1913–1988

75 YEARS OF STAINLESS STEEL

1913–1988

YEARS OF STAINLESS STEEL

Contents

Grateful thanks for assistance in the production of this brochure are given to the many former employees of the UK's Stainless Steel Industry.

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CHAPTER ONE

STAINLESS STEEL — THE TIME, THE PLACE, AND THE MAN.

Harry Brearley 1871-1948.

The story of stainless steel is a fascinating one. From humble origins has come today's successful, multi-national industry with a bright, exciting future.

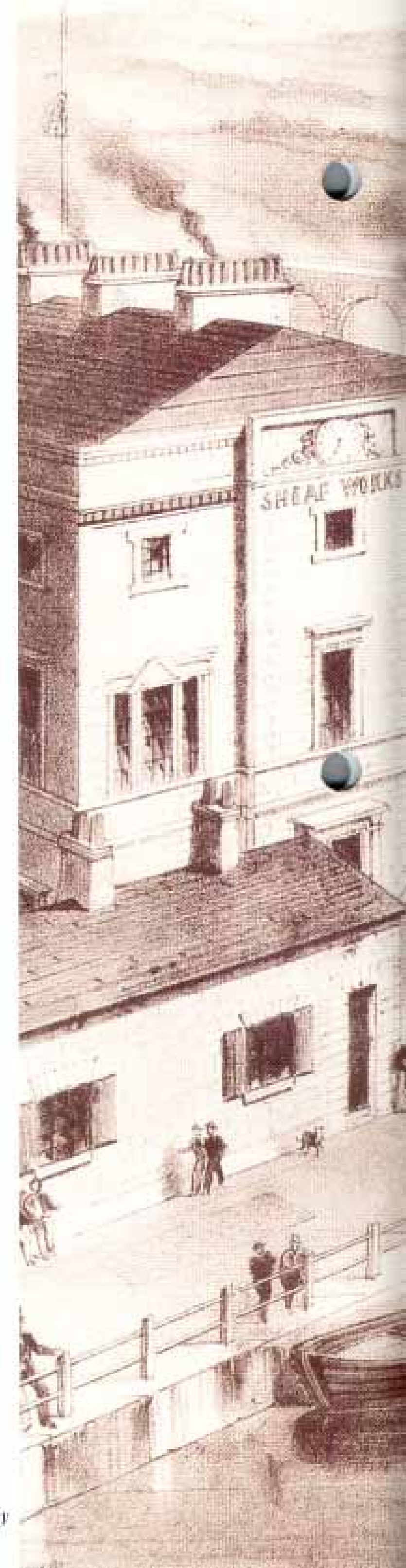
Today, no-one expects to find cutlery going rusty, but at the turn of the century it would have been no surprise at all. Steel cutlery had to be dried carefully after washing to prevent tarnishing. In addition it required regular polishing with scouring powder to keep it shiny. But in 1913 a Sheffield man called Harry Brearley changed all that when he developed martensitic stainless steel.

Harry Brearley was the eighth child of country bred folk attracted off the land by the developing steel industries of Sheffield. He was born in 1871 in 'Ramsden's Yard' a collection of cramped terraced houses off Spital Street. The family lived in one 10 foot square downstairs room with a bedroom and attic above. Life was hard, and in later years, Brearley likened his childhood to that of a 'Sheffield Street Arab'. He disliked school, preferring to explore, watch and learn from the local artisans active in the many small workshops near his home.

Later, by taking his father's lunch into the local steelworks, he became so fascinated with the art of steelmaking that he joined Thomas Firth's as a cellar lad in their crucible steel melting plant. This, however, did not last long — at the age of 11 he was sacked for being too young.

The following year he went back to Firth's and got a job as bottle-washer in their Chemical Laboratory. This proved a turning point in his life for he came under the influence of the Chief Chemist, James Taylor, a man of similar background. With Taylor's encouragement, the young Brearley attended night school and at the age of 20 he was introduced into the metallurgical profession for a premium of £50 which he had to borrow. He combined his laboratory assistant training with part time metallurgical tuition at Firth College, and having now joined Kayser Ellison and Company, he collaborated with one of the lecturers to write a book on 'The Analysis of Steelworks Material', one of the earliest authoritative works on the subject.

The 'street arab' was now a competent metallurgist.



Part of the industrial Sheffield that Brearley knew as a young boy.

In 1903, at the age of thirty two, he rejoined Firths as Chief Chemist at their Salamander Works in Riga, Russia. Within two years he was works manager taking full responsibility for the production of ordnance and tool steels.

At the end of 1907 the two neighbouring Sheffield steelmakers, Thomas Firth and Sons and John Brown and Company took the, for those days, pioneering step of setting up a joint research and development department and Harry Brearley was invited to return to Sheffield as the first Head of the Brown Firth Research Laboratories.

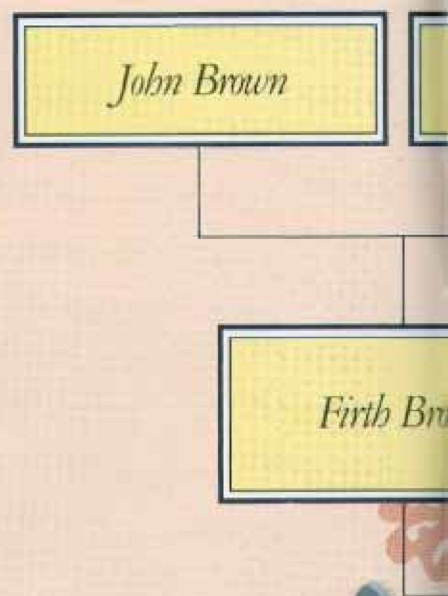
Harry Brearley during his period in Russia (c. 1903-4). ◄◄

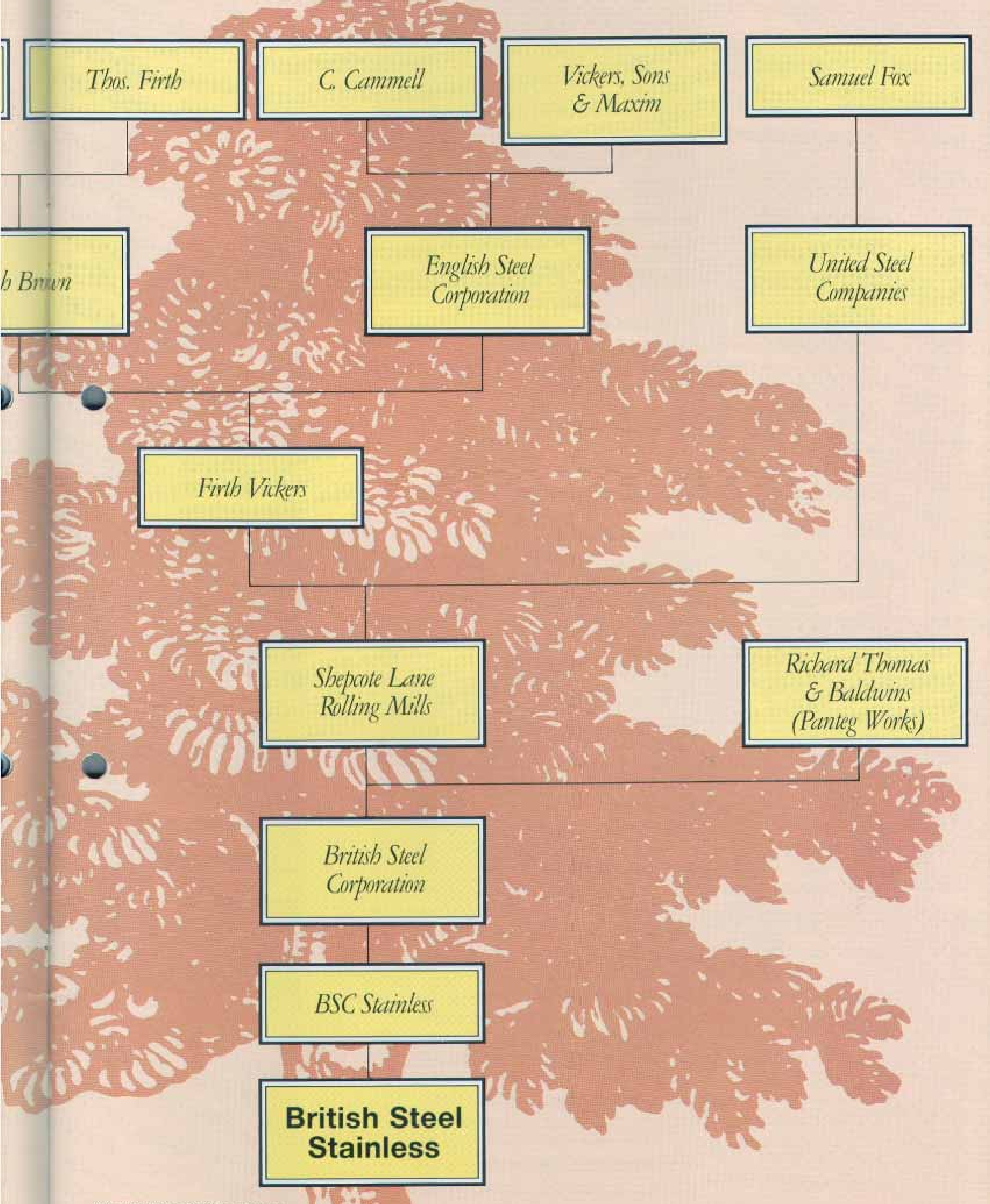
The interior of the Brown-Firth Research Laboratories, c. 1912. ◄

He came back, but over the previous few years, he and his brother Arthur, had also been operating a private consultancy business in the developing area of pyrometry. The Brearleys, whilst in Riga, had introduced what they referred to as 'Sentinels', cylinders of carefully mixed proportions of various compounds which would melt at specific temperatures. They had devised these as essential devices to ensure the proper heat treatment of shells. Placed on porcelain stands in the furnace, the cylinders would lose their shape when the appropriate heat treatment temperature was reached.

These ideas may appear a little primitive in today's electronic age but they were of real value at the time. In order to exploit the invention Brearley became a partner in the Amalgams Company in Sheffield, who were capable of making and marketing the devices.

Consequently, when he accepted the post as Head of the Laboratories, he was careful to write clauses into his contract which enabled him to continue this work and gave him an equal share with the company in the patent rights, and income from the sale of licences, on any developments for which he was responsible. This latter clause was eventually agreed by the two companies with some reluctance. In accordance with this agreement, however, half the proceeds of his latest book 'The Heat Treatment of Tool Steels', published in 1911, were handed over. In addition, the volume was dedicated to 'Thomas Firth and Sons Limited, in whose service labour and learning have been agreeably combined from 1883 to the present time'. This, then, was Brearley's situation in 1912, when he became interested in the manufacture of steels with high chromium contents.





The British Steel Stainless heritage.

A Lee Enfield .303 rifle. The type Brearley was working on in 1913.

In May 1912 Brearley had to visit the Royal Small Arms factory at Enfield in connection with the failure of rifle barrels due to internal erosion. In a confidential laboratory report dated 4th June 1912, having discussed the properties of the 5% chromium steel currently available, he concluded that a steel with upwards of 10% chromium could possibly be of advantage. After further consultation with the customer, he ordered two crucible melts in October 1912, with 0.30% carbon and with chromium contents of 10% and 15% respectively.

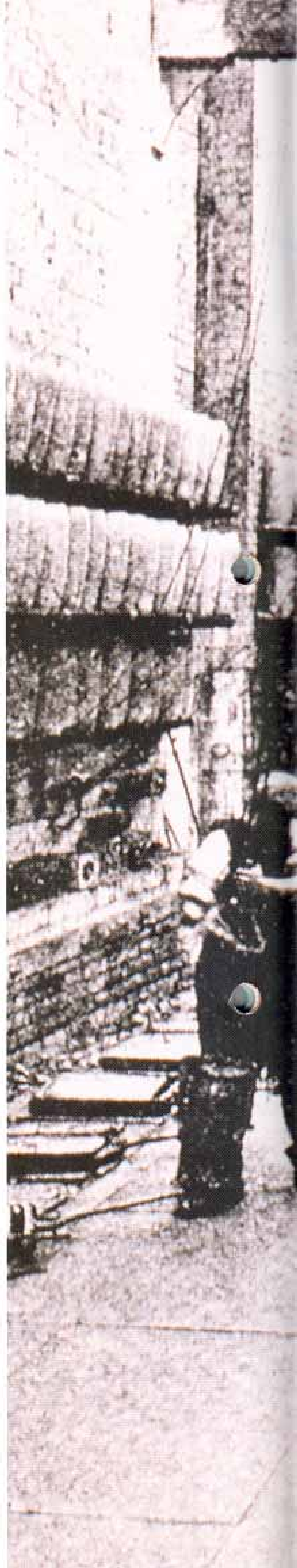
Both melts turned out too high in carbon, but the 15% chromium alloy showed some promise. Further crucible melts were ordered, with chromium contents up to 20%, but all were higher in carbon than desired. In June 1913, he asked for an electric arc cast to be made, with 0.30% carbon and 15% chromium.

