despatched from Clydach.

This second Canadian trip was rather a tour of inspection than a visit for the making of important decisions. It was essential to prevent the slow start of his company from arousing any doubts in official quarters as to its eventual success. Doctor Mond, therefore, took care to meet every influential person that he could. An hour with this forceful old man was calculated to remove all misgivings on the subject of the Mond Nickel Company's future. At New York he was welcomed by the American section of the Society of Chemical Industry; in Canada he met ministers, bankers and industrialists, and left an atmosphere of confidence behind him.

On his return, though he longed to go to Rome, he felt unable to leave the country till the Clydach works had started production. He spent the winter, therefore, once more at Bath, from which he made weekly visits to South Wales. When in the end he decided to go to the Palazzo, if only for six weeks, he found himself even there resolving scientific problems. For various of his Italian friends were investigating such different questions as the action of cyanic acid on wood and the furniture beetle, and the causes and prevention of the corrosion of bronze. Into these pursuits he threw himself with apparently inexhaustible energy.

Nickel experiments and work on the carbonyls were also being conducted by Italian scientists, and Ludwig Mond found time to examine their findings. In addition to this he presented valuable laboratory equipment to the Universities of Rome and Padua, and gave some time and attention to its selection. This service to Italian science was rewarded by his election as foreign member by the *Rèale Accademia dei Lincei* of Rome, an honour which gave him very great pleasure. On his return to London the affairs of Winnington and Clydach, of his gas-producing and ammonia-recovery plants provided him with sufficient problems. Yet one more was added. The white-lead works at Brimsdown were on the point of completion, and here he had no able second-in-command, nor much prospect of making Bischof's process into a success.

The summer saw further delays and difficulties at Clydach. At the Nickel Company's first general meeting he could only say that the mines were developing satisfactorily and that the refinery had started production. His son Robert, on whom he had come increasingly to depend, was taken ill in July and, though he quickly recovered, the state of his health demanded that he should spend his winters, as has been said, in Egypt. Between Doctor Mond and Doctor Langer there was none of the affectionate collaboration that had made the worst disasters at Winnington bearable to Ludwig Mond and John Brunner.

In the summer of 1902 Doctor Mond found it impossible to go to Switzerland. His strained look was again commented on by all those who were nearest to him. But now the machine had got control of the man. After a short holiday in

Brittany and the Channel Islands, he returned to London, and from there moved to Bath, in order once more to be nearer to Clydach. There the biggest technical difficulties had been solved, but there remained the danger to the workmen's health from toxic gases. The carbonyl itself and the carbon monoxide formed during the process were alike lethal. In October and November there were cases of gas poisoning. What is more there had been a strike at Clydach, a thing that had never occurred in the thirty years' history of Brunner, Mond & Co.

Ludwig Mond faltered. The memory of those early deaths through scalding, when the boilers exploded in the first year of Winnington, recurred to him. He was almost willing to give the whole nickel project up, and return the capital to his shareholders out of his own pocket. But that was a momentary weakness; such things cannot be done. His son Alfred hurried to Clydach to contrive measures for safeguarding the workmen's health, and so effective were they that there were no further accidents of the sort. But the threat to all his labours of the last twelve years was more than his overtaxed frame could stand up to. On December 6th Ludwig had a heart attack and remained in bed at 'The Poplars' for a fortnight.

When he got up, it was as an invalid; and for the remaining seven years of his life, though he continued to take the very keenest interest in the vast undertakings he had created, in science, in art and in the welfare of his workers, though his mind remained as acute and his powers of working for short spells did not deteriorate, he never brought the full weight of his will and intelligence to bear as he had done in the past. Always he was conscious of being a sick man, and his incapacity distressed him. It never occurred to him to retire. He did not perhaps ever abandon hope of somehow miraculously regaining his old health. But he was content, for the present, to be treated as an invalid.

He was a heavy man, and the mere process of transporting himself was an exhausting one. He ordered a bath chair, and from that time was content to be dragged about in it. He dreaded the labour of climbing stairs, and had lifts installed at 'The Poplars' and in the Wyatt wing. Frida Mond, who

had been unable to persuade her husband to rest, who perhaps, possessing as she did tireless energy herself, had not thought it necessary for him to spare himself, now took control. In the company of his family, a doctor and a nurse he left London for Cannes on Christmas Day, and stayed there for five months. During this time he took some short walks and drives, and attended to very little business. Affairs at Winnington went on none the less well, and the Mond Nickel Company did quite as badly. His sons, his nephews and countless men whom he had chosen and trained remained to carry on his work. By stages he moved to the Italian Riviera, and from there to Switzerland. A cold caught on the journey retarded his recovery. He was advised to take a cure at Caux on the Lake of Geneva, and there a series of visitors began to arrive and discuss matters of business. He recovered sufficiently to walk and drive again.

His doctors wanted to keep him away from London, where difficult problems awaited him. The Nickel Company had been in danger of passing its dividend; there were no profits. Stocks of matte were piling high, and there was a blockage at the refinery. Owing to the strike it had worked for a bare quarter of the year only. One of the most beautiful and cheapest processes for manufacturing nickel—to quote Doctor Mond's own words—was in danger of proving a failure. On his own responsibility Alfred Mond, taking his father's place at the boardroom table, offered £14,500 of the Doctor's money to pay the accrued dividend of the preference shareholders. Ludwig Mond had in addition lent the Company almost £100,000 out of his own wealth.

But on top of these problems, which, being purely financial, perturbed the Doctor comparatively little, was the problem of markets. The world demand for nickel had grown to a far smaller extent than he had anticipated. When Clydach's output reached its maximum it would be difficult to find an outlet for so great an addition to the annual supply. Alfred Mond was compelled to bring his attention back from politics, and study the question of markets for nickel. Fortunately this did not imperil his political career; there was no likelihood of an election until 1906.

CHAPTER 8

THE 'OLD MAN' FIGHTS ON

LUDWIG MOND returned to London after a stay in Dieppe early in September, resolved to pick up all his problems at the point where he had laid them down. But he was irritated and depressed to find that his powers of concentration had deserted him; he could only work for a little while at a time. He felt, moreover, that he might never be well again, and he could not face that prospect. The weather was damp, and he seemed to have lost the power of walking, which he had lately regained in Switzerland. Everywhere he had to be pulled in his bath chair by a footman. He broke off, therefore, and set out for Rome, where the mild weather restored him. For a while he was content to let his business worries rest.

His nephew Robert Mathias had promised to bring him out a full report of everything in January, and until then he devoted himself to the task of recuperation. Gradually he began to walk again. In February he moved out to Frascati, where he was joined by his son Alfred. Friends visited him there, and reports came from Clydach and from the Gas Producers. He returned to London in May 1903, resolved to visit Clydach and himself clear up the troubles there. But the strain of two days at the refinery was too great, and he was obliged hurriedly to return to London. A journey to Winnington proved less exhausting, and Ludwig Mond was able to go from there to take an honorary degree from Victoria University, Manchester, the science department of which he had fostered from the time before the University's incorporation.

In search of health once more, he left in July for Badenweiler, in the Black Forest, to put himself under the care of a German specialist, who prescribed exercise. The weather was hot, however, and the exercise proved too much for him. He went on to Switzerland, and from there returned to London, no better for his cure. It was not perhaps till now that he definitely recognized his weakness, and perhaps resigned

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himself to a future of diminished activity. So poor a view was taken of his condition indeed, that during his absence from England a telegram was sent by some unidentified person in Chester announcing to the press that Doctor Mond had died in Rome. The news was printed and spread, and for a day or two was not contradicted.

On the Doctor's first appearance at Winnington, therefore, after his return the workmen turned out in a mass to cheer him, in sign of their gladness to see the 'Old Doctor' still alive. In the evening there was a grand firework display, which Ludwig Mond watched from the window. He spent three days in the Wyatt wing, where he held a series of conferences with his directors, but he made no attempt to inspect the plant itself, which now towered on every side of the long, elegant house that he and John Brunner had bought thirty years before. It was good, no doubt, to be back after being so ill, though it was strange to mount to his octagon bedroom in the newly installed lift, strange to know that the bell above his bedroom window would not peal now whatever the emergencies of the night. But there were seldom emergencies any more, and they were dealt with, if they arose, by the manager on duty.

In London he had confined himself more and more to the garden, round which his gardener, a serious Norfolk man by the name of Clarke, would walk by his side when he came slowly out to see the progress of the spring and summer flowers. Between the two men there had grown up a sympathy that was chiefly expressed by silence. When Ludwig Mond had engaged him, Clarke had made some remarks about the place being in a rough state, to which his employer had replied that he would not have dismissed the old gardener if it had not been. This had led the Norfolk man to suggest that if there was an improvement Doctor Mond would no doubt be sensible of it. Whereat Doctor Mond had, in Clarke's own words, turned his heavy head and with a sweet smile replied: 'I must ask you that if at any time you have occasion to speak to me that you will not use two words if one will do, as I am a busy man and work very hard.' Such a rebuke might have discouraged a man of less sound sense than Clarke. He

took the lesson to heart, and henceforth, if he had anything to say, said it briefly. In time he grew very attached to Doctor Mond, and recognized a true kindness and consideration in him which was sometimes expressed in actions, seldom in words.

There was an equally close bond between the Doctor and Tom Clark, a Cheshireman, who acted as his personal valet, and who in the days before his illness would follow him in emergency visits to the works or on his sudden journeys to Clydach, himself remembering all the small comforts that his master might need. In his illness, this other Clark was almost continuously by his side.

It was Frida, however, who provided for everything, Frida for whom he looked when she had disappeared on some household errand. 'She is here, she is there, she is everywhere, she is nowhere!' he would exclaim almost petulantly, as he thought of his own immobility, and of her ceaseless activity. But her activities had always been secondary to her duties as wife and housekeeper; and though she had taken very great interest in such projects as the founding of the British Academy, which the Monds had supported from the first, and for which various members of the Mond family in later years endowed lectures; although through her friendship with the poetess Mathilde Blind, and the young Shakespearian scholar Israel Gollancz, she had come to interest herself in contemporary writers and writing, as well as in music, which she had always followed; yet these interests were always secondary to her partnership with Ludwig and to her support of her sons in their various pursuits. A visit to George Meredith at Box Hill or a lecture at the British Academy were no more than the ultimate continuation of that education which she had mapped out for herself as a girl, the education to fit herself to be the wife of a distinguished man.

At Christmas 1904 Doctor Mond again formed a huge family party, this time to go to Torquay. On his return he felt well enough to spend a few weeks in London, attending to the business of Producer Gas and to the extensions which were to be made at Clydach. He had now grown used to being an invalid, and had come to know and acknowledge the limits of

his capabilities. After a short stay in Paris he went to Rome, where once more he attended to business, even to the extent of thoroughly studying the zinc deposits of Sardinia. But it did not occur to him, as it would have done only a few years before, to make a visit to the island.

He had worked out a technique in dealing with such investigations which has been described by Mr Oliver Hall, who was at that time mining engineer to the Mond Nickel Company. Mr Hall had joined in the critical search for ores in 1905, and several times visited his chief in London or Rome, to report. Doctor Mond's method was to have one, two or three lots described to him each day, and he insisted on hearing the physical as well as the mineralogical details of the district in question, after which he would end up by asking for magnetic readings and general conclusions. Then next morning he would go over all this detail from memory, before he would allow his experts to describe anything more. In this way he had completely mastered both ranges of the Sudbury nickel district and was able to follow all progress made from the other side of the Atlantic till the day of his death.

Once more, however, the progress to his health received a setback. He was laid up in Rome for a fortnight with an attack of bronchitis, took a cure at Salsomaggiore, and was there overwhelmed by the heat. When he got back to London, nevertheless, in July 1905 he was more capable of attending to his business affairs than at any time in the last two years. He was in the Chair at the annual meeting of the Nickel Company, in the future of which he so fervently believed. This year it had made a modest profit. He went also to meetings of the Royal Society and to Royal Institution lectures, which he had not done for some time past. For the summer he took a country house at Tunbridge Wells, where he assembled his sons and their families. But still his progress towards recovery was not sufficiently rapid to satisfy his doctors. It was decided, therefore, that he should spend the next winter on a yacht belonging to his son Robert, which was anchored in the Nile, and he had already reached Rome on his way to Egypt when he was greeted with news of the tragic death of his daughter-in-law at Luxor: Edith Mond had inadvertently

taken an overdose of some opiate in order to cure a headache. Her father-in-law was prostrated with grief, and in order to find some distraction, threw himself more vigorously than ever into his affairs. Frida, meanwhile, had to make some arrangements for the future of her two small granddaughters, who were hurried back to Rome, where the Palazzo Zuccari was in confusion, since Ludwig had now bought it in Miss Herz's name and was supervising large architectural alterations.

