# THE STORY OF MOND NICKEL

*PRIVATELY PRINTED*

1951

*Written for*
*The Mond Nickel Company's Jubilee*
*by A. C. Sturney*
*decorated by Eric Fraser*
*and printed at*
*The Curwen Press, Plaistow, E.13*

# CONTENTS

It has been said that the enterprise whose story is recorded in these pages was founded on an accidental discovery. It certainly sprang from the unexpected, but it is more truly regarded as an instance of the speedy recognition of the industrial significance of a casual observation. More important still is the fact that throughout the fifty years of its existence, the growth and progress of this same enterprise have been due in large measure, not only to an untiring quest for further scientific knowledge, but also to an unfailing readiness to see, and to take advantage of, the wider industrial opportunities which that increasing knowledge gave.

That, in essence, is the theme of this book.


*AXEL CRONSTEDT*

# BACKGROUND

IN 1751 Axel Cronstedt described to the Swedish Academy of Sciences the experiments which led to his discovery of a new metal. He had isolated it from an ore containing iron and cobalt and described it as 'more silver-like' than either. He called it 'nickel'.

The name was not his own invention. It had already been used, and was well known among geologists of that day, as an adjective identifying a particular type of ore, an ore which was believed, rightly or wrongly, to contain copper. The story of its origin has been told many times and with many variants; it is sufficient for the present purpose to recall that it comes from medieval Central Europe and is centred in frustrated attempts to extract useful metals from ores which, though promising in appearance, yielded nothing that was valuable. Superstition laid the blame for these disappointments on supernatural powers, personified by beings of the underworld known as 'nixes' or demons. Our colloquialism 'Old Nick' is probably derived from the same source, so that 'kupfer-nickel', as these ores were termed in the German language, may reasonably be rendered in English as 'Old Nick's Copper'.

Cronstedt was able to show that the specimen of kupfer-nickel which he was examining had this new metal as the dominant base. He therefore borrowed the term which hitherto had represented its nature or its effect, and applied it to the metal itself.

Some time elapsed before Cronstedt's discovery was generally accepted and it was not until fifty years later that a German chemist, J. B. Richter, produced the first pure nickel and—with remarkable accuracy—described its properties. Interest in the metal, from a wider point of view than the purely academic one, may be said to date from that time.

That is not to say that it had never been used before. There is indeed evidence that even in remote ages, by methods which remain wrapped in mystery, peoples of the Far East were able to produce

alloys of copper and nickel, and fashion them into coins. Leaving this aside, however, as an art which was lost in the mists of time, there remains the European importation of Chinese ornamental ware in alloys of copper, nickel and zinc which, even before Cronstedt's day, had made this beautiful, silvery-white material familiar to at least the wealthy classes of the Western world. By the turn of the eighteenth century, when nickel had been generally recognized as an elemental metal, its presence in the Chinese ornamental ware was also established, together with that of copper and zinc. This gave rise to European attempts to produce similar alloys, and resulted in the commercial manufacture of German silver—as these alloys were first called—by 1824.

It is interesting to notice, in passing, that the first recorded production of nickel silver in Great Britain was made in 1833 by Charles Askin, the forerunner of the Birmingham firm that later became known as Henry Wiggin and Company, and today is a part of The Mond Nickel Company.

Meanwhile Faraday and others were beginning to probe the secrets of electricity and not long after the introduction of European German silver, it was found possible to enhance its appearance by a coating of silver, applied electrolytically. The electrodeposition of nickel, to give a cheaper silvery-white appearance to various base metals and alloys, followed a little later.

The use of nickel in coins dates from 1850, when a German silver alloy, containing silver as well as copper, nickel and zinc, was introduced for Swiss currency. A copper-nickel alloy was adopted for a U.S.A. coin a few years later. The use of the pure metal for coinage purposes awaited knowledge of the means whereby nickel might be rendered malleable and it was not until 1881 that Switzerland—the pioneer—put into circulation a twenty-centime piece in this material.

Until sixty or seventy years ago, these were substantially the only known uses for nickel. At that time they accounted for an annual world consumption of about one thousand tons, half of which was for German silver.

So far, nickel had been regarded as a comparatively rare metal. Although its existence in almost every explored part of the world had become known, or at least guessed, the difficulties associated with its extraction were such that it is doubtful whether a larger market could have been supplied, even had it existed. By 1870 or thereabouts, nickel was being produced in Central Europe, Great Britain,



Norway, Sweden and the U.S.A., but the quantities which came from each refinery remained very small. In Great Britain, for instance, the total production was never much more than two hundred tons a year. The ores which were treated in this country were chiefly the arsenical minerals associated with cobalt deposits in Bohemia and Saxony and both nickel and cobalt were marketed, being separated from one another, and from the useless ingredients, by wet processes. In other parts of the world, similar ores were treated by similar methods.

A considerable impetus to the production of nickel was given by the discovery, around 1870, of extensive silicate ores in New Caledonia, a French possession in the Pacific. These ores quickly created a supply which was in excess of the demand and in the resulting instability the industry experienced large and frequent changes of fortune. Most of the other producers were replaced by the New Caledonian enterprise, though in the early days this itself was several times threatened with disaster. In the first three years the price of nickel dropped to less than one third of its former figure.

A serious challenge to the French nickel industry resulted from the discovery, in the 'eighties, of large deposits in Northern Ontario. The presence of nickel in that region was indeed recorded a quarter of a century earlier, but in 1883, in the course of constructing the Canadian Pacific Railroad, a rich outcrop of ore was discovered, and the large potentialities of the area were realized. At that stage the prospectors who flocked to the district were not aware of, or not interested in, the presence of nickel, but regarded the ore as providing a valuable new source of copper. It was not until refiners had found serious difficulty in extracting the copper that the significance of the nickel content was appreciated. At length, in spite of formidable production difficulties, Canadian nickel began to come into the market in quantities and at prices which seemed likely to replace all other sources.

The Canadians were as anxious about the future as everyone else, for the continuance of their operations required a far larger potential market than was then apparent. Accordingly they gave a good deal of attention to this aspect and, recollecting interesting experiments made some years earlier by an Englishman, John Gamgee, looked especially at the possibility of using nickel as a means of improving the qualities of iron and steel. Their visits to British and Continental steel makers, seeking to arouse their interest

in this direction, appear to have led to James Riley's famous study of the properties of nickel steel and to his historic paper, presented to the British Iron and Steel Institute in 1889. In that paper Riley demonstrated that nickel conferred on steel qualities of toughness and strength hitherto unknown, qualities whose importance was quickly realized by the makers and users of armour plate, one of the principal markets for high quality steel at that time.

A bright prospect for nickel was thus unfolded and it soon became clear that whatever immediate difficulties might remain, a steadily increasing demand would call for the combined production of New Caledonia and Northern Ontario.


*CARL LANGER*

# CARBONYL DISCOVERY

WHAT has been written so far has been but the background. The story begins with a discovery which was to have as significant a bearing on the production of nickel as that of Riley had on its consumption. The discovery was announced in a paper presented to the British Chemical Society in August 1890, so that it must have been made more or less at the moment when the potential importance of nickel in the manufacture of nickel steel was hot news.

The paper itself was prosaic enough. Entitled *Action of Carbon Monoxide on Nickel* and bearing the names of Ludwig Mond, Carl Langer and Friedrich Quincke as its authors, it described the formation of a gaseous compound of nickel and carbon monoxide, by the reaction of the latter gas with finely divided metallic nickel. In the words of the investigators, 'When a finely divided nickel . . . is allowed to cool in a slow current of carbon monoxide, this gas is readily absorbed as soon as the temperature has descended to about 100 deg. and . . . a mixture of gases is obtained which contains . . . nickel-carbon-oxide'. They decided that the composition of this new compound corresponded to the chemical formula $Ni(CO)_4$ and they found that by heating the glass tube through which the gaseous products were passed, there was formed on its walls a metallic mirror which proved to be nickel, mixed with a small quantity of carbon. In the words of Lord Kelvin, nickel had been 'given wings'.

So much for the paper. Behind it lies an interesting story. It appears that in the late eighties Mond, who had established a thriving chemical industry in the Midlands, was directing a series of experiments aiming at the production of bleaching powder as a by-product of what was known as the 'ammonia-soda' process. This involved the construction of a plant for volatilizing ammonium chloride, and as the vapour seriously attacks the majority of metals, considerable difficulty was experienced in finding suitable materials. Eventually it was decided to use iron vessels lined with glazed tiles for

the volatilization plant itself, and to make the required valves from pure nickel, one of the few metals that appeared to offer substantial resistance.

The production of the nickel valves was itself a matter of difficulty, the melting and casting technique for this metal being then in its infancy. This initial problem was solved by Albert Tangye, an assistant at Mond's Winnington Hall plant, who found that the addition of a small quantity of magnesium to the molten metal facilitated the production of sound castings.

The volatilization process having proved promising on an experimental scale, a large-scale plant was built at Winnington. To Mond's disappointment it was found that in this larger plant the valves soon became coated with a black crust and ceased to function satisfactorily. The black crust proved on examination to be a deposit of carbon. A careful inquiry into the differences between the laboratory and the large-scale operations revealed the fact that, in the former a current of pure carbon dioxide was used to sweep ammonia out of the apparatus, whereas in the larger plant the inert gas contained a small percentage of carbon monoxide. It was concluded, therefore, that the condition of the valves was due to attack by the latter gas.

The first use that was made of the discovery that nickel and carbon monoxide could thus be made to combine was as a method of removing carbon monoxide from a mixture of hydrogenous gases required for the operation of a voltaic gas-battery. After finely divided nickel had been found entirely suitable for this purpose, closer attention was paid to the reaction itself, and the gaseous compound was first recognized.

Whatever part in the discovery was played by Quincke, not long after the presentation of the paper to the Chemical Society he dropped out of the team, leaving the long and arduous road from inception to industry to be traversed by Mond and Langer, very largely on their own. It may be appropriate at this point, therefore, to say something about these two collaborators, whose persistence and skill had such an important bearing on the subsequent history of the British nickel industry.

At the time of the discovery, Ludwig Mond was approaching his prime, a rather short man, with a profusion of black hair on his head and face. He was a shrewd business man who also had a deep interest in the practical side of the chemical industry with a clear understanding



of both its technical and its human problems. Of German origin, Mond had settled in England some twenty or more years earlier, had become a British subject, and, surmounting innumerable difficulties and set-backs, had at length, in partnership with John Brunner, succeeded in establishing a prosperous chemical industry in Cheshire. It was as a chemicals manufacturer, concerned with the improvement of his processes and the development of new ones, that he had set up the laboratory in London.

It appears that, as a young man, Ludwig Mond was something of a Socialist, and at his own works had attempted to put his ideas—then far in advance of his times—into practice. Their almost inevitable failure made him a saddened and disappointed man and in the years immediately preceding the events related in this chapter he was regarded, even by his co-directors in the chemical business, as a somewhat fearsome personality. There is no doubt that he was strong-willed, quick to see to the heart of a problem, ruthless when the need arose; yet with all this he passed through the phase of bitter querulousness to reach a benignancy and generosity of spirit which won him something greater than respect from all his colleagues and work-people.

Carl Langer was an Austrian. He came to England as a young man, specially engaged by Ludwig Mond to undertake research associated with the ammonia-soda ash industry. He appears to have had little direct contact with the manufacturing side of the business, spending most of his time, prior to 1890, at Mond's private laboratory in London. Later on he was described as a chemical engineer of great drive and ability, a first-class draughtsman, a man of his word, but choleric, and with a tendency to obstinacy.

To return to the discovery; interest was first centred in the gaseous compound itself, and some months must have been spent in investigating its physical and chemical properties and in trying to obtain similar compounds with other metals. At length the ease with which nickel could be made to combine with carbon monoxide, and the difficulty experienced in producing a similar reaction with other metals, suggested to Mond that here was a possible method of refining nickel. That this was in his mind, at the time the paper was presented to the Chemical Society, is shown by the fact that almost simultaneously he applied for a patent covering 'The Manufacture of Nickel'.