Thomas Firth and Sons were pioneers in electric arc melting in Sheffield and in 1911 had set up a 50 cwt. Heroult type furnace. The first record book registering operations on 'E Furnace' has survived; unfortunately it ends in January 1913 — before this melt was made — but shows that 8" square ingots, weighing some 6 cwt. each, and with 7 or 8 ingots per cast, were regularly produced, each heat taking around 7 hours. It was on this furnace that Cast No. 938 was produced in July 1913; it was again too high in carbon (0.50%); the chromium content was 14.84%. The repeat, Cast No. 1008, made on 20th August 1913 was more successful. Its analysis is recorded as:

C	Si	Mn	Cr
0.24%	0.20%	0.44%	12.86%

An ingot was forge cogged to 3" square and the billet subsequently rolled to 1⅛" diameter bar. This was softened and machined without difficulty. Twelve sample gun barrels were then forwarded to the Ordnance Factory at Enfield on 14th January 1914, but it seems that they did not show the desired improvement. Material from the same cast was also eventually made into cutlery blades. This, then, was the first commercial cast of what was subsequently known as Stainless Steel.

As was his practice on any new material, Brearley carried out tests to determine its mechanical and physical properties and response to heat treatment. (A report giving a series of mechanical test results on samples from this first case has survived). In carrying out the accompanying metallographic work to determine the effect of heat treatment on structure, he found that the etching agents employed for normal steels either failed to react with his new material or reacted very slowly. He also noted that cut samples left in the laboratory atmosphere, quite unexpectedly, did not rust. Together with a report dated 2nd October 1913, he sent two pieces of the new steel (one in 'hard temper' and the other in 'soft temper'), and a piece of 0.30% carbon steel, to his management. All the pieces had been polished and exposed to the laboratory atmosphere for twelve days, but whereas the samples of chromium steel were perfectly bright, the sample of carbon steel had rusted.



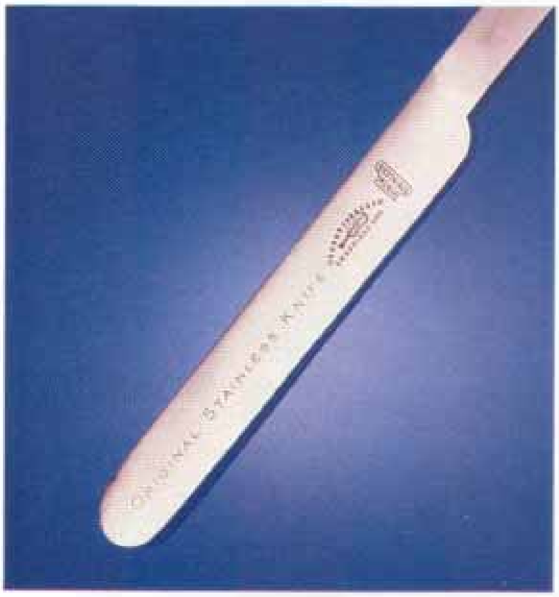
Crucible Steel production

His report commented that his new steel had considerable advantage over the 25% nickel steel, hitherto used for its resistance to tarnishing, in that it could be softened for machining and could subsequently be hardened. He also demonstrated that the resistance to corrosion was dependent on the previous heat treatment.

As mentioned earlier, the ordnance application which had instigated the investigation had proved abortive, but Brearley had recognised possible commercial applications, based on its corrosion resistance. He wrote in this report:

'. . . these materials would appear specially suited for the manufacture of spindles for gas and water meters, pistons and plungers in pumps, ventilators and valves in gas engines and, perhaps, certain forms of cutlery'.

The application of the material to cutlery was not straightforward. Two cutlers, George Ibberson and James Dixon, originally supplied with sample bars from this first cast, reported that it was almost impossible to forge, difficult to harden and dirty when polished. An early knife from this first cast made by Ibbersons has been preserved. Part of the problem was certainly prejudice; the idea of producing, on a commercial scale, knife blades which would not corrode was stated by one of the foremost cutlers to be 'contrary to nature'.



One of the original batch of stainless steel knives produced by George Ibberson in 1914.

Even one of Firths directors is reputed to have remarked that 'rustlessness is not so great a virtue in cutlery, which of necessity must be cleaned after each using'.

The new material, by its very nature, required different handling. For instance it needed a higher forging temperature than the normal carbon steel would stand, but, if this was taken too far, a useless brittle blade with a coarse structure would result. In addition, the hardening and tempering treatments were more critical to the achievement of optimum resistance to corrosion.

But Brearley was not easily discouraged. He knew he had made a major discovery.

There are two points which should be raised at this juncture. Subsequent to the confidential report put out by Brearley on which his claim to be the discoverer of stainless steel is based, rumours began to circulate to the effect that a French magazine, found at the Riga works in October 1912 giving details of a steel which would not rust, had been sent to Brearley by an employee. Brearley was said to have made an ingot to the specified composition and, having put it on one side, subsequently found it had not rusted. Therefore it was said, Brearley's discovery actually belonged to a Frenchman.

In Brearley's defence, it must be pointed out that the timing appears to be wrong, since he had already made his proposals in the previous June. Furthermore, an as-cast ingot, exposed to the atmosphere, would not exhibit rustlessness unless it were planed or ground. In addition, had this been a French invention, one would have expected some evidence of commercial exploitation or a protest against the British claims; neither occurred.

The second point, however, is more difficult to explain. The Amalgams Company, with which it will be remembered Brearley was intimately connected, ordered one hundredweight of 'Firths Aeroplane Steel' (FAS) early in 1914. This was a steel destined to be used throughout the 1914-18 War for the provision of aero engine valves and seems to have contained about 0.4% carbon and 14% chromium. The inference is that it had been developed for this particular purpose. Indeed, in 1916, the production of high chromium steels for other than defence purposes was prohibited by Government decree for the duration of hostilities.

The valves in the engine of this SE5a were made in stainless steel.

How this particular composition had been arrived at and why it was not seen earlier as being a stainless steel is now inexplicable. Brearley obviously saw its potential as a cutlery material and persuaded his friend Ernest Stuart, of the cutlery firm, R. F. Mosley and Company, to try some samples.

Stuart was sceptical that there could be such a thing as a rustless steel, but a week later he announced that he had made some blades and, indeed, when polished, they had proved to be rustless. However he told Brearley in no uncertain terms that the steel was so hard to forge that his *!*!*!*! tools were ruined.

Eventually with Brearley's advice on forging and heat treatment, satisfactory procedures were developed and, within a very short time, Mosleys were ordering more and more of this steel. Brearley expected Firths would be delighted. He further proposed that Firths might care to supply heat treated blanks of the new steel to the cutlers instead of just raw material. Naturally, he also suggested some reward for himself, in line with his contract of employment, whereby the patents based on his discoveries would be joint property. Firths response infuriated him. The firm refused to take out a patent; the blanks proposal was turned down and Brearley was ordered to supply customers with information and instructions on handling the new steel. Brearley found this completely intolerable and on 27th December 1914, he handed in a letter giving six months notice of his resignation from Brown Firth Research Laboratories.

He was succeeded by Dr. W. H. Hatfield, who was to play a major role in the further development of corrosion resisting steels. Meanwhile Firths had passed information to L. Gerald Firth, manager of their American subsidiary, Firth Sterling Limited in Pittsburgh, and on 3rd March 1915 the first American stainless steel ingot was cast, destined for an American knife manufacturer.

Table cutlery stamping shop circa 1928.

At the beginning of July 1915 Brearley became Works Manager at the Brown Bayley Steelworks and stainless steel was soon being manufactured there. With no British patent coverage, stainless steel similar to the original Brearley material was also being produced over the next two years by John Brown and Company, Hadfields, Sanderson Brothers, Vickers and other Sheffield firms in addition to Firths and Brown Bayleys. However on 29th March 1915 Brearley, assisted by a Mr. John Maddocks, applied for an American patent.

The first application was turned down. Brearley thereupon solicited the help of Sir Robert Hadfield, Dr. Stead and F. W. Harbord, all of whom provided written statements in support of a new application. Eventually, on 5th September 1916, he was granted American Patent 1,197,256 for improvements in cutlery, covering steels with 9% to 16% chromium and less than 0.7% carbon. This turn of events, when it became known to the directors of Thomas Firth and Sons, was seen as a possible restriction to the operations of Firth Sterling.

They considered taking legal action, but finally decided to purchase a half share in the American patent. This was accepted and arrangements were concluded which saw the birth of the 'Firth-Brearley Syndicate', formed to foster the worldwide production of stainless cutlery steel.

This implied the renewed association of Brearley with the directors of Firths, people whom he considered had not acted responsibly to him. In the event, the arrangement seems to have worked reasonably well. In fact, the only friction reported came some years after the formation of the syndicate when the marking of knife blades with the name 'Firth Brearley Stainless' was dropped and replaced by the simpler 'Firth Stainless'; this was a matter which Brearley only accepted after making strong private and public protests over a considerable period.

Brearley's American Patent.

UNITED STATES PATENT OFFICE.

HARRY BREARLEY, OF SHEFFIELD, ENGLAND.

CUTLERY.

1,197,256. Specification of Letters Patent. **Patented Sept. 5, 1916.**

No Drawing. Continuation of application Serial No. 17,856, filed March 29, 1915. This application filed March 6, 1916. Serial No. 82,301.

To all whom it may concern:

Be it known that I, Harry Brearley, residing at Sheffield, Yorkshire, England, have invented a certain new and useful Improvement in Cutlery, of which the following is a full, clear, and exact description.

My invention relates to new and useful improvements in cutlery or other hardened and polished articles of manufacture where non-staining properties are desired and has for its object to provide a tempered steel cutlery blade or other hardened article having a polished surface and composed of an alloy which is practically untarnishable when hardened or hardened and tempered. This alloy is malleable and can be forged, rolled, hardened, tempered and polished under ordinary commercial conditions.

The invention results from the discovery that the addition of certain percentages of chromium and carbon to iron will produce a steel capable of taking a polish and having the characteristics above referred to. I have discovered that the addition to iron of an amount of chromium anyw... tween nine per cent ... cent ...

cent.; iron 86.4 per cent. In producing such steel I preferably use an electric arc melting furnace. It can be readily made in such furnace. It forges easily into sheets or strips such as are required for knife blades and can be hardened and tempered by ordinary commercial processes.

Knife blades embodying my invention are made from the steel above referred to being formed, hardened and polished by grinding or buffing in the ordinary manner, the product being a polished cutlery blade similar in appearance to other polished blades but possessing the remakable quality of being practically untarnishable when subjected to the ordinary uses to which knife blades are subjected, because made from the alloy above described. My blades are tempered so as to be sufficiently resilient for ordinary requirements.

Small amounts, up to say one or two per cent. of nickel, copper, cobalt ... molybdenum and ... with...

Throughout the 1920's the Firth Brearley Syndicate in this country busied itself in the fostering of stainless steel production elsewhere in the world, granting licences and disseminating know-how and also protecting itself against infringements.

There were a number of court cases, both in this country and America. Perhaps the most famous one was against the American Ludlum Company where judgement was originally given against the American Stainless Steel Company. It was only after Harry Brearley drew up a comprehensive report in support of the case that the appeal

Harry Brearley circa 1920.

An assortment of early stainless steel table knives.

was won. Strangely enough, the steel in question was not strictly stainless but a material with 3% silicon and 8% chromium, eventually to become widely used as an exhaust valve steel. There was also a case in which the Syndicate took action against the London store of A. W. Gamage and Co. concerning the illegal stamping of the name 'Firth Stainless' on blades not made from Firth's steel.

Something known only to a very select few at the time was that Firths took the precaution of 'labelling' their melts of 13% chromium steel by the incorporation of a small amount of 'Element X', added in unmarked brown paper packets by the melting shop manager towards the end of the melt. Only the Chief Chemist and one laboratory assistant knew the identity of 'Element X' and any analysis needed for arbitration cases was carried out by one analyst, working after hours, alone in the laboratory. It now does no harm to reveal that the mysterious constituent was cobalt, at a level of around 0.03%.

Ben Bagshawe, the Chief Chemist of the Brown Firth Research Laboratories at that time, confirmed that the colour test used was quite definite in distinguishing genuine Firth Stainless from any competing 'pirate' material which gave no reaction. Interestingly, a recent examination of an early stainless knife blade has revealed this cobalt addition.

The early commercial developments of stainless steel were all based on near variants of the Brearley analysis but it would have been more valuable had it been more amenable to producing sheet material and had it been easier to weld. Attempts were made, by reducing the carbon content, to improve these aspects and work both in Sheffield and in America showed the value of lower carbon materials in some applications, particularly as steam turbine blade materials. To provide a corrosion resistant material with a wider range of applications, however, needed a different approach: the development of austenitic chromium-nickel corrosion resisting materials as outlined later in this brochure.

Harry Brearley was awarded the Bessemer Gold Medal of the Iron and Steel Institute in 1920 for his work. Characteristically, he suggested that his brother, who had been with him ever since he started at Firths, deserved half the medal.

Brearley's Bessemer Gold Medal. (Photograph courtesy of Miss Sue Brearley —H.B.'s great grand daughter.

Harry Brearley receiving the Freedom of the City of Sheffield in June 1939.

He also acknowledged the great help he had received from those who had worked with him:

'. . . the desire to find out and to understand things was not confined to those who regularly wore clean collars and he was proud to confess his lifelong indebtedness to scores of friends with hard hands and black faces who toiled at laborious tasks in mills and forges'.

It was with similar feelings towards his early boss that he provided funds for the James Taylor prize to be awarded by the Sheffield Metallurgical Association to those who . . .

'. . . showed the greatest originality of conception or dealt most usefully with some metallurgical subjects of current interest'.

He also founded 'The Freshgate Trust Foundation' which he hoped would 'help lame dogs over stiles'. The Foundation is still actively pursuing this aim. The final honour paid to Harry Brearley was the granting of the Freedom of the City of Sheffield in June 1939.

Badge of the Master Cutler displaying the Arms of the Company of Cutlers in Hallamshire.

