SESSION III

April 25, 1989

<u>Chairmen:</u>

J.F. Collins, The Ferroalloys Association - USA.

F. Vogt Lorentzen, Institute des Producteurs de Ferro-Alliages d'Europe Occidentale - Europe.

<u>Introductory Address</u>:

"The Need to Develop Markets for Ferroalloy Products - The Experience of the Nickel Industry", J.P. Schade, President Nickel Development Institute - Canada.

*1. **"The Recovery and Solution Rate of Ferroalloys"**, S.A. Argyropoulos, University of Toronto - Canada.

*2. **"Advancement of Cored Wire Applications Within the Steel and Cast Metal Industries"**, H. Mair, Odermath Stahlwerkstechnik GmbH - West Germany; and D.B. Marsh, Miller and Company - USA.

*3. **"The Cored Wire Aspect of In-Ladle Metallurgy"**, J. Simmons, Affival Inc. - USA.

*4. **"The Influence of the Solidification Process of Silicon-Rich Ferroalloys on Product Quality"**, O. Raaness, Sintef - Norway.

*5. **"Contribution to the Study of Hydrogen Contents of Ferroalloys and Its Influence in the Steel's Quality"**, W.F. Carmo, Companhia de Cimento Portland Maringa - Brazil.

*6. **"Recent Technology of Low and Medium Carbon Ferromanganese Manufacturing"**, A. Kitera, Mizushima Ferro-Alloy Company, Ltd. - Japan.

*7. **"The Rotary Hearth Furnace Direct Reduction Process"**, G. Rath, Mannesmann Demag Huttentechnik - West Germany.

*Papers are found in Volume I of the Proceedings

J.P. Schade of the Nickel Development Institute in Canada introduces Session III with a paper on developing markets for nickel.

Speakers for the first half of Session III are (left to right) J.P. Collins (Chairman), F. Vogt Lorentzen (Co-Chairman), S.A. Argyropoulos, D.R. Marsh, J. Simmons, O. Raaness, and H. Mair.

Awaiting the start of the second half of Session III are (left to right) F. Vogt Lorentzen, J.F. Collins, O. Raaness, W.F. Carmo, S. Suzuki, and G. Rath.

The Need to Develop Markets for Ferroalloy Products

The experience of the nickel industry

by
Johannes P Schade
President
Nickel Development Institute
Toronto, Ontario, Canada

In 1927, Henry Ford - an engineering genius who put America on wheels - faced a disastrous situation. He had mass-produced more than 15 million automobiles of the Model-T series, lovingly called the Tin-Lizzy, when he had to stop his assembly lines for a whole year. Unsold cars were piling up at the plant and in dealerships.

Ford had thought he could serve the market well, at a competitive price. His product had earned a solid reputation in almost 20 years of performance, and it was affordable to millions of Americans.

Nevertheless, Henry Ford failed.

He failed because he did not appreciate the dynamic character of the marketplace. He persisted in offering a car in any colour, provided it was black while his competitors lured customers away by offering a variety of colours, new technical concepts, more comfort, stronger engines and so forth.

History informs us that Henry Ford and his company survived that competitive battle and, after a year of hectic transition, he started to produce a more modern automobile. But his adjustment to market demand was too tardy to prevent him losing his position as Number One in the auto industry to General Motors.

There are any number of similar examples in the history of modern technology that demonstrate, quite clearly, that an industry might easily go the way of that magnificent dinosaur, if it is not ahead of technological change and market forces.

Why would Singer stop producing sewing machines? Why would International Harvester no longer produce farm tractors? Or, can you imagine what serious decisions would confront you today if you produced mechanical or electrical typewriters, or carbon paper, at a time when word processors and photocopiers are taking away virtually all your business?

Ladies and Gentlemen of the INFACON organization, I am most grateful for your invitation to talk to you about market cultivation and development and what we in the nickel industry have done about safeguarding end-use markets for our products, nickel and nickel-containing materials.

There was a time - not too many years ago - when the top priority of minerals and metals producers was to produce ever increasing tonnages of metals and minerals. Customers from the U.S., Europe and Japan would stand in front of our doors - so to say - and were waiting to contract their share of production, often at the price the producer thought was adequate.