It is of course one thing to patent a new process and quite another

to make industrial use of that patent, and it may be assumed that before he gave serious consideration to the practical exploitation of the discovery, Mond made himself aware of the various important factors which would govern success.

He was aware, of course, of the advent of nickel steel. The interest aroused by Riley's paper had been deepened in the months that followed and it was probably common knowledge that nickel steel had been definitely adopted by the U.S.A. for armour plate.

Riley was the manager of Tennants, a British firm that manufactured nickel on a small scale, and it cannot be doubted that he would not let discussion be dropped. In any case, however, the visit of Canada's High Commissioner in London, in the interests of the Canadian nickel industry, to most of the important European steel makers and ordnance manufacturers, would ensure that the important qualities of nickel steel would not be forgotten. It is true that the British Government had not so far displayed any marked enthusiasm for the new material—indeed a few years later they definitely rejected it—but Mond's foresight must have assured him that a far larger market than then existed was only a question of time.

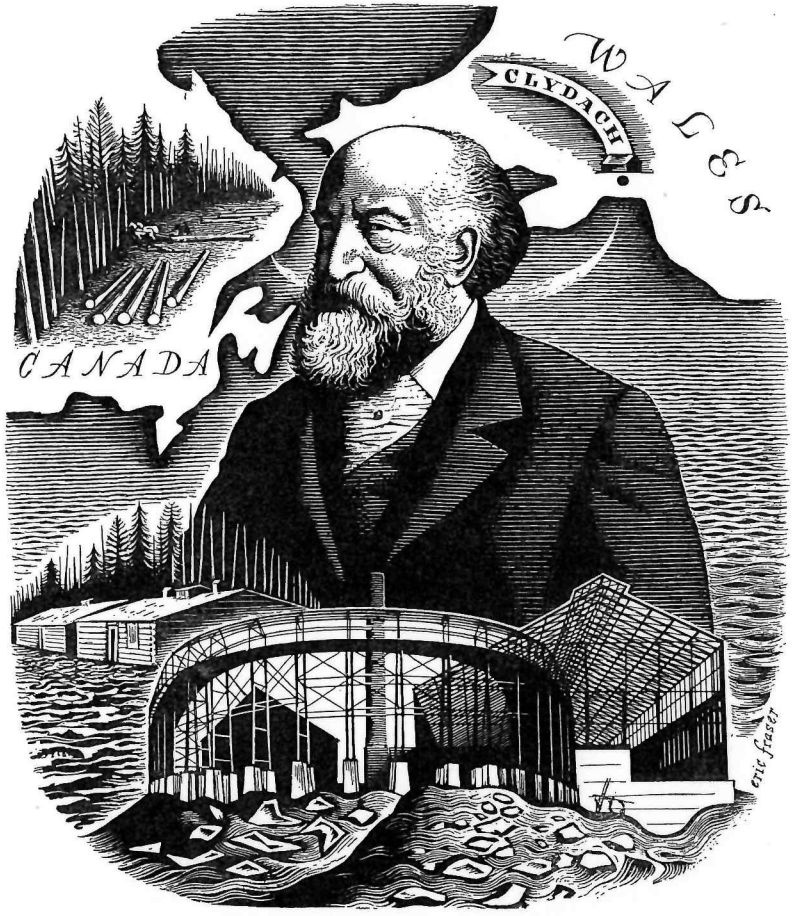
Competitive production was also a matter of importance. Although the vast resources of Ontario had been revealed, there was still some doubt as to whether they would successfully compete with French supplies. Neither of these mining enterprises sent refined metallic nickel directly to the market. Canada's product—very largely from the Canadian Copper Company—was in the form of a matte (sulphides) with a content of nickel-plus-copper amounting to about one third of the total weight. This went largely to Colonel Thompson's Orford Copper Company, to emerge as a nickel oxide. Other lots went to Joseph Wharton's small electrolytic refinery in Philadelphia, to Tennant, Henry Wiggin, and Vivian in Great Britain, all using wet processes, and to a refinery at Hamburg. At this time Vivians also had mines of their own in Ontario, and were refining small lots of nickel from these.

Thus the general picture, as Mond would have seen it in those days, was of large potential sources of nickel without the means of easily and cheaply converting them to the metallic form, or to a form suitable for large-scale industrial use. The famous Orford process of separating copper and nickel, which revolutionized the extraction processes a year or two later, was at that time only in the development stage and it is quite probable that Mond knew nothing about it.



Some such consideration must have led him at an early stage to decide that his discovery was of great importance, at any rate potentially, and within a few months he was seeking ways and means of making practical use of it. It is said that one of his first actions was to offer the process to English steel makers and then to one or other of the British refiners. If any such proposals were made, however, no one was willing to undertake the formidable task of developing the process on an industrial scale, and it soon became clear to Mond that if he was to prove the industrial worth of the discovery, he would have to do so by his own effort.

Accordingly he decided to design and erect a large-scale experimental plant and made an arrangement with Henry Wiggin and Company whereby part of their land at Smethwick, with some buildings standing on it, was placed at his disposal. There, in 1892, a complete experimental plant was built at Mond's expense.




*LUDWIG MOND*

# THE COMPANY FORMED

THE erection of a large-scale experimental plant, though in a sense it was only a first step, probably represented nearly two years of intensive activity on the part of Ludwig Mond and Carl Langer, particularly of the latter, who seems to have been responsible for practically everything associated with design and experimentation and who must have encountered formidable difficulties.

For one thing, he was dealing with two gases which were invisible, more or less odourless, and poisonous—carbon monoxide and its compound with nickel, by then known as nickel carbonyl. Therefore, the provision of gas-tight vessels, pipes and joints, not only affected efficiency but was also an important safety measure.

Secondly, he soon discovered that exact control of the conditions was essential to success. He found, for instance, that the reaction between finely divided nickel and carbon monoxide was at its maximum efficiency only at normal temperatures, but, on the other hand, that it was accompanied by the generation of heat, which therefore had to be dissipated. It became clear, also, that the decomposition of nickel carbonyl could be most economically and efficiently accomplished only over a rather narrow range of temperature, around 180 deg. C., and, further, that special steps had to be taken to obtain the resultant deposited nickel in a manageable form.

These, and other considerations, were preliminary, and must have been in the minds of the collaborators even before the designs of the large-scale experimental plant were committed to paper. It may be assumed that another problem of major importance at the outset was that of obtaining a supply of raw material of a suitable nature and in a suitable form. The fact that Henry Wiggin and Company were nickel refiners was no doubt important in determining the site of the plant, for there Langer would be able to make use of Wiggin's equipment and accumulated experience to produce materials to which the new process could be conveniently applied.

Wiggin obtained their nickel-containing ores where they could. Prior to 1890 most of them came from the Continent, and consisted largely of arsenides containing iron, nickel and cobalt. In 1890, however, they were receiving copper-nickel sulphide mattes from Canada and possibly some of the partially treated silicate ores from New Caledonia came their way. Their own extraction process was directed to the recovery of copper, cobalt and nickel, and the first stage was a smelting operation to remove most of the iron. This was followed by repeated crushing and calcination, which gave a mixture of nickel, cobalt and copper oxides, with some iron oxide and other impurities. Wet methods, involving solution and precipitation, were then applied to this intermediate product, in order to separate the metals one from the other. It is virtually certain that it was an intermediate product of this type to which the large-scale Mond process was first applied.

While Langer was involved with the technicalities of the process, trying this experiment and that, taking down and rebuilding faulty or inefficient apparatus, teaching unskilled workmen the operational intricacies, Mond was looking around and ahead, engaged in solving the more general problems with which he was confronted and determining the future course which it would be wise to pursue. At one and the same time he had to be concerned with questions of supply of raw materials, of the market for nickel, and of the economics of his process. He had also to face the major decision, once the process was perfected, as to whether he would sell his rights or operate it himself.

One important question to be answered was, what suitable ores were available? With this in mind, in 1893, Mond appointed a Dr. Mohr, a mining engineer, to make a preliminary survey of properties in Germany and in various parts of North America. Mohr's report indicated that, of the properties which he had seen, only those in the Sudbury district of Northern Ontario could be considered to be of lasting importance.

But Mohr's report also provided useful, and somewhat depressing, information on the nickel industry as a whole. On the one hand, it informed Mond that Colonel Thompson, of the Orford Copper Company, had made an assured success of his 'Orford tops and bottoms' process for separating nickel and copper, and had thus solved a problem that had harassed producers for years.

Mohr indicated, on the other hand, that the Canadian nickel



industry was in a depressed condition. The nickel steel developments had not made very substantial progress and there was over-production at the mines in Canada, due, probably, to a strong prejudice against Canadian and in favour of New Caledonian nickel. The latter was of course a well tried product, which users knew how to handle, and it is likely that they experienced some initial difficulties with the Canadian material. It was not long before only the Canadian Copper Company and the Orford Copper Company, the one mining and smelting and the other refining their product, were left in the field. Dr. Mond—he received his degree, *honoris causa*, in 1894—was not unduly dispirited, however. He was convinced that a large market awaited nickel if its cost could be substantially reduced, and he was satisfied that once his process was perfected he could refine nickel at a profit.

Meanwhile Langer was running into further difficulties at Smethwick. They arose from the attempt to refine material originating in the Ontario Mines, the only source likely to provide nickel on a scale sufficient for treatment by his process on an economic basis. The material was a sulphide matte containing about eighteen per cent of copper and thirteen per cent of nickel, whereas previously only nickel matte had been dealt with. It was found that only about one half of the nickel could be extracted from this mixture by Mond's process and a means had to be found of eliminating a substantial proportion of the copper before applying the carbon monoxide reaction. It is said that Langer owed the solution of this problem to Dr. Boeddicker, the Works Manager of Henry Wiggin and Company, who suggested that the copper might be dissolved from the matte by treatment with sulphuric acid. The idea was tried and found satisfactory, about one half of the copper going into solution without any appreciable quantity of nickel being dissolved. This treatment proved far more important than immediately appeared, for not only did it solve the problem of extracting nickel from these recalcitrant Canadian copper-nickel ores, thus assuring Mond of a good supply of material, but it also provided another product, copper sulphate, for which there was a ready market.

It is probable that by 1895 the major technical difficulties had been overcome. Certainly in that year Wiggin tried to dispose of some of Mond's product, and in November Mond, addressing the Society of Chemical Industry on the subject of his process, expressed his own confidence in its ultimate commercial success.

But while the technical processing difficulties had been mastered, the other problems confronting Mond remained formidable. He saw that it was not enough to evolve a new and unique process; that he had to extract and market a substantial quantity of nickel if the process was to become an economic success. Where was he to obtain his raw material, when the Canadian Copper Company held all the ores that were worth treating? How was he to dispose of his product, in a market that was by no means eager for Canadian nickel?

It is hardly surprising that at this stage Mond concentrated his attention on the sale of his rights in the patent. In 1896, through Walter Wiggin, the carbonyl process was brought to the notice of Colonel Thompson who, having successfully separated nickel and copper in the Canadian ores, was then operating an electrolytic process for the production of pure metallic nickel. Thompson expressed considerable interest in Mond's process and various proposals were made; none of them, however, came to fruition.

Another possibility explored by Mond was that of selling his patents to the Canadian Copper Company. These were the people who held all the best mines in Canada, but who had no refinery. Their product was treated chiefly in New Jersey by Thompson's concern, and about this time, because there was some agitation in Ontario against the export of unrefined nickel, they had a considerable interest in the prospect of economical refining on the spot. Accordingly, the Company sent an observer to Smethwick and arranged for material to be supplied for purposes of test. From start to finish the negotiations with the Canadian Copper Company along these lines extended over a period of nearly two years to the summer of 1898. Their rejection of Mond's offer of the patents was to the effect that his claims had not been substantiated. That this may have been at least to some extent a bargaining point is perhaps shown by their inviting Mond to offer them better terms.