Harry Brearley retired from active involvement in the steelworks in 1925 although he retained his seat on the board of Brown Bayleys Steel Works Limited. He retired to Torquay where he wrote a number of books including an autobiography entitled 'Knotted String' and a fascinating record of the old Sheffield crucible steel trade entitled 'Steelmakers'.

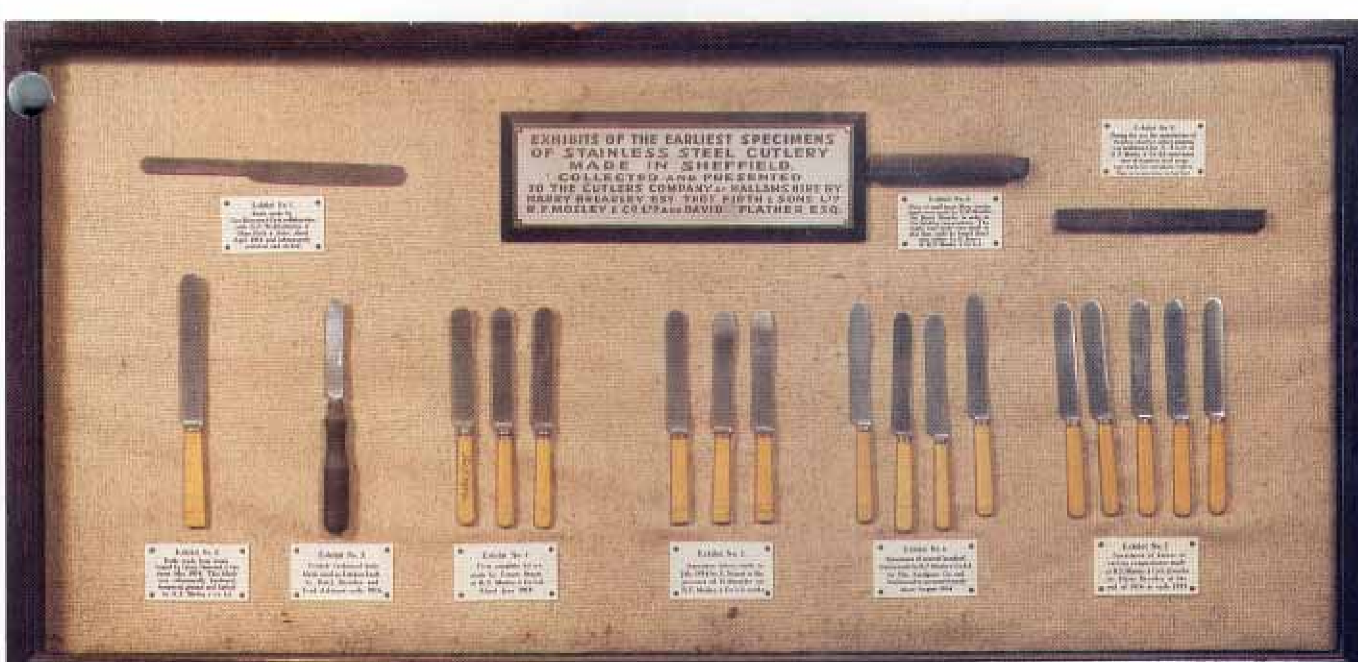
He died on 14th July 1948.

But the story doesn't end there. On 14th December 1931, Brearley had placed a sealed packet, containing his sworn declaration on the history of stainless steel, in the safe keeping of the Cutler's Company in Sheffield with the instruction that it was not to be opened until the day of the Forfeit Feast on 20th June 1960 ... 'by which time the persons concerned are unlikely to be living ... to avoid causing inconvenience or giving offence'.

Because of the disagreements between Brearley and Firths almost forty years earlier, and as it was already known that the sealed document would contain information on companies, dates, people and places involved in the discovery of stainless steel, the 29th June 1960 was looked forward to with great interest and anticipation. It was therefore with a sense of deflation that the document was found to contain no startlingly new revelations.

Some observers denounced the declaration as insignificant whilst others felt that it was actually a useful document giving factual information which was known to the principal people involved but to very few others.

The sealed document was accompanied by a large display case showing the cutlery samples produced at various times during the early years of stainless. These samples represent the first stainless steel ever produced and are most certainly prime examples of the world's first stainless steel cutlery. This display case is still on public display in the Cutlers Hall, Sheffield.



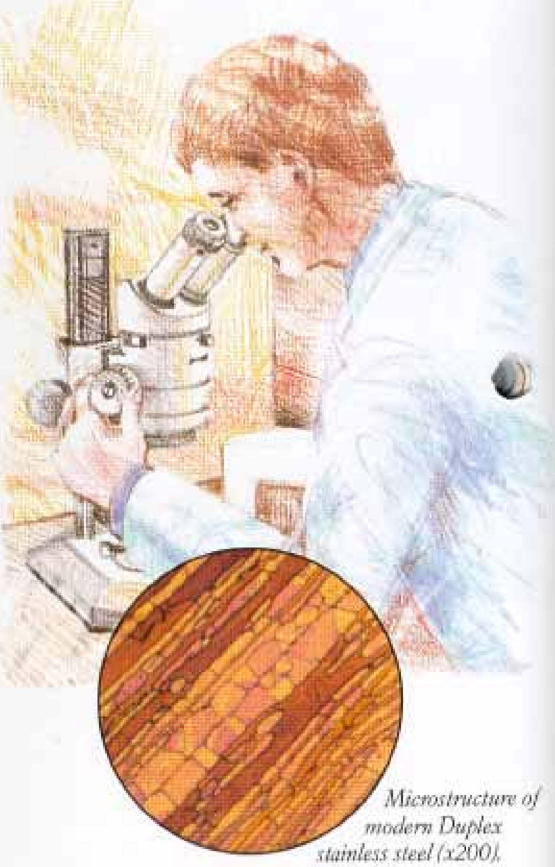
WHY IS STAINLESS STAINLESS?

Looking back seventy-five years, the basic principle behind Harry Brearley's invention now looks relatively simple. But it required someone with Brearley's combination of metallurgical ability, industrial experience, commercial acumen and, above all, persistence to ensure success. As with many other classically simple ideas which have changed the course of history, we may well wonder why the discovery of stainless steel took until 1913.

1766 and all that . . .

It has been suggested that the stainless steel story started with the discovery in Siberia, in 1766, of a new mineral, chromite. The chromium metal subsequently extracted from it was found to have extremely good resistance to corrosion, the feature still used today by every chromium plated article.

In the 1800's, the Sheffield steel industry was furiously developing special steels to meet the growing engineering demands of the Industrial Revolution. Several people, including Sir Robert Hadfield, came very close to discovering stainless steel, but they all failed to recognise the commercial significance of their work. Harry Brearley was perpetuating the metallurgical skills of a long line of local industrialists who had established Sheffield as the centre of the world's special steels industry, when he realised that the key to preventing rusting lay in getting both the chromium content and the heat treatment of the steel right.



Microstructure of modern Duplex stainless steel (x200).

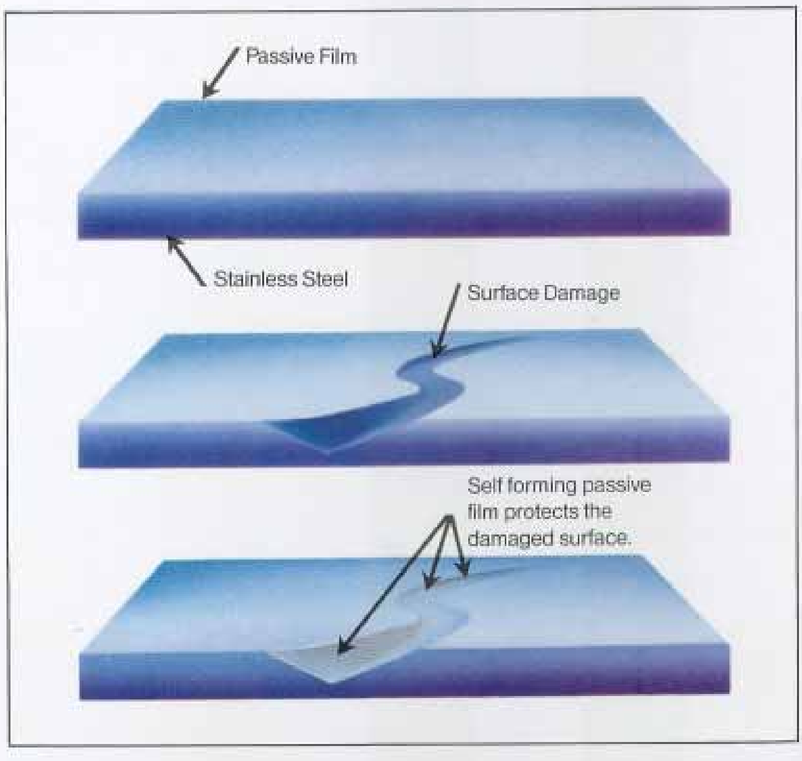


Diagram illustrating the self-repairing property of stainless steel.

The Stainless Factor

It is now known that the reason for the good corrosion resistance of chromium is due to the properties of the oxide film formed naturally upon its surface. All metals react with oxygen and water in the atmosphere to form a surface layer of oxide. That formed on ordinary carbon steel, which is 98% iron, is an hydrated iron oxide. Being porous this permits further penetration of oxygen and water allowing oxidation to continue underneath it, producing what is commonly known as rust.

Chromium Nickel steel alloyed with molybdenum for resistance to marine atmosphere corrosion. (Photo courtesy of British Gas).

Chromium Nickel Austenitic type steel, ideal for sinks.

Brearley's original type of steel still used in today's kitchen knives.

The only way to prevent this rusting process is to protect the carbon steel's surface. By alloying the steel with chromium, Brearley was able to alter the type of oxide formed to one very similar to that formed on pure chromium.

Although only a few nanometers thick, this chromium bearing oxide protects the metal surface from further reaction with the atmosphere. This tightly adherent 'passive' film is invisible to the naked eye, allowing the natural brightness of the metal to be seen but, if scratched, has the ability to reformulate itself within seconds, thus maintaining its protection.

The stainless heritage

All stainless steels rely on this passive film to maintain their appearance but the work by Brearley and his contemporaries was only the beginning of the stainless steel story. Since 1913 there has been a vast amount of research work carried out to develop new types of stainless steel for specific uses.

There are currently over 200 different varieties of stainless steel used throughout the world. Some have been developed for good formability, others for high strength; some are designed to operate at red hot temperatures, others to operate at the sub-zero temperatures of liquid gases.

Sheffield's tradition as a centre of stainless steel expertise has grown and matured to such a level that it now possesses research and steel production facilities that are the envy of the world's stainless steel industry.

Good metallurgist that he was, even Harry Brearley could not have foreseen just how far reaching his discovery was to become a scant 75 years later.

British Steel Stainless continuous slab caster viewed from the control room.

Tensile testing in the Materials Test Cell at British Steel Stainless, Shepcote Lane.

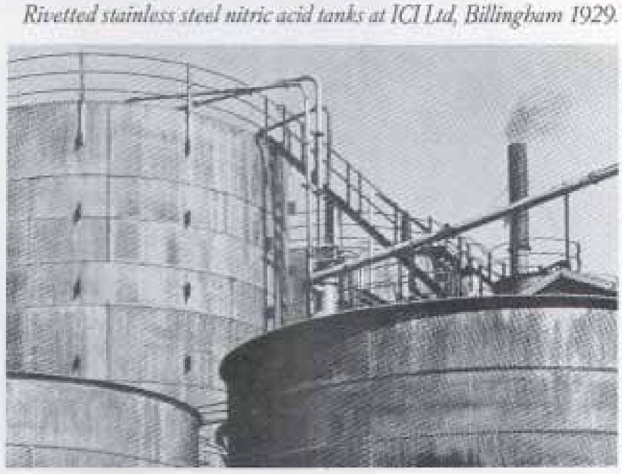
THE FIRST TWENTY FIVE YEARS 1913-1938

Within twenty-five years of the discovery of chromium in 1797, scientists in Europe and America were working on iron chromium alloys. Many including Michael Faraday, Berthier, and later Sir Robert Hadfield might have become the discoverers of stainless steel had it not been for the purist approach adopted by some of them, ill chosen experimental designs by others, or sheer bad luck. Consequently, it is not surprising that continental contemporaries of Brearley were also working on corrosion resisting steels. The outcome was a 0.25% carbon, 25% chromium, 7% nickel steel that, being austenitic, was more suitable than Brearley's compositions for the fabrication of components for the developing chemical industry. The two types of steels complemented each other, and somewhere in late 1923 or early 1924 the Firth Brearley Syndicate came to an arrangement which allowed them to make chromium nickel steels in Britain.