Doctor Mond was also applying himself feverishly to arrangements for the Sixth International Congress of Applied Chemistry, which was to be held at Rome in May. In his depressed state, all these activities combined to overstrain him once more. The death of his daughter-in-law was like the deaths at Clydach, a tragedy for which he felt himself to be responsible. The medicine case from which Edith Mond had taken the fatal pills had been lent to her by a German companion, of whom Ludwig Mond very much disapproved. It was possibly through this woman's carelessness that the opium pills had occupied the place of some more harmless remedy, and for such an accident might he not himself have been somewhat to blame? Should he not have insisted on Robert's dismissing that woman and finding someone more suitable to keep his wife company while he was excavating his tombs?

Ludwig Mond returned to London, and after a fortnight went to a large country house in Oxfordshire, which he had taken for the summer. Here he received the usual series of visitors from Dudley Port, Winnington, Clydach and Canada. He had gathered all the threads once more into his capable old hands. Sometimes, however, after working for three or four hours on end, he would find his pulse beating irregularly. Nevertheless his powers of application had greatly increased by the end of the summer, and it was decided that a yachting cruise in the Mediterranean that winter would consolidate his recovery.

He was no more than sixty-six, and although his heart was impaired, although his weight made all movement an effort, he saw no reason why he should not be able to remain as active as he then was for many more years. He was incapable, however, of brainwork of long duration. But in the short con-

ferences to which he was now accustomed his mind was as acute as ever. He had never been a man for too many words. Now there was a double reason for the brevity which he had always demanded of his executives.

In London that autumn he attended a number of functions and meetings, at one of which he presented to the Royal Institution a large picture by H. J. Brooks, showing the lecture room crowded with well-known people during a Friday evening discourse, which is being given by Sir James Dewar. The head of Ludwig Mond appears in the front row, and nothing in his features reveals his invalid state.

But what the painter did not see or record was abundantly evident to those who worked beside him.

I had the impression of a grim old man [writes A. E. Wallis, whom he took on as a junior laboratory assistant at 'The Poplars' in the winter of 1905]. He seemed querulous and ill. I never once saw him smile or heard him use three words when a grunt would suffice. He was not a talkative man. The staff respected and feared him. But this fear was, maybe, akin to awe. He was usually dressed in baggy trousers, velvet waistcoat, a cape about his shoulders and an old floppy felt hat. [The cape and hat were Italian purchases.] With a rather gloomy countenance [continues Mr Wallis] he would listen to the account of the experiment in progress, and more often than not stalk away without a word. When fumes or smells from the laboratory reached the rooms of 'The Poplars', some two hundred yards away, he became very angry, and I can hear him raving at me yet: 'You damned boy, I buy fume cupboards. Use the damned things.'

On another occasion young Wallis was sent for to deal with an electrical breakdown over at the house. On arriving he protested that he knew nothing about electricity. 'Oh,' replied Doctor Mond: 'Well, now's your chance to learn.'

Mr Wallis, owing to his youth, however, had comparatively few direct conversations with his employer, who was only sporadically interested in the experiments going on. Most of his information about the 'Old Man' he derived from Robert Mond, who gave him a picture of a man whose life had been

one of hard slogging work in a framework, or cage, of Inorganic Chemistry.

There seems [comments Mr Wallis] to have been no relief from this; it appeared to me that Cheshire had salted out from Ludwig Mond's life the worth-while spiritual values; as though if one abstracted from his life's record work and anxiety, then little remained.

To such a shell of his former active, idealistic self did the Doctor shrink in his last years.

But for a while at the end of 1906 he seemed to those who knew him best to have regained some of his old cheerfulness, and to be capable of more activity than before. The sea voyage, however, proved a failure. It was a bad winter in the Mediterranean, and the yacht was forced to anchor in ports that he found cold and depressing. Perhaps, too, the enforced idleness of long days on a hired yacht brought back his melancholy. He was laid up with bronchitis for a fortnight at Palermo, and when he finally reached Rome, in February 1907, he was in a very nervous state. But at Rome he found an accumulation of business letters; the reconstruction of the Palazzo was going ahead, and there were many friends to visit. Somewhat invigorated by three weeks in that city, he rejoined his yacht at Civitavecchia and returned in it to Cannes.

All through the voyage he had complained of sleeplessness, and he benefited very little by the drugs prescribed for him. In the summer of 1907 he went to Harrogate to undergo a cure, which failed to improve his condition. Nevertheless he was once more able to attend to business, though only for an hour or two at a time. In September he returned to London, and in October attended an encaenia at Oxford, at which he received an honorary Doctorate from that University. The ceremony greatly fatigued him.

He had recently bought a large estate at Combe Bank near Sevenoaks, a part of which he intended for the use of his son Robert and his motherless granddaughters, who were now fairly constantly at 'The Poplars', or travelling with him as he travelled. At Combe Bank he had a laboratory installed so that work could go on there as it did at St John's Wood.

Frida, too, was not without occupations. For the bringing up of her grandchildren, though a welcome duty, involved her in great responsibility. Their education was a problem which she took most seriously. Always she had believed in education, and even the humblest servant girl sent down to her from Cheshire would be instructed if she showed the least interest in the mysteries of the 'mummy room', as 'The Poplars' staff called the library with its collection of 'bible pictures', or in the history of Mrs Mond's own collection of pilgrims' bottles, which occupied the recesses of the oak dining-room. To two small girls 'The Poplars' was full of curiosities, and the Palazzo a place of wonder.

Robert Mond had not got Combe Bank ready for his father before the last weeks of 1907, and the Doctor spent some weeks of the autumn at Bournemouth, from which he returned eager for business. After a grand Christmas party at Combe Bank, therefore, during which the whole clan, sons, daughter-in-law, grandchildren, nephews, niece and their families, together with personal servants were accommodated in the new house, he summoned all the chiefs of his companies to visit him there and made all his dispositions for the winter and spring. Then at the end of January he left for Rome, where he found all the alterations to the Palazzo completed.

It was a delight to be back in that city, and yet he could not sleep. His doctors gave him narcotics, which, though they relieved him at night, left him heavy all the next day. But his will to work remained, and he still followed the daily reports that reached him. Brunner, Mond could be allowed to work on its own. The men he had appointed were mature enough to take even final responsibility. But the Nickel Company still required his close control. Every development in Canada was decided by him, and no responsibility was given to Langer for the extensions at Clydach.

Alfred was now once more absorbed in his career of politics. He had been the member for Chester for the past two years, and was making a name. David Lloyd George had come to speak for him at the 1906 election, in which Violet Mond had proved herself once more a capable organizer—this time the

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3 Sir Robert Mond, FRS
4 Dr J. Mitchell Bruce
5 Maures Horner, Esq
6 Sir Arthur Church, KGOV,
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7 Dr Rudolph Messel
8 W. B. Gibbs, Esq
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10 Rt. Hon. Sir James Stirling,
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12 His Grace The Duke of
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13 Lady Rayleigh
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15 Rt. Hon. Lord Kelvin, OM,
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16 Sir William Huggins, OM,
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17 Rt. Hon. Lord Lister, OM, FRS
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38 Lady Priestley
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40 Lady Crookes
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123 Sir Alexander Mackenzie
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125 Professor Sir James Dewar, FRS
126 J. W. Heath, Esq
127 R. N. Lennox, Esq



Sir James Dewar lecturing on liquid hydrogen at the Royal Institution
(Key to plate beneath)



Sir James Dewar lecturing on liquid hydrogen at the Royal Institution

organizer of victory—and Alfred had mastered his nervousness on the platform.

Ludwig began to admire his son. He was impressed by his practical ability, by the astuteness of his move in sending five Chester workers to South Africa, to work in the mines and so confute the Tory tale that conditions there would allow only of Chinese or Kaffir labour. Alfred Mond had taken the risk of being proved wrong, since he knew very little about South Africa. However, when the men returned after six months they bore out his statement that there was no reason why Chinese labour should be imported into South Africa. Actions of that sort convinced the 'Old Man' that even if his younger son was no scientist he was capable of acting in a scientific way.

Of his widowed elder son's cleverness he had no reason to ask proof. Half of Robert Mond's attention was still given to Egyptian excavation, a field in which he was gaining an important reputation. But he was continuing his work also upon the carbonyls of cobalt, ruthenium and molybdenum. Ludwig Mond did not complain at the fact that neither of his sons was at that time capable of taking over his responsibilities. Both were available when he wanted them, and, in addition, his two nephews, Emil Mond (formerly Schweich) and Robert Mathias, served in directorates under him and supported him as he needed them. Perhaps it pleased him to think that it required four men of his sons' generation to replace the man he had been before he fell ill, and that even yet they still needed him at their head.

In Rome, in the spring and summer of 1908, he attended the meetings of the Accademia dei Lincei, of which he was so proud to be a foreign member, and there instituted a biennial prize in the name of his friend Cannizzaro, open to all the chemists in the world. Once more, also, he attended to the arrangements for the International Congress of Applied Chemistry, the seventh, which was to be held in London in the following year.

This time he returned to England, and Combe Bank, in far better health and spirits. After two years' absence he presided at the annual meeting of his Mond Nickel Company,

and breathed the old optimism. Soon the demand for nickel would be so great that the company's profits would soar. Of this Doctor Mond was confident; and he was not wrong, though it required a world war to fulfil his prophecy.

At Combe Bank he and Frida entertained more freely than they had done for several years. The poet Arthur Symons, whose writings had still not earned him an income on which to live, received generous help, the more successful playwright Arthur Sutro and his wife were still occasional guests, and several painters, friends for the most part of Sigismund Goetze, received aid, hospitality and commissions.

The Monds were understanding patrons, and far less given to 'lion-hunting' than others in their commanding position. For their interest in the arts was always a practical one. In Rome Ludwig Mond would visit the studios of artists out of curiosity concerning their technique with stone, metal or pigments, and would often commission portrait busts or medallions of himself. Frida Mond, in her turn, cared more that scholarship or creative work should go forward with her help than that the artist should talk to impress the company. Frequently 'The Poplars' was opened to give hospitality to impecunious friends in its owners' absence. Mathilde Blind spent two winters there. A cottage was bought for Symons at Rye, and when his wife complained that the water supply was polluted, Ludwig Mond immediately told Robert Mathias to see that a new and expensive well was dug, rather than that Symons should return to his unsatisfactory life in London.

Among the scholars whom Frida Mond still most fervently supported was her early protégé Israel Gollancz, who had been made secretary of the British Academy on its foundation. His engagement to Miss Herz's niece, Alida, an art student who was studying in Paris, gave Ludwig Mond particular pleasure. This ward of his beloved friend spent much of her free time at the Palazzo Zuccari, and Ludwig had grown very fond of her. For he became easily and charmingly attached to good-looking young women. Often during his bouts of sleeplessness she and other young people would stay up into the early morning playing cards with him.

In this summer of 1908 Ludwig Mond seemed to have regained his health. On his way back to Rome that autumn a doctor at Lausanne, in whom he believed and who had often looked after him before, found him generally very much improved. No one would have supposed that this was to be his last visit to this city that he so loved. He had now bought a car, and frequently took drives out into the Campagna.

He had held out against petrol-driven motors for some time. He had put the earliest electric light into Winnington, which required huge ceiling fittings the size of station lamps; he had installed telephones at 'The Poplars' at their inception; he had bought an early electric brougham. But though his sons had possessed cars from the beginning he had held out against this evil-smelling innovation. Now, however, he began to enjoy long drives along the dusty carriage roads, and once more his zest for business returned to him.

On March 7th, 1909, he held his seventieth birthday party at the Palazzo. All the members of his family came out from England, many Italian friends were invited and a monster cake with architectural decorations was baked by his French chef. The old German birthday songs were sung, poems were recited, presents worked by his grandchildren in anticipation of the day duly placed in his hands. He seemed on that day to have so far recovered that he might reasonably expect years more of active life. Indeed so active was he that in the late spring he hurried back to London at an earlier date than usual to prepare for the Chemical Congress, which was to take place in the last days of May. On his way through Paris he stopped to make final arrangements with the French delegates.

Back at 'The Poplars' he threw himself into the work of the Congress, attending the inaugural assembly and several of the sectional meetings, and giving a giant garden party to the delegates. Here on a fine afternoon at the end of May the leading chemists of England and of Europe paid their respects to the veteran of the heavy chemical industry. As he walked about his lawn, leaning on a stick and talking in French, in German, in Italian and in his guttural English, speaking of the events and discussions of the Congress, of research still to be done, and of the work going on in his own laboratories, at

the bottom of the lawn and at his country house, he seemed to look forward to a lengthy old age.

Standing between Frida and Miss Herz, he had received the men in whose hands he felt the destiny of civilization to rest; the men on whose discoveries and on whose training of a future generation depended the brighter and richer future that Doctor Mond foresaw for humankind. It was a dramatic afternoon, and, as the evening fell, the chestnut tree on the lawn was lit with fairy lights. Then, as a crowning surprise, the famous Isadora Duncan, whose performances attracted and shocked fashionable London, dropped out of the thick branches to dance barefoot on the grass. It was a daring thought of Frida's thus to introduce her, as the representative of the arts, into this solidly scientific assembly.