By the autumn of 1898 Mond had probably given up all hope of disposing of his rights to either the Canadian or the Orford Company, and at this date he sent Langer and Mohr to Canada again to see what alternative sources of supply of ore there were, sufficient to give an output of up to one thousand tons a year from the projected refinery. At the end of 1898, having received their report, Mond finally broke off negotiations with the Canadian Copper Company and from that time onwards he had the fixed objective of going into the nickel business on his own account, acquiring properties in the



Sudbury region, carrying out preliminary treatment on the spot, and refining the metal at a specially constructed plant which he contemplated at Swansea.

The Langer-Mohr report, dated December 1898, showed that the investigators were favourably impressed by some properties owned by a certain Ricardo McConnell and his friends, which appeared to contain sufficient promising deposits to serve Mond's purpose. As a result, McConnell was invited to London to negotiate an agreement.

By the time McConnell arrived, in January 1899, Ludwig Mond had gone to Italy, where he usually spent the winter, and was represented in the preliminary discussions by his younger son Alfred, a member of the legal profession. As a result of these discussions it was felt that an agreement satisfactory to both parties might be reached and McConnell thereupon went on to Italy, with Langer and Mohr, to negotiate with Ludwig direct.

The most important of the properties offered by McConnell were Denison and Garson, situated in townships of these names not very far from the line of the Canadian Pacific Railway. He was sole owner of the Denison property and had a seven-eighths share in that at Garson, the remainder being owned by the Canadian Copper Company. Mond agreed to buy McConnell's share of Garson for 30,000 dollars and to take a five months' option on the Denison property, with an agreement to pay the cost of exploration and, if 200,000 tons of ore with at least five per cent of nickel-plus-copper were proved, to purchase for 200,000 dollars, less the sum advanced for exploration.

Returning to Canada, McConnell went ahead with arrangements for development work at Denison, being anxious to get men, plant and camp equipment on the spot before the spring thaws made the area more difficult of access. While the snow lasted it was possible to use sledge transport where, in the absence of good roads, conveyance by horse wagon over rough ground would prove extremely difficult.

Exploratory diamond drilling appears to have begun in April and, by the middle of May, Dr. Mohr and a Mr. Culbrand Henrikson, a former Norwegian employee of Vivian, arrived on the scene. Henrikson was an experienced mining engineer, engaged by Mond to watch his interests on the spot and to give advice to McConnell on the exploration. At about this time, too, Dr. Mond engaged a Mr. W. H. Holland, a former Assistant Book-keeper of the Canadian Copper Company, to act as clerical assistant and book-keeper.

By the end of June, McConnell, with commendable energy, had cut and partially graded seven miles of wagon road, built and equipped accommodation for eighty-five persons, including a laboratory, storehouse and blacksmith's forge, sunk two shafts each over fifty feet deep, made many cross-cuts, bored nine hundred feet by diamond drill, arranged and overlooked all contractors' surveying work and carried on much correspondence with lawyers over Garson and with the owners of land and timber surrounding that property and Denison. Holland, too, proved a useful man, especially in negotiations with the Government and in the tracing of elusive owners of some of the lands that Mond wished to acquire.

Meanwhile the Canadian Copper Company had been induced to sell their interest in the Garson property, so that by May 1899 it only remained to draw up the conveyances and register clear titles to Denison and Garson and to the required properties surrounding them, Mond having satisfied himself, as far as he could, as to the quality of the Denison ores. Purchases and development work to this date had cost Mond something like 320,000 dollars.

Thereupon McConnell, with Holland and a Sudbury land surveyor, went to London to settle his financial affairs and to discuss the further development of the Denison property, which was renamed the Victoria Mine. A mass of details relating to the building of railways and sidings, purchase of rolling stock, timber, mining machinery, crushers, boilers, and so on, was dealt with and it was decided to obtain in Canada plans for a smelter.

A new crop of problems awaited their return to Canada, in January 1900, and Holland had to conduct protracted and vexatious negotiations with the Ontario Government and with the Canadian Pacific Railway authorities before the way was clear for serious development of the Victoria Mine.

While these negotiations were going on, a metallurgical engineer, Mr. Hiram W. Hixon, arrived on the scene to superintend the erection of the smelter. It may be convenient, at this point, to review very briefly the processes which Mond proposed to adopt for the treatment of his ores. These were essentially a mixture of sulphides of iron, copper and nickel, there being about five per cent of nickel-plus-copper and about forty per cent of iron. After hand-sorting on belts and tables at the mine the material was to be taken by aerial tramway to roast yards, where a good deal of the sulphur would be burnt off by what is now a primitive system of stacking the



material in great heaps over a timber fuel bed, setting fire to the fuel, and leaving the process of sulphur removal to continue over a period of months. The roasted ore would then be passed to the smelter, where blast furnace smelting would remove siliceous material and increase the proportions of copper and nickel relative to the remaining iron and sulphur. This treatment would be followed in the same building by what was called Bessemerizing, a process in which a blast of air is blown through the molten material, which is mixed with quartz. In this process practically all the iron combines with the silica in the quartz and is removed in the slag formed on the surface of the molten charge, leaving a 'matte' containing very little besides copper, nickel and sulphur. Mond planned to ship this matte to his projected refinery at Swansea, where, after the wet extraction of copper as copper sulphate, his carbonyl process would be employed for the recovery of the nickel.

Before Hixon began his activities in Canada, in May 1900, he had had conferences with Dr. Mond in London and there a detailed programme, aimed at having everything completed by the coming autumn, was drawn up. It was followed by a voluminous correspondence touching every detail of preparation, not only at the smelter but also at the mine shaft, engine house—steam was to be used as the source of power—and railway. Hixon seems to have been as energetic as Holland, for he not only attended satisfactorily to all these details but found time to inspect other properties and to look into matters which were not, strictly speaking, his concern. One of his immediate suggestions was that waterfalls on nearby rivers—the Vermilion and Spanish Rivers—should be used for the generation of hydro-electric power, a suggestion which, however, was flatly rejected by Mond.

By this time the erection of the refinery at Swansea had been started, the ceremony of cutting the first sod, by Mrs. Langer, having taken place on 12 February 1900. The location was chosen because it provided a good port at which supplies of matte could be landed and from which the finished products could be shipped for the overseas market. It provided also a good and cheap supply of high-quality anthracite, needed for the production of carbon monoxide and for the supply of heat and power; and an adequate water supply. The actual site was at the village of Clydach, about six miles up the Swansea valley and adjoining the Swansea Canal and the River Tawe. The construction was undertaken by Mr. P. Morgan, a local builder,

whose son, Dr. J. Gwynne Morgan, in later years became the Mond Company's Medical Officer.

The time had come to make plans for the formation of a public company, to take over Dr. Mond's processes and properties, and for the purposes of the prospectus it was necessary to have the report of an independent consultant. The latter's survey was made in the summer of 1900 but he found that development had not proceeded far enough to justify a favourable report. Accordingly, Dr. Mond decided to postpone the preparation of a prospectus for the time being although by now he was committed to the early formation of a public company. It is apparent from his correspondence with Hixon in July, that Dr. Mond was disappointed with the results of diamond drilling, believing that the actual quantity and quality of the ore were much better than had been demonstrated. At the same time he appears to have at least concurred in Hixon's search for other properties likely to be of value, and authorized the latter to take an option on a concession at Levack, some sixteen miles north of the Victoria Mines, on terms which, to say the least, were favourable to the vendor. Though, as is now well known, the property was in fact a valuable one, the results of early development work were unpromising and the enterprise was abandoned, with a loss to Mond of 20,000 dollars. It is of interest to note, however, that when the Company eventually secured this property, thirteen years later, the purchase price was less than one third of what Mond would have had to pay under the terms of the option.

In order to see for himself the developments at the properties he had acquired or was considering, and to be on the spot for some of the negotiations that were still pending, Dr. Mond visited Canada in October, accompanied by his elder son Robert. At the age of thirty-three the latter was already a versatile scholar, having studied Chemistry, Sociology, Egyptology, and Biology at four universities; for some years he had been assisting his father in carbonyl research. What part Robert took in the Canadian discussions is unknown, but it is probable that he went there mainly as an observer. Though he later became very intimately concerned with the nickel industry, he never had the same deep interest as his father, preferring to encourage the arts and sciences on a wider basis. In due course he became a great benefactor and initiator of research in many different fields and ultimately received the honours of knighthood and Fellowship of the Royal Society.



Before leaving for Canada, Ludwig Mond had had the satisfaction of seeing his labours of the past ten years brought to formal fruition by the registration, on 20 September 1900, of The Mond Nickel Company Limited, and one of his first tasks was to obtain from the Canadian authorities a licence to permit this Company to carry on business in the province of Ontario. The licence was granted on 16 October, without any difficulties being raised, but the flotation of the new Company was delayed by the discouraging report of a second mining expert, deputed to examine the properties with a view to providing information for the prospectus. He expressed doubt as to whether the Victoria Mine would produce more than 100,000 tons of ore, and, in short, whether Mond owned enough mining property to put his business on a sound and lasting basis. He advised the purchase of further deposits. As a result Mond acquired the Little Stobie Deposit and an option on the Sheppard Deposit in Blezard. With these properties added to the Victoria and Garson Mines, the way was clear for the flotation of The Mond Nickel Company, and a subscription list was opened on 17 May 1901, for a capital of £600,000. For the business, patents—there were seventy of them—and properties, Mond received £325,000, having from first to last expended more than four-fifths of this sum from his own pocket, a rare procedure on the part of those concerned with Company flotation.


*ALFRED MOND*

# EARLY STRUGGLES

THUS in the course of ten years, ten years of research and experimentation, of planning and bargaining, of buying and building, an idea had become a material fact. Mines, smelter and refinery were linked in an organization which gave them life; caused them to operate and produce—nickel. In those early days the organization was very much a family concern. Ludwig Mond was at its head, as Chairman; his sons Alfred and Robert were among the other Directors, and a nephew, Robert Mathias, was appointed Secretary. The last-named, by the way, had taken an intimate part in the long negotiations of the 'nineties. For some years he had been Ludwig Mond's private secretary.

The Victoria Mine was ready for operation in February 1901 and six months later copper-nickel matte began to flow from the smelter. Some measure of the credit due to those on the spot—chiefly Hixon and Holland—for achieving such a result less than two years after the purchase of the mine property will be given by reflecting that the work included not only the difficult series of negotiations to which reference has been made, but also the purchase and erection of a great mass of equipment, in a region that was snowbound for months at a time; the collection of numerous stores; and the building of homes and other amenities for the workers.

It was unfortunate that various delays—inseparable from the design and erection of such a novel plant—hindered completion of the refinery, so that treatment of the matte was not begun until the spring of 1902. The first deliveries of metallic nickel and copper sulphate were made in the summer of that year.

To give an idea of the plant and equipment that had to be installed at Clydach, it is necessary to outline the main processes to which the matte from the smelter was subjected. It arrived in the form of lumps which had first to be ground to a fine powder and then roasted in calciners to remove the remaining sulphur. From the calciners—large, box-type affairs, heated by gas burners to about

750 deg. C.—the powder passed on to lead-lined vessels in which the bulk of the copper was dissolved by treatment with sulphuric acid. Copper sulphate was crystallized out from this solution.

Filtration separated off the nickel-containing material, which did not dissolve, and this was passed to the 'Nickel Shed', where the Mond Carbonyl Process—the heart of the entire industry—was applied. The first operation—that of reduction—was conducted in a series of towers each consisting essentially of a number of cylindrical boxes, one above the other. The material was gradually conveyed down these gas-heated towers, together with a stream of water gas—a mixture of hydrogen and carbon monoxide—and in its passage the oxides were reduced by the action of the hydrogen, producing a mixture of finely divided metallic particles of nickel, with some impurities.