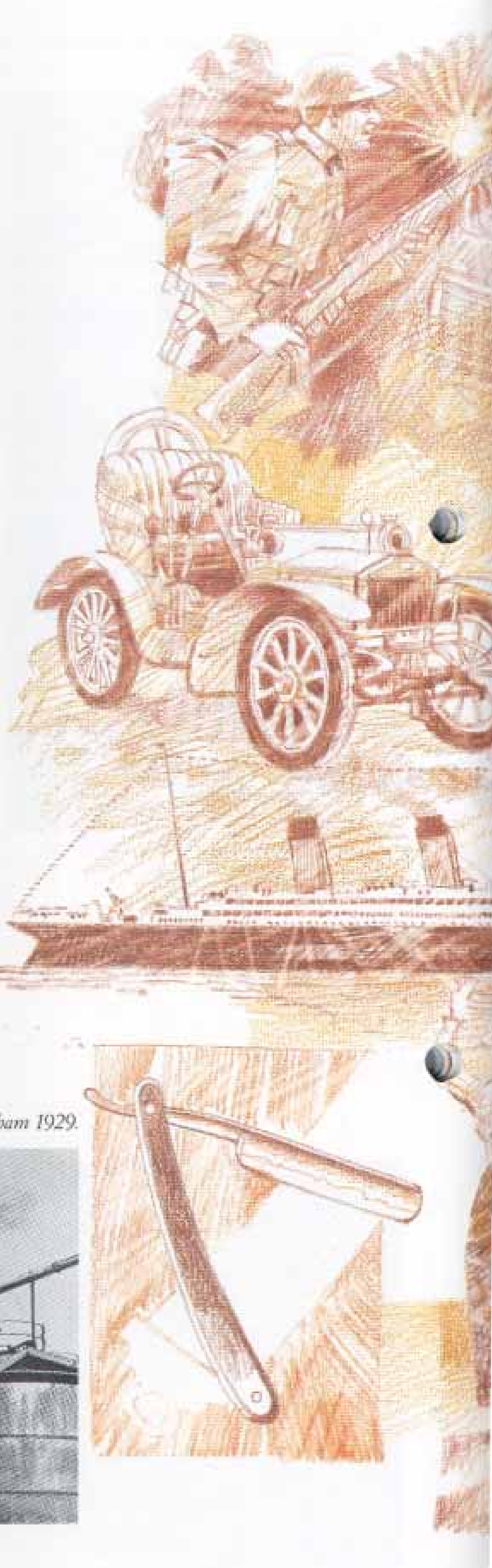
By this time Brearley had moved to Brown Bayleys and Dr. W. H. Hatfield had been appointed Head of the Brown Firth Research Laboratories. After Hatfield's appointment, there followed an intense period of research work on stainless steel at the Brown Firth Research Laboratories and elsewhere in Sheffield.

Dr. Hatfield quickly established the now well known 18% chromium 8% nickel composition, containing around 0.2% carbon. Unfortunately, it was observed in some of the early applications that failures began to occur in the heat affected zone of welded plate, due to 'intercrystalline corrosion' or 'weld decay'. Photographs of early chemical vessels clearly show that a rivetted construction was used to avoid this problem. Eventually, failure was recognised to be due to precipitation of chromium carbide in the austenite grain boundaries during welding giving chromium depletion and hence loss of corrosion resistance. Hatfield initially added tungsten in order to prevent the chromium carbide precipitation, but this was only partially successful. Subsequently he used and patented the addition of titanium. This steel became the now well known Type 321. He also possibly developed the first quality control test to detect material susceptible to sensitisation — the copper sulphate/sulphuric acid test.

Dr. W. H. Hatfield.



Rivetted stainless steel nitric acid tanks at ICI Ltd, Billingham 1929.



The 20's and 30's saw a wide range of specialist steels developed in Sheffield including a 12% chromium 12% nickel deep drawing steel, a molybdenum bearing version of 18% Cr 8% Mo now called Type 316, the chromium/nickel series of heat resisting steels and the low carbon 12% chromium stainless iron.

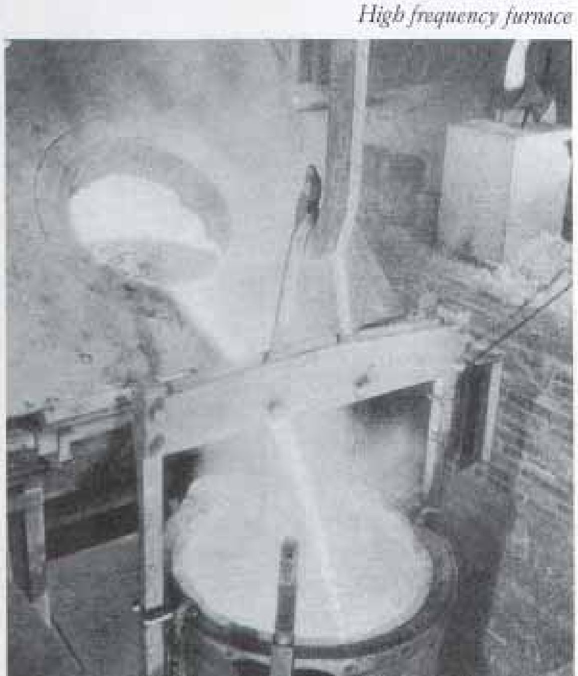
This latter type was pioneered by Brown Bayley, where Harry Brearley had also been joined by J. H. G. Monypenny. In order to overcome steelmaking problems, selected low carbon ferro chromium was used, giving an analysis of 0.07% C 11.7% chromium in the first commercial cast, made in June 1920. They also found that increasing the chromium content to 17-20% gave improved corrosion resistance, but eliminated the hardening response. This was, of course, a single phase ferritic Type 430 composition. They restored the response by adding nickel instead of carbon to produce Brown Bayleys 'Two Score', a 20% Cr 2% Ni steel. This formed the basis for the well known S80 steel.

In the thirties, stainless steels were being made by many Sheffield steelmakers including Firth Vickers, Brown Bayleys, Hadfields, Jessops, Edgar Allen, Kayser Ellison and Samuel Fox.

The Sheffield stainless steel industry was established.

Although some companies initially relied on crucible furnaces, these were largely superseded at the end of this time period by basic lined, high frequency induction furnaces using charges based on stainless steel scrap. However the main production of stainless steel was done in the basic electric arc furnace, with the furnace size increased from the 1913 original 2.5 tons to 15/30 tons by the end of 1938. Ingot sizes also increased over the same period, from the original Brearley 6 cwt. to around one ton; typical ingot sizes were 16" x 10" section for sheet production or 14" square for bar. The practice of forge cogging the ingots was also gradually replaced by hot rolling to billet or slab. Billets were rolled to bars in hand mills; rod for wire drawing was made in looping mills, which necessitated the roller catching the free end and feeding it into one stand whilst it was still being rolled in two or more previous stands—a most hazardous operation, particularly when the final rod, travelling at high speed, had to be caught and entered into the coiler. During the 1920's forgings and castings also became available.

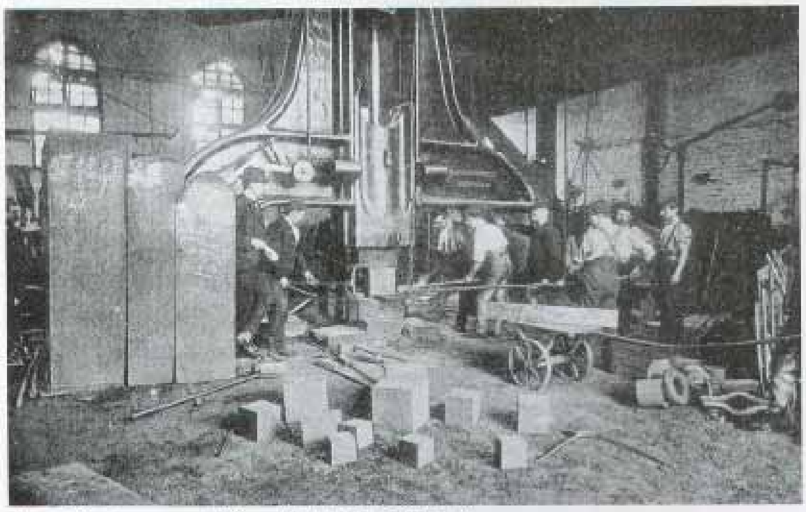
High frequency furnace



To make sheet, ground slab was hot rolled into intermediate thicknesses referred to as 'moulds'. These were often surface ground and then reheated for the final rolling in hand mills, prior to being batch softened and then descaled by pickling in an acid bath.

For the best finish, the material had then to be cold rolled, again softened and descaled and finally given a light cold pass to improve shape and consolidate the surface. The limiting factors on sheet production proved to be the cold rolling and descaling facilities; there are records from 1926 indicating that the maximum width of cold rolled sheet was 16", whilst it was not possible to descale a plate larger than 5' x 2'. Such descaling, incidentally, was carried out in tanks in the open. With the workforce housed adjacent to the works, it is hardly surprising that housewives complained of rotting curtains! During the 1930's sheet production became semi-automated; sheets were still produced on hand mills but overhead conveyor systems were built which moved them through softening furnaces, quenching zones, acid baths, water rinses and drying areas.

The technical development work done in these pioneering years is much better documented than the market development work that must have been required to exploit the new products. Although it is doubtful whether the word marketing would have crossed the Atlantic from its American origin circa 1910 to the Sheffield of 1913, it is quite clear that the basic principles were understood. However, before examining the published and verbal information obtained on these marketing activities, it is perhaps useful to remind oneself of the commercial scene at the turn of the century.

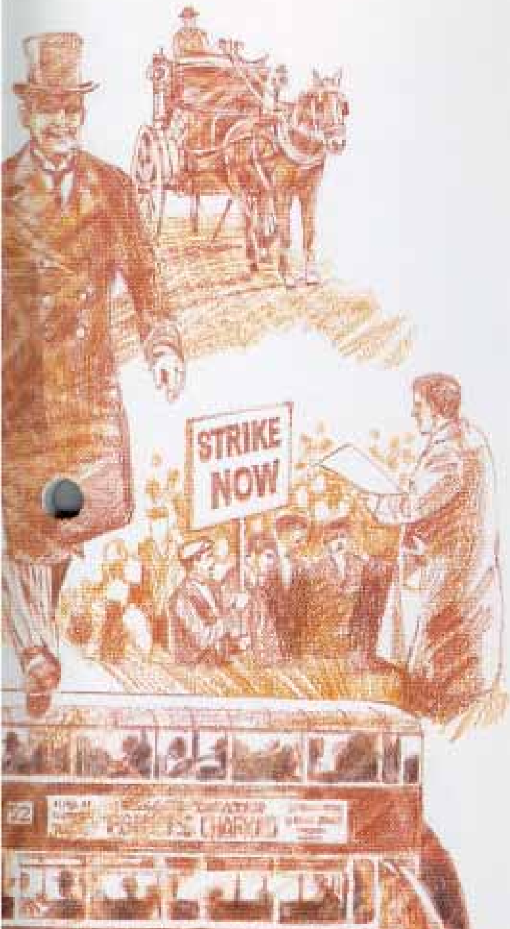


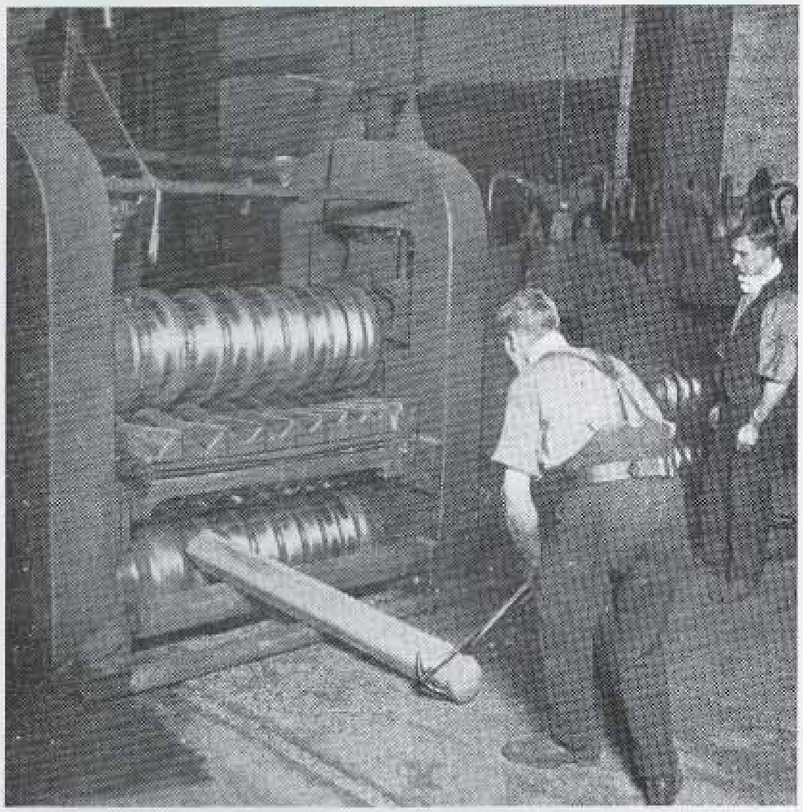
An old forging press in Thos. Firth's Norfolk Works.

For instance, one of Brearley's contemporaries describes how in the early 1900's a steelmaker's representative would post a duplicate hand written report to his management after visiting a customer. (Incidentally, he would have made the visit wearing a silk top hat and morning coat required for his position in the firm). The telephone and telegraph revolutionised this inward flow of information, just as the motor car later gave the representative a step-change in mobility.

Against this background, Brearley and Firths were faced with major product launch problems when, after the First World War, stainless steel production was decontrolled.

Firstly, they had to convince people that they really had a steel that did not rust. Firths initial reaction had been unenthusiastic — so much so that they never bothered to patent the invention. When they were convinced, their immediate reaction was to instruct Brearley to transfer technology on the forging and heat treatment of his stainless steel to the cutlers. He argued that they should retain this intellectual property





Rolling stainless steel billet.

and exploit it by supplying forged and heat treated blanks. (Not unnaturally, he also wanted a share of the added value that would be generated). Their disagreement leading to his resignation has been mentioned earlier.