After the Congress Doctor Mond felt the fatigue of reaction. For some weeks he stayed quietly in London, before retiring to Combe Bank for the summer. There he quickly seemed to regain his strength, and in August decided to pay a visit to Winnington, from which he had been absent for too long. He stood the journey well, and on his arrival found that once more a great reception had been prepared for him. That evening the workers of his huge plant assembled to greet him and he was pushed out to meet them in his bath chair. 'I have been very ill,' he said. 'But I am much better now. Very soon I shall be working with you again.'

The square before the offices, which stood where once had lain the Hall's vegetable garden, was filled with jostling, cheering men. It was a quarter of a century since the Doctor had moved to London, and many of them only knew him as the visiting boss in the black hat and long coat whose occasional comings caused a stir; others who knew him hardly better were nevertheless conscious that this whole works were in effect the 'Old Doctor's' creation and there were others who had laboured beside him from the beginning and knew by what right it was his. But to all of them, even to those who saw him now for the first time, he was a great figure, the man who had come to Winnington when it was no more than a tumble-down manor house, and planted the works around it, transforming the whole district, and with it Winnington Hall, one

half of which—the Brunner half—was used even then as a manager's club. For a moment perhaps, moved by the sincerity of his guttural words, they believed his promise, saw him one day getting out of his bath chair and walking through the works, as his sons, as the other directors from London, did on the occasion of board meetings. Perhaps he even saw himself once more climbing into the hoist to inspect the brine intake at the top of that ten-storey building that was still supported on the mighty timbers that had been erected for him nearly forty years ago.

Of the early team Holland, who had found the money, and poor Ned Milner had gone; the rest were with the company still; and if they were there, John Brunner, Watts, Schellhaas, Jarmay, Brock, Tangye: his partner and the men they had made, the men who had helped to make Brunner, Mond the name it was, to send the sign of the crescent moon on sacks and packages to the ends of the earth, then how could Ludwig Mond desert them? Next day he was taken to the rebuilt works at Lostock Gralam, the ammonia-soda plant which had been built to compete with Brunner, Mond's, which had failed to make a profit and which had been sold to its successful rivals at the beginning of the century. Two years before it had begun production on the Solvay-Mond system after a complete remodelling.

Doctor Mond's bath chair was placed in the lift of the Lostock plant, and he was wheeled out on to a platform from which he could take a complete view of that once rural countryside which he had transformed. A couple of miles off rose the chimneys and the great bulks of the parent plant at Winnington. Beside it wound the wide canalized Weaver on which the company's own craft loaded the freight that they carried downstream to the Mersey; in the sidings and on the tracks of the Cheshire railways puffed the company's own locomotives; behind them, not so far off, was the Middlewich works, the creation of yet another would-be competitor, and further away Sandbach, the first rival of all, and the first to be absorbed.

Around, extending almost to the walls of the works, was still the old rural Cheshire that he and John Brunner had seen

when they first walked from Hartford station, or drove in Edward Milner's trap to call on Falk, who was so anxious to lease them his land, or on the agent of Lord Delamere, who was equally anxious to keep them away. The men who had brought him up to this point of vantage had withdrawn; the hot summer sun beat down on the exposed platform. He began to doze. So this was the great Babylon he had builded. Tall factory chimneys of pale pink brick on every side, crowned with plumes of smoke that did not poison the countryside as the old Le Blanc chimneys had done, spreading their acid drizzle of destruction over the surrounding trees and crops. Below him, and on the steep further bank of the river, the green of oaks and ashes was yellowing; across the valley ran a gently stirring line of those poplars that were almost a Cheshire tree, of poplars like those that wind down the rivers of Central France. He felt deeply satisfied.

Doctor Mond returned to Combe Bank heartened, and during September and October came up several times to London for business conferences. Once more heads of departments were called to see him, and for the last time such stalwarts as A. W. Tangye were able to testify to the continued acuteness of the 'Old Man's' brain. Arrangements were being made for his son Robert and his nephew Emil to visit the Solvay plants in America, and for Mr Tangye to accompany them.

Ludwig Mond himself was now spending long hours with his lawyers, during which he no doubt ran through the thirty-three-page will, which he had made in the previous autumn. But he had overlooked nothing; everything was provided for. At Frida's death his pictures were to go to the National Gallery, except for those in Italy, some to his sons, and one or two more which were to belong to Henriette Herz.

That old friend was magnificently provided for. Not only was the Palazzo Zuccari hers, but she was assured of a large income for the remainder of her life. For Ludwig she was always the partner who had supported Frida and himself since those first days when Frida had found life at Appleton so bleak; Harry Herz, he would tell any stranger to whom he introduced her, had been the first to lend him a little capital

during the trying early months of Winnington, when everything that could burst did burst.

But besides Henriette, there were cousins, relatives, former servants, and friends for whom more or less provision was made. Distant relatives in America, the descendants of the eldest Levinsohn sister, who had emigrated there when Ludwig was a boy, were not forgotten. Large sums of money were put aside for the endowment of research by the Royal Society and for Heidelberg University, where they were to be used for similar purposes. The Munich Academy of Arts, too, was remembered. While, nearer home, generous provision was made for pensions to veteran workers at Brunner, Mond, as well as for the education of his own relatives born and unborn. Ludwig Mond would die a very rich man.

On October 24th the Doctor left Combe Bank for 'The Poplars'. In London there were more meetings. Once more he took the chair at the annual general meeting of the Mond Nickel Company; and this time he had to report the disastrous effects of a forest fire in Canada. But he continued to be buoyantly optimistic about the company's prospects.

There were many friends to see and much business to settle before he could leave for a quiet winter in Rome. On November 12th, however, after a long interview with his lawyers, Ludwig Mond collapsed. For a month he lay at 'The Poplars', suffering from complete exhaustion, caused by his old heart complaint. During this time he thought seriously of religion, perhaps for the first time since he had so lightly forgotten the Jewish feasts in the days of his apprenticeship. Perhaps he now felt the emptiness that young Wallis had detected in him.

A rabbi was sent for and, stranger though the veteran scientist was to the Hebrew rites, it was arranged that the Jewish burial service should be read at his funeral in the Finchley cemetery where he had bought land for a mausoleum. Then his family were summoned to his bedside, his son and his nephew called back from Chicago, where they were staying, to arrive just in time to find him alive.

His grandson too, Alfred's eleven-year-old son Henry, the second Lord Melchett to be, was summoned from school and

shown into the darkened sickroom in which his grandfather lay with his beard now quite white on the white sheet. Violet Mond led her son to the bedside, and the old man turned his head. 'We all hope that Henry will carry on your tradition,' she said to her dying father-in-law. 'We all hope that Henry will make himself necessary,' he answered. To make oneself necessary to the great Babylon he had builded remained with him the ultimate test of character to the last.

POSTSCRIPT

FIVE years after his death the country of Ludwig Mond's adoption was at war with the country of his birth; and the two chemical industries, that under which he had served his apprenticeship and that which he had so largely helped to create, were providing the material for the killing of those millions for whom he had hoped his efforts would provide a better standard of life. A hundred and seventy-one of the Winnington workers alone were killed on active service: more than a tenth of those who joined up.

It is difficult to conceive of an old man who had been so passionately distressed by the accidental death of a workman in a factory explosion cheerfully watching the whole of his plant being turned over to the manufacture of munitions. It is equally impossible to think of his protesting against what would have, no doubt, seemed to him a necessary measure. Had he survived, as he promised his men he would, to work beside them for a few more years, he would have died sick at heart. For science, in which he had so implicitly believed for the whole of his working life, had turned itself over to work of pure destruction.

Where soda could be manufactured, works could be adapted for the production of ammonium nitrate, the basic material of the newer explosives; and as the war progressed bleach works came to be transformed for the making of poison gas.

The first problem put to Brunner, Mond on the outbreak of war was that of ammonium nitrate. All the thought that had been devoted to the ammonia-soda process was now given to its transformation. Not only was the total output of ammonium nitrate raised from a figure somewhat under 5,000 tons in 1915 to one of 216,000 in the last year of the war, but entirely new methods of production were worked out. The problem of T.N.T. for filling shells was also brought to the 'Old Doctor's' firm who turned their Silvertown works entirely over to it, while they built a new plant in a lonely district of Cheshire to take over the manufacture of this highly

inflammable material from their plant in a crowded part of East London. Unfortunately, however, even when the new works were in production the manufacture of T.N.T. was not discontinued at Silvertown. In January 1917 a fire in the plant led to the most disastrous explosion, which destroyed the whole buildings together with a great number of the surrounding houses.

The test of war production confirmed the soundness of Ludwig Mond's choice of men, which young Wallis saw as his outstanding experiment. It was to the generation who had worked under him, to Jarmay, Tangye and others of their years, that the head of the High Explosives Department of the Ministry of Munitions, a brilliant retired patent lawyer, Lord Moulton, turned for the solution of his problems as they arose.

So short, indeed, was the country of men of their training and experience that it was to dons and Public School science masters that he turned when seeking men to reinforce this very small team that Ludwig Mond had chosen. One of their most capable wartime colleagues was Doctor Fisher, who had left the senior science post at Clifton for the Army, and who had to be withdrawn from military service to superintend the manufacture of Phenol at Winnington. Shortly after the armistice Doctor Fisher returned to teaching, and was chosen in 1921 as Headmaster of Oundle.

On the conclusion of the war a committee was empowered by the Versailles Peace Delegation to inspect the German chemical works, most of which were by that time shut down owing to shortages of material caused by the continued blockade. Travelling in open cars and unwarmed trains through the rigours of the 1918-19 winter, the committee, of which Mr Tangye was a member, met sometimes friendliness, sometimes passive resistance from the works managers of concerns which only a few months before had been providing the now disintegrated German armies with munitions of war. The towns were in disorder, the workmen and returned soldiers rioting spasmodically, and everything was at a standstill.

The most important advance that had been made in Germany under pressure of war had been the manufacture of

synthetic ammonia by the Haber process, which had made her independent of imported Chilean nitrates, and in the war's final years the British government had decided to build works for a similar purpose, for which they had already started to prepare a site at Billingham, near Stockton-on-Tees, when the armistice was signed. The Haber process was well-known in principle, but very little progress had been made in Britain towards its working out on a factory scale. The visits to Germany were, therefore, of the first importance. For the design of the German plant had remained a closely-kept secret.

Having learnt the lesson of the war: that supplies in any future struggle might quite likely be cut off by enemy blockade, the British government was anxious that the Billingham scheme should be carried out in peacetime and that Brunner, Mond should take it over. It was pointed out when this proposal was put forward, that the German scheme had only proved possible thanks to the loan of official capital. It was further pointed out that Billingham was not a promising site, owing to one disadvantage among many, its proximity to the North Sea, and its consequent danger from bombardment in the event of another war.

'Oh!' replied Lord Moulton to this objection. 'There will be no European War for twenty years. When it does come it won't matter which side of this little island this works is on.'

So, as the outcome of its success in wartime production, Brunner, Mond was officially backed in a policy of large-scale peacetime expansion, which took them out of the world of Ludwig Mond, who remained first and foremost a chemist, into that of his son Sir Alfred, who was primarily a policy-maker, a manipulator of capital, a 'rationalizer'—to use an expression of the time, which he himself coined.

A second visit to the Haber works at Oppau put Brunner, Mond into possession of a series of plans, which were, however, stolen from their delegates' baggage at the Customs station on their leaving Germany. Their first task on returning to England, therefore, was to reconstruct them from memory. For a few months afterwards, when the German plant had partially resumed work, it was totally destroyed by a tremendous explosion, which also laid waste the town of Oppau.

The government was relieved of the Billingham undertaking by the Synthetic Ammonia and Nitrates Co., the shares of which were held by Brunner, Mond, who had bought the site. In addition they developed a large new plant at Wallers-cote in the Winnington valley for soda production; a project planned before the war but postponed by several years. In addition ancillary companies of varying size and importance were taken over during the war and immediately afterwards, including the Buxton lime firms, which had all along been supplying the limestone for the ammonia-soda process. This rapid, and perhaps too vast, expansion of the company led to a crisis from which it was rescued by the return of Alfred Mond, now Lord Melchett, from politics to industry.

As First Commissioner of Works in the wartime coalition, and Minister of Health in Lloyd George's post-war government, he had become an expert on housing and on large-scale production. His career in politics was, however, blocked by his differences with Lloyd George over his agricultural policy and over the issue of anti-Socialism, which was to Alfred Mond fundamental, to his old chief merely a matter of politics.

When he moved over to the Conservative party, however, Alfred Mond's reception was not warm and his prospect of rising again to high ministerial rank seemed far from good. During his first term out of office, the few months of Ramsay MacDonald's first Labour Government, he had rejoined his boards, and created a combination of the leading anthracite colliery owners of South Wales with himself as chairman. He had then gone over to Canada to organize fresh markets for Welsh coal. At the same time he tried to bring some measure of agreement into the warring nickel industry. Alfred Mond was, therefore, admirably equipped to bring about the re-organization of his father's expanded companies, and the foundation of Imperial Chemical Industries, which he and Sir Harry MacGowan achieved by means of a merger of Brunner, Mond with the British Dyestuffs Corporation, Nobel Industries and United Alkali in December 1926.