To produce something today, in the hope there will be a market for the product, can be absolutely fatal. On the contrary, we have to adjust quickly to technological changes and market forces. We must defend the products we produce in their existing applications and find new applications, by early recognition of trends in technology and consumer behavior. Only in this way can we position our products so that they will serve tomorrow's technological needs.

If we metals and alloy producers were involved in the production of consumer goods, anything from electric appliances to cosmetics, exploration of consumer behavior and fashion trends, product innovation and promotion would be a vital part of our daily lives.

In producing raw materials from natural resources, our industries carry a tremendous handicap, as in most cases we are several steps away both from the decision-makers that decide the future demand level for our products as well as from the end-use industries that are the ultimate consumers of materials containing a small percentage of what we produce as our main product.

Let me ask you, can a producer of iron ore exercise an influence on the people who decide whether automobiles will be built in future of steel or plastics? Can a nickel producer prevent the erosion of the market for stainless steel kitchen sinks? Can manufacturers of copper save the market for automotive radiators against the inroads made by aluminum?

I think the answer is yes, provided we have sound technical arguments on our side, activate our research and development capabilities, and don't consider substitution as our fate.

The nickel industry has almost performed miracles in the past seven years. The producers have gone through a cost reduction exercise that has shown impressive results in terms of increased productivity and reduction of operating costs.

But, what has happened to the demand of nickel?

Slide 1: Nickel Consumption 1947 to 1988

What you see here on the screen is the development of nickel consumption from 1947 till today. In rough figures, the demand for nickel has increased six fold from 100 000 tonnes just after the war to more than 650 000 tonnes last year. This represents a compound growth rate on the order of 3.5 per cent per annum.

As there is no, or almost no, natural market for nickel this demand is totally derived. Nickel was consumed in increasing tonnages to produce metals and alloys, which in turn were sold to manufacturers of process equipment, jet engines, railway cars, pipelines, electronic components, knives and forks and so on.

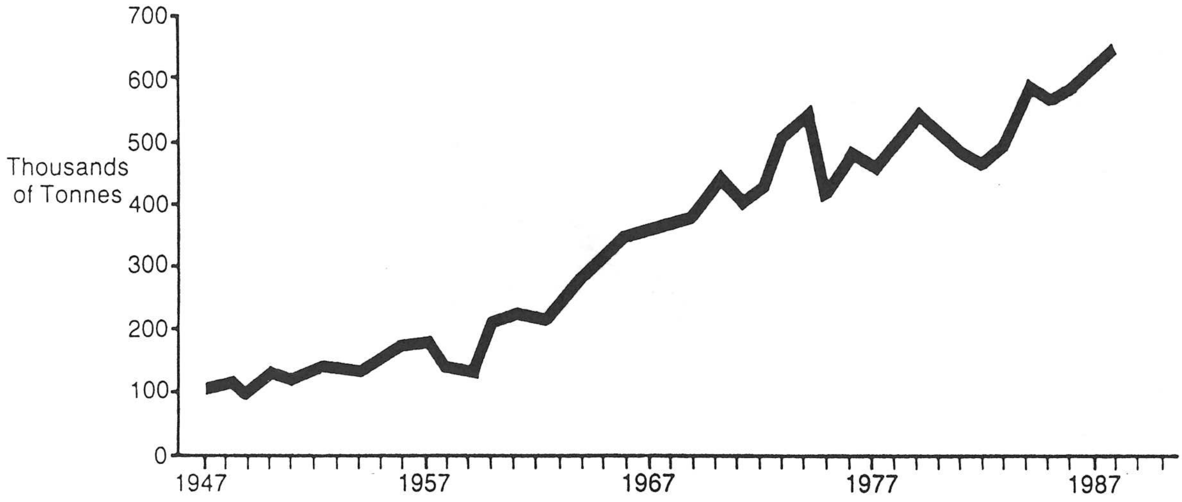
It is a fact that today's markets for nickel are proliferated to an extent that we count some 10 000 individual nickel alloys and several hundred thousand end-use applications of nickel.

Unfortunately, it is true to say that in almost any of these applications nickel-containing materials can be substituted by other competing materials. Whether or not materials engineers, specifiers, designers and architects will specify nickel-containing materials, such as stainless steels, depends almost entirely on cost, both for the initial installation and over the life cycle of the product.