In some respects the subsequent outcome in the UK and USA is worthy material for a Business School Case Study on the exploitation

However Firth's didn't change their commercial strategy. It is interesting to examine the sort of information used by them to assist their customers. The contents were largely factual, and almost to emphasise this point, their technical publications were presented in the hard backed format of metallurgical text books: in many respects this is exactly what they were. Metallurgy as an applied science was becoming increasingly recognised and there was a need to graft it on to the decades of skills inherited by craftsmen in the cutlery and other manufacturing industries.

The stainless steelmakers were also aware that they had to keep abreast of developments in manufacturing industry. For instance some mere thirteen years after Brearley's invention a special Director of Thos. Firth and Sons wrote how the role of a steelworks representative had changed, with more emphasis being placed on…'a thorough practical appreciation of (the customer's) engineering problems and his firm's products'.

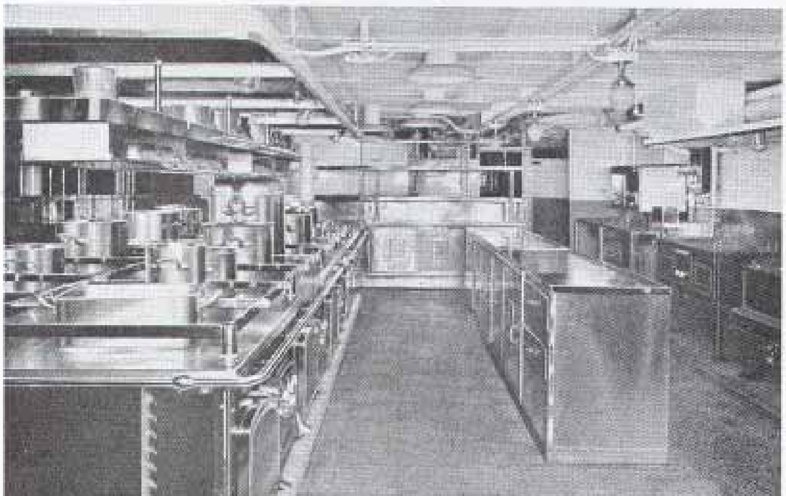
This philosophy is as valid for today's industrial marketeer as it was then.

But the marketing problem began to take on another dimension in the 1920's when it was realised that stainless steel could be used in the consumer durable market sector, as well as in industrial markets. The pioneers therefore had to consider how to approach mass markets. Looking back, it is clear that they adopted the classic marketing approach of identifying consumer needs that could be satisfied by stainless steel goods, encouraging and educating manufacturers to make them, followed rapidly by assisting in the creation of a market demand.

However, the communication problem was very different. Now it was necessary to get the message to millions of householders throughout the country, instead of hundreds of industrial buyers situated in discrete and clearly identifiable locations. Remember this was at a time when television was still an untried invention and cinema and radio were in their infancies. Again, a classical marketing solution was adopted. They segmented the market and targeted on the sectors offering the highest probability of conversion, at the upper end of the socio-economic groupings. Their media were Punch, Ladies Journals, the quality newspapers of the time, and posters, including London Underground sites.

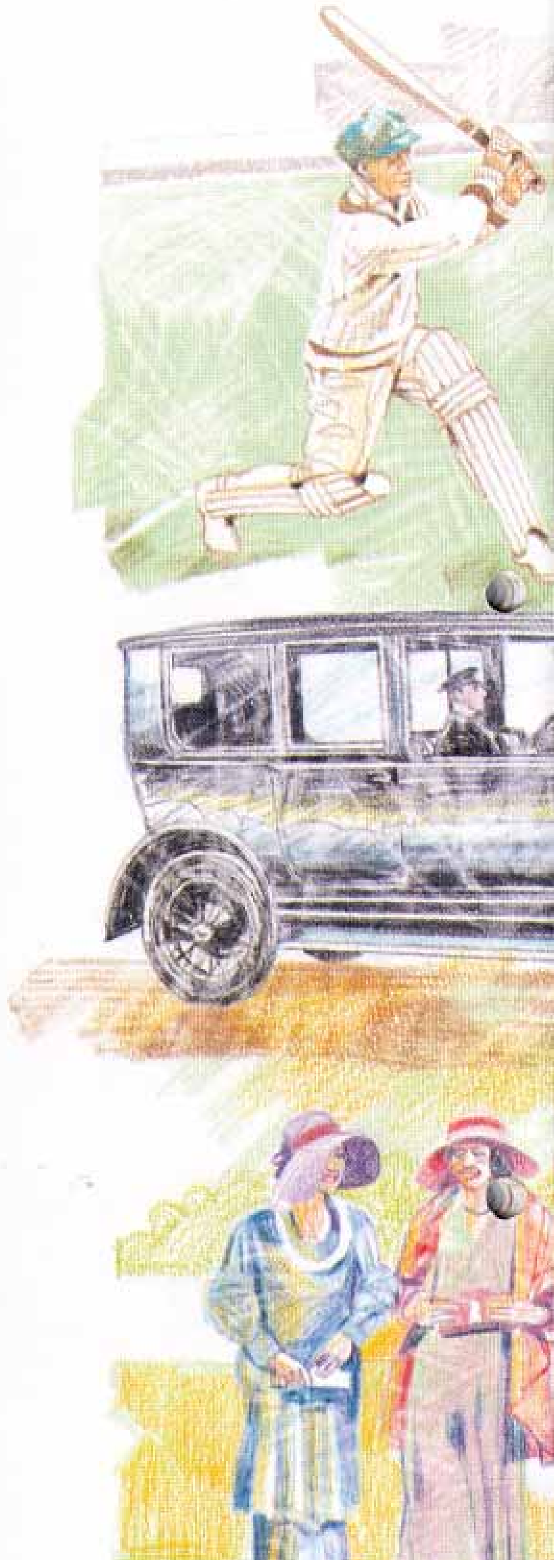
But telling people about stainless steel products was not enough. You needed to demonstrate their advantages — and show where they could be bought. In other words you had to develop the distribution chain. One of Thomas Firth and John Brown's solutions to this problem was to organise 'Staybrite City' at the Daily Mail Ideal Homes Exhibition where '...by invitation, many of the manufacturers of goods made from 'Staybrite' steel and Firth Stainless Steel are illustrating and describing their various manufactures...'

Posters displayed on London underground stations circa 1938.



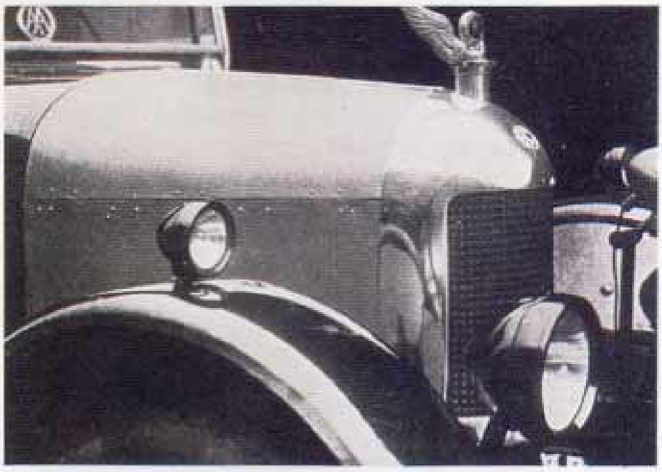
The stainless steel kitchens of the Queen Mary launched in 1934.

The four hundred and sixty four page catalogue for the 1934 exhibition gave examples of where stainless steel was used, illustrations of the products, and names and addresses of shops throughout the UK where they could be bought.



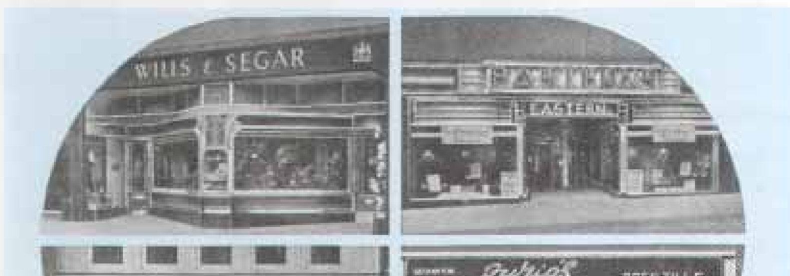
When Dr. Hatfield visited America in 1928 he found that 18% Cr 8% Ni steel was being produced in large quantities and was widely assumed to be an indigenous development. He took some delight in pointing out that the composition had originated in his own laboratories and was a Sheffield product which had spread to America — and other countries.

Henry Ford began fitting his cars with rustless fittings of 'Allegheny Metal' in 1930, some four years after Hatfield had embellished his own Bullnose Morris, and made it the subject of an article in Autocar. Again Hatfield was not slow in publishing the fact that he had stressed the opportunities for 18% Cr 8% Ni with visitors from the Allegheny Steel Company to his laboratories in 1926. He had also held further discussions with them in 1928 when he visited their plant in America, and later talked with Henry Ford in Detroit.



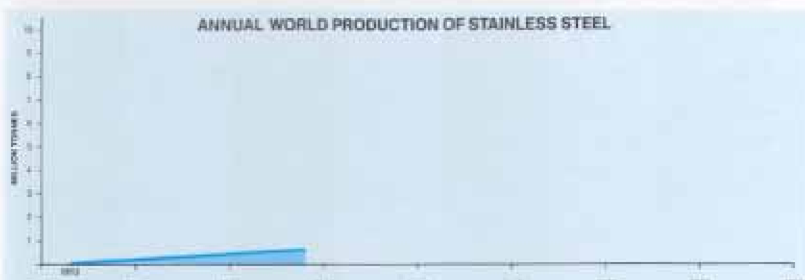
The first car to sport stainless steel radiator and trim — the Bullnose Morris Cowley of Dr. W. H. Hatfield.

The 20's and 30's saw a rapid expansion in usage of stainless steel, with steelmakers in Europe and America actively promoting their product into a wide range of market sectors including consumer durables, buildings, architecture, kitchens, catering and automobiles, as well as the food and drink, chemical and engineering industries.



Stainless steel shop fronts circa 1936.

Although no firm data have been located, it is estimated that world stainless steel production had grown from zero to 0.6 million tons by the end of these 25 years.



THE SECOND TWENTY FIVE YEARS 1938-1963

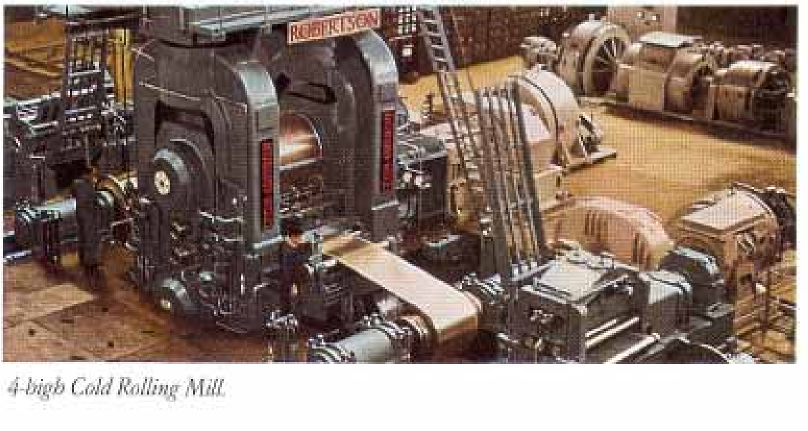
During the Second World War the output of stainless steel was again directed towards the war effort. In the UK this included crucial components in the Whittle Jet Engine WI, where it was specified to withstand the high temperatures generated within the engine. In Germany, however, shortage of strategic materials stimulated the development of high silicon and aluminium heat resisting alloys that still remain a feature of this market. When peace came the immediate need was for investment to replace worn out plant. With investment came modernisation and capacity increases in order to meet the growing demand for stainless steel from both the industrial and consumer durable markets. The commercial environment was also changing. Overseas, Japan was set to emerge as a major new market force. Trade was to become more international and marketing concepts were being increasingly adopted.

This period saw the beginning of major changes in production. Cold rolled production technology was moving away from sheet rolling to continuous cold rolling. Later, led by America, the technology was further advanced by the introduction of the Sendzimir Mill. Consequently ingot sizes rose to 12 tons and slab ingots were first rolled to approximately 40" x 6" slabs in powerful reversing mills. The slabs were then rolled down in hot-coil mills to produce hot band which was subsequently cold rolled to sheet thickness.

The coils were then fed through continuous softening and descaling lines, followed by being cold rolled, softened and descaled, pinch passed, decoiled, flattened, sheared, inspected and packed. Continuous bright annealing plant was also developed to supply some of the market that had previously required polished material, as well as opening up opportunities in new markets.

The investment cost of these developments demanded bulk production in order to be economic. Electric arc furnace sizes therefore increased to around 80 tonnes and ways were sought to improve their productivity. The availability of tonnage oxygen from air liquefication plants enabled oxygen blowing to be used in order to reduce refining time, but the associated costs, largely in terms of refractory wear, were high. However, development work was being done in the 1950's on another cost saving aspect—continuous casting.

The concept of near net shape production is particularly appealing to stainless steelmakers because the material's high inherent cost makes yield losses very expensive. Continuous casting was seen as a major opportunity to assist in this respect, as well as lowering the energy cost to achieve a slab or bloom compared with the ingot route. This period therefore saw the development and introduction of continuous slab casters for stainless steel.



4-high Cold Rolling Mill

In product development terms, the debate about stress corrosion cracking, started in the late thirties, continued as more experience and metallurgical information became available. Corrosion as a topic also received more attention. This was partly due to the larger numbers of graduate metallurgists coming out of the expanded higher education facilities as well as the rapid development in metallurgical testing and examination equipment plus the expansion of research departments within industry.