By this giant amalgamation and a similar combination of Mond Nickel with the rival Canadian interests Alfred Mond—now Lord Melchett—succeeded in bringing a unity to the

chemical and light metal industries that he had failed to bring to the warring Liberal factions of Asquith and Lloyd George. Moreover, with it his father's life work was both continued—for Ludwig Mond had eventually seen the advantages of amalgamation—and expanded to a scale in which it was no longer recognizable.

Gone was the day in which the Chairman of the company sketched out the plans for his works extensions, received figures of production in his palace at Rome, passed blueprints and interviewed departmental chiefs in his library, and made private provision for the welfare of his men independent of nation-wide regulation of hours and wages. The day of Ludwig Mond had yielded to one in which major issues and minor could no longer remain under one hand; and one cannot feel that he would have liked the new scheme of things. Once he had complained to John Brunner that the firm was making money, not chemicals. Now it was no longer even making money for men who had risked their work and their own small private fortunes in it. It had become a branch of the national, almost of an international, economy.

Frida Mond outlived her husband by eleven years, for the last few of which she was an invalid confined to her room at 'The Poplars', from which she watched with matriarchal eyes the careers of her sons, her grandchildren and her nephews and nieces. She was an omnivorous reader, and in going through the Press, domestic and foreign, she would always keep her eye open for news of interest to either of her sons. Bundles of political cuttings would be set aside against Alfred's next visit, of archaeological gleanings against Robert's. And to her friends, to Ludwig's old collaborators in the business, to their children and relatives she was a ready giver of presents, never forgetting a birthday, always welcoming a visit from anyone passing through London. With A. W. Tangye in particular, the dapper little bachelor who had been behind her husband in so much, and who was her fervent admirer, she would gossip about the old times, about her first home in England, about the journey to Winnington and about the exciting days of the plant's erection and first working. She

lived in the legend of her husband and helped to perpetuate it, distributing his possessions at times as if they were holy relics.

Dear Mr Tangye [runs a note on a black-bordered visiting card, dated September 1912], Just a word to accompany the Carpet. I wish for you it was a flying one, and the wine. The champagne glass is from Cassel home, the Rhine Wine Glass from the Cologne home, red wine glass from Winnington. The Grafenberger was a favourite with Dear Ludwig.—I was so pleased to see you so well and bright, and hope we may soon meet again.

Frida Mond not only helped to preserve her husband's legend, she also began to collect and preserve his papers with an eye, no doubt, to a future biography. On the basis of family correspondence and of his exchange of love letters with her she compiled an account of his early life up to the time when he built the Le Blanc factory for Smits. This consisted almost entirely of excerpts from letters typed out in their original German and interspersed with the minimum of commentary by her. But when she reached the date 1864 these letters suddenly break off.

Her next deed of piety towards her husband's memory was to have a selection from this very full correspondence translated into English, and supplemented by material which took the story of Ludwig Mond's life up to the moment of Winnington's first production of soda. At this point again her energy seems to have flagged, and she left not even a collection of letters behind as a guide to the events of her husband's later life. Perhaps she had by then relapsed too far into invalidism. To the last, however, she kept her position as head of the family, watching every event from her sickroom, sympathizing, prescribing medicines from her private cupboard, and remembering the past.

After Ludwig Mond's death Henriette Herz left for Rome, where, but for occasional visits to England, she spent the remainder of her days at the palace he had bought for her. At her death, in 1913, it passed with its art treasures and its considerable library of books on art to become a centre for German art-students; and since that time its possession and

use have been disputed by the German and Italian dictatorships. But since the Second World War it has now been reopened for the purpose for which she intended it, and its pictures are once more on view at the Palazzo Venezia.

Ludwig Mond's ultimate reconciliation with the faith of his ancestors was repeated by his son Alfred, who late in his life, after distinguishing himself in the industrial field as he had done in the political, championed the cause of Zionism, bought land in Palestine and threw his energies behind the industrial development of his people's old and new country. Indeed almost alone, as vice-president of the Jewish Agency, he championed the cause of the emigrants into the Mandated Territory with the Colonial Office and in correspondence with the Press Barons.

To his distress in the last year of his life he saw the disastrous riots of 1929, and the hardening of British official opinion against Zionism. He then fought hard against the White Paper, which seemed to make the establishment of the National Home an impossibility, and with remarkable foresight persisted in pointing out the importance to Britain of having a friendly power in possession of the great outlet to the oil pipe-line at Haifa, a position so close to the Suez Canal. Now at the end of his life, none of his interests—Empire Economic Union or industrial reconciliation along the lines of the Melchett-Turner conversations—seemed as important as the championship of the future state of Israel. In his late self-identification with Judaism he was followed by his son and by his daughter, Eva Marchioness of Reading, who were both active also, after his death, in the relief of refugees from Hitler's Germany. His son, Henry, the second Lord Melchett, made himself necessary to Imperial Chemical Industries, as his grandfather had hoped he would. He was, before his early retirement owing to illness, its deputy-chairman.

Sir Robert Mond continued to divide his time between his scientific and archaeological interests, and he too played a leading part in the rescue of the Jewish population of Germany.

No member of the Mond family is now connected with the chemical industry, nor has the generation of Ludwig's

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great-grandchildren concerned itself with Jewish affairs. The assimilation of their sturdy pioneer stock is complete; and if this is a moment at which to sum up the benefit to this country of Ludwig and Frida Mond's settlement in that inhospitable part of Lancashire, where the winter fogs reeked of works smoke and chemicals, it may be said that in return for its hospitality, carelessly extended, Britain gained the foundation of an industry and the devotion of three distinguished men, each in his own right a Fellow of the Royal Society, as well as very great benefactions both to science and the arts, not the least of which is the collection of pictures in the National Gallery.

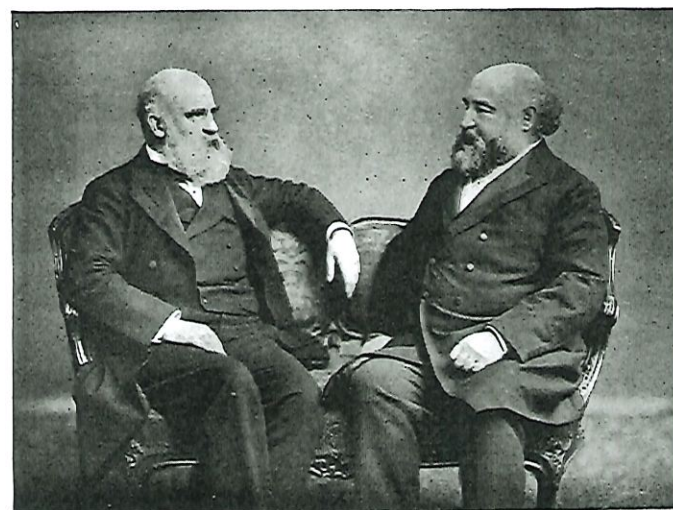
The Bar of the Club at Winnington Hall is in that part of the house that was once John Brunner's. From its back wall, behind the barman's head, it is lit by a window which gives on to the yard in the centre of the building known as Fountain Court. On the opposite wall another window faces down the timbered Bar Court towards the stables and outhouses that were Brunner, Mond's first offices, and beneath which are now housed fire-engines, ambulances, and patrol cars. The Bar is in the centre of Winnington Hall, and Winnington Hall seems, at least to a visitor to the Alkali Division, to be the centre of Imperial Chemical Industries from which all the rest has sprung. It is in that small, undecorated room, therefore, that one must look if one hopes to discover the ultimate legacy of Ludwig Mond, forty-five years after his death. For there are the successors to the team he recruited, some from Germany, some from Roscoe's classrooms at Owens College, and some of his own idiosyncratic, but clear-sighted selection.

Among all these men who have parked their cars on the wide asphalt drive before the Hall and slipped in between leaving the works and going home to gossip for a quarter of an hour over a drink there is not one with Mond or Brunner blood in his veins, and few of them are descended from the men who helped to found the ammonia-soda industry. There is no relic here of the family business that was merged into Imperial Chemical Industries a quarter of a century ago.

Yet if Ludwig Mond's legend persists here it is not only



Frida Mond in later life



Sir John Brunner, Bart, and Dr Ludwig Mond, F.R.S., 1898. Presentation photograph taken to mark the 25th Anniversary of the foundation of Winnington Works

because of his association with the place. Little of the works as he knew them stands in its original shape; of his own first building only the sturdy timbers remain, reinforced with steel by a later generation. If the Mond myth lives it is because the work of these men is a continuation of his; and for that reason it has spread from here to other Divisions of I.C.I. that did not exist in his lifetime. For there was something of his spirit presiding over the great coal-into-oil plant at Billingham, which was the company's largest single achievement in the years between the wars; there is still something of him, perhaps, in the most recent joint development of the Alkali and Plastics Divisions, the very name of which—polythene—would have meant nothing to him. For polythene, this plastic which is squeezed out of ethylene gas by fantastic pressures that before were only common in naval ordnance, seems almost a new form of matter. Polythene, with its thousand and one applications in everyday life, and in a whole new world of electronic engineering, would have fascinated Ludwig, though the physical chemistry of it would have defeated him. Yet it was discovered in a laboratory not a dozen feet behind his statue, in a building that is the direct descendant of the stables at 'The Poplars'.

This outcome of pure research and its subsequent development has a boldness that only he, of his generation, would have appreciated.

The world has caught up with Ludwig Mond. The building of an industry on the basis of laboratory discoveries has become a commonplace; concern for the housing and welfare of employees has grown general among large companies, who appoint special staffs to attend to such things. There is nothing that the 'Old Man' could teach these men who pass and repass his large photograph as they go in and out of his house, that is now their club. Some of them indeed would smile at the hasty pocket-book sketches and calculations on which he based even his most important decisions. Yet in their unhesitating mastery of scientific processes—in their utter reliance upon facts—they are his legitimate successors.

The Bar at Winnington Hall strikes the stranger as rather like that of an airport, at which last-moment messages are

exchanged before departures. There is always someone on the point of leaving for America, coming in from Buenos Aires, bringing news from India, some visitors from Italy or Canada discussing the working of some patent. In this out-of-the-way corner of once rural Cheshire, one finds oneself in the centre of a life that one did not know to exist.

Airport—messroom perhaps, but also the University common room are present in the mixture that has gone to the making of this place. From the University comes the informality of dress: corduroy trousers, the bright rowing club tie, the sporting cap. It is from the Universities that this group of men have been drawn, and particularly from Oxford and from Cambridge. It is more than half a century now since there has been any need to look for foreign-trained scientists to fill the posts at Winnington and elsewhere.

These are men who have taken high honours in the various branches of science, and whose careers are now the Industry's; they are men who have adopted a way of life as distinct as that of the civil service, the army or the law: a way of life that was first mapped out for them by Ludwig Mond. 'Give all your attention to the study of pure science,' he told the students when he opened the Schorlemmer Laboratory in Manchester, nearly sixty years ago. 'Have no thought for immediate practical results.' The men whom his successors have chosen for the principal positions in their company have been educated in this tradition. One cannot think of Winnington as a centre of pure science. Its policy must ultimately be guided by the interests of its shareholders. But the unit is sufficiently large, the scientific tradition sufficiently strong, for the technical aspects to override the purely commercial. Where many business companies tend to transform their technical experts into men of commerce, at Winnington one finds that the man who sells the product is equipped as a technical expert rather than as a salesman. One is not aware, in the chatter of the Winnington club, of any line of demarcation between the scientist and the business man; and this merging of functions, though perhaps it is in the spirit of the present century, is something that would have seemed natural to Ludwig Mond, almost alone among his contemporaries

in the last. For to him science had no boundaries; it began in the laboratory, it was then applied to problems of chemical transformation on a large scale, and after that to the utilization of the materials which these transformations produced.

To Ludwig Mond one of science's chief tasks was that of economy. When he came into industry he saw waste-tips and factory smoke not only poisoning the countryside but squandering half the material that the works consumed. One after another of his processes was directed by his urge to conserve what had hitherto been wasted; his persistent attempts to save the chlorine atom in the ammonia process and to turn it into bleach as the Le Blanc manufacturers did in theirs, cost him time and thought that were never rewarded by the discovery of any practicable manufacturing process. Even the ammonia-soda process produces its wastes—there are hundreds of tons of boiler ashes alone to find room for, not counting the impurities in the limestone that leave the process in a singularly intractable form. In Ludwig's day their volume was so small comparatively that they presented no problem in an already industrialized landscape. To-day, with yearly outputs of soda in the millions of tons, the problem is formidable indeed to those who love the green Cheshire fields that march with the works on every side. However, with a patient persistence that was very foreign to the impetuous Ludwig, his successors have solved this problem. Not, it is true, by a remunerative process of recovery, but by a method of disposal that will leave no more scars on a lovely countryside.