The mixture was then conveyed to a similar series of towers, called Volatilizers, where at room temperature it was brought into contact with carbon monoxide and the nickel was converted to gaseous nickel carbonyl, leaving small quantities of copper, iron, and other impurities in the residue.

The nickel carbonyl then passed through pipes to the Decomposer, another tower, filled with nickel shot, and gas-heated to maintain a more or less exact temperature of 180 deg. C. At this temperature the carbonyl was decomposed into nickel and carbon monoxide, the former being deposited on the nuclei of nickel shot in a kind of onion-skin formation, and the latter passing back to the volatilizers to do its work again.

It will be readily appreciated that these various operations necessitated somewhat complicated apparatus, very accurate control, considerable fuel for heating purposes, and a supply of gases for the chemical processes. All the heating was by producer gas, made on the spot from South Wales anthracite. The water gas, which gave hydrogen for reducing the matte, and carbon monoxide for the volatilization process, was also made on the spot.

Even these considerations, however, give but little idea of the array of complications and practical problems that had to be faced and overcome, largely by Carl Langer, who was responsible for the design and operation of the plant. To mention only a few—he had to make the whole apparatus gas-tight, to devise means for ensuring that the temperature inside the large decomposer towers never varied by more than a few degrees, and to arrange that the nickel shot inside the tower—about nine tons of it—was kept constantly in motion so as



to ensure that it did not cake into a solid mass when the nickel was deposited. It is a tribute to his skill and foresight that for nearly fifty years the essential features of the main nickel-shed equipment and process have remained unaltered. It is small wonder, too, that two years elapsed between the beginning of building operations and the production of nickel.

Of course these were but a fraction of the problems with which Ludwig Mond and his fellow directors had to wrestle. Not least among them was that of finding suitable staff, and it says much for his wisdom in choice that quite a number remained in the Company's employ for many years. Robert Mathias was Secretary until 1912, when he became a Director. Frederick Bloomer, whose association with Mond and Langer began in 1892, became the first Works Manager at Clydach and held that position until his death, in 1923. Herbert and Edward Gibbon entered the Company's service during the first year or so, the former on the commercial and the latter on the technical side, and continued until they retired, thirty-five or more years afterwards. Still engaged in process research at Clydach is A. E. Wallis, who was appointed—first to Mond's private laboratory—as long as forty-five years ago, and has made substantial contributions, from time to time, towards raising the technical efficiency of the plant. In 1905 C. V. Corless, previously a lecturer at McGill University, was appointed General Manager of the Canadian Operations, continuing in this post until he retired in 1928. For the last ten years of his service he was also a member of the Board. A man of considerable ability, combined with a pleasing personality and unquestionable integrity, Mr. Corless won the respect and regard of all who knew him well. Always interested in academic pursuits—he was granted a Doctorate of Laws in 1921—Mr. Corless maintained a close association with McGill throughout his active service and especially in his retirement, an association which has continued even to the present day. Mr. Oliver Hall, the Superintendent of Mines, also remained with the Company for over twenty-five years. Dr. Carl Langer, whose son Carl, by the way, married a daughter of Mr. Corless, was of course a Director from the beginning and Dr. Bernard Mohr, who had been closely concerned with all the negotiations in Canada, was elected to the Board in 1906.

In the summer of 1901, 25,000 preference, 300,000 ordinary and 50,000 deferred shares were issued, representing a capital of £475,000. A Profit and Loss Account was not opened until after the end of the

first financial year, 30 April 1902, because up till then there had been no sales of copper sulphate or nickel. Unfortunately, before there could be sufficient products to produce any substantial income, the Company was gravely endangered, in the summer of 1902, first by a lengthy labour dispute at Clydach and then by technical defects which caused a number of serious accidents at the refinery. As a result the plant was shut down for practically three-quarters of the year and the Company ended the year with the modest profit of £2,000 but with debts increased by nearly £100,000. The greater portion of the total loan had been made by Dr. Mond himself and in addition, as a free gift to the Company, he found the additional sum of over £14,500 with which to pay the accrued dividends to the preference shareholders. Where lesser men, in such straits, would have faltered and perhaps have been tempted to give in, Mond's faith in the value of his process and his boundless energy encouraged and empowered him to hold fast in adversity and so saved his enterprise from premature extinction.

Even when the immediate production difficulties had been overcome, Mond and his colleagues became acutely aware that their troubles were by no means over. The problem of selling their products, now beginning to trickle from the refinery, but soon likely to become a steady and weighty stream, was looming up as one that might prove as intractable as any they had faced. It was on Alfred, who had by now assumed much responsibility for the commercial side of the Company's affairs, that a large part of the burden of this problem fell and it was mainly his business ability and persistence that in due course achieved the mastery.

The situation at the turn of the century was that nickel steel had found general acceptance as the best material for armour plate and for some other armaments, and as a result the total world consumption of nickel had gone up to something like eight or nine thousand tons a year. Of this, about one third came from Canada and practically all the remainder from New Caledonia. In Europe there was a general preference for the French nickel, and the principal users —about ten of them—had a joint long-term contract with S.A. Le Nickel, the New Caledonian producers, for the supply of all their requirements. The contract was made, by the way, after an abortive attempt by the Steel Manufacturers' Nickel Syndicate, as the joint buying organization was called, to treat New Caledonian matte themselves in Great Britain.



In consequence, as soon as the Monds began to have substantial quantities of nickel to dispose of they found themselves up against this most formidable obstacle. The British Admiralty, at that time the only British Government purchasers of nickel, expressed themselves as being entirely satisfied with French nickel, and, indeed, stated that the products emanating from Canada were not so good. They even went so far, at one stage, as to say that Mond nickel was too pure. It took two years of persistent effort, including much experimentation entirely at Mond's expense, to persuade them that the Mond product was acceptable.

Alfred then tackled the armour-plate manufacturers—an even more formidable proposition because of their long-term agreement with Le Nickel, and at long last he managed to secure a similar long-term contract for his own Company, a contract which assured a worthwhile share of this particular market. It was not a very stable market, though there was a general upward tendency. Unfortunately a sharp rise tended to be followed by a long period at the new level, making it difficult for the nickel producers to make economical long-term plans.

At about this time, too, the vast resources of The International Nickel Company's Creighton Mine were becoming a factor to be reckoned with in the European market. This Company, by the way, was formed in 1902 to take over the properties of the old Canadian Copper Company.

The sale of copper sulphate did not present the same difficulties, for there was a ready market, chiefly among the Continental wine-growers, who used it as an insecticide. Here, however, the Company had to contend with the fact that the price of copper, settled on the Metal Exchange, was constantly changing within wide limits, so that the amounts which the copper sulphate sales would realize could never be predicted. The production of nickel sulphate in those days was insignificant, and the plating trade took practically all that was made.

Of course the Company was constantly searching for markets which would make it less dependent, for its sales of nickel, upon the makers of armaments. The use of nickel for motor-cars, in the form of nickel steel, was mentioned as early as 1905 in the Chairman's speech at the annual meeting, though even he, with all his wise foresight, probably did not realize how important a factor this would later become. At the same meeting a good deal of stress was placed upon the use of nickel for coinage and the vain hope was expressed

that Britain would soon be free from the 'cumbrous copper coinage'! Though there were no Development or Publicity Departments in those early days, there is no doubt that much energy and much technical skill were even then devoted to the search for new alloys and new uses.

By 1905 the utility of nickel was becoming much more widely recognized; sufficiently so that it was decided to put down additional refining plant at Clydach. With the knowledge gained from experience, and with the fruits of experimentation in the private laboratory operated by Robert Mond, it was possible to make many improvements over the original plant.

The host of technical and commercial problems with which Mond and his fellow directors had to wrestle in that first decade did not prevent them from recognizing the vital importance of the human side of their Industry. In many senses Ludwig Mond was a model employer. He was certainly a pioneer in many steps which he took to ensure the well-being and contentment of his employees. At Clydach he instituted an eight-hour day, by no means usual at that period, and within a year or two he began the building of a model village—which even today is the pride of Clydach—to house his employees. A large recreation hall, adjoining the works, followed some years later, giving facilities for almost every kind of indoor amusement; and much encouragement was given to the formation of a band, a choir, a photographic society and, of course, of clubs for every kind of sport. The Company was among the first in Great Britain to introduce holidays with pay for weekly paid workers. With such a spirit animating its founder and passing on to those who succeeded him in the direction of affairs, it is hardly surprising that long service and almost complete freedom from serious disputes have been throughout its existence prominent features of the Company's relations with employees.

By 1908, because of increased sales, it became necessary to begin mining operations at Garson, the second of the properties purchased from McConnell. At the same time it was decided that it would now be more economical to use electric power in place of steam, and a hydro-electric power station was built on the Vermilion River, at a point about twelve miles from the Victoria Mine. A year or two later a subsidiary, the Lorne Power Company, was formed to operate this undertaking and to supply the parent Company with power. In this year, too, the Company first brought itself prominently to the notice of



the British public, displaying its products at the White City Franco-British Exhibition. The uses that were exemplified at this exhibition were chiefly those of offence and defence, such as guns, shells and armour plate, for the consumption of nickel was still very largely for purposes associated with armaments.

Copper sulphate and nickel sulphate were also displayed at the Franco-British Exhibition, but one constituent of their ore—later to assume considerable importance—which the Company did not show, was the group of precious metals—platinum, gold, and the rarer metals—present to some extent in almost all the Ontario ores. They were not displayed for the very good reason that at that date none had been extracted. Their presence was known, of course, and from time to time in those early years, a good deal of thought was given to the prospect of their recovery. The refinery residues—very small in bulk after all the copper and nickel had been extracted—which contained all the recoverable precious metals, were gradually accumulated and at length were sufficient in weight to justify their treatment. At first the Company did not attempt its own extraction processes, however, but sent the residues to Hatton Garden, where gold, silver, platinum and palladium were extracted and refined on a toll basis for some ten years or more.

The year 1909 brought the grievous loss of the Company's founder, who died on 11 December, deeply mourned by his family and closest friends, and honoured for his great technological achievements, his wisdom, energy and driving power, and his extraordinary liberality and kindness. He was perhaps the outstanding scientific industrialist of his day and his regretted passing was noticed in the press throughout the world.

By now, however, the Mond Nickel Company was firmly established and, under the able Chairmanship of his son, Alfred—already intimately familiar with the business, especially on the commercial side—continued its forward progress. When it is remembered that Alfred Mond also became Chairman of his father's long-established chemical industry, Brunner-Mond and Company, and was a Member of Parliament—he was first elected in 1905 by the Liberals of Chester—the leadership that he gave to the Nickel Company, especially before the First World War, compels admiration. He had received the honour of a baronetcy in 1910, so that it was as Sir Alfred Mond, Bart., M.P., that he met the Company's shareholders for the first time as the Chairman of their Board.

One of Sir Alfred's first actions was to pay a visit to the Company's properties in Ontario, accompanied by Robert Mond and Dr. Mohr. He found that everything was going on satisfactorily under Corless and was especially pleased with the new hydro-electric plant. But by then the need for a greater production had become apparent, a need which could not be satisfied by further extensions to the smelting plant at Victoria. It was therefore decided, in the course of Sir Alfred's visit, to build an entirely new smelter on a site at Coniston, some thirty miles to the east, and adjoining the two main railway systems of Canada. The new site was also close to the Garson Mine which by this time was producing the bulk of the ore.

The new smelter was considerably larger than the original, and its building involved not only heavy expenditure, but also much skill and labour in design and construction. That it was designed, erected and put into operation in less than three years reflected great credit on Corless and his engineering colleagues.

In addition, accommodation had to be provided for the work-people, with many ancillary services, but the Company was not content merely to provide these minimum comforts for its employees. In due course it built two schools, a club-house, a boarding-house, and a public library, and provided land for churches, shops and other amenities.