The development of electron optics also allowed a major step forward in metallurgical understanding. The ability to observe structural changes and precipitation processes started a flood of knowledge papers at the end of this period which explained many of the property and corrosion features of steels developed by the previous generation of metallurgists.

Advanced metallographic techniques also contributed to the development of new steels, but these tended to be used for specialist applications where high strength, creep resistance or good elevated temperature properties were required. As they did not cater for bulk markets, their production fitted uneasily into the large plant configurations. The world's stainless steel industry therefore started to polarise into bulk producers and specialist producers.

'Creep' testing laboratory.

Turbine blades manufactured from creep resisting steels.

This period also saw an increase in the provision of property data, often led by the Japanese who were devoting a great deal of effort to research by the 60's. There were also moves to improve and standardise practical quality control procedures for corrosion testing.

Product development was reacting more to market pressures. The American work on high manganese, high nitrogen austenitic steels as an alternative to nickel steels during the nickel shortage is one good example. Another is the development of steels for the advances in electrical power plant that occurred over this period. In particular the drive towards greater generating efficiencies, higher steam temperatures, pressures and set sizes that occurred in the UK involved concurrent development of improved high temperature boiler plant steels, together with higher strength 12% chromium steels to meet the higher working stresses developed in the longer turbine blades. Developments in military and civil aircraft were also great stimulants for work on high alloy 12% chromium steels for gas turbine blades and discs plus controlled transformation steels, that were soft enough to press and yet could be hardened with minimum distortion by refrigeration or low temperature treatment. American workers also extended the range of high strength, age hardened steels and less exotic ways to increase mechanical properties were developed such as warm working and the use of high nitrogen contents.

The marketing environment was also changing. Film was establishing itself as a communication medium, the number of trade and technical journals was rapidly expanding together with specialist consumer journals allowing more precisely targeted advertising. Later TV became available. The silk top hat and morning coat image had gone, although a steelmaker's London representative was expected to wear a bowler hat, dark suit and carry a rolled umbrella.

The importance of customer education continued, with liaison engineers/metallurgists being appointed to give technical help to steel users. Technical literature was produced to support their efforts, together with back-up research programmes on identified problem areas. This was the period when the importance of marketing development was acknowledged, although the early practitioners might have had titles derived from sales or commercial development functions.

A late 50's advertisement for stainless steel.

This was the heyday of stainless steel marketing when countless new opportunities awaited those with the foresight and drive to fulfil them. They were helped by the refinement of existing steels and by the development of special grades arising from expansion of research facilities.

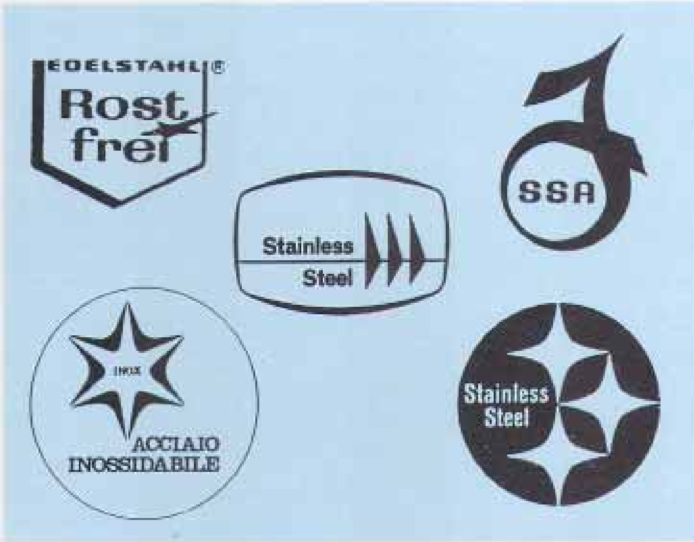
Two other factors also helped.

Firstly, there was a realisation by some raw material suppliers that as part of the demand for their product came from the consumption of stainless steel, it was in their own interest to develop the stainless steel market. In particular the International Nickel Company and Climax Molybdenum deserve a mention for their efforts in the 50's and 60's.

Secondly, there was a wide movement towards the establishment of national stainless steel development associations, sponsored by the individual country's steel industry. These, together with the American Iron and Steel Industry's committee of stainless steel producers, did a great deal…

'…to broaden the demand for and appreciation of stainless steel in major market areas, so that the marketing efforts of individual steelmakers are more effective.'

The great marketing advantage of these organisations was that they were perceived as a body of professional people divorced from the commercial activities of individual steelmakers. They approached the status of a neutral data source and were able to disseminate information with a high level of credibility and authority.

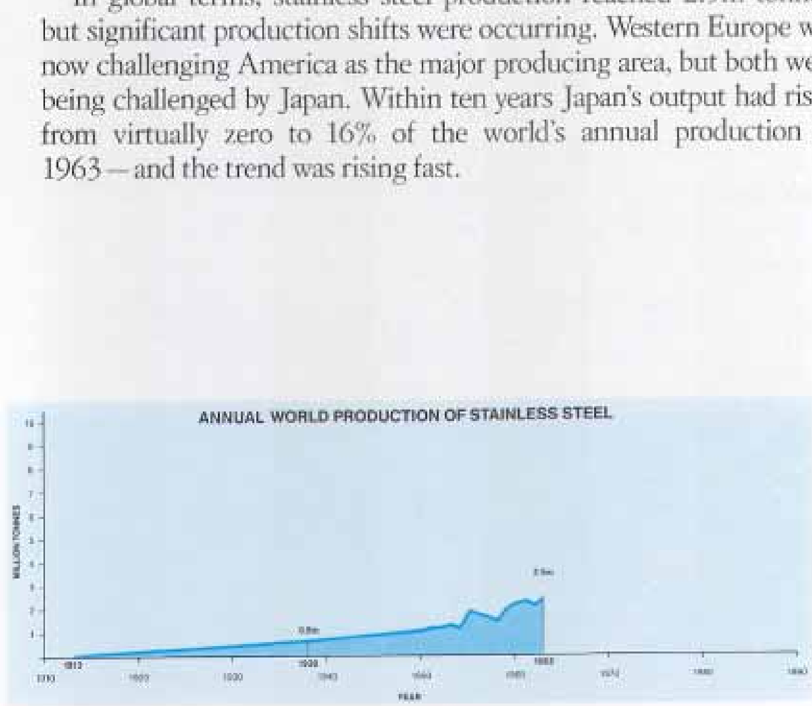


Logos of Stainless Steel Associations from around the world.

Although it may be invidious to pick out one example, the 1950's AISI approach to developing an awareness for stainless steel in the current and future generations of American housewives illustrates how far marketing techniques had advanced. Their marketing plan was a co-ordinated market-pull approach involving advertising and below the line activities such as producing and distributing audio-visual packs to the home economics departments of high schools, writing and circulating editorials plus the 'Gloria Wright' campaign. The concept was to have a credible, authoritative home consultant who would appear live in departmental stores, speak to women's groups, give radio interviews and take part in TV programmes. Before she came into the city or region, arrangements would be made for 'in-store' stainless steel shops to be established, a training programme would be run for store assistants and point of sale literature would be produced. The result was totally co-ordinated city or regional campaigns that integrated into a national campaign. Of course in order to achieve this there were numerous Gloria Wrights going round the country, but each was carefully selected to give the right image and equally carefully trained to present a stainless steel story that built on the caring, hygiene conscious, modern self-perception of the American housewife.

Consumer durables were now a major part of the market for stainless steel.

In global terms, stainless steel production reached 2.5m tonnes, but significant production shifts were occurring. Western Europe was now challenging America as the major producing area, but both were being challenged by Japan. Within ten years Japan's output had risen from virtually zero to 16% of the world's annual production in 1963 — and the trend was rising fast.



THE THIRD TWENTY FIVE YEARS 1964-1988

The world's stainless steel industry began this period with an optimism based on past growth but then ran headlong into the new and very different economic situation produced by the 1973 and 1979 oil crises. Retrenchment, rationalisation and concentration occurred within the established stainless steel producing areas. Staff levels, research budgets, marketing activities were cut. There was a knock-on effect upstream. The reduced demand for raw materials together with other commercial pressures forced Inco and Amax to contract and then stop their development activities. Survival became the key business objective of steelmakers. When the survivors emerged they found that the new, post OPEC crisis world contained different opportunities for stainless steel.

The cost of money forced industrialists and consumers to consider the true ownership cost of articles, thus giving stainless steel a life cycle cost advantage. The search for alternative energy sources opened up new applications, as did increasing public pressure to protect the environment.

But structural changes were also occurring within the world's steel industry. In 1967 Western Europe's annual production of stainless steel overtook America's. Three years later America was also overtaken by Japan. Meanwhile new producing areas were waiting to emerge.

This period also saw the adoption of a major breakthrough in stainless steel making. In the early 60's attempts were made to exploit the thermo-dynamic fact that carbon removal by oxygen was easier, more complete and involved very little chromium loss if the reaction could be made to take place below atmospheric pressure.

Of the processes that emerged, the Argon-Oxygen-Decarburisation technique has been most widely adopted in which a mixture of argon and oxygen is used to reduce the partial pressure of oxygen.

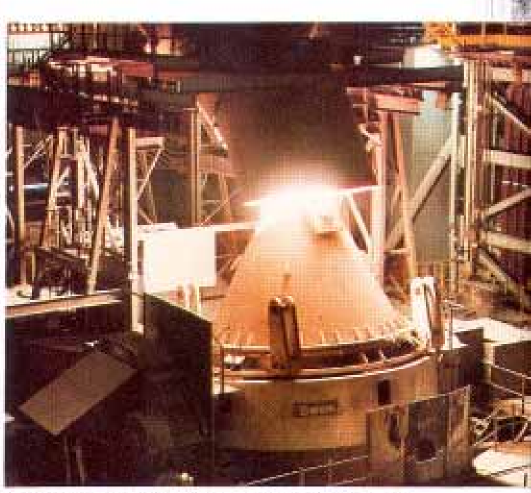
In addition to obtaining metallurgical benefits, economic benefits were derived by the ability to use cheaper high carbon ferro-chromium. The way was open to use the high powered electric arc furnace as the melting unit, and then transfer the liquid steel into an AOD vessel for refining. This gave faster bulk production opportunities with furnace sizes rising to about 120 tonnes.

The downward trend in real prices, begun in the previous 25 years therefore continued, as this technological innovation was adopted, giving a 2% per annum reduction, in trend terms.

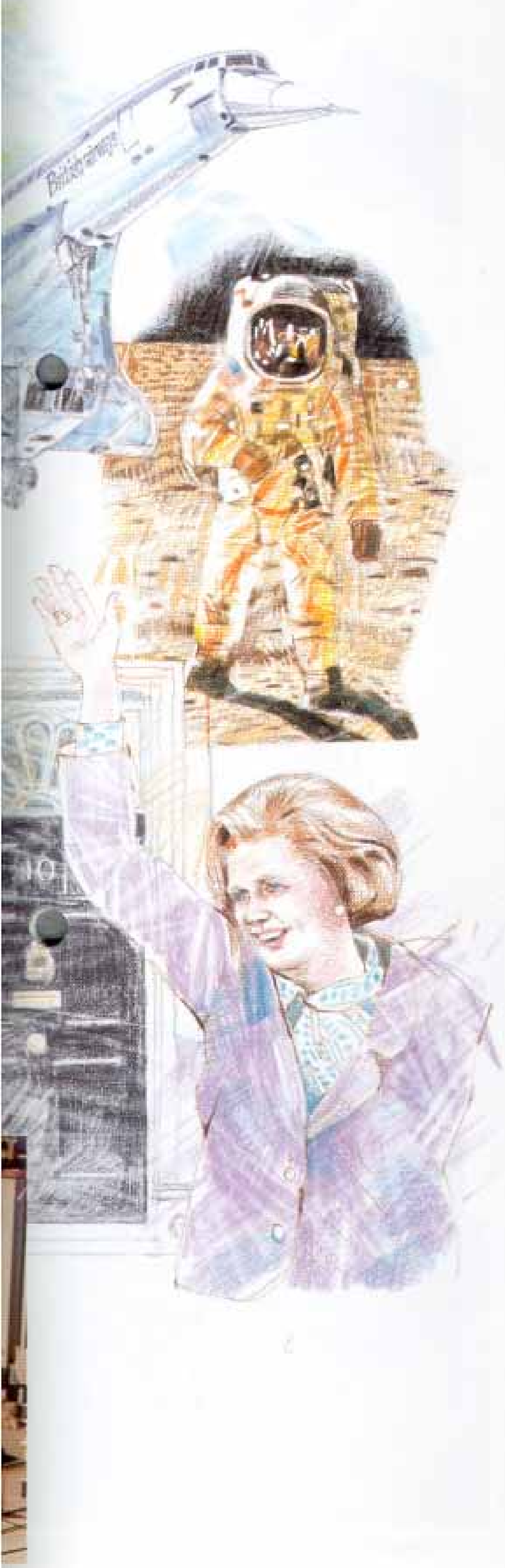
Other factors also contributed to this cost reduction.

Continuous casting was further developed, the amount of sequential casting was increased, piece weights were raised in order to minimise down time on batch processing areas such as cold rolling mills, and cold rolled coil widths increased to 1500mm then 2000mm. Later tandem mills were being used to supply some markets.

The economic savings of near-net-shape production never lost their attraction and powder metallurgy approaches were explored. Water or gas atomisation was used to produce the powder, followed by dry compaction or slurry techniques to produce green strip for sintering, followed by cold rolling. Although still used for specialist alloys, these techniques could not compete in cost with bulk production of common grades.