Yet the conservation of material has gone very far in the forty odd years since Ludwig Mond's death, and now factory production flows almost as smoothly and as wastelessly as a laboratory experiment. There is no longer danger that the excessive hardness of impure water may cake the pipes. Dials at every stage in production register the slightest variation of pressure or temperature. The works are a miracle of concealed processes, the evidence for which can only be read on these dials that cluster symmetrically on walls at unexpected stages on one's journey up or down the iron stairs and platforms, suspended in the hollow ten-storey-high works. Only exuding

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from a sample-pipe a faint smell of ammonia remains to remind one of the waste by leakage in the early days.

All that the 'Old Man' could have desired has been accomplished by these scientists before whose laboratory, on a site near the boundary of Winnington Park, stand the bronze figures of their founders in a flower-garden, whose brightness testifies to the purity of the atmosphere within a few hundred yards of ten smoke-plumed chimneys. Those flowers are his fittest memorial.

TECHNICAL APPENDICES

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APPENDIX I

THE TRANSITION YEARS, 1871-1873

AMMONIA OR SODA?

In 1871 Ludwig Mond was thirty-two and getting thoroughly unsettled. He felt that it was now or never, and that if he did not make the effort and launch out on his own, he would, like his proposed waste treatment company, get 'dreadfully stuck in the mud'. Although, perhaps best acquainted with alkali manufacture by the Le Blanc system, he had many other interests: his early work with Herr Werner at Mainz and with Herr Mergler, 'the crazy druggist' of Heckenberg, had given him an insight into the manufacture of inorganic pigments, and some knowledge of the techniques of distillation; the experiments that he had carried out for Herr Weil on the recovery of ammonia and tar-products from leather waste familiarized him with the general state of the gasworks and fertilizer trade; his constant meeting with men like Deacon and Hargreaves made him aware of the 'discoveries relative to soda manufacture which will probably bring about a revolution in this business' some time before these discoveries were patented.*

It is not surprising, therefore, that Ludwig's private copy book shows unmistakable signs of feverish activity in early 1871. For not long after Easter he was making inquiries about the availability of unexploited gas-liquor in the larger Dutch towns. Further correspondence in May, however, indicated that he was finding the idea of making ammonium sulphate either in England or abroad economically less attractive, as most of the available gas-liquor in England was bespoken and (as he wrote)

competitors in London and everywhere else have made prices of gas-liquor rise excessively. In this little place [Widnes] where they do not gasify more than 25,000 tons of coal during the whole year, you have to pay 8s. 6d. a ton for gas-liquor. Now that I am better acquainted with the matter, I know that production in Holland would not be worth our while.

Then, perhaps as a result of further chats with John Brunner, the manufacture of one of the more simple Le Blanc by-products cropped up: on the self-same day as he gave up all idea of ammonium sulphate

* Deacon's chlorine process: B.P. 1908/1871. Hargreaves's direct saltcake process: Hargreaves and Robinson, B.P. 1733/1871.

manufacture, he wrote to Walter Weldon suggesting a five ton a week bleaching-powder factory at Widnes and inquired his terms for granting a licence under his newest patent.

A few days later, Ludwig sent a detailed estimate to Philip Goldschmidt for a chemical plant near Widnes for making 5,000 tons of saltcake and 1,250 tons of bleaching powder a year. This letter was most optimistic: for a capital of £10,000 he hoped to show a net profit that would cover the capital in the first year's working. Goldschmidt, however, was away on holiday at Marienbad and the delay caused by his absence for once did not greatly irk the impatient Ludwig. An offer had just come from Germany for him to start a fertilizer factory there, using the leather distillation process that he had worked on for Herr Weil at Ehrenfeld some ten years before.

His letters now to Cologne were filled with his new plans and requests for help: 'I should be awfully pleased if you could find out the price of old leather, shoes, etc., and the tonnage one could get. Weil's idea seems as though it is now going to be respected.' However, in a letter a few days later, Ludwig wrote of the difficulty of getting the raw material and finally, once he had the prices from Cologne, he found that, on closer consideration, the project did not appeal to him for the moment.

The second reason why Goldschmidt's dilatoriness did not worry Ludwig was that Deacon's and Hargreaves's new processes held out a promise of improving the Le Blanc system. So Ludwig, for once, was prepared to wait. A letter of his to M. Brivet, one of his licensees at Salindres, puts it succinctly:

There is plenty of inducement for a visit to Widnes at present. In fact, we have lately had quite a pilgrimage of Chemical Manufacturers to the place. The remarkable success of Mr Deacon's process for the manufacture of chlorine by passing hydrochloric acid gas and air over bricks soaked in copper sulphate, which is now working on a large scale, has created quite a sensation. Besides this, Mr Hargreaves is experimenting in Widnes on the large scale with his process for making sodium sulphate without lead chambers, and though he has not yet quite overcome all practical difficulties I am able to say from close inspection of his experiments that it is sure to be soon in satisfactory working order.

While these ideas were simmering, the possibility of recovering sulphur from waste turned up again. His patent had only two years to run and the River Pollution Bill was not likely to become law for many months to come. So, in anticipation of a rash of alkali waste treatment plants which would bring in little beyond consultant's fees,

Ludwig decided to set up recovering sulphur on his own. Just then, however, the possibility of further business with a French alkali plant at Salindres cropped up, almost at the same time as a letter came from Cassel, asking him to go into partnership with a young business man who intended making potassium chromate and oxalic acid.

AMMONIA-SODA

On January 10th, 1872, Ludwig Mond wrote a letter that certainly marked a turning point in his life: it may well have marked a turning point in the history of Great Britain. To a Continental colleague, M. Henroz, he wrote:

Mr Deacon has told me that you have spoken to him about the rapid development in Belgium of the manufacture of soda by the ammonia-soda process. You will understand that this process, which produces no waste, is very disturbing to me. I would be grateful for all the details that you can give me about it. . . . What I should be particularly interested to know is: how far has this process which has been tried so often before unsuccessfully, succeeded at Charleroi; the output of soda and the capital employed; the price of the raw materials at Charleroi; the source of the carbon dioxide used?

To make assurance doubly sure, he repeats the letter to Professor van den Gheyn at Ghent, reiterating that what interested him particularly was how Solvay had succeeded when so many others had failed.

His newly aroused interest seems to have died down, however, because at the end of January he was in correspondence with A. G. Kurtz of St Helens, sending to him what amounts to a draft agreement for the purchase of an acre of land hard by his waste-heaps, with rights of access by the works siding and sole use of the yellow-liquor drainage for fifteen years, all for a royalty of 15s. a ton of available sulphur contained in the yellow liquor.

I prefer this way of fixing the royalty [Ludwig went on] to a royalty payable per ton of sulphur recovered, because I intend to utilize a considerable portion of the liquor for the direct manufacture of various chemical products without first recovering the sulphur from it.

However, his interest in Solvay's plant did not wholly flag, because a few weeks later, just when negotiations with Kurtz were showing signs of falling through, Ludwig wrote off for a whole sheaf of ammonia-soda patents, and started a correspondence with James Young—'Paraffin' Young of shale-oil fame—who had then taken out

some recent patents in connexion with the ammonia-soda process. His letter to James Young sings rather a different tune to his anxious inquiries of M. Henroz.

I have [he wrote] for many years held a very favourable opinion of this process, and have long been convinced that it only required to be seriously and energetically attacked by an eminent practical man to be made a great success and in this respect it could certainly not have fallen into abler hands than yours.

Perhaps what Ludwig learned from Paraffin Young was enough; for nearly a month the archives are blank. All we know is from Ernest Solvay's own words: that one day in April he opened the door to a stocky German with piercing eyes who introduced himself in stilted French, getting down to business without more ado.

I am working [he said] a process which I have invented for utilizing the residues arising from the Le Blanc process of making soda. It is annoying to have to take such trouble to extract from these residues the sulphur which one has so painfully to introduce for the reaction. Now M. Merle of Salindres, in whom I have great confidence, has convinced me that the success of your process makes mine no longer necessary. In these circumstances, I prefer to employ myself making soda, and I have come to try to make terms with you.

APPENDIX 2

THE FRESNEL PROCESS

EARLY HISTORY

The beginnings of the ammonia-soda process lie almost as far back in the past as the origins of the Le Blanc system. In fact, as Ernest Solvay himself put it, 'Never before was the industrial realization of any process attempted so frequently and for such a long period of time.'

The French engineer, physicist, and optician, Augustin Jean Fresnel, was the first to describe in 1811 the precipitation of sodium bicarbonate from a saturated solution of salt (sodium chloride) by the addition of ammonium bicarbonate. Fresnel, however, was no industrial chemist and asked advice about his invention from such savants as Vauquelin, from the younger d'Arcet and from Thénard. This was, had Fresnel but known it, a most injudicious thing to do, because these three were wrapped up in the Le Blanc system which then, thanks to the Napoleonic wars, was most profitable. For in a few years, because of the blockade and the consequent shortage of Spanish *barilla*, the price of black ash had doubled to nearly £90 a ton, whereas it could be still made for a mere £35.

Thénard pronounced Fresnel's process good, but thought it unworkable on the large scale, and more expensive than the Le Blanc system and its other rivals. It is only fair to say, however, that Fresnel had hoped to sell the ammonium chloride that is the by-product of the reaction, recovering it by evaporation from the clear solution left after the sodium bicarbonate had been filtered off. This, Thénard pointed out, would not be easy, in spite of what Le Blanc wrote 20 years before, when he listed ammonium chloride as a possible by-product of his own process and stated that it was a substance 'of which the Arts stand in need, and which they buy so dearly from abroad'. So Fresnel gave up his idea and left the field clear for the Le Blanc system.

Basically the ammonia-soda process is exactly what Fresnel discovered—the precipitation of the relatively insoluble sodium bicarbonate from an aqueous solution containing sodium, chloride, ammonium, and bicarbonate ions. It results from a simple exchange of chemical partners: in solution in water sodium chloride (common salt) reacts with ammonium bicarbonate to give ammonium chloride (sal

ammoniac), which stays in solution, and sodium bicarbonate, which is precipitated. In actual practice, the situation is more complicated: the ammonium bicarbonate has to be made as it is required, and the ammonium chloride—which is produced in quantities ample to saturate the market fifty times over—has to be decomposed so that the ammonia may be re-used to make more ammonium bicarbonate. Still, though complex, the process was far more economical of fuel than the Le Blanc system, and produced soda that was much purer than Le Blanc soda. Particularly, ammonia-soda was freer from those compounds such as iron salts that impart an undesirable colour to glass, and the glass trade, then as now, was one of the alkali makers' best customers. Furthermore—and this was what perturbed Ludwig—Fresnel's process produced comparatively little waste, and what waste there was was quite innocuous and quite incapable of large-scale exploitation.

THE PROCESS

The ammonia-soda process worked to-day is essentially Fresnel's as developed by Mond and Solvay, and differs in certain important details, particularly in apparatus, from the previous unsuccessful attempts to exploit the reaction that filled the years from 1836 to 1863. The raw materials for the process—all naturally occurring—are salt brine, limestone, coke, coal, make-up ammonia, and water.

The limestone (calcium carbonate), mixed with the coke, is first burnt in shaft kilns to give quicklime (calcium oxide) and carbon dioxide gas. The quicklime, slaked and slurried up with water to form milk-of-lime, is used in the ammonia recovery step; the carbon dioxide gas goes forward to make the ammonium bicarbonate.

Solid salt is not needed, which is another of the advantages over the Le Blanc system. Salt brine is either pumped from natural streams or, as it is to-day, won by controlled methods from deep boreholes. This incoming brine is made to absorb ammonia gas (distilled from the ammonia recovery step) until it will virtually absorb no more. From this absorption stage, the ammoniated brine goes forward for carbonation.

Carbonation takes place in tall 80-foot-high vessels that still to-day bear the name *Solvay Towers*. Into the top goes the ammoniated brine and into the bottom is pumped the carbon dioxide from the kilns. By the time that the ammoniated brine has reached the bottom of the first bank of Solvay Towers the ammonia has been almost completely converted into ammonium carbonate. In a second bank of towers, more carbon dioxide is pumped into the brine-ammonium carbonate solution, but in such quantities that ammonium bicarbonate is formed

high up in the tower. This exchanges chemical partners with the salt (sodium chloride) and sodium bicarbonate is precipitated. By the time the liquor reaches the bottom of the 'making' Solvay Tower, it is a thick milky sludge of crude bicarbonate fast settling out of an ammonium chloride solution.

At the next stage the stream splits. The crude bicarbonate is filtered out of the ammonium chloride solution, and goes on to the finishing furnaces. Here it is heated to drive off unwanted moisture and carbon dioxide, and adherent ammonia, all of which are collected and returned to the process cycle once more. The finished soda ash—anhydrous sodium carbonate or the 98-99 per cent light ash of commerce—is then cooled and packed for sale.

The clear ammonium chloride liquor from the filters is first boiled to drive off carbon dioxide and free ammonia and is then mixed with the milk-of-lime from the kilns. This frees the fixed ammonia, reacting with the chloride to form calcium chloride. The ammonia, along with that from the preliminary boiling, is cooled and goes back to saturate fresh brine, and to start the cycle all over again, while the calcium chloride flows to waste, for not more than a tithe can be economically recovered and sold.