While this work was going on, the Directors were giving thought to the acquisition of additional mining properties and in 1911 they purchased what was known as the Frood Extension, about eight miles from Coniston. In later years this property came to have a profound bearing on the Company's history, but for a long time its output was of relatively minor importance. Much more important at first were the Levack Mines, some thirty miles to the north west of Coniston, which were acquired in 1913. Additional hydro-electric power was, of course, needed to service these large Canadian extensions, and a new plant was installed on the Spanish River, at Nairn Falls. Nor were these all. Extensions at Clydach had brought with them the need for more employees and therefore for more houses, and the year 1913 saw the formation of a second subsidiary, Clydach Estates Limited, solely for the purpose of building and maintaining houses in that district.

These vast extensions demanded considerably more capital, and in 1914, with this in view, it was thought prudent to undertake a financial reorganization of the Company, which was liquidated and



its assets transferred to another of the same name. The practical effect, coupled with an issue of further shares, was to increase the issued capital to about £2½ million, double what it was in the previous year, and do away entirely with the deferred shares. Thus when the war of 1914–18 began, the Mond Nickel Company, with large resources and equipment in Canada and in Great Britain, was well prepared to meet whatever additional demands for its product the war might bring.


*ROBERT MOND*

# 1914–28

THE immediate result of the outbreak of war was to provide the Company with a fresh crop of anxieties. One was the problem of financing the Company's operations, which gave considerable difficulty. Generous loans from the banks on both sides of the Atlantic and the issue of Redeemable Debenture Stock—in effect, loans by private investors—saved the situation, and the Company was able to face a long period of augmented production without further undue anxiety on this score. In the course of the war it was able considerably to step-up its mining operations, to enlarge the capacity of its smelter, and to increase the number of its nickel-producing units at the refinery from three to five.

Another anxiety was on the score of labour. Out of some 850 men employed at Clydach on the outbreak of hostilities, no less than 250 joined the Forces in the early months of the war. The Company was justly proud to be associated with such a prompt and generous response to the country's call to arms although the problem of finding so many replacements and of providing additional labour for the large extensions was formidable. In spite of the fact that no less than 450 British employees joined the Armed Forces in the course of the war, the Clydach labour force in 1918 was three times what it was in 1914. It was possible to do this, and to avoid the damaging labour disputes which many other concerns had to suffer in the course of the war, only by the exercise of generosity, patience and understanding on the part of the Board; and by the utmost wisdom and unselfish devotion to duty on the part of those concerned with day-to-day managements. Those who remained, and those who came into the refinery during the years of the war, were treated with every consideration for their interests. From the very beginning it had been the Directors' policy to regard their employees' welfare as an integral part of their business and during the war they went even further by setting up what amounted to a Works Council, to provide for regular meetings of representatives of both the Board and the workmen.

Problems and difficulties were discussed and ironed out at these meetings, which effectively prevented irritation and discontent from developing into serious disputes. In this, the Company was something of a pioneer; there were very few, if any, organizations of this kind in existence at that time. Indeed the hope was expressed at an annual meeting of the Company that the Mond scheme would be adopted by other companies and would lead to very satisfactory results in a broader field. Viewing the industrial management-employee relationships of the present day, and the elaborate machinery for preventing discontent and disharmony, it is a matter for pride that the Mond Company thus anticipated much that has been developed since.

For a good part of the war period, the whole of the Company's production was at the disposal of the Government. The Control demanded all the nickel that could be produced, and more, and in addition to sinking much additional capital in the building of plant, the Company had to adopt every possible means of getting the last ounce of nickel from the matte that came in from Canada, to say nothing of ensuring that the ores were made to yield the utmost matte that the size of the plants would permit. Not only so, but the sea hazards of those days compelled the Company to maintain abnormally large stocks of matte at Clydach, so that losses *en route* might not lead to disruption in the supply of nickel. In the course of the war, Mond's production went up from 2,300 tons in 1913 to 4,400 tons in 1918.

1915 saw the appointment of the Royal Ontario Nickel Commission. It arose from a resurgence of the agitation in favour of home refining, an agitation that had existed, though sometimes suppressed, from the earliest days of the nickel industry in that Province. It was fanned into flame early in the war by the fear that since a large proportion of Ontario's ores were going to a neutral country—the U.S.A.—to be refined there, the danger existed that some of this nickel might reach an enemy with whom Canada, as an integral part of the Empire, was at death grips. The flame was fed by the submarine *Deutschland*'s spectacular expedition to the U.S.A. and its return to Germany with a quantity of nickel and other commodities.

The Commission pursued its labours throughout 1916, visiting all the important mining, smelting and refining centres, not only in Ontario, but throughout the world; interviewing manufacturers and



users, Government officials and scientists; and amassed a comprehensive volume of information on the production of nickel and its uses. The report which was subsequently produced contains within its pages an account which in range has never been equalled. In the course of their inquiries the Commission heard evidence from Sir Alfred and Robert Mond, from Robert Mathias and from C. V. Corless, the Manager in Canada. The most searching questions were all answered to the satisfaction of the Commission, and the Company's representatives argued very strongly the case for retaining the refinery in Great Britain. Their case was undoubtedly a good one but it is doubtful whether it would have been sufficient if it had not happened that at that time the International Nickel Company adopted plans to build a refinery in Canada. This enabled the Commission to report that home refining on a large scale was in fact under active preparation, and made it unnecessary for them to urge that a British company should locate the whole of its operations in Canada as well.

In the midst of the war the Company had to suffer the loss of the Chairman's services, Sir Alfred Mond accepting the important office of First Commissioner of Works in the Lloyd George Administration. The Board's pride in the fact that Sir Alfred's outstanding abilities were thus recognized and placed more directly at the service of the war effort, was coupled with some anxiety lest the accomplishments of his Company should not be paralleled under the new direction. In the event, the fears were unjustified.

By this time the Board had been further strengthened by the election of Sir Ellis Griffiths, a Member of Parliament and a noted barrister, of Sir Robert Hadfield, a prominent steel manufacturer, and of the Marquess of Reading, then Viscount Erleigh.

Mr. D. Owen Evans, another barrister, who had already rendered much useful service to Sir Alfred in Swansea, became the Company's Secretary at this period and was later elected a Director. Robert Mond succeeded his brother as Chairman and, with the loyal support of all the managerial staff, took pains to ensure that the high level so far achieved should be maintained. The ability and application displayed throughout the organization did in fact enable the Company to weather the severe storms which arose during Sir Alfred's absence with a far greater measure of success than was the lot of many other British industries.

The Company's contribution to the war effort was not confined to

the unrestricted supply of nickel for war purposes, at prices which by no means fully reflected the enormously increased costs of production, and to the ready release of the many men who, though they were in a protected occupation, felt compelled to take a more combatant part. The platinum metals, still refined by outside metallurgical firms, also met an urgent need by their use for vital scientific apparatus, catalysts, and other equipment; while copper sulphate, for many years at the service of Continental vine-growers, found a more mundane but more important wartime role as an aid to potato growers. The Company's research staff found that copper sulphate not only increased the growth of the crops but also tended to prevent blight and other diseases. In collaboration with the Board of Agriculture's Food Production Department, a special mixture was placed on the market in a form suitable for solution in water and use as a spray. The term 'Blighty', which was given to this mixture, will appear singularly apt to those who recall its use by the wartime troops.

When victory was at last achieved, the Company found itself confronting some of the toughest problems of its history. In the course of the war the productive capacity had been substantially increased. On the other hand, the market for its main product virtually disappeared overnight, with the Armistice of 1918. It was not as though the Company could simply revert to pre-war conditions, for throughout its existence, so far, a very large proportion of the output had been used in the manufacture of armaments, no longer needed.

One of the first steps taken was to increase the capital of the Company by a million pounds to meet the very heavy capital expenditures, largely decided upon to meet the needs arising from, and during, the war. It says much for the faith that the shareholders and the general public had in the Company, despite its close connection up to that time with war materials, that the issue was quickly subscribed.

The other immediate step was to reduce very considerably the output of the plants both in Canada and Great Britain. In the circumstances of the time, with large accumulated stocks which nobody wanted, this was the only prudent course to take, though it was taken with reluctance and disappointment and with distress that it should thus become necessary for many employees, who had given good service during the war, to find jobs elsewhere.

With the virtual disappearance of the armaments market for a number of years, however, these steps alone would not have saved the



Company from disaster. The Directors planned for a gradually increasing demand from the steel makers as soon as the motor-car and other industries were on their feet again, and they did everything possible to encourage the replacement of nickel coinages absorbed for munitions during the war, and the adoption of this metal in countries where it had not yet been tried. No less than nine different countries issued new nickel coins during the four or five years after the war and no doubt the Company's efforts in this direction were at any rate partially responsible.

It was also known that before the war there was an increasing market, particularly on the Continent, for cooking utensils in pure metallic nickel and the Mond Company decided to develop this field. In pursuit of this task, the Directors opened conversations with Henry Wiggin and Company, with whom, as has been seen, they had had close and friendly relations for many years. Wiggin was a producer of semi-manufactured nickel and nickel alloys and during the war the production had been greatly extended for munitions purposes, especially the manufacture of nickel-copper alloys. When the war ended, the bottom fell out of the Wiggin market as well.

Thus it became evident to both the Mond and Wiggin concerns that with the potential increased civilian demand for mill products, there were substantial advantages in combining their skills. Mond had ample financial resources to tide it over initial difficulties but had practically no experience of the milling business and might find the difficulties overwhelming. Wiggin had long experience and was well equipped to produce almost any nickel alloy, but its financial resources were suffering a most severe strain by the pressure of post-war conditions. The almost inevitable upshot was that an arrangement was made by which the Mond Company acquired the entire shareholding of Henry Wiggin and Company, leaving one or two past members of the Wiggin Board—Mr. G. A. Boeddicker and Col. W. H. Wiggin—with Robert Mond, to direct its general policy, and retaining the whole of the Wiggin staff, under Mr. W. R. Barclay, to provide the skill and experience needed for the running of the milling operations.

The immediate result of the amalgamation was that Wiggin transferred its nickel salts production to Clydach, and addressed its energies to the production of nickel and nickel alloys in rolled forms, and of cobalt metal, oxides and salts.

An important effect was to give the Mond Company better opportunities of developing and introducing new or improved materials to meet

the changing needs of peacetime industries. In the early years of the post-war period the production was begun of a wide range of electrical resistance materials, and the production of coinage strip in both nickel and cupro-nickel was also a substantial item in the production.

The production of rolled nickel and nickel alloys was not, however, the Mond Company's only venture into new paths in the first days of peace and by no means the only step it took to meet the post-war depression. For some time past the Directors had been quickening their interest in the precious metals contained in their ores and Dr. Bernard Mohr, who, it will be recalled, had been associated with the pioneering work in Canada, and who was now mainly concerned with research work in London, had conducted a number of experiments in refining. It was now decided that the results of these experiments, coupled with the intrinsic value and potential peacetime importance of the platinum metals, justified a more comprehensive programme of refining research. Accordingly in 1919 the Company acquired a disused soap factory, occupying part of the site of the Marshalsea debtors' prison in south-east London; and there, under Dr. Mohr's general guidance, it installed a pilot plant for this purpose. To have charge of this plant it appointed Major Cuthbert Johnson, M.B.E., M.A., whose father had been closely associated with Ludwig Mond in developing his alkali industry.

Within a few months Dr. Mohr died and Major Johnson, with his colleagues, not only brought this experimental work to a successful conclusion, but has remained in charge of precious metals recovery ever since. The separation of these metals—gold, silver, platinum, palladium, rhodium, ruthenium and iridium—from the remaining, hitherto valueless, material left in the Clydach residues and from one another, involves a series of protracted metallurgical and chemical operations and it is much to the credit of those early experimenters that by 1924 the development of suitable plant and processes had reached such a stage as to justify the building of a specially designed full-scale refinery at Acton. This was brought into operation in 1925 and, though there have been process developments and extensions from time to time, the main outline of processes and the basic nature of the plant has remained the same for twenty-five years.