Argon Oxygen Decarburisation (AOD) Vessel.



The demise of cheap energy also stimulated the development of techniques to use it more efficiently, with the result that the energy content of finished products decreased dramatically. Computer assisted processing was also developed to increase product quality and consistency.

At the same time computer techniques were introduced to do repetitive jobs, with resultant savings in manpower. The modern steelworks became highly automated, with notably beneficial effects on productivity.

With similar production plant being used worldwide, and with five common steel types accounting for over 75% of usage, it is hardly surprising that stainless steel became a commodity—particularly as transport costs were a relatively small part of the final transaction price. Non price aspects of stainless steel supply therefore became increasingly important to bulk producers, with quality and consistency being key components of the marketing mix. Emphasis on these two aspects increased as component manufacturers,in their fight for international survival,sought to reduce their own expenditure on the quality control of incoming material by pressing for quality assured supplies of stainless steel.

This led to statistical process control techniques.

The success of such techniques, however, depends on a good understanding of the essential process route features that influence quality and hence are the most effective to monitor and control. However, a great deal of research work had already been done on the process parameters influencing product aspects such as surface quality, homogeneity, inclusion content and roping.

For commercial reasons much of this work was not published, neither was other research work done to optimise the performance of a steelmaker's material for specific customer processes such as deep drawing and stretch forming.

The steelmaker's research departments therefore installed facilities to reproduce customer fabrication techniques in order to translate their technical requirements into steel technology terms. Eventually this application research began to overshadow alloy development work in the Western World. However Japan devoted considerable effort to both aspects.

As the potential for new alloy systems diminished, it became increasingly difficult to develop new compositions that were commercially attractive. There are exceptions such as the reawakening interest in duplex steels, (although this alloy system had been used since the 1930's in castings), the use of a rare earth, yttrium, to improve scaling resistance by influencing the oxide/metal bond and, of course, super-ferritics.

As far back as the early 1950's the good resistance of low carbon, low nitrogen ferritic steels to stress corrosion cracking had been demonstrated using laboratory material but it was not possible to make them commercially. However, AOD steelmaking altered this situation.

Sendzimir Rolling Mill.

Horizontal concaster in the Panteg Works of British Steel Stainless.

Carbon and nitrogen contents could now be economically lowered to levels that gave attractive combinations of impact transition temperatures and corrosion resistance. The early grades such as 17% Cr 1% Mo, 18% Cr 2% Mo were soon superseded by product development work which resulted in a 28% Cr 4% Mo steel that gave very good corrosion properties, but marginal mechanical properties and fabricability. A small addition, 2 to 4%, of nickel improved these and formed the basis for a range of super ferritic steels produced in America, Europe and Japan. The principal use is for marine heat exchanger tubing, replacing more expensive nickel alloys, non-ferrous alloys and very high alloy austenitic steels. More advanced vacuum steelmaking techniques were also tried in order to give superior properties by lowering the combined carbon and nitrogen contents to less than 0.025%.

However at the other end of the alloy spectrum, research work was being done to produce low cost engineering versions of stainless steel.

Legislation in America to reduce environmental pollution from automobile exhaust fumes produced a market for a 12% chromium type steel with little aesthetic requirements. The answer was 'muffler' grade steel.

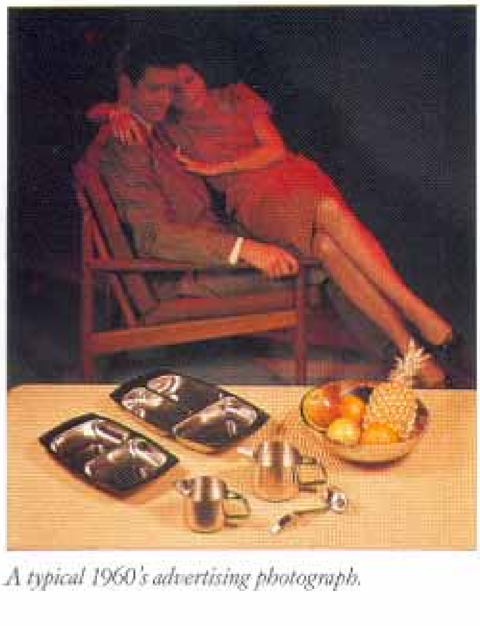
This now accounts for about 15% of American stainless steel production and will become increasingly important elsewhere in the world as similar clean air legislation is adopted. Meanwhile workers in South Africa were developing a 12% chromium base steel for a wide range of general engineering applications.

The rapid fall off in marketing effort started by the economic downturn after 1973 continued into the 80's in the Western World. The few remaining marketeers, however, soon found how to benefit from the explosion in information technology. TV advertising, video presentations, direct mail, a plethora of trade & technical specialist and consumer magazines complemented more traditional approaches. Cinefilm as a communication medium was virtually dead, except perhaps for initial shooting before being transferred to video. In West Germany, TV viewers could even call up information about stainless steel on their screens by the late 80's.

The era of the steelmaker's 'representative' was over. The people out in the market were now salesmen — together with an ever increasing number of saleswomen. They had fax machines, telex, direct computer access and portable telephones. In some instances orders were sent down the line from 'phones into mainframe computers as the salesperson moved amongst his customers. In others, the customer's computer entered the order direct into the steelmaker's computer — and could interrogate it for order progress information.

Marketing development effort began to re-emerge as business confidence increased in the mid and late eighties. The raw material producers again recognised the derived demand feature of their markets and restarted both market development and product research work. This was now organised on an industry basis, rather than being done by individual manufacturers. In particular the Nickel Development Institute and Chromium Centre sponsored work in many countries, including advertising campaigns aimed at consumers.

The importance of national development associations is also being increasingly recognised, with a new one being formed in Spain. The market education role of such organisations is perhaps more important than ever, as older people with experience on stainless steel in manufacturing industry retire, new specifiers emerge from tertiary education and the activities of competitive material producers intensify.



A typical 1960's advertising photograph.

In Britain, for instance, the Stainless Steel Advisory Centre dealt with over 6,000 enquiries in 1987. This organisation also started to run Stainless Workshops in order to transfer stainless steel technology into the market. Similar work is being done by the Italian, Japanese and Swiss development associations. As in the sixties, the market education and information diffusion work is intended to underpin the activities of individual steelmakers.

Today most steelmaker's marketing development strategy contains two broad elements.

Firstly, the traditional image of stainless steel as a prestigious material is being sustained for many applications.

Secondly, there is an increasing trend to establish stainless steel as a cost effective engineering material for more mundane applications.

It has been traditional to regard stainless steel as a prestige, expensive metal that maintains a corrosion free surface. This was how it was marketed in the 50's and 60's, and the image still persists. However, it is an engineering material in its own right and, as such, can be used in applications where structural integrity is more important than appearance. Consequently, segments of the surface protected carbon steel market can be explored, introducing a new dimension to the competitive situation. For instance, a relatively low grade of stainless steel may be perfectly adequate as a replacement for galvanised carbon structural steel, as shown by South African experience. The Japanese have also shown how painted stainless steel can replace painted mild steel for roofing. In the UK, the simple 18/8 type of austenitic steel is displacing galvanised mild steel in building components.

The result is a movement towards the larger volume base of the triangle as shown below, where the type of life cycle costing argument outlined by Prof. Kiessling can be a very persuasive marketing tool.

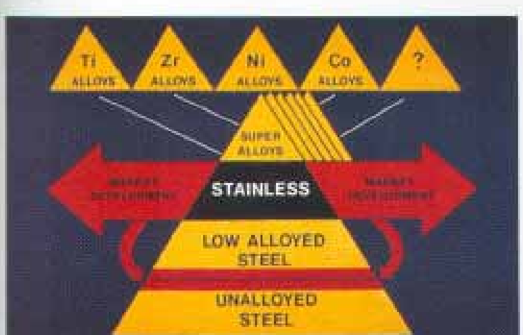
In order to achieve these strategies the marketing development work is being targeted on quite specific market segments, with full use being made of modern communication facilities.

The outcome has been that, in spite of the 1973 setbacks, world production of stainless steel during 1988 is confidently expected to reach 10 million tonnes.

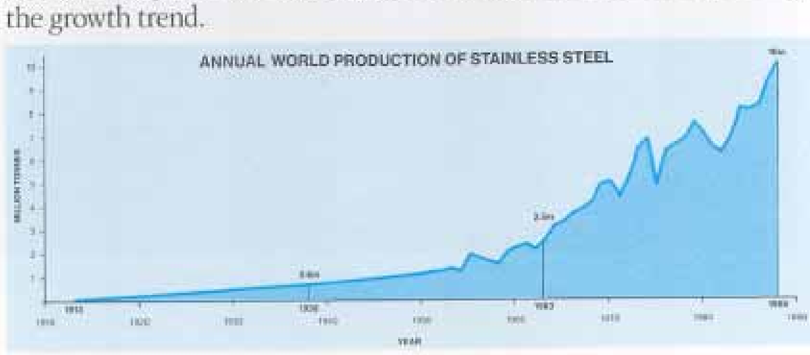
Helped by its decreasing price in real terms together with its wide range of capital goods and consumer durable applications, stainless steel is still in a growth market. Over the past ten years the growth rate has been 3.7% per annum.

UK consumption lagged behind this trend over the early part of the decade, but its growth rate has increased dramatically over the past five years, averaging 12.70% per annum.

Elsewhere, the USA has only achieved a growth rate of 0.8% per annum over the decade. On the other hand, Japan has achieved 3.6% per annum, roughly in line with Europe at 4.3% per annum. Other parts of Asia, however, have fared much better as the increased spending power of advanced developing countries provides new market opportunities for stainless products. This factor, combined with increased Western World applications associated with environmental control, energy, transportation and with a wider appreciation of the life cycle cost advantages in the capital goods markets, is expected to prolong the growth trend.



Schematic diagram of current marketing strategy.



TODAY'S STAINLESS STEEL WORLD

Look around at home or work and you'll see stainless steel in some shape or form. This remarkable metal also plays an increasing role in aspects of our daily life that you don't see. Electricity generation, offshore oil and gas, environmental control, transportation and many other facts of modern living that are taken for granted rely on stainless steel.

Food Preparation

Steels similar to those invented by Harry Brearley continue to be used for one of his earliest applications, namely cutlery and kitchen knives. Other types are used in the kitchen for pans, dishes, utensils, mixing bowls, sinks, washing machines, dish washers, decorative trim and more recently microwave ovens.

In fact, stainless steel is the automatic first choice where hygiene and hard wearing good looks are required. These features also make it the obvious choice for commercial catering equipment, whether it's out of sight in the kitchen, cold rooms and food preparation areas or up front with the customers in serving counters or open plan fast food establishments. Wherever it is, it can stand the heat, the cold, food spillages and the knocks dished out by busy people and not only look good after cleaning — but also remain hygienic. Tests have shown that bacteria and other food hazards have little chance of surviving on stainless steel surfaces after proper cleaning.

Stainless steel holloware.

Commercial catering equipment.

Medicine

It is this very factor that makes stainless steel first choice in the medical field. Its ability to undergo rigorous sterilisation treatments, combined with its hardness and strength makes it the ideal material for surgical instruments of all types. Softer versions of stainless steel have also been used for over half a century in the manufacture of operating tables, instrument tables, stretcher trolleys and other operating theatre equipment, as well as smaller but equally important items, such as hypodermic needles.

Its bio-compatibility, strength and toughness also allow stainless steel to be used for joint implants, or plates and screws in bone repair surgery.

Stainless Steel in the operating theatre.

Process plant.

Chemicals

Chemical plant was another early user of stainless steel. Stainless steel's corrosion resistance and ability to withstand stresses at elevated temperatures was an important factor in the development of the chemical industry. Modern steels such as the HyProof and HyResist grades enable these frontiers to be extended further. However the corrosion resistance of the simpler basic grades are used to advantage in fine chemicals, pharmaceuticals, plastics and biotechnology plants where maintenance of product purity is absolutely essential.

The petrochemical industry's reliance on stainless steels ranges from the use of simple 12% chromium types for bubble caps in distillation columns to sophisticated types in more demanding downhole conditions of today's,and tomorrow's,deeper wells. But stainless steel is not only used at the frontiers of production technology. It is also used in offshore platforms for mundane architectural cladding and topside components such as cable ladders, cable trays, heating and ventilation ducting, fire doors and louvres. Its selection is based on long, low maintenance life, weight savings and excellent performance in an accidental fire.

Stainless steel for hostile environments.

Energy

Stainless steel is used in primary energy industries such as oil and gas production, solar heating, tidal power and coal mining. Stainless steel solar heating panels and water turbine components are well established, but its use in coal mining is fairly new — and growing. Faced with cost pressures from open cast mining, the deep coal mining industry is responding by increased automation and improved equipment availability. Against this background, more emphasis is being placed on life cycle costing, creating opportunities for stainless steel in coal face equipment and coal preparation plants where steels that combine corrosion resistance and wear resistance are attractive.

Modern coal fired power generation plants have been dependent for many years on stainless steel for steam raising components such as superheater tubes and steam turbine blading. There is now a move towards the use of stainless steel for trouble free storage and handling of coal.

Bulk handling hoppers and chutes.

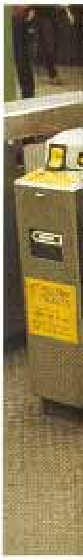
Stainless steel making nuclear power safer.

Nuclear power is dependent on high grade stainless steel not only for the nuclear island, but also for the control and safety systems. In the case of Pressurised Water Reactors, stainless steel weld cladding is used on the interior of the structural steel vessels and stainless steel is also used for the steam generator tubing that transfers heat from the nuclear to the conventional part of the plant.