This process—cyclic and continuous—requires perfect continuity and a geared smoothness of working that was unique in those early days. It is little wonder, then, that Ludwig Mond, dog-tired and worn out by repeated struggles with a process that he could not master, later remarked to the young Mr Hasenclever:

This Works is, to be sure, quite different from anything we've known before: a plant connected from one end to the other by three or four systems of pipes with thousands of interconnexions and hundreds of taps, and everything of necessity gas-tight. One is dumbfounded . . .

THE PIONEERS. 1836-1861

Although the German chemist Vogel had drawn attention to the ammonia-soda process in 1822, and although John Thom had actually manufactured soda by the process on the very small scale—about 80 lb. a day—at Camlachie in 1836, the true pioneer works and patent* was that of Harrison Gray Dyar and John Hemming. Their plant, built at Whitechapel, used solid ammonium sesquicarbonate, which was dissolved in the brine and carbonated. The reaction went very slowly, so that a batch took as long as twenty hours to complete the precipitation of the sodium bicarbonate. This, coupled with the

* B.P. 7713/1838.

difficulty of making ammonium sesquicarbonate, and the enormous ammonia losses involved, made the process uneconomical. Dyar and Hemming struggled for two years to make a practical success of the process, but finally their funds ran out, and, with little hope of ultimate success, they abandoned their works and the process. They had, however, introduced the important step of decomposing the residual ammonium chloride with lime—a procedure that had not been contemplated by Fresnel twenty-six years earlier.

While the Whitechapel works were in production they were regularly visited by Sheridan Muspratt—a son of James, the Le Blanc pioneer. Muspratt often brought with him James Young—later of paraffin fame—who was then assistant to Dr Graham of London, and so possibly acquainted with John Thom, the Camlachie pioneer, who had been one of Dr Graham's assistants a year or two earlier. A couple of years later, James Muspratt himself became interested, and engaged James Young to build an ammonia-soda plant at Newton in Lancashire. In spite of every effort this venture, too, failed, falling down because the then unavoidable loss of ammonia from the cycle made the product much more expensive than Le Blanc soda. Finally, about 1842, the Newton plant was shut down, having cost its sponsors some £8,000.

About the same time a company bought the Hemming and Dyar patent, and built a works in Cheshire, where they were helped by a Mr Waterton, an early ammonia-soda patentee.* Little is known of them beyond the fact that they, too, lost all their capital and gave up the works. Then followed a decade of spasmodic patents and spasmodic attempts to work the process, but with no better results. Little plants popped up at Vilvorde in Belgium, at Berlin, and at Liesing near Vienna, ran for a while and then came to the same inevitable end.

From 1852 onwards there was a revival of interest and quite a crop of patents came out in the early fifties. A Mr Bowker of Hunslet, near Leeds, actually sold soda made by the process and kept going longer than anybody, but by the sixties he had been forced to shut down for economic reasons. In Widnes, the doggedly inventive William Gossage had turned his attention to the ammonia-soda process and from 1854 his patent was followed by patents taken out by Theophile Schloesing on the Continent, and by Deacon in Widnes. Gossage does not appear to have done very much about his patent, and later mentions that Deacon had tried to exploit it with no more success than anybody else. But one very definite trend is apparent from the patents: more and more the patentees were realizing that the success of the ammonia-soda process was a matter of plant design

* B.P. 8608/1840: it resembles Dyar's and Hemming's very closely.

rather than any inherent chemical difficulty in keeping the valuable ammonia in the cycle.

The final attack in Great Britain was one of which John Brunner and Ludwig Mond knew well. Henry Deacon had been in a short-lived partnership with William Pilkington, a glass manufacturer of St Helens. Perhaps he saw in the ammonia-soda process a method of making soda so free from iron and other colouring oxides that it could command a premium in the glass trade: whatever the reason, he made a serious attempt to conquer this will-o'-the-wisp process. In October 1853 Deacon leased some land for building a pilot plant and by the New Year was in partnership with Holbrook Gaskell. Work went ahead, but with little result until July 1855, when the plant went properly into production, making an average of some two tons of soda a week. Deacon carried on for some nine months, when Gaskell reckoned that the process had been given a fair trial, but had failed to prove itself. Deacon, however, had not lost confidence and was certain that £1,000 more would see Gaskell, Deacon & Co. over the crest of the hill. But Holbrook Gaskell was adamant, and threatened to withdraw from the partnership, so the plant was closed down.

Schloesing, in partnership with an engineer—M. Rolland—built a works at Puteaux, by Paris, and in the course of two years made 316 tons of soda, but at a cost that could not compete with Le Blanc soda. That then was the position when Ernest Solvay started his experiments in 1861.

ERNEST SOLVAY. 1861-1872

Ernest Solvay was born in such a lucky concomitance of circumstances that if he had failed to make a success of the ammonia-soda process it might easily have been well on in the twentieth century before the rise of the electrolytic chlorine processes forced the Alkali Trade into an alternative to Le Blanc. Solvay's father owned a small salt refinery at Rebecq-Rognon in Brabant; his uncle, M. Semet, was director of a small gasworks at Schaarbeck, just outside Brussels. Solvay himself said that he was brought up in an atmosphere of salt: he might have added ammonia to the list as well.

When Solvay was about seventeen, he fell seriously ill and had to give up all idea of a University course. During his convalescence he kept the books for his father, but found ample leisure to study chemistry and physics. By the time he was twenty-one he had recovered sufficiently for him to join his uncle at Schaarbeck, and learn something of the smell of ammonia. Part of his early duties were concerned with utilizing the by-product ammoniacal gas-liquor, for which there was a small sale. In order to save transport costs, he

devised a simple reflux apparatus for concentrating the dilute gas water and, further, manufactured strong ammonia by distilling the concentrated gas-liquor with lime. Thus he early learned one of the prime techniques of the ammonia-soda process—ammonia recovery.

Much of the ammonia in gas-liquor is combined with carbon dioxide as various ammonium carbonates, and of these, ammonium sesquicarbonate at that time commanded a ready sale at a high price. So Solvay's first experiments were directed towards making ammonium sesquicarbonate from gas-liquor, a project that led directly to nothing of commercial value: indirectly it had the widest repercussions. One day, in idle speculation, he mixed ammonium sesquicarbonate and salt together in the bottom of a tumbler and stirred them up with a little water. The fact that part apparently did not dissolve interested him and further investigation confirmed his first opinion that interaction had taken place with the formation of sodium bicarbonate. Solvay had, all unwittingly, rediscovered Fresnel's reaction.

Without further ado Solvay patented the reaction in Belgium (April 25th, 1861) and started to set up a pilot plant at Schaerbeek in conjunction with the gasworks and a lime kiln so that he could get the process going satisfactorily enough for demonstration purposes. For a year Ernest Solvay and his engineer brother Alfred worked night and day to get the plant working, coping with all the hundred and one troubles of unproved apparatus. They had, too, sheer bad luck, such as running out of cooling water at a crucial stage of the work, and near tragedy when a leak of kiln-gas all but asphyxiated the two brothers and their foreman.

By the summer of 1863 matters had advanced enough for the brothers to interest industrialists in their process, and by the end of the year an agreement had been signed with M. Endore Pirmez and the firm of Solvay & Co. was founded at Couillet. But it was during the negotiations leading up to this agreement that Solvay made the horrifying discovery that he was not first in the field, and learned at the same time the sorry tale of loss and disappointment that had dogged ammonia-soda's footsteps since Dyar and Hemming's failure thirty-five years before. Something of his feelings can be gauged from his own words:

It was a heavy blow to me. . . . To what must these persistent setbacks be attributed? Had the new process some constitutional vice? There were times when my faith in the success of my process suffered shocks; nevertheless, I quickly recovered and was sustained by the conviction that in my apparatus for bicarbonation I had an advantage over my predecessors.

*of a ton of Bleaching Powder
in works in this neighborhood.
And, and of the terms
on which you would be
willing to grant a licence.
An early reply will oblige
me, having delayed this
in the hope of seeing you
here. In haste*

*Yours very truly
Ferdinand Mond.*

W. Weldon, Engineer.

29. The Cedars

Putney S.W.

May 18th 71.

My dear Sir,

*Having some stores of
going shortly into the manu-
facture of alkali and
Bleaching Powder, I should
feel obliged, if you would
inform me of the cost of
plant for making 5 Tons
of Bleach Powder per week
by your process including
shutters and stills for the
decomposition of natron.
I may as well make up for
the losses of the actual cost*

Letter dated May 1871 inquiring for a licence to build a bleaching powder factory under Weldon's patents

Indeed, the future success of the ammonia-soda process was implicit in the oft-quoted dictum—Le Blanc invented a process; Solvay an apparatus.

The whole of 1864 was spent in getting the works at Couillet ready, but before the plant could start up, the money was spent and fresh capital had to be secured. Trouble with water shortage and leakages continued but by mid-1865 production had reached between 12 and 18 cwt a day. Next M. Pirmez began—like Holbrook Gaskell—to jib at the great expenditure and the small returns, but was finally quietened by an admirably worded declaration of faith carefully penned by Ernest himself.

Then, in October, their main unit blew up, carrying away, it would seem, their last hopes. The works were shut down under the pretext of a general overhaul and the Solvay brothers retired to the family home at Rebecq to recover strength and faith. They returned refreshed, bringing with them 40,000 francs which represented their family's last savings.

The works were got going again with new apparatus, and by the spring of 1866 were turning out a ton a day. In the late summer, it looked as though the outbreak of the Austro-German war would be the last straw, but trade was not badly affected, rather the reverse, and with the attainment of a steady make of one and a half tons a day, the corner was turned and M. Pirmez saw some return on his investment.

The position was consolidated and the make gradually rose to two and even three tons a day, when, in April 1872, Ernest Solvay had the first flattering recognition of the value of his invention: Ludwig Mond, 'a distinguished industrial chemist', stood at his door, and the doom of the Le Blanc system was assured.

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THE DECLINE AND FALL OF THE LE BLANC SYSTEM 1873-1920

THE THREAT OF AMMONIA-SODA

The introduction of the ammonia-soda process into England did not have any immediate effect on the Le Blanc factories. For one thing the Le Blanc system produced, in addition to soda ash, numerous products such as saltcake, sodium sulphide, hydrochloric acid, and bleaching powder for which there was a ready sale, while demand for chlorine for a vast potential market in chloro-organic compounds was just at that time starting to grow.

Ludwig Mond had always seen that the Le Blanc works could survive by concentrating on these products, turning themselves into chlorine factories pure and simple, disposing of their surplus saltcake by converting it into soda and selling it for whatever it would fetch. The Le Blanc system, thought Ludwig, would always supply the hard core of demand for crude alkali, even at give-away prices, while the pure ammonia-soda product would take up the margin—a good and growing one—between that and the full demands of the market. But he, like the Le Blanc manufacturers, had made these calculations at a time when Hamilton Young Castner was only known to a small circle of teachers as a provocative student at the Columbia School of Mines.

Then too, Winnington's early vicissitudes were well known in Widnes and the paladins of the Le Blanc system had seen too many such crack-pot plants flourish for a few brief months before dying a natural death, so they consulted their oracles and waited with folded hands for Brunner, Mond & Co. to collapse. Widnes had never believed in ammonia-soda and it did not quickly change its mind.

But this time the oracles were wrong, and ammonia-soda plants began to spread across the face of the earth like a sudden rash. This rapid development, to quote one of the oracles—Walter Weldon—came 'like a thunderbolt out of a clear sky'. Two years after starting at Winnington, Brunner, Mond & Co. were producing a mere 200 tons a month. Eight years later their annual production was 52,000 tons—one-eighth of the total soda production of the country.

Apart from competition with home-produced ammonia-soda, the Le Blanc works were faced with even more alarming developments

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abroad. In France, Solvay's second works at Dombasle came into production at the same time as Mond's Winnington plant, and by 1881 works had been built at Syracuse in the States and at Beresniki and Lissichansk in Russia. Four years later works were in production in Germany and Austria. By then Belgium had ceased Le Blanc production entirely, and nearly half of the national output of soda in France and Germany was coming from ammonia-soda plants. Of the world soda production of 708,725 tons in 1883, 163,225 tons—about a fifth—was made by the new process. In 1889 in Great Britain alone 219,279 tons of soda were made by Fresnel's process, as against 584,203 tons by Le Blanc's.

As late as 1875 the *Warrington Guardian* could report:

Little further is known of . . . what is called the 'ammonia process'. Messrs Brunner, Mond carry it on at Northwich, but their operations, I understand, are kept so secret that nothing is known of them outside their Works. Mr Weldon, who has examined into the subject, expresses opinion at a recent meeting . . . that the process is so slow, and the apparatus so expensive, that it could not economically be used.