Slide 2: Three Phases of Nickel Consumption

SLIDE 1

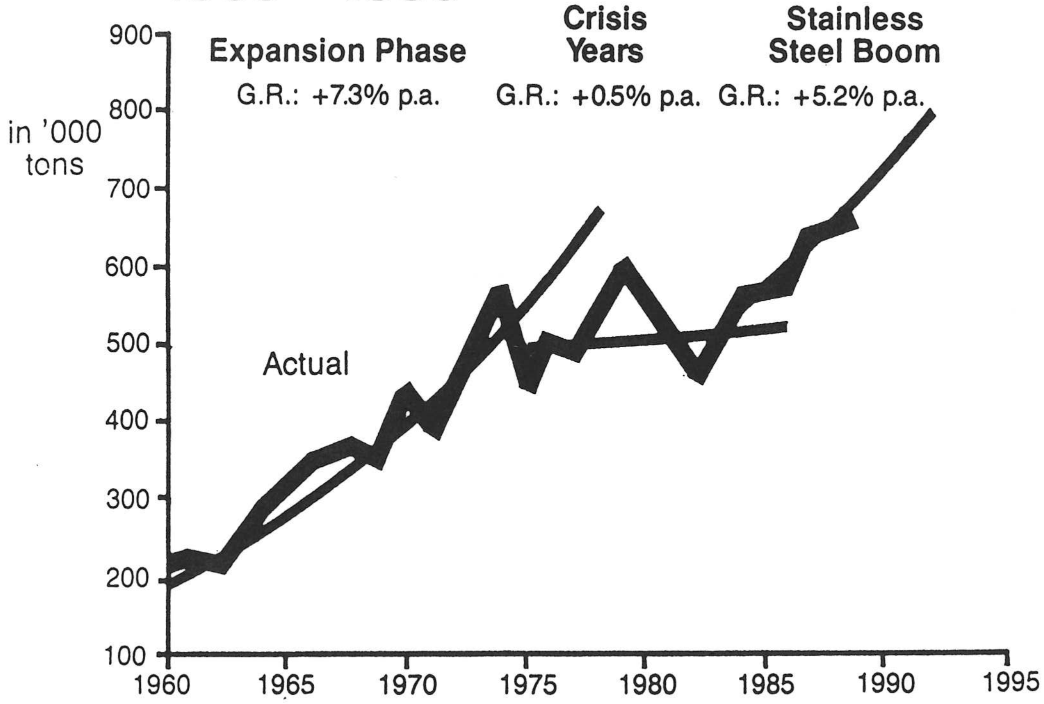
NICKEL CONSUMPTION
Western World 1947-1988



47-86 Metallgesellschaft
87 H. H. Parlser
88 Estimate

SLIDE 2

PRIMARY NICKEL CONSUMPTION 1960 - 1988



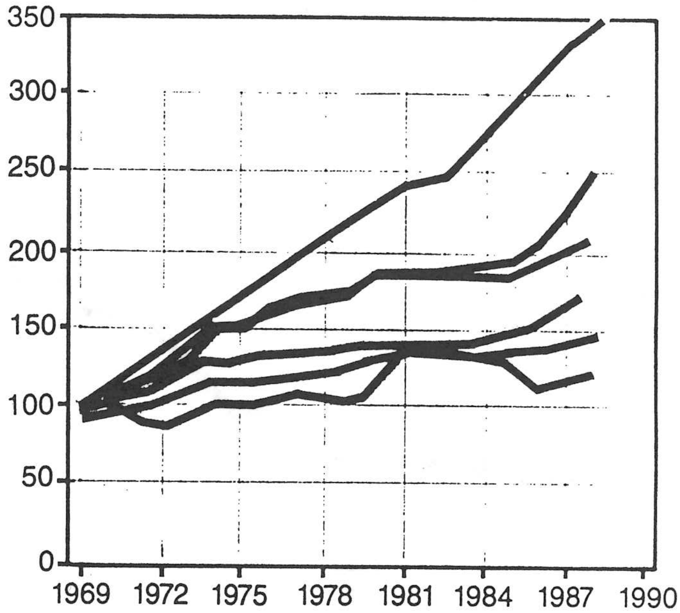
Source: H.H. Pariser

SLIDE 3

GROWTH RATE OF SELECTED MATERIALS
(5 Year Moving Average)

Index 1969 = 100

- Plastics (USA)
- Stainless Steel
- Aluminum
- Nickel
- Copper
- Titanium Sponge