Nuclear power is also associated with a secondary market, namely fuel production, reprocessing, safety and transportation. Here again, stainless steel plays a vital role involving standard steels together with British Steel Stainless NAG grades developed for the extraction process and a special high boron, neutron absorption steel, HyBor 304.

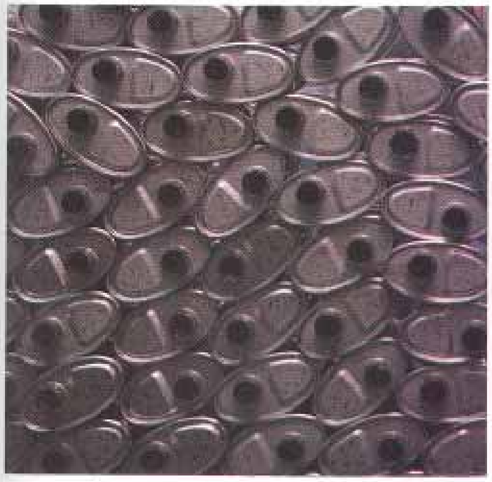
Natural gas is also an important primary energy source. At the moment, most of it is being transported by long distance pipeline, but growth in liquid natural gas transportation, cooled to minus 100°C, by trans-oceanic tankers to large land based storage tanks are potential market development areas. The use of stainless steels for chemical tankers is well established. Its suitability for rail tankers carrying chemicals and liquids for the food and drinks industry is also proven. Similarly, it is widely used in road tankers and as hygienic linings in containers.

And there is a lot of stainless steel on road vehicles that is out of sight.



Passenger Cars

One common marketing strategy adopted by all mass produced car companies is to reduce the cost of car ownership by achieving better fuel economy and lower maintenance costs. As a result over thirty per cent of cars produced in Western Europe now have 'hybrid' exhaust systems in which 12% chromium steels such as HyForm 409 are used for components vulnerable to external and internal corrosion in order to double the exhaust system's life. The ability to reduce the thickness of such components also contributes to weight savings and hence better fuel economy. This has been taken further by some companies who are replacing cast iron manifolds with lighter ones fabricated from stainless steel.



Stainless steel exhausts.

Concurrent with these developments, legislation is demanding a reduction in environmental pollution. As a result, catalytic converters are being fitted, creating more demand for stainless steel. This demand could increase further, if a policy of fitting an exhaust system to match the life of the catalytic converter, say 100,000 miles, is adopted.

Stainless steel railway carriage.

Mass Transit

In some parts of the world, road congestion and parking problems have led to city commuters abandoning road transport and moving to mass transit systems. Fortunately, the laws of physics cannot be avoided and costs associated with the kinetic energy changes involved with the repeated stopping and starting of railway carriages can only be reduced by lowering vehicle weight. The heavy mild steel commuter carriage is disappearing, with stainless steel fighting for the business. This is not a new market. American pioneers such as Budd entered it in 1931, but the combination of a custom built Type 301 stainless and design refinements have brought the weight of these commuter carriages to almost that of those made from aluminium — and roughly half the weight of conventional carbon steel carriages.

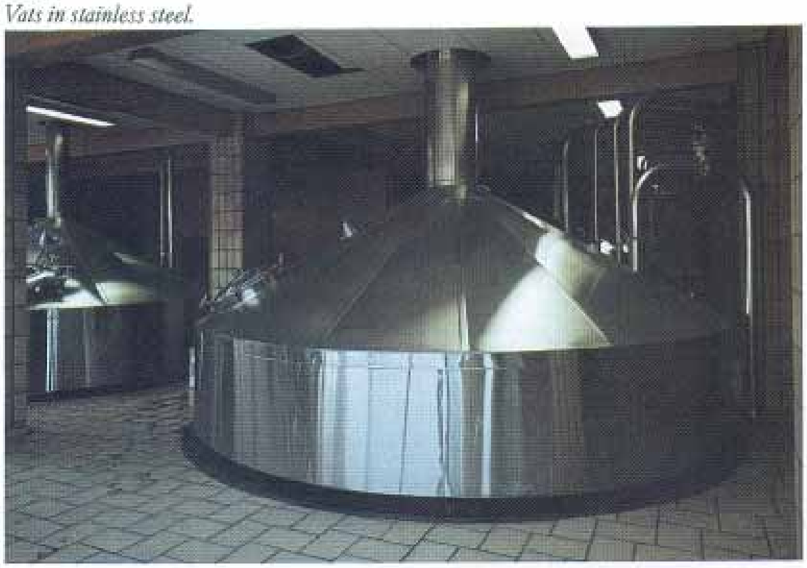
Stainless steel ticket barriers.

In order to be successful, mass transit systems have to be attractive, efficient handlers of people off the track as well as on it. Station entrances, ticket machines and information systems have consequently become significant applications for stainless steel. Similarly, airports have adopted stainless steel for a wide range of passenger related uses. The aircraft itself carries special stainless steel in critical areas such as engine combustion chambers and wing flap air brakes.

Food and Drink

Food and drink are two of the oldest market sectors for stainless steel. The movement towards improved living standards in developing countries plus greater emphasis on food hygiene worldwide will keep these markets buoyant. In addition, there are other factors which will sustain demand. For instance the trend towards factory farming has created opportunities associated with computer controlled animal feed storage and distribution, perforated flooring for animal pens and automated, continuous effluent disposal systems. Food merchandising has gone through many different cycles in the developed world, with fast food being the latest, very stainless-intensive phase. Concentration in the drinks industry also creates a market for all forms of stainless steel as new, larger plant is built to produce beer, lager and cider — in changing volumes that reflect movements in consumer taste. Modern wine production is inconceivable without stainless steel. From posts and wire in the vineyards through stainless steel presses, vessels and bottling plant, the corrosion resistance and taste neutrality of stainless steel are exploited. For these reasons, it is also used for transporting beer, lager, cider, wine and fruit concentrates in a wide range of containers.

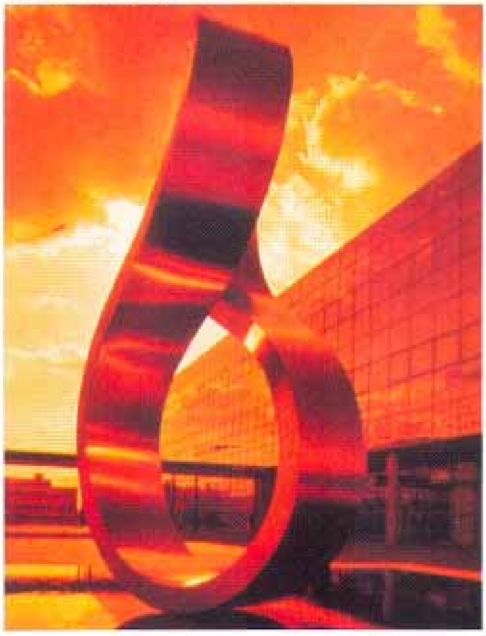
Vats in stainless steel.



Stainless steel road tanker.

Of course water remains the householder's most widely consumed liquid, and stainless steel piping is demonstrating its ability to distribute water with reduced leakage, and resultant cost savings. It is used in pumps operating in deep wells as well as desalination plant on the surface, producing drinking water from sea water. Even the growth in mineral water consumption has given opportunities for stainless steel in carbonation plant.

Wendy Taylor's 'OCTO' Sculpture, Silbury Boulevard, Milton Keynes. (Photo courtesy of Carol C Pack).



Architecture

Chrysler's decision in 1929 to clad the top 88m of their 320m high skyscraper with stainless steel is often regarded as a landmark in the architectural use of the material. However, within months of this event stainless steel was also being used for structural applications, when a stainless reinforcing chain was fastened around the dome of St. Pauls Cathedral in order to hold it together. The recognition of architectural and structural merits continues to be a feature of present usage.

Both sectors demand durability, but the architect also selects stainless steel for aesthetic reasons. The steel industry responded by offering a wide range of surface finishes, ranging from bright annealed through a range of polished finishes including hairline to surface ground, mill patterned surfaces and rigidised material. Colour has also been introduced using the Inco process, copper plating or painting. A lead 'look-a-like' is also available in terne coated stainless steel.

As a result, although the material continues to be used for commercial buildings, it is also being increasingly used for industrial buildings as a long life, low maintenance cladding. In this latter respect the development of hidden fixing techniques for profiled panels has been a valuable step forward, with the system being used for new work and for re-furbishments. If a fully welded roof is required, a weldable version of pre-painted stainless steel has been developed. Within the UK, emphasis has been placed on the use of bare 430 for heavy industry roofs, offering an extremely competitive roofing system.

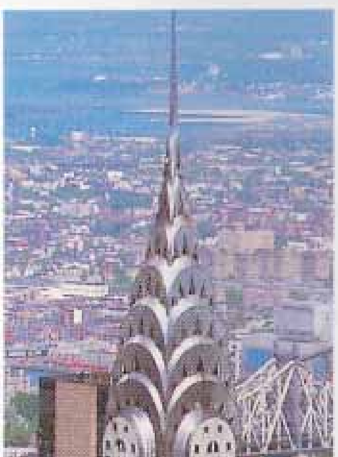
Down at ground level, stainless steel is widely used for shop fronts, doors, entrance halls, column cladding and internal features for aesthetic reasons.

The aesthetic aspect of stainless steel is not relevant in one of the latest growth areas, namely building components. These include brick support angles, wall ties, lintels, nail plates, joist hangers, metal lath, plasterers bead and flue linings. In these examples stainless steel is selected for its corrosion resistance and engineering integrity, with the components being buried deep in the fabric of the building.

This survey has drawn on relatively few examples from the wide range of stainless steel's applications. However, it is suggested that one common theme to emerge is the impact that stainless steel has had on the quality of life expected today. From its most recent applications in flue gas desulphurising plant to reduce acid rain, through its role in hygiene, medical, food, transportation and power, to its impact on the environment in terms of architecture, public space and even as a medium for sculpture, stainless steel plays a vital and vibrant part in today's world.

Lloyds of London, Lime Street, EC3.

Stainless steel interior cladding.



New York's Chrysler Building. Clad in stainless steel in 1930 — and still looking good today.

THE NEXT SEVENTY FIVE YEARS

The first 75 years of stainless steel have seen massive improvements in almost every aspect of life in the United Kingdom and other developed countries. The next 75 will certainly see many further and rapid changes, including much improvement in the living conditions of many under-developed nations who will automatically turn to the advantages of stainless steel to improve their quality of life.

Energy is the muscle behind economic development and, as the more accessible reserves of fossil fuels are depleted, there will be increasing efforts to obtain oil, coal and natural gas from Nature's most hostile environments such as deep sea and polar regions.

Vital Role

Eventually as the world oil and gas resources become scarce, the development of synthetic gas and petrol from coal will become increasingly viable. Stainless steel, in its many forms and types, will play a vital role in this work. It will also contribute towards the effective development of renewable energy sources such as wave and tidal power systems, just as it does now in the exploitation of solar energy in many locations — the Mediterranean area, Middle-East, Central America and the Far East.

Its role in the safe production of nuclear energy is well established as a material used in all current and planned commercial nuclear plant.

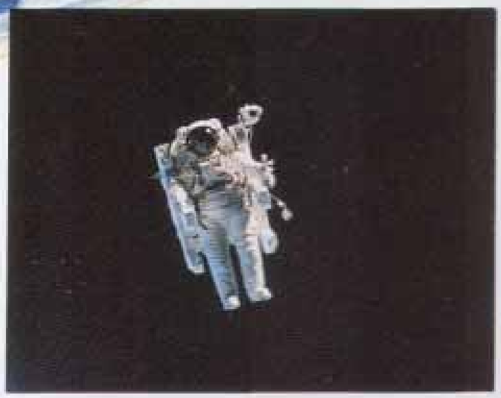
In the Bloodstream

If energy is the muscle of economic development then transportation and communications represent the bloodstream, transferring materials, people and technology within and across national frontiers. In the longer term, alternative forms of power such as super-efficient batteries, hydrogen cells and highly sophisticated steam engines could drive private cars. However, much more use will be made of mass transit vehicles — super-trams, light railways and magnetic levitation trains in urban transportation.

In many parts of the world, railways are already enjoying a new lease of life for long distance travel, using energy efficient carriages made from stainless steel. The revolution in affordable air travel will continue and new generations of supersonic aircraft will emerge utilising stainless steel components.

Stainless steels in information technology, although hidden in the depths of electronic equipment, will continue to play an important role in the highly sophisticated componentry, microchip lead frames and contacts of data input keyboards.

In communication satellites, where extreme low temperature performance and high strength/light weight characteristics are major criteria for material selection, stainless steels will perform key roles in the containment and protection of electronic components.



Environmental Improvements

The quality of life in the future will be enhanced by stainless steel. Systems helping to clean the air are already with us. Coastal waters will benefit from improved sewage treatment plant, while more advanced desalination systems will make arid areas habitable as the world's population increases.

This growth will require more food needing increased production of artificial fertilizers to replenish the soil nutrients. There will also be increased dependence on biotechnology to produce not only animal foodstuffs but protein for human consumption. Stainless steel is already playing a vital role in these aspects of food production and will make an even larger contribution as technology moves forward.

Out of this World

Stainless steel was extensively used in the Saturn V rockets which powered the 'Apollo' series of manned space journeys culminating in the landing of Apollo II on the moon. Man's further ambitions in space will doubtless produce more, exciting challenges for that most versatile material — stainless steel.

1913–1988

75 YEARS OF STAINLESS STEEL