Five years later Weldon had to eat his own words and to report: 'The consideration that constitutes the chief ground of hope of the makers of Le Blanc soda for salvation against the ammonia-soda process is that the World requires chlorine as well as soda.'

Ten years later the paladins of Le Blanc lost their most practical prophet, and the field was left clear to the impeccable scientific reasoning of their chief chemist, Ferdinand Hurter. He insisted that the only economical way of decomposing common salt was by the Le Blanc process and that

as far as reasoning from scientific principles will permit us to judge, there appears to be no great probability that any enormous revolution will endanger the present [Le Blanc] plant. The greatest danger of the chlorine manufacturers is over-production, but the ammonia-soda process will keep it in bounds.

UNION IS STRENGTH. 1866-1890

Ludwig Mond was never a rationalist. He never, apparently, had dreams of the economy of large combines—that vision was left to his younger son. But it was the success of Ludwig's ammonia-soda process that caused one of the first combines in the history of the chemical industry. For in 1880 it became increasingly evident to the Le Blanc alkali makers that improvements in plant and processes alone

would not serve them in their struggle with ammonia-soda and the adverse conditions developing in foreign markets.

Collective action was no new thing to them. As early as 1866 the representatives of the Alkali Makers' Association had negotiated for more favourable terms in a commercial treaty that the government was proposing to make with France. They had also formed a united front to avert restrictive legislation that might have arisen from the report of the Royal Commission on Noxious Vapours. When, therefore, it became urgent to limit the free and unrestricted production of chlorine, which was reducing its profitability, the Le Blanc manufacturers again took collective action.

The Lancashire Bleaching Powder Manufacturers' Association was formed in 1883, with John Brock, its moving spirit, as Chairman. They drew up marketing arrangements for bleaching powder, and laid down production tonnages for each works, selling all surplus possible in America through the agency of James Lee & Co. of New York. This co-ordinated action of the bleaching powder makers was an essential commercial counterpart of the technical improvements effected in their factories to fight the virtually non-chlorine-producing cheap soda process. But far more than maintaining chlorine production as a profitable venture, the Bleaching Powder Association confirmed among the paladins of Le Blanc the acceptability of co-operation. In working together on the bleaching powder issue, the rival alkali makers became personally known to one another. Thus, towards 1890 when the difficulties of the Le Blanc system were becoming acute it was evident that some further radical reorganization was necessary if the industry based on that system were to survive.

Some eighteen months earlier the Salt Union had been formed to protect the salt interests in Cheshire, for the pan-sheds were also feeling the cold draught that was blowing round their customers of the Le Blanc factories. So with this precedent Sir Edward Sullivan and John Brock saw, in early 1890, the virtual fruition of a long-cherished scheme for amalgamation—the United Alkali Company was conceived and all but born. But at that moment a financial crisis loomed up; the banking house of Baring had undertaken large loans to Argentina and guaranteed interest on capital invested there. The continued default of the Argentine government forced Baring's to suspend payment with liabilities of £21,000,000, and only the prompt action of the Bank of England and the joint-stock banks prevented a national disaster. Into this troubled winter of 1890 the United Alkali Company was launched with a share capital of £6,000,000.

MCKINLEY AND CASTNER. 1890-1920

In the last decade of the nineteenth century two events occurred that doomed the moribund Le Blanc system: first William McKinley became a fiscal power in the House of Representatives and introduced his initial tariff on chemicals one month before the United Alkali Company was floated. In 1897 he was President of the U.S.A. and, joined by Dingley, piled tariff on tariff till British chemical products were virtually excluded from what had once been their largest foreign market. In 1898 the United Alkali Company paid no dividend on the ordinary shares.

In the same decade the fortunes of the Aluminium Company at Oldbury were at a very low ebb. New electrolytic processes, used in conjunction with hydro-electric power, had so cheapened aluminium as to render the Castner-Deville sodium route almost suddenly uneconomic. The Aluminium Company was able to reverse its misfortunes by the profitable sale in the United States of the patent rights of the Castner electrolytic sodium process, and by developing new uses for metallic sodium which was no longer required for aluminium manufacture by the Deville process.

Castner's sodium cells were always giving him trouble: Le Blanc caustic soda was, by the very nature of its manufacture, impure, and the impurities used to decrease the efficiency of the cells, and interfere with steady production. Castner, as always, went to the heart of the matter and decided that the only cure was to produce specially pure caustic soda. As there was no simple chemical way of doing this, he turned to electrolytic processes and in 1892 patented his first mercury cell for the production of chlorine and pure caustic soda from a solution of salt. That was the second event that doomed the Le Blanc system.

Although this had hammered the last nail in the coffin of the Le Blanc system, the paladins remained conservative in their attitude towards the new electrolytic development: not altogether, perhaps, without justification, for in the late nineties it remained to be shown that brine electrolysis would prove successful when operated on a scale similar to that of the Le Blanc undertakings. As late as 1898 John Brock was confident enough to tell his shareholders,

Everybody . . . thinks there is some magic in electricity. . . . This, however, is not the case. We have examined to the best of our ability every new process that has been brought out, but we have not yet come to the conclusion that they could manufacture cheaper than our Company can.

Even with the growing threat of chlorine production by the Castner-Kellner process the Le Blanc system dragged on. As late as 1906 the paladins held out hope that they could still compete with electrolytic chlorine.

Indeed [one wrote in *The Times*], the commercial recovery of chlorine and sulphur from [Le Blanc but not ammonia-soda] 'wastes' has not only prolonged the existence of the Le Blanc system of manufacture, but has also rendered it highly improbable that this classic process will ever die out.

But that was not to be. The Le Blanc system dragged on, took on a final lease of life during the First World War, but by 1920 it was dead.

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MOND'S AMMONIA SYNTHESSES AND POWER GAS

THE BARIUM CYANIDE PROCESS

With the formation of the limited company in 1881, Ludwig could turn his consideration to his sources of raw materials, the least satisfactory of which was the make-up ammonia required to keep up the strength of his ammonia-soda cycle-liquors. But he was not wholly obsessed with a raw material for his alkali works—the work of Liebig was well known to him and he saw the value of a home-produced fertilizer. He also saw the steady stream of money—some £5,000,000 a year—that Europe was spending in order to buy South American nitrate of soda for her nitrogen-hungry fields.

Although, as he said himself, Ludwig was naturally biased in favour of the distillation of coal—an extension of his boyhood's experiments—the chemist in him was attracted in the first place to processes in which nitrogen from the air was made to form a nitride or cyanide that could later be decomposed with steam to give ammonia. His first attack was concentrated on boron and titanium, both of which elements form nitrides that give ammonia when treated with steam, but neither proved suitable. The second attack was on metals that readily formed cyanides and, of these, barium proved to be the most promising.

In Ludwig's process, as finally designed, ground barium carbonate, briquetted with carbon and pitch, was fed into the top of an externally fired vertical retort, the top part of thin fireclay, and the bottom part, below the furnace, of cast iron. A current of nitrogen—obtained from the waste gases of the ammonia-soda process—was passed in at the bottom of the retort. The briquettes, heated to some 1,400° C. in the upper fireclay section, gave off carbon dioxide and absorbed nitrogen and carbon, thus converting the barium carbonate into barium cyanide. The sintered cyanide briquettes were withdrawn from the bottom of the retort, having cooled in the steam of incoming nitrogen. The cyanide briquettes were then steamed in a separate apparatus, ammonia being evolved and barium carbonate reformed.

This second attack failed, however, in the matter of materials. The quality of fireclay then available to Ludwig Mond would not stand the temperatures involved, and the process became one of his beloved failures.

THE LIFE OF LUDWIG MOND

THE DISTILLATION OF COAL

As long ago as 1872 Solvay—whose uncle Semet was a gasworks proprietor and hence a coker of bituminous coal—had hoped to obtain ammonia by passing steam and nitrogen over red-hot coke, and Ludwig then had stated his belief that it was only the nitrogen already present in the coke that appeared in the effluent gases. So Ludwig Mond, disappointed in his chemical attack on the problem of ammonia production, turned from air to earth, to the nitrogen reserves combined in the huge quantities of coal that was Britain's wealth. So careful experiments were started which, on the one hand, proved that no fixation of nitrogen occurred if air and steam were passed through glowing coal—at any rate at practicable temperatures—and, on the other, defined the optimum conditions for the production of producer gas from which the maximum quantity of ammonia could be recovered as sulphate. For, as Ludwig calculated, if only one-tenth of the fuel then burnt in Great Britain could be burnt his way, the whole of the European demand for ammonia could be met.

As a method of cheapening ammonia, or of coming to the assistance of a fertilizer-starved world, Ludwig's invention was not a startling success. But the producer gas which at first he envisaged as a useful by-product soon became of over-riding interest to him as smokeless fuel that could be used for power generation and heating furnaces and kilns. From this, as Mr Cohen has written, were born the Power Gas Corporation and the South Staffordshire Mond Gas Co.—separate companies that Ludwig formed when further interests claimed his immediate attention.

One charge levelled against Mond Gas was that its low calorific value made it useless for work where real heat was required, for instance, in a steel works. With characteristic energy Ludwig Mond had an open-hearth furnace built at Winnington, and called in the doubters to see the steel that it made. For, at Winnington, row after row of Mond gas producers had been built, first to fire Ludwig's patent finishing furnaces, and later to drive the great gas engines that generated the electricity for Ludwig's electrolytic processes.

HERBERT HUMPHREY AND THE GAS TURBINE

Once Power Gas grew out of his dreams of utilizing the nitrogen of the atmosphere, Ludwig grew resigned to comparative failure on the nitrogen fixation side and concentrated on extracting the maximum efficiency from his gas. For this he required someone with a firm command of thermodynamics and experience with gas engines, and it was

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Herbert Humphrey—later, of the Humphrey pump fame—that eventually he chose.

Ludwig Mond was disturbed by the low efficiency of his gas engines. However finely made and skilfully run, they could produce as electrical energy no more than a twelfth of the potential energy of the original coal—this was an inherent defect of the heat-cycle used. So Ludwig, the theoretician, set his staff to work to evolve a gas battery that, theoretically, could deliver almost all the input energy as electric energy and Ludwig, the practical man, set Humphrey to investigate whether or not a gas turbine, fired with Mond Gas, would not show efficiencies well above those possible with reciprocating engines. In the end neither line came to anything, for Humphrey reported that, in the then state of the metallurgical industry, a gas turbine of commercial efficiency was not a practical proposition, and the gas battery proved too cumbersome and the practical difficulties too great.

THE HYDROGEN CELL

The hydrogen cell—the so-called gas battery—was an old dream of the electrochemist. If hydrogen is burned in air and used to raise steam which, in turn, is used to generate electricity, then only a twelfth of the potential energy of the hydrogen could be converted into electric power. If, however, hydrogen is 'burned' chemically in a battery and the resultant energy converted directly into electricity, then, as Ludwig Mond himself showed, at least half of the potential energy of the reaction could be usefully recovered.

Ludwig knew of the first hydrogen cell constructed by Lord Justice Grove in 1839—for, after all, he was an electrochemist at heart. Then one day, shortly after the completion of his Mond Gas plant at Winnington, Ludwig—as he tells us himself—was wandering round the works, looking at this thermometer, tapping that pressure gauge, and gazing down from a high platform in a reverie, lost in a forest of cast-iron towers and tortuous pipe-work. Coming slowly down from his eyrie, he wandered along the firing floor of his finishing furnaces—his wild, but eminently successful, adaptation of the Thelen crystal-lizer. That day all was quiet except for the steady slap-slap of the driving belts and an occasional groan from the ponderous swinging stirrers. There was no bustle of stokers, of trimmers unloading wagons; no sharp metallic ring of shovel on brickwork; no clank and bang of slicing bars: only the subdued hiss of his Mond Gas as the long colourless tongues of flame slid through the furnaces and licked the flue-drops.

The beauty of that flame, now faintly luminous, now the palest

and most transparent blue, fascinated him: but it also saddened him. Then groping amid his half-forgotten memories his mind fixed itself on Sir William Grove and his hydrogen cell. Versatile as it was, his Mond Gas would be far better employed yielding up its energy direct as electricity. Immediately Carl Langer was sent for, and returned to 'The Poplars' to start experiments on a new and improved gas battery.

NICKEL CARBONYL

Another problem was troubling Ludwig at Winnington. His chlorine plant was eating up its slender profits with endless maintenance. He knew that the vapours of ammonium chloride were intensely corrosive; he knew that on the laboratory scale pure nickel was resistant to them: but on the plant the nickel cocks were corroded, their faces becoming covered with a black crust that jammed them shut and, if finally dislodged by violent hammering at the plug, left the cocks free but leaking. Something in the scaling up from bench to plant had gone awry.

It was not long before analysis showed that the crusts were mainly carbon, and this, though it puzzled Ludwig at first, pointed quickly to the cause. In the laboratory pure nitrogen had been used to sweep the last traces of ammonia from the apparatus: on the plant the nitrogen contained a small percentage of carbon monoxide. A check in the laboratory soon showed that nickel had the unsuspected property of removing carbon catalytically from one molecule of carbon monoxide, the resulting oxygen combining instantly with another molecule of carbon monoxide to form the dioxide.