* 1988 Estimate

SLIDE 4

MISSION:
Identify, Develop, Promote and Defend Markets for Nickel and Nickel-Containing Materials

Australia	MEQ Nickel Mount Isa Mines Western Mining
Brazil	CODEMIN Morro do Niquel Tocantins
Canada	Falconbridge Inco Sherritt Gordon
Finland	Outokumpu
Japan	Shimura Kako Sumitomo Tokyo Nickel
South Africa	Impala

Let us look at the development since 1960 in more detail. From this slide you can clearly recognize three growth phases of nickel consumption. During the expansion phase in the post WW II period we had very strong 7.3 percent growth as a consequence of the consolidation of European economies and Japan's rapid development as one of the world's leading industrial powers.

When oil shocks and hence the lack of capital investment affected the economies of the developed world in the 70s, the consumption trend suddenly changed direction. For a decade we lived in a world with almost zero economic growth. During this period oversupply of major commodities, aggravated by increasing imports from COMECON countries, caused commodity prices to fall to levels which took even the industry's low cost producers to the borderline of financial failure.

During this period from 1980 to 1983 the industry panicked, it got into a survival mood. All activities considered "non-essential", such as applied research, market development and promotion were severely curtailed or totally abandoned, together with all executive privileges and advanced employee benefit plans.

The reasoning was straight forward: The only way to survive is cost control and increase of productivity. Let's worry about the future when we know we will enjoy one.

Management looked into a grim future:

- Competition was increasing in a no-growth market;
- Sales prices of our products were substantially below production costs;
- Traditional metals such as copper, nickel and zinc were passed in their growth by plastics and aluminum, in other words, sub-situation took its toll.

Slide 3: Growth rate - selected materials

Fortunately, in the face of disaster, some leaders in our industry kept their cool.

In 1984 after two major planning meetings in Toronto, Canada, fourteen leading nickel producers from around the non-socialist world agreed to establish and support the Nickel Development Institute (NiDI). Very simply, NiDI's objective or task set by its Members was to identify, develop, promote and defend world markets for nickel.

Slide 4: Nickel Development Institute

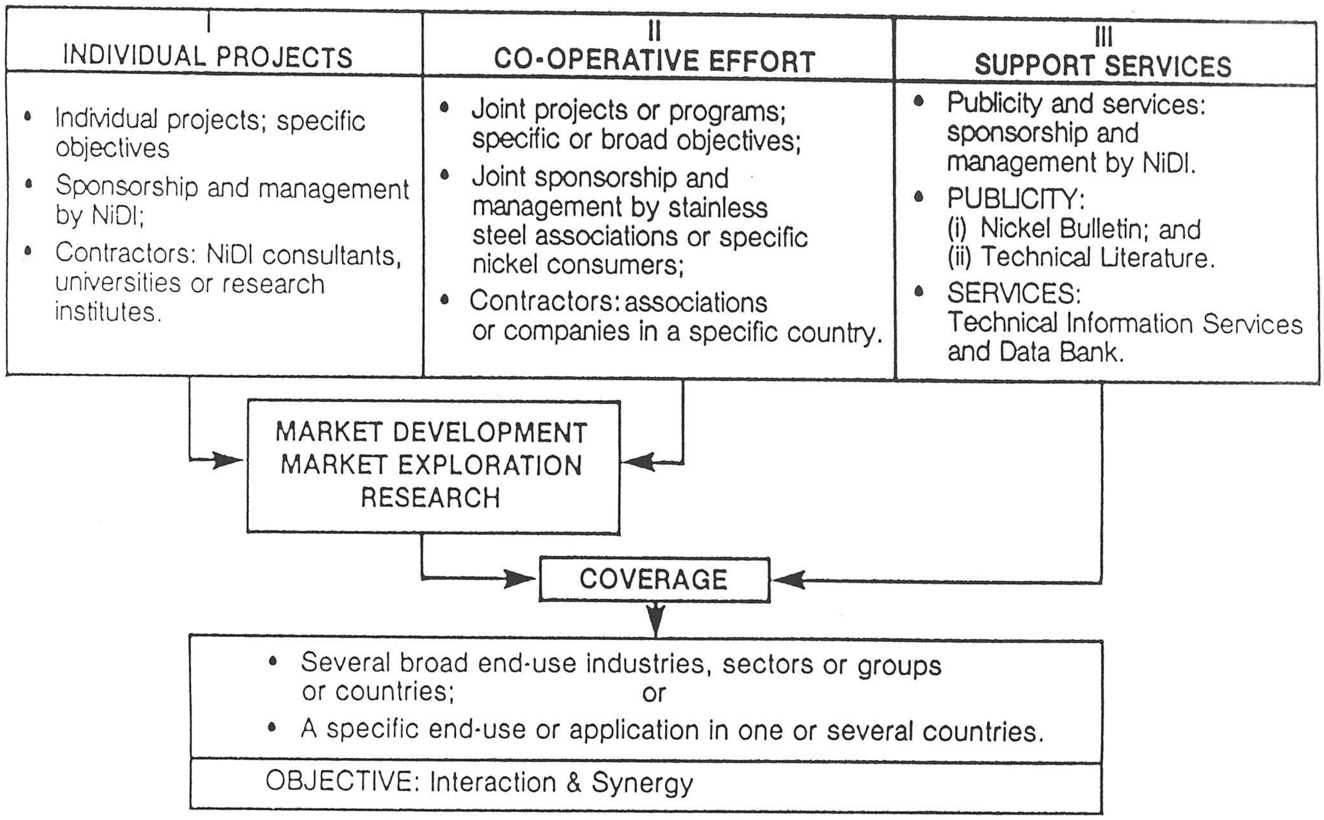
NiDI's program strategy to achieve this objective can be subdivided into three basic categories,