In 1922 the Mond Company set up an adjunct of the Wiggin operations in the United States, the American Nickel Corporation of Clearfield, Pennsylvania. This works was to produce malleable nickel in a variety of forms and Dr. Dethloff, previously the Company's



Chief Engineer in Canada, was appointed General Manager. A little later the Company associated itself with one which produced and placed on the market nickel utensils and other finished products in this metal.

Unfortunately these American ventures were beset with difficulties from the very beginning. Much of the work was largely experimental on both the technical and commercial sides, and accidents and other troubles also caused much delay, with the result that for five years the Company was operating at a loss.

Two other, minor, investments by the Company during the early post-war years remain to be mentioned. One was the formation, in 1924, in association with the Central Mining and Investment Corporation, of the Victoria Syndicate Ltd. It was felt that the experience of Mond's highly skilled mining organization might be used in trying to locate, elsewhere in Canada, mineral deposits that would warrant economic development. Many prospects were investigated, but in due course the syndicate was closed down.

The remaining acquisition, in 1927, was that of The South Wales Primrose Coal Co. Ltd., operating a colliery at Pontardawe, near Clydach, which for many years had supplied Clydach with anthracite of a quality that was considered essential to the process. In that year the colliery, a public company, found itself in financial difficulties and in order to ensure the continuation of supplies Mond acquired it. The colliery was ably managed for nearly twenty years, after which it was taken over by the Government.

These ventures, however, were not of great importance to a Company which, by 1925 or so, had successfully weathered the storms of the immediate post-war period. This was not brought about simply by drastically curtailing production—though that had been necessary—nor by the purchase of Henry Wiggin's works and their operation on new and extended lines, though this was undoubtedly a factor. Some members of the Staff, including Mr. W. R. Barclay, were constantly engaged in exploring every avenue by which nickel could be put to fresh use, and a good deal of the prejudice against the use of nickel was overcome by technical research.

It was largely through Mr. Barclay's influence and advice that the growing importance of nickel alloys, as compared with that of the pure metal, was fully appreciated by the Company. Two years later the Chairman was able to point out that whereas formerly seventy per cent of the world's nickel went into armaments, the market of

1928 was made up of thousands of different uses, making not only for stability, but for steady and continuous growth in the sales. This development work included not only scientific research, but also the publication of the knowledge thus gained for all concerned to read. Leaflets were also published on nickel coinage and on the properties of a wide range of nickel products. It is of interest to note that it was during this early period that Mr. F. B. Howard-White, then a member of the Company's Sales Department, wrote the only book on nickel ever issued by a British publishing house.

The Mond Research Department, and that operated by Henry Wiggin in Birmingham, were reorganized and consolidated in 1926, Mr. W.T., later Sir William, Griffiths being appointed to build up and have charge of all research and development work directed to the expansion of nickel sales. For a couple of years Mr. Barclay continued to have the general supervision of this work, but was then appointed Managing Director of Henry Wiggin and Company. Under Mr. Griffiths the department continued various pieces of research, especially in the copper-nickel alloys, then under way in Birmingham, and sponsored or supported work that was carried on by outside organizations. Two years later the Company's *Mond Nickel Bulletin*, begun some time previously for internal circulation, was issued in printed form and distributed to the technical public. It consisted of a collection of abstracts of published information on nickel and its alloys. This publication, later called *The Nickel Bulletin*, was so deservedly popular, meeting a long-felt need in industry, that it has been issued more or less monthly ever since and has achieved a circulation, almost entirely as a result of requests, running into many thousands and covering the entire civilized world.


*R. C. STANLEY*

# INCO AND MOND

BY an interesting coincidence, the very first entry in *The Nickel Bulletin* related to a magazine article by Mr. A. C. Sturney, who had been recently appointed by The International Nickel Company, to have charge of the British section of a European organization similar to the Mond Research and Development Department.

At that very time The International Nickel Company and The Mond Nickel Company were being drawn closer together, in a strictly physical sense, in the winning of their ores from the earth. It will be recalled that in 1911 the Mond Company purchased a property known as the Frood Extension, about eight miles from Coniston. No serious development work was conducted here until the 'twenties, when an upward move in the demand for nickel once more stimulated interest in this property.

Now it happened that International Nickel held the property within which the Frood Extension lay, where they were carrying out development work, and it became known that in their property a very valuable ore body had been located at a depth of 3,000 feet. In due course the Mond Company's explorations came upon the same ore body, which ran through both the Frood and its Extension, and found it to be so rich in nickel and copper, particularly the latter, as to be more valuable than all the other Mond mines put together.

It was, of course, obvious to those in charge of affairs of both companies that for the winning of material from this single ore body, two sets of shafts and two separate complete sets of underground and surface establishments would be grossly wasteful, and that by combined operations a very large reduction in capital expenditures and in running costs could be achieved. It was equally obvious that only a single mining plan would ensure maximum utilization of the entire ore body.

Accordingly, after these facts became apparent, Mr. R. C. Stanley,

President of The International Nickel Company, and Lord Melchett —Sir Alfred Mond took this title when he was raised to the peerage in 1928—negotiated an agreement pursuant to which in 1929 the interests of The Mond Nickel Company were merged into The International Nickel Company of Canada through the issue of the latter's stock in exchange for the outstanding stock of Mond.

Dr. Carl Langer had retired from the Mond Board a few months earlier and had thus brought to an end his long and affectionate association with the Company. The carbonyl discovery was mainly his. He, largely unaided on the technical side, had turned the discovery into a process, and the process into a works; and for nearly thirty years he had superintended the intricate operations at Clydach. He retired to Switzerland, the home of his youth, and died, while on a cruise, in 1935.

Members of the Mond Board who retired as a result of the merger were Mr. Emile Mond, Deputy Chairman, and his son Philip; Mr. Robert Mathias, closely associated with the undertaking since before the formation of the Company, Viscount Erleigh, Sir Robert Hadfield and Mr. Saxton Noble. Directors who joined the Board of the new Parent Company included Lord Melchett, his brother Robert, and his son Henry, Mr. Grant B. Shipley, of Pittsburg, Mr. J. P. Bickell, of Toronto, and Mr. D. Owen Evans, formerly the Mond Company's Secretary, who became Inco's Chief Executive Officer in Europe with the title 'Delegate Director'. Sir Harry (later Lord) McGowan, who had been closely associated with Lord Melchett in other enterprises, and Lord Weir also became members of the new Canadian Board.

At the time of the merger Inco were of course developing the ore body in the Frood Property proper, but most of their nickel was coming from Creighton, an immensely valuable mine which they had been operating continuously and exclusively for ten years. They had a large smelting plant at Copper Cliff, close to the main township, Sudbury, and three or four miles south of the Frood property; and in Southern Ontario, at Port Colborne, they had their electrolytic nickel refinery. It was decided, however, also to continue refining operations by the Mond process at Clydach.

In the U.S.A., the small rolling mill of the American Mond Company was shut down, the large and well-equipped Inco mills at Huntington, West Virginia, being fully adequate to serve this market.



To follow the subsequent developments on the other side of the Atlantic, vastly important and interesting as these have been, would take this story far beyond its intended scope, which is limited to the progress of The Mond Nickel Company. In what follows, therefore, references to events in Canada and the U.S.A., or relating to the Parent Company, will be confined to those which must be included to explain events and developments with which Mond has been particularly concerned.

In 1929 the world's consumption of nickel reached the then all-time record of about sixty thousand tons. In consequence, thought was given to finding ways and means of increasing the output, and a number of improvements in the Clydach plant and operations was decided upon. Most important of these was the replacement of Bessemer matte from Coniston by a material, produced at the Port Colborne refinery, having a much higher nickel content and much less copper. When this change was introduced, in 1930, a very large proportion of the copper was extracted in Canada and refined at a new electrolytic refinery situated at Copper Cliff. Thereupon the production of copper sulphate at Clydach was no longer economic. It may be mentioned, in passing, that recent further changes in the nature of the raw material received at Clydach have made it desirable to resume the production of copper sulphate, though on a comparatively small scale.

The increased production of nickel and copper automatically involved an increase in the residues containing the platinum metals and it soon became evident that an enlargement of the Acton refinery would be needed. Substantial extensions were completed in 1931 and were formally opened in the presence of the Dominions Secretary and the Canadian High Commissioner. With improved process technique, these extensions permitted a very large increase in output, making Acton the world's largest producer of platinum metals.

Considerable improvements were also made in the Wiggin plant, including a large extension of the hot-rolling capacity, which placed the Wiggin Street Works in the forefront of British non-ferrous alloy manufacturers. A further consolidation of the British operations was effected a year or two later, when the plant of Monel-Weir Limited, at Glasgow, was acquired.

Monel-Weir began as a department of the well-known Scottish Engineers, G. and J. Weir Limited, who for many years previously had been concerned with the fabrication of nickel-copper alloys, and

particularly with The International Nickel Company's Monel. The steady growth of this business and the need for extended fabrication and sales facilities resulted in the formation of Monel-Weir Limited, as a more or less self-contained unit, and in this plant, under the direction of Mr. A. B. Graham, much valuable pioneering work, especially in the production of extruded sections, had been accomplished. When the plant was acquired by Wiggin the manufacture of tubing and cold-drawn shapes, in all Wiggin products, was concentrated in this 'Zenith' Works, which established for itself a pre-eminent position in the hot-extrusion of nickel-copper and nickel-chromium alloys.

In 1927 there came into being a factory known as Birmingham Electric Furnaces Limited, and later as Birlec Limited, which resulted from development work conducted by Henry Wiggin and Company, over a period of years, on nickel-chromium electrical resistance materials. It had become clear to Wiggin that electric furnaces, then in their infancy, provided a large potential market for these materials and a special design department operated in consultation with Mr. A. Glynne Lobley, a University lecturer, was set up. This pioneering work provided such promising results that it was decided to form a special subsidiary company to produce and market furnaces of the electric resistance type, and premises at George Street, Birmingham, previously used as the Wiggin administrative offices, were set aside for this purpose. Mr. Lobley was appointed Manager, and it was not long before the infant began to grow at such a rate that its accommodation became inadequate and a new factory was erected on a site outside the city. As the years passed, the business, pioneered and developed by Mr. Lobley, grew into a manufacturing concern which had an even greater importance as a producer of electric furnaces, of all types, than as a consumer of Wiggin electrical resistance materials. Associated with the business from the very beginning, Mr. Tinker the present Managing Director—he succeeded Mr. Lobley on the latter's death in 1950—now has charge of a large factory making almost every type of industrial electric and gas furnace and selling them all over the world.

This, however, is a digression which has taken us in advance of our main story, and we must retrace our steps to the bleak days of 1931 when, no sooner had the consolidations and extensions resulting from the merger been completed, than the blast of the world-wide depression of the early 'thirties made itself felt. The greatly reduced



demand for nickel necessarily curtailed the scope of operations in the mines, smelters and refineries. In 1930 trade became so poor that it was necessary to cease refining at Clydach for a period of some months. With commendable foresight, and in line with the Company-wide programme in Canada, advantage was taken of this shut-down to remove the antiquated calcining plant and to install a battery of up-to-date rotating-hearth calciners; and when in due course trade began to revive, the wisdom of this action was seen in the much higher efficiency that resulted.

It began to revive, so far as the nickel business was concerned, in the latter half of 1933, much sooner than in many other industries, and a good deal of the credit for the advantage enjoyed by nickel must be given to the policy of research, development and publicity which had so materially helped to provide a multiplicity of applications for this metal.

It will be recalled that before the merger, the Mond Company had become alive to the importance of this aspect, and in 1927 had set up a Research and Development Department. Well before that time, however, The International Nickel Company, inspired largely by the far-sighted leadership of Mr. R. C. Stanley, its President, had set up such an organization on the other side of the Atlantic, had sponsored research in Birmingham, Paris and Aachen and had established development departments in England and France. Thus, after the merger, a very considerable impetus was given by Inco to this development policy.