At 'The Poplars' Langer had completed the first phase of his hydrogen cell research. One thing was certain—that was, that the hydrogen had to be very pure indeed. The traces of hydrocarbons that were present in Mond Gas, as well as the large quantities of carbon monoxide contained in it, poisoned the platinum black used in the cell and destroyed its absorptive power for hydrogen. The cure seemed obvious: the behaviour of nickel that was such a trouble on the chlorine plant seemed a panacea for the trouble with the Mond Gas battery. It was not long, therefore, before the problem of purifying the Mond Gas was solved: Ludwig had only to pass a mixture of Mond Gas and steam over finely divided nickel at 400° C.—well short of red heat—and the steam and carbon monoxide combined to give carbon dioxide and more hydrogen, leaving a gas that, after a simple alkaline wash to remove the carbon dioxide, could be used successfully in the hydrogen cell.

But Ludwig was not content: he liked to know the reason for things.

So Dr Langer, joined by now by a young German, Friedrich Quincke, was detailed to make an elaborate study of the action of carbon monoxide upon nickel, to see whether he could identify the evanescent compound that was responsible for the catalytic action.

In the course of these experiments a combustion tube was set up, in which finely divided nickel was treated with pure carbon monoxide made by the action of sulphuric acid on a formate. To keep the poisonous carbon monoxide out of the atmosphere of the laboratory, the tail-gases from the combustion tube were passed through a glass jet and there burned. The experiment was started each morning and shut down each night, the nickel being allowed to cool off in the stream of carbon monoxide before the whole apparatus was shut down.

One evening in 1889, however, the assistant who usually remained behind to close down the experiment, had gone home early, and Langer himself was waiting for the flame to die down and the last of the carbon monoxide to be burnt before locking up. It was the first time that he had done so, and he was quite unprepared for what he saw. For as the apparatus cooled he saw, to his great surprise, the flame of the jet grow luminous and increase in brightness until the temperature fell below the boiling point of water, when the flame faded again. Furthermore, from its usual lambent blue the flame had turned a sickly green.

Ludwig Mond was called at once to witness the strange phenomenon, and together they stared in silent wonder. At first both thought of the arsenic that might be present in the sulphuric acid. Arsenic was known to form a volatile hydride that would tinge the flame with green. But that was readily tested—a cold porcelain tile was thrust into flame and was immediately coated with a shiny mirror, not unlike, but significantly different from, the spots left by arsenic in Marsh's test; and when the neck of the combustion tube was heated, a bright mirror formed on the glass and the luminosity of the flame disappeared.

The mirrors were analysed and appeared to be nickel, but such was the improbability of so heavy a metal as nickel forming a volatile compound that Ludwig would not believe his own tests, and postulated an unknown element in the nickel. Both the carbon monoxide and the nickel were then purified as carefully as possible, but still the phenomenon occurred. It was not, one feels, until the gaseous nickel carbonyl had actually been frozen to a mass of needle-shaped crystals that Ludwig could really believe that he had, in Lord Kelvin's words, given wings to a heavy metal.

APPENDIX 5

MOND'S EARLY CHLORINE PROCESSES

A FAILURE AND A THREAT

Although Ludwig Mond's heart was in the laboratory—that laboratory was paid for by Winnington Works, and Winnington Works were still in direct competition with the Le Blanc factories in the rest of England. These now had changed heart and, recognizing the superiority of Ludwig's plant for producing soda ash, looked to the bleaching-powder market to keep them going, treating soda ash as a by-product to be disposed of as best they could.

Ludwig's second thrust in the battle with the Le Blanc system was somewhat abortive: he tried to develop an alternative bleaching agent to replace chlorine. In 1882 he patented the manufacture of calcium peroxide as a bleaching agent, a process which seems to have squibbed off and been forgotten. Widnes' riposte was more serious: Ferdinand Hurter, the high priest of Le Blanc, patented, with Eustace Carey, a variant of the ammonia-soda process in which the Le Blanc by-product saltcake was used instead of salt as the prime raw material. This decided Ludwig, and he settled down to study the second principal problem that beset him—the manufacture of chlorine from the waste chloride ion of the ammonia-soda process.

THE NICKEL-CHLORINE PROCESS

In the ammonia-soda process not only did some quarter of the input salt issue unchanged in the effluent, but also the calcium chloride of the effluent contained all the chlorine of the reacted salt bound almost as firmly to the calcium as it had been originally to the sodium. This, to Ludwig, was throwing away a deal of the advantage that his process gave him over the Le Blanc works, so the recovery of this chlorine from this waste chloride came in for intensive—if then fruitless—effort. It is doubly interesting to read of his efforts to-day, when the phenomenal rise of the chlorine market has outstripped the more leisurely advance of the demand for caustic soda, the inevitable co-product of the electrolysis of brine. For to-day, all over the world, alkali makers are turning their attention to processes that will yield chlorine without the equivalent caustic soda. They may be, indeed, even now reviewing Ludwig Mond's pioneer work to see whether they cannot—with modern techniques and improved metallurgy—succeed where he had failed.

Solvay had tried to attack the problem by recovering chlorine from calcium chloride crystallized from the effluent of the ammonia-soda process or from magnesium chloride formed from it, but his ideas had failed in practice because of the excessive temperatures needed. The chemistry of those days, indeed, was at a period of transition. The alchemist's crucible was giving way to the chemist's beaker, but most industrialists were still basing their processes on the power of fire to bring about chemical transformations. The ammonia-soda process—a pioneer of the chemist's water-borne transformations in which fire played little part—was a novelty, and so it was natural that Ludwig should turn first to fire to effect the liberation of chlorine.

Solvay had tackled, unsuccessfully, the route via calcium chloride: Ludwig tackled the route via ammonium chloride, the *sal ammoniac* of the liquors that left his filters. The first step was to isolate the ammonium chloride and this was relatively simple. The next step was to obtain hydrochloric acid from it, but this was not nearly as simple as it first appeared. If ammonium chloride is treated with sulphuric acid, as salt (sodium chloride) is in the first stage of the Le Blanc process, hydrochloric acid should be given off, which could readily be converted into chlorine by known methods. The residue would not be the saltcake for which demand was falling, but would be ammonium sulphate—a valuable fertilizer.

However, this idea failed because of the difficulty of carrying the reaction to completion, so Ludwig's next approach was to attack ammonium chloride in the vapour phase. He arranged a series of retorts in which ammonium chloride was volatilized, the vapour of which was passed over pills of nickel oxide and china clay. Theoretically the nickel oxide should be converted into nickel chloride, while steam and ammonia passed on. Heating the nickel chloride in air would reform the nickel oxide with the liberation of chlorine. Thus theoretically: in actual practice the non-volatile impurities in the ammonium chloride, the painful slowness of volatilization, and the breakdown of the nickel pills made the process inoperable. The process that had seemed a success on Ludwig's laboratory bench, when carried out with pure reagents and boosted up by Ludwig's incurable optimism, proved a failure when worked on the large scale and with commercial chemicals.

THE MAGNESIA APPROACH

Nothing daunted, Ludwig replaced his nickel oxide pills with magnesia pills and redesigned his apparatus. This plant, in the devoted charge of Dr Eschelmann and Albert Tangye, struggled to a start,

but soon ran into trouble with the fact that the magnesium chloride formed had a high affinity for water and this caused high losses of chlorine as hydrochloric acid. Eschelmann, however, knew that in the Stassfurt deposits a compound of magnesium chloride and potassium chloride occurred which had no affinity for water, so that by mixing potassium chloride with the pills much more efficient operation was attained. This idea, Eschelmann thought, was worth money; so unbeknown to Ludwig he patented it.

Ludwig was furious, but Eschelmann had the whip hand, and a violent altercation led to Ludwig buying Eschelmann's rights for £2,000 and having to be satisfied with this and Eschelmann's resignation. So Eschelmann departed for Germany saying, incidentally, to Tangye as a Parthian shot: 'It is so good of you Englishmen to found your colonies and do all the rough work—they will some day be ours.'

Eschelmann's departure left Tangye in charge of chlorine production, and the strange plant hobbled along for some years producing a thousand tons a year of bleach—a small make, but just enough to act as a thorn in the flesh to the paladins of Le Blanc, and as a weapon in John Brunner's hands when it came to bargaining with the United Alkali Co.

HOEPFNER *v.* CASTNER

The next stage in the history of Ludwig Mond's chlorine ventures is a strange one. The magnesia-chlorine process was not a money-spinner and was, in fact, only kept on because of its moral effect on his Le Blanc rivals. Ludwig, however, was not depressed, as he had on his laboratory bench a new process worked out by Carl Hoepfner that pleased him a deal more than the old magnesia-chlorine process, for it involved a neat chemical preparation followed by electrolysis.

In 1894, however, a process was being developed which threatened to put both Ludwig's chlorine processes and Le Blanc out for the count. Hamilton Young Castner had just got some experimental mercury cells working at Oldbury near Birmingham and invited interested parties to see them producing chlorine, hydrogen, and strong, pure caustic soda solution.

Actually, the United Alkali Company were first in the field, negotiating with Castner through the Aluminium Company for whom Castner worked, but their protracted negotiations finally broke down largely, as far as one can see, because the Directors were suspicious of Castner's American bombast and brash enthusiasm, and were not convinced by his economics. Ludwig, too, a sadder and wiser Ludwig, may have diagnosed the optimistic egoism of his own youth, for he

carefully considered the process, but turned it down, leaving it to Solvay to develop on the Continent and the Castner-Kellner Alkali Company to exploit in Great Britain.

Now Ludwig had cut his industrial milk-teeth on electrolysis in the Galvanoplastische Institut at Köln and so was familiar with its possibilities. Electrical generators, driven by his own Mond Gas, and even his hydrogen battery, had obvious applications in electrolysis; but Castner's method of the electrolysis of brine he turned down.

Perhaps Ludwig was suspicious of Castner himself and his ridiculously self-confident statement that '... having reached finality as regards the invention there is no fear that the process will be soon superseded'; perhaps, too, Castner's equally optimistic estimate of £2 9s. 4d. per mixed ton of caustic-bleach turned Ludwig against him; perhaps Ludwig shared the fear that the volatility of mercury would make the process noxious; perhaps he was too deeply committed to plans for his new Hoepfner zinc-chlorine plant; or perhaps, as Tangye has suggested, Ludwig was fanatically determined to obtain his chlorine from the chloride that left his process as waste, not from a fresh lot of sodium chloride altogether. Be that all as it may, his youthful bias towards waste recovery triumphed and Castner's patent was rejected. For Hoepfner's process made use of two wastes—those of the ammonia-soda process and of the abandoned lead mines of North Wales.

THE HOEPFNER ZINC-CHLORINE PROCESS

Dr Carl Hoepfner was another of Ludwig's young research chemists, who had been given the problem of recovering chlorine from the waste chloride of Winnington Works. Ludwig knew from theoretical considerations that the electrolysis of metallic chlorides, such as those of zinc and copper, were, on the whole, trouble-free. This much he knew from his Galvanoplastische days. The problem that Hoepfner had to solve was the most economic way of converting the calcium chloride of the ammonia-soda plant waste to another metallic chloride more suitable for electrolysis. Two sources of suitable metal were available—the copper slag of the Le Blanc pyrites burners and the huge zinc-blende dumps at the abandoned lead mines in North Wales.

It was the zinc-blende that proved the more attractive and Hoepfner's process was basically simple. The zinc-blende—zinc sulphide—was roasted in furnaces designed by Ludwig's boyhood friend, Dr Hasenclever, to form zinc oxide, while sulphuric acid (used to make ammonium sulphate in the Mond Gas plant) was made from the

sulphurous gases evolved. The zinc oxide was then mixed with the waste calcium chloride liquor and carbon dioxide gas from the ammonia-soda kilns was blown in. In the reaction that followed, chalk was precipitated, and a solution of zinc chloride left. This, when electrolysed, gave very pure zinc and chlorine.

A considerable plant was built forthwith, but, as usual in those days, the scaling-up of a laboratory plant to full scale was done too quickly and there were many months of heart-breaking disappointment before the full-scale plant settled down into production. In the middle of these protracted teething troubles, Dr Hoepfner faded quietly from the scene to try, equally unsuccessfully, to make electrolytic zinc at Frankfurt along with the imperially-minded Dr Eschelmann.

The Hoepfner zinc-chlorine process ceased to be of strategic importance when the success of the Castner-Kellner Works at Runcorn virtually sealed the death-warrant of the Le Blanc process, but it was kept alive because of the extremely pure zinc it produced. The process was not dropped, in fact, until the end of the Kaiser War made it no longer necessary. Long before that, however, Hoepfner's approach had been given up and the zinc chloride was made by dissolving pure zinc oxide in Le Blanc hydrochloric acid.

And with this last failure to recover the waste chloride ion of the ammonia-soda process, Ludwig Mond's interest in chlorine faded away completely, joining unwept the dim ghosts of his beloved failures.

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