Slide 5: NiDI's Program Strategy

1. Individual Projects - NiDI's plan emphasizes market development or technical research projects aimed at specific end-use sectors or applications. Project priorities are identified by careful market research or exploration programs. Normally, NiDI manages its own market development and market exploration programs using highly qualified technical specialists and consultants.

SLIDE 5

NICKEL DEVELOPMENT INSTITUTE
SUMMARY OF PROGRAM STRATEGY



SLIDE 6

Nickel Development Institute
1989 WORK PROGRAM

- 36 market exploration projects
- 35 market development projects
- 18 applied research projects
- 24 projects completed and results published

In technical research, NiDI sponsors projects at several well-known universities and technical institutions. Our technical research is always designed to support specific market development activity or projects.

Slide 6: NiDI Programs

Currently NiDI manages some 90 development, exploration and research programs around the world.

Slide 7: Co-operative Efforts

2. Co-operative Efforts - in addition to the 90 plus individual projects sponsored and managed by NiDI, we place considerable emphasis on co-operation with related market development organizations worldwide. NiDI's working relationship with Stainless Steel Development Associations everywhere in the world is a splendid example which demonstrates just how this type of collaboration benefits both parties and supports the international market for stainless steel.

   Frequently, successful end-uses for nickel or proven market development programs are known only in one country. On several occasions, NiDI has become the catalyst for transferring successful non-proprietary marketing concepts and ideas from one market to another. If an appropriate market development organization does not exist in a key market, then NiDI seeks out and works closely with major nickel consumers in that area.

Slide 8: Support Services

3. Support Services - over the past four years as NiDI has matured and become better known the demand for our technical literature and technical service has grown markedly. Requests for assistance come from engineers, designers, specifiers and architects around the world. NiDI offers a library of more than 200 technical bulletins, papers and reports all concerned with the use of nickel-containing materials or with resolving corrosion, high temperature, fabrication and other materials related problems.

Education and Promotion

From the early 1970s through the mid 1980s growth in nickel consumption was hindered by insufficient understanding of nickel, and nickel-containing steels and alloys including their applications, properties and appropriate methods of fabrication.

Thus in NiDI's formative years we focussed our programs and activity on education and promotion directed at two key audiences:

- Specifiers, designers, engineers and architects; and
- Fabricators and manufacturers.