At the Mond Research Laboratory, in Birmingham, Dr. L. B. Pfeil and his colleagues, guided by Mr. W. T. Griffiths, were conducting research which had increasing nickel consumption as a long-term objective; were taking an active share in the organization and support of appropriate work by outside scientific bodies; and were constantly investigating special problems which arose during the production or use of nickel alloys. Another section of the Company's Research and Development Department was collecting published information from all sources, building up what has become perhaps the most comprehensive metal bibliography ever compiled; and yet another had metallurgists and engineers constantly out in the field, giving advice and assistance to all who had problems which nickel might help to solve, or needs which nickel might meet.

Side by side with these activities were those of the Bureau of Information on Nickel, originally started by Inco in 1927, which took

the information of more general interest, as to the properties and uses of nickel, and presented it, in various forms, to all who might be interested. Mailing lists containing many thousands of names were compiled, booklets were printed and distributed, information centres were set up at trade and technical exhibitions, and every possible means was taken to ensure that the consumption of nickel should not suffer through ignorance of its properties—or of those of its alloys—on the part of those who were responsible for the choice of materials for chemical, engineering, and allied purposes. Hundreds of different publications were printed and distributed in the years immediately preceding the 1939–45 war.

Nor was this all. In Paris, Frankfurt, Brussels, Milan and Tokyo, similar bureaux, established by Inco, were operating, deriving their information partly from the Company's own research centres in the U.S.A. and the U.K. and partly from work which they sponsored. The Paris Bureau was the first of these European information centres, having been established in 1927, before that which was set up in London. It was in the charge of M. Joseph Dhavernas, who had been associated with the production and marketing of nickel from the early years of the century, and who remained the Bureau's President until his retirement in 1950.

This network of information and development centres was acknowledged as having materially shortened nickel's share in the world trade depression and, once that was past, as having played a large part in the rapid increases in the consumption of nickel which followed. By 1934 the total world consumption was estimated to be above that of 1929, the pre-depression peak year, and by 1937, before armaments once more became the important factor, it exceeded 100,000 tons, almost doubling that of 1929.

To keep pace with the growing demand, the Company made further improvements at the Clydach refinery, reconditioning and remodelling some of the plant and, in their process research laboratory, investigating the possibilities and advantages of producing nickel carbonyl, under pressure, in a liquid form. By this means they were able to treat less highly processed material and, in a comparatively small space, to provide the main plant with a useful auxiliary. This more or less experimental work had important consequences in other directions. The early pioneering work of Dr. Langer, forty years earlier, had shown that under suitable conditions it was possible to produce carbonyls of metals other than nickel; that although at



atmospheric pressure and normal air-temperature only nickel would unite in this way with carbon monoxide, other combinations of temperature and pressure could be made, selectively, to cause reactions with other metals, notably iron. This knowledge was now followed up with further experimental work, in the Company's extended process laboratory, which showed that from the liquid carbonyls it was possible to produce certain metals in a state of finely divided powder, a state needed for a number of new electric and magnetic instruments and equipment being developed in the late 'thirties. Thus, by the time the war came, the Company's accumulated knowledge of this subject proved of great importance for the production of what came to be an important war material, namely iron powder.

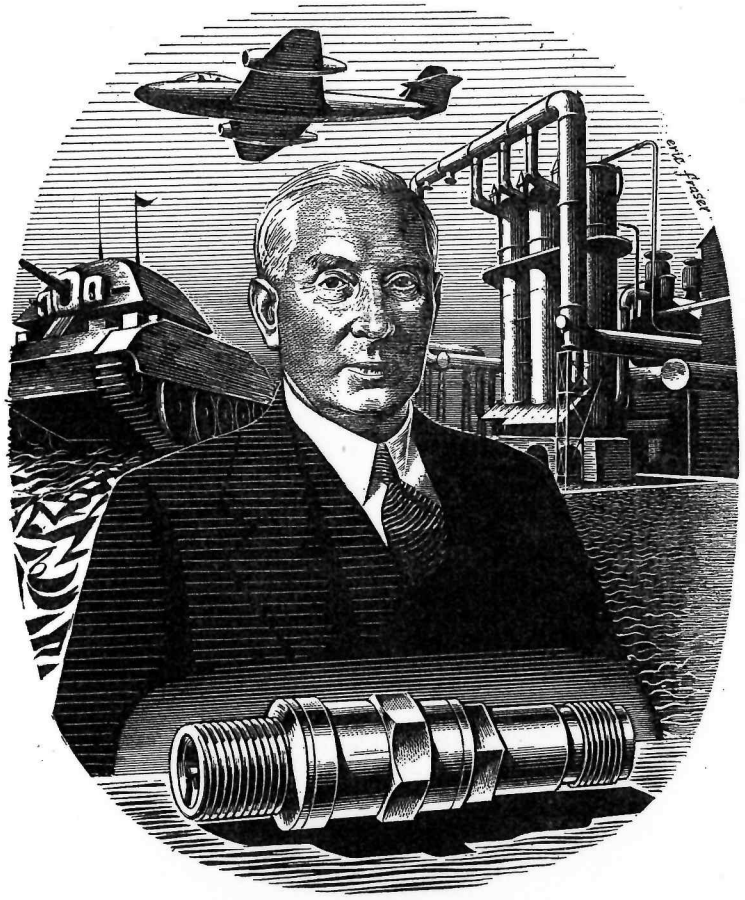
Among other measures taken to answer the call for still higher production, was the decision to treat the lower-grade ores lying near the surface of the Frood property. These ores were won by open-pit methods, akin to quarrying, and as time went on the Frood-Stobie open pits became of very great importance. Another step in the search for greater productive capacity was the acquisition of a concession at Petsamo, in the north-eastern tip of Finland, where preliminary prospecting had suggested the occurrence of nickel-bearing material in appreciable quantity. Exploratory work in this area, then remote from roads or railways, was carried out in 1935 under the direction of experts from The International Nickel Company's Canadian plants and of Mr. Edgar Pam who, after many years' mining experience in South Africa, had been appointed consulting engineer to the Mond Company. Diamond drilling at Petsamo revealed the presence of a substantial tonnage of ore, and plans were made for the opening of a mine, the building of a smelter, a hydro-electric plant, and the many houses, shops, schools, etc., that would be needed to provide for hundreds of employees and their families imported to a region remote from other centres of population. Unfortunately the 1939 war came before the programme was completed and after various vicissitudes the concession was taken over by the Russian Government, in whose territory it came to be situated.

The mid 'thirties were years of extension and improvement in almost every direction. Much new equipment was installed at the Wiggin works in Birmingham, then under the management of Mr. I. A. Bailey, and one of the world's largest non-ferrous extrusion presses was installed at the Zenith factory, to aid in the production of tubing in nickel and high-nickel alloys. Plans were also made for

the installation at Clydach of a complete new plant for the production of producer-gas and water-gas, a project which proved of inestimable value when, during the war, shortages of coal necessitated the highest efficiency in its conversion to the gaseous raw materials needed by the refinery.

Throughout all this period of accelerated progress, the Company never ceased to keep the welfare of employees very much in mind, and in the ten years that followed the merger with Inco very large sums were spent in providing recreational and athletic facilities, in addition to expenditure on canteens, medical centres, and so on. At that period the latter, indeed, compared favourably with the medical arrangements in any other British industry and the Company took just pride in continuing and elaborating the pioneering work of Dr. Amor, its first full-time medical officer, who was appointed in 1924. Employees of all grades also enjoyed the protection and security of Inco's retirement scheme, which provided substantial pensions to all who had spent their best years in the Company's service. It took the place of an ingenious Employee Participation Scheme introduced by the Mond Company some years before the merger. Later on the funds needed were vested in an entirely separate Company, the Mond Nickel (Retirement System) Trustees Limited, thus giving additional security to the hundreds of pensioners and long-service employees on the Company roll.

As a further recognition of long service, the Inco-Mond Company encouraged the formation of a 'Quarter-Century Club', membership of which, being strictly limited to employees of twenty-five years' standing, whatever their positions in the organization, has become a highly appreciated honour. Here the Storeman and the Secretary, the Director and the Doorkeeper, meet on equal terms and, with the common bond of tales of the past, cement still further the friendly relations that have existed throughout the years between the many and varied members of what all are glad to think of as the 'Inco Family'.



*D. OWEN EVANS*

# WAR ACHIEVEMENTS

BORN of a scientific discovery, nurtured throughout its history by the ready application of further scientific knowledge, the Company, by similar though intensified means, reached even higher levels of achievement during the war which burst upon the world in 1939.

It was recognized from the beginning of the war that although for the past twenty years the Company's activities had been almost entirely concerned with the expansion of permanent peacetime markets for its products, their nature and properties were also of great importance at such a time. The qualities that provided such large outlets for nickel alloy steels in the motor-car industry, for instance, gave these materials equal importance for vital parts of army vehicles of every kind; the radio sets which utilized the electrical and magnetic properties of nickel and nickel-iron alloys, were quickly developed into the wartime instruments of communication and location; the chemicals, which in peacetime had played their part in beautifying china and glass, now found themselves in sterner roles; even the platinum metals, so closely associated in the public mind with adornment and fashion, were pressed into such important service as to win the special recognition and commendation of President Roosevelt, in an official report to Congress.

Quickly, therefore, the Company transferred the whole of its activities, directly or indirectly, to furtherance of the war effort and the story of those anxious years is one of unremitting and very largely disinterested service in fields that went far beyond the Company's normal scope.

Nothing was spared, of course, to ensure that the maximum possible supplies of nickel should be available for every purpose of wartime importance, and enormous sums were spent by Inco in extending the supplies of ore from the mines and open-pits to the utmost limit.

Under the management of Mr. I. A. Bailey—transferred from the

Wiggin works in 1936—the Clydach refinery operated night and day to squeeze the last ounce of nickel, as quickly as could be done, from the supplies of matte which came in from the other side of the Atlantic.

Amid the difficulties of the war the new gas-plant proved a great boon, for it not only contributed much to the increased efficiency of the nickel-extraction plant, but enabled the Company to save no less than 50,000 tons of coal every year. A much larger demand for nickel and cobalt salts—the manufacture of which was transferred from Birmingham to Clydach in 1939—was also satisfactorily met, and a special plant was installed for the production of selenium dioxide, another product of the Ontario ores which came to have national importance. The manufacture of iron powder in the carbonyl pressure plant has already been touched upon.

Much work that was entirely outside the refinery's normal scope was also undertaken. It included the production of press tools, the shaping of plates for tanks, and the training of machine operatives for munitions factories. With all this there were the multifarious tasks of construction and personnel training that arose from the necessity to take precautions against air raids and sabotage. Many of the younger men were called to the Forces, and practically every one who remained was engaged on Civil Defence, in some form or other, outside his normal hours of work. For the first time in its history the refinery accepted and indeed welcomed the labour of women, and many wives and daughters of present employees and pensioners can look back with justifiable pride on their activities at Clydach during six years of war.

A similar tale can be told of the Company's other plants. The Acton precious metals refinery was entirely concentrated on the production of precious metals required for war purposes, and in purity and in the speed and efficiency with which they were produced, even under 'blitz' conditions, these precious metals excelled any refined in earlier years. Supremely important among the products were the platinum sparking plug alloys which, in the words of President Roosevelt, were worth more than diamonds to the R.A.F. and the United States Air Force. Plugs in these alloys gave four or five times the length of service of those previously installed and probably saved the lives of thousands of British and U.S. bomber crews.