SLIDE 8

Nickel Development Institute

INTERNATIONAL CO-OPERATION PROGRAM

- NiDI representation in 4 continents
- Formal co-operation with 9 national and/or international organizations
- Global market development forum for stainless steel
- World materials congress
- 30,000 copies of **Nickel** to 81 countries

SLIDE 7

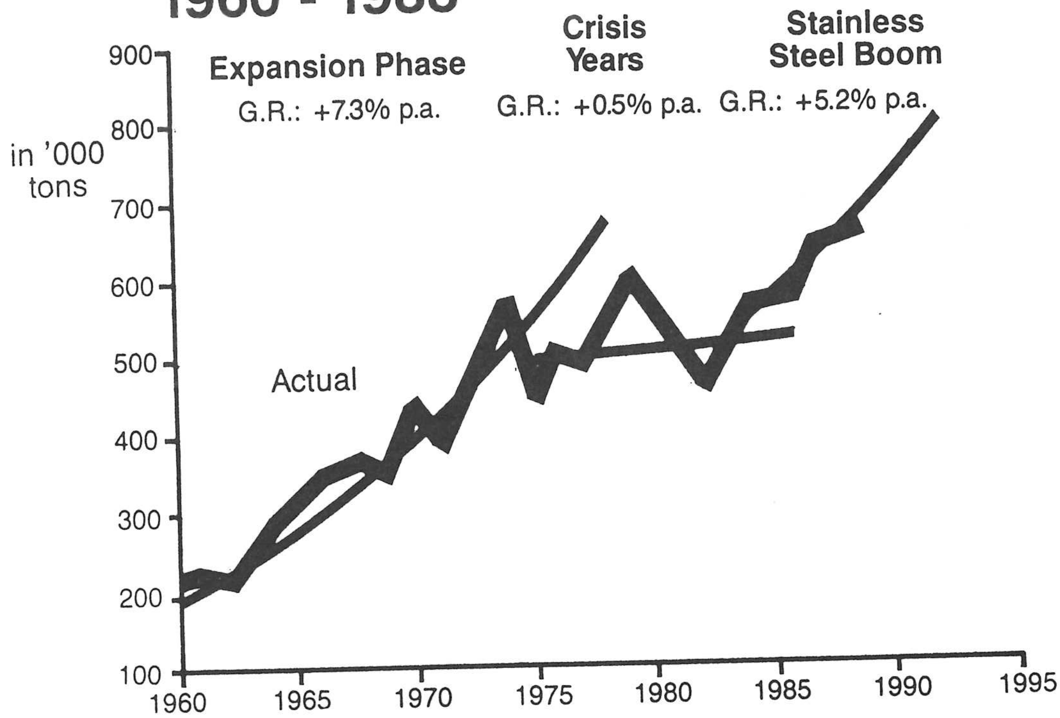
Nickel Development Institute

SUPPORT SERVICES

- Promotional/technical literature (205 titles)
- Technical service on behalf of the industry (more than 1,000 calls per year)
- Educational activities (over 100 engineering seminars held in North America and abroad)
- Technical presentations and lectures
- Exhibitions and trade shows

SLIDE 9

PRIMARY NICKEL CONSUMPTION 1960 - 1988



Source: H.H. Pariser

SLIDE 10

1987 PRIMARY NICKEL CONSUMPTION

First-use Sectors Western World

	1987 %	Growth Rate 1960/1987 % p.a.
Stainless steel	55.5	6.0
Alloy steels	10.3	3.0
Ni base alloys	12.8	3.8
Cu base alloys	2.2	1.9
Plating	11.5	1.3
Foundry applications	4.6	−0.4
Others	3.1	—
Total	100	3.5
in mill. lbs.	1,420	

Successful development of the market for nickel-containing materials requires a continuing dialogue with these two groups both of which play significant roles in the materials selection process. If an engineer is unaware of the properties and technical or cost benefits of nickel-containing materials, it's unlikely that he will specify them and, effectively, there will be no market growth.

A fabricator who is not up-to-date on the technical and economic advantages of using nickel-containing stainless steels or alloys, encountered problems with machining or welding these materials, will probably opt for another material and often a non-metallic.

Market development is of course the main thrust of NiDI's programming. Key or essential features of our program and promotional effort include:

- Personal contact - One on one contact by NiDI specialists is an integral part of market development projects pointed at specific end-use sectors or applications.

For example, during the past four years the Institute has presented more than 75 engineering workshops to materials engineers, maintenance supervisors and other key groups in engineering firms and various industries throughout the United States. Industries covered have been as widespread as power generation, oil and chemical refining or even phosphate production and processing.

Similarly, NiDI specialists have organized and presented materials workshops or seminars in Europe, India and Brazil.

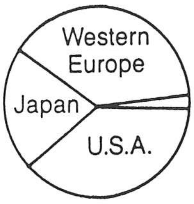
Many projects are designed to support individual products such as the nickel stainless kitchen sink which in Europe and more recently in North America has become subject to competitive pressure from newly developed and improved non-metallic materials.