At the Wiggin works the demand for high-nickel alloys grew to astonishing proportions and in spite of a much less expert labour force, increasing scarcity of raw materials, the wear and tear of



machinery forced to operate without proper maintenance, constant danger of enemy attacks, and the need for planning and installing much new equipment for urgently needed experimental work, a peak of production far beyond anything envisaged in earlier years was achieved. A similarly astonishing record was achieved at Henry Wiggin's Glasgow works, where, as has been said, extruded tubes and intricate sections in high-nickel alloys were the principal products. The 2,000-ton press, for instance, normally handling a little over five hundred billets per month, reached in 1944 an output well exceeding nine times that figure! Nor was the plant confined to the production of nickel-containing materials; aluminium alloys—a totally unfamiliar product—made up a substantial proportion of this amazing output. Even this did not exhaust the achievements of the Glasgow works, however, for in 1941 the management accepted responsibility for the erection and operation of a huge factory, built on the Company's playing-fields, for the production of shell cases. Under the direction of Mr. A. P. Hague, Mr. D. P. C. Neave, and Mr. A. B. Graham—the Zenith Works Manager—this plant was built and began operations in less than six months.

At all these works, as at Clydach, men who were not called to the Forces gave much more than their normal working hours to the service of their country, and several at Wiggin Street lost their lives while fire-fighting at adjacent premises. Offices and factories alike made full use of the services of women.

At the hub of all the vast and intricate operations in this country, deciding desperately important problems of policy, conducting negotiations with Government departments, and, even when past the normal retiring age, handling a multitude of day-to-day difficulties and queries, was Mr. D. Owen Evans, the Company's Delegate Director. And, added to all these duties, were those in his constituency and in the Commons and Committee Rooms, as a Member of Parliament. Few in the nickel organization gave themselves more unselfishly and unreservedly to the service of the country than Mr. Evans, and it was a delight to all his friends to hear, in 1945, that he was to receive the honour of knighthood. But the strain of those years had been more than his physical strength could bear and he died 'in harness', before the honour could be conferred, beloved by all who knew him well and deeply respected by his colleagues.

In the interests of stability and continuity, the Company took the prudent step, before the end of the war, of setting up a Delegate

Board, to share with Mr. Evans, who was appointed Chairman, some of the very heavy executive responsibilities crowding upon him. Those appointed to the Board were Mr. E. Pam, by that time Mr. Evans's deputy, Mr. A. P. Hague, the General Manager of Operations, Mr. L. H. Cooper, who, in 1928, had followed Mr. Evans as the Company's Secretary and later was Assistant to the Delegate Director, and Dr. W. T. Griffiths, who subsequently succeeded Mr. Evans as Chairman.

Less direct, but nevertheless vital, contributions to the Company's war effort were made by the Accounts and Shipping Departments who, under the managership of Mr. R. A. R. Hill, worked all hours of the day and night, under conditions of particular difficulty, to deal with the multitudinous and unfamiliar problems of book-keeping, taxation, shipping schedules and so on, that arose during the war; and by the various sales staffs who, in conjunction with the Accounts Department, ensured that the materials that were required by the Government and by industry, should reach their intended destination at the proper time. Mr. Hill and Mr. Howard-White, now the Company's chief legal officer, were appointed Joint Secretaries in 1939.

The Research and Development Department, under Dr. W. T. Griffiths, also made an important contribution. This department, it will be remembered, was concerned before the war with research into the properties of existing and newly created alloys containing nickel and with the development and extension of uses which these properties made possible. Throughout the pre-war years the department had been continuously extended by additions to the staff and equipment and in 1936 a new research laboratory—perhaps the finest of its type in the country—had been erected in Birmingham. Some years earlier a special research section had also been created at Acton to deal with the platinum metals. By the time the war came the strength of the department, in scientifically trained personnel, in buildings and equipment, and in accumulated knowledge and experience on a wide range of materials and alloys, was second to none of its kind in the country.

The question immediately arose as to how best these resources ought to be used in the common interest. One course open was to release the staff from their duties with the Company so that each might employ his personal knowledge and abilities in whatever branch of the national service was most appropriate. The other was



to retain the organization as an entity, thus providing a team of experts whose experience and technical qualifications could be backed by the very substantial documentary resources of the department and augmented by the ample research facilities that were available. Government departments that were consulted advised the latter course and thus, with the concurrence of the Directors, a special and complete 'Technical and Research Unit' was placed at the disposal of the authorities.

The various British Ministries availed themselves of this service so fully that very soon the pressure of work reached the limit of capacity. Advice was given on subjects covering almost every field of metallurgy and ranging beyond those with which nickel was specially concerned. Indeed one of the important contributions made by the department was in the direction of suggesting substitutes for this metal against the day when it might be less readily available.

Advice and consultations at all levels involved close liaison with many Government departments, including the Non-Ferrous Metal Control and the Directorate of Tank Design, of the Ministry of Supply.

Most outstanding among the thousand-and-one problems that were dealt with by the department during the war, and—because of its extreme importance—deserving of an extended reference, was that associated with the development of jet aircraft. The problem was posed in the first instance by the Air Ministry who for some time had been supporting work on gas turbines and jet-propulsion engines, pioneered in the early 'thirties by Wing Commander, now Sir Frank, Whittle.

The position at the beginning of the war was that although promising results had been obtained with this type of power unit, its development was hampered by the lack of materials which would withstand the stresses set up at the high temperatures required for efficient engine performance. What was wanted was a material which could be made into intricate turbine-blade shapes by forging and machining but which, on the other hand, would not creep or distort at the high working temperature of the engine and under stresses above any that had been hitherto encountered.

When the problem was placed before the Research and Technical Unit, their experiences in the development and production of nickel-chromium alloys for high-temperature uses suggested that a solution might be found among materials of this general type. Research was therefore directed to the improvement of the properties of

nickel-chromium alloys by modifications in their composition and heat-treatment. It was a formidable undertaking, requiring initially the production and testing of a thousand or so different alloys.

Even this statement gives only an inadequate indication of the work involved. It must be borne in mind that the vital property was resistance to creep, that is, to slow distortion under combined conditions of stress and temperature. It followed that the better the creep characteristics, the longer was the period needed to ascertain their exact nature, so that the process of whittling down these many alloys to one or two, involving hundreds of additional tests of the most promising, became an almost superhuman task.

It was accomplished, so far as the wartime solution was concerned, within twelve months or so of the request, when the department was able to offer a modified nickel-chromium alloy which met all the then requirements.

The technical difficulties of large-scale production remained to be solved, of course, and here the equipment of the Wiggin works and the experience and skill of the Wiggin production staff, came to the aid of the Ministry and the Mond Research Staff. The high temperatures at which these alloys had to be worked and their great strength created production difficulties which were overcome only by the addition of enthusiasm and determination to technical skill. They *were* overcome, however, and as a result jet aircraft were in the air to combat the flying-bomb menace of 1944. No one doubts that without the Nimonic alloys, as these new materials were called, there would have been a much less effective answer to the grave aerial threat that developed towards the end of the war.

Other outstanding wartime achievements made by the Company's Research and Development Department included the successful investigation of problems associated with tank components, bombs and shells, the development of the platinum-tungsten spark plug, to which reference has already been made, armour for fighting vehicles, and the examination of enemy equipment. It is small wonder that this vital 'Research and Technical Unit' should have received high praise from the Ministries who received its help, or that Dr. W. T. Griffiths, who was in charge of the unit, should subsequently have been honoured with a knighthood, and Dr. L. B. Pfeil, who was in charge of the Research Laboratory, with the O.B.E. The latter was further honoured, in 1951, by his addition to the Roll of Fellows of the Royal Society.


# POST-WAR

A MAJOR problem at the conclusion of hostilities was the reinstatement of the hundreds of employees who had been called upon to serve in the Forces. During their absence they had been treated with generosity and, in order to lighten the burden of separation from home and fellows, a news magazine was sent to them every month. Thus, wherever they went, the vast majority still felt themselves a part of the Mond family and, when they were freed, came back naturally to the tasks they had been compelled to relinquish for a time. The task of resettlement was eased, partly by the fact that many of their places had been filled by women—to whom a warm tribute of praise is due—who were, in the main, quite glad to leave when the war ended; and partly because the Company did not experience the same grave recession in trade that followed the earlier war.

Since the war the long tradition of good relations between management and employees has been well maintained; fostered by the setting up of Works Councils, where little difficulties are set right before they can become big; by the provision of excellent facilities for meals, sports and indoor recreation; by constant attention, under the direction of Dr. Gwynne Morgan, the full-time medical officer, to the health and comfort of workpeople; and by a wise policy of keeping everyone 'in the know' about both Company and Club activities, through the media of a magazine, local exhibitions, and films.

Further improvements have been made in plant, equipment, and processing methods at the various works but, immediately after the war, major attention was given to the reorganization and expansion of the Company's sales and associated activities. Mr. Pam died in 1945 but the Delegate Board was subsequently strengthened by the appointments of Mr. G. Archer, C.M.G., formerly Under-Secretary in the Ministry of Supply, and of Mr. L. K. Brindley, formerly President of the Falconbridge Nickel Company.

When Sir William Griffiths left the Organization, at the end of

1950, he was succeeded by Mr. L. H. Cooper, as Chairman, and by Mr. L. K. Brindley, as Managing Director. At the same time the Mond Board was further strengthened by the appointments of Mr. I. A. Bailey, who had previously returned to Henry Wiggin and Company as its Managing Director, Dr. L. B. Pfeil, the Company's Development and Research Department Manager, and Dr. A. G. Ramsay, who succeeded Mr. Bailey as Manager of the Clydach refinery.

Fundamental and other research, so wisely brought into the service of the whole organization by Inco's late Chairman and President, Mr. R. C. Stanley, continues unabated, on both sides of the Atlantic, with the active encouragement of his successor, Dr. John F. Thompson, and of Dr. P. D. Merica, Executive Vice-President. Even better Nimonic alloys have been developed and put into service; isothermal transformations in nickel steels and nickel cast irons have been intensively studied; techniques of electroforming and electropolishing have been improved; nickel iron alloys with special expansion characteristics have been developed; further research has been made into many different kinds of corrosion; powder metallurgy has been advanced; and a host of other subjects and materials has been dealt with.

Fifty years ago the important outlets for nickel could have been counted on one hand; today it goes everywhere. It remains an all-important alloying element for steels, and particularly for stainless steels, it can vastly improve the properties of cast iron, it is alloyed with chromium, iron, copper, aluminium to give special properties for mechanical, chemical, electrical, magnetic and other purposes. It is a vital element in the equipment used in almost every means of transport and of communication; in the growing, processing and service of our food; in the production and distribution of fuel; in the manufacture of the papers we read and the clothes we wear; in fact almost every amenity of modern civilization owes something to this versatile and 'sociable' metal.

Almost equally versatile are the Company's other products. The uses of cobalt salts range from sheep medicines to pottery colours; platinum and her sister metals palladium and rhodium assist chemist and jeweller alike; selenium colours glass and activates the photo-electric cell. A score of different products, in a wide variety of forms, issues in an almost unceasing stream, to serve mankind in the four corners of the earth.



What is still to come? The answer lies with those who are yet preparing to take their places in the onward march of civilization. In workshop and factory and laboratory they will find nickel at their service, to be turned to whatever new uses, in whatever new ways, their discoveries may determine. They need not be ignorant of its achievements so far, for to school and college and technical institution the Company freely offers its educational services. It has gone even further. In the Mond Fellowships, established a year or two ago, the Mond Company encourages the young scientist and technician of today to look outward from his laboratory and his study, to the world which needs his gift of knowledge; needs, too, to be shown how it may best be used.

And some members of that younger generation will come into this nickel family, inheriting its fine traditions, its enthusiasms and its good fellowship; sharing its continuing search for improvements in process and product alike. May their achievements, in the second half of their—and our—century, take them to heights as yet unknown.

## ACKNOWLEDGEMENTS

Much of the material contained in these pages has been derived from the Company's records and especially from those compiled by the late Capt. F. P. Barton, C.M.G. The personal recollections of Mr. Robert Mathias, Miss Langer, Mrs. Carl Langer, Mr. A. E. Wallis, Mr. A. W. Tangye and Mr. P. Morgan, have also been of assistance.