- Technical Papers and Literature - as an integral part of each development project NiDI specialists are encouraged to prepare and present relevant papers at international symposia or seminars. You will thus often see NiDI represented at meetings sponsored by societies such as NACE (National Association of Corrosion Engineers), the Institute of Metals (UK), the American Institute of Mechanical Engineers (USA) or ASM International. Such papers, of course, eventually add to NiDI's growing library of technical publications.

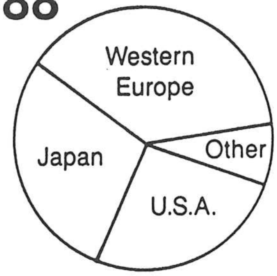
- Technical Committees - NiDI specialists also seek to offer their lengthy experience and when appropriate serve on technical committees which set or influence specifications such as the International Standards Organization (ISO).

SLIDE 11

WESTERN WORLD STAINLESS STEEL PRODUCTION 1968 - 1988



1968
4.04 million tonnes



1988
10.5 million tonnes

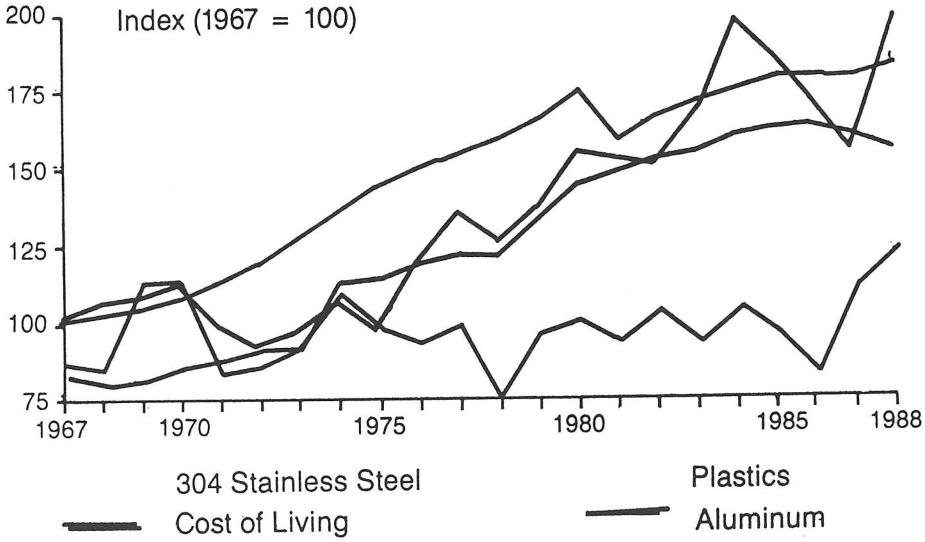
SLIDE 12

REASONS FOR THE PHENOMENAL GROWTH OF STAINLESS STEEL

- Corrosion resistance
- Mechanical properties over a wide temperature range
- Physical properties
- Ease of fabrication
- Finishing characteristics
- Appearance

SLIDE 13

PRICE COMPETITIVENESS OF STAINLESS STEEL WEST GERMANY, 1967 - 1988



- Exhibitions and Trade Shows - participation in well-known international trade fairs such as the ASM World Materials Congress (Chicago, USA, 1988), ACHEMA, (Frankfurt, West Germany, 1988) and the Latin American Stainless Steel Congress (Sao Paulo, Brazil, 1986-88) is yet another key ingredient of NiDI's development activity. Attendance at these shows helps NiDI to spread its message to an even wider audience and to identify and establish key contacts for mailing lists and future reference.

- Co-operative effort - as mentioned previously the transfer and sharing of ideas and technology beyond national borders and individual interest groups is a most effective way of building demand for nickel, nickel stainless steel and nickel alloys.

The Institute demonstrated the effectiveness of co-operative effort when together with the Chromium Centre and Chromium Association we organized the First Global Market Development Forum for Stainless Steel. Held in London (UK) in May 1988, this meeting was attended by more than one hundred and forty delegates from seventeen countries who discussed and compared notes on stainless steel markets and end-uses today and in the future.

In its short history, the Institute has demonstrated that there is no need to "reinvent the wheel". Our programs recognize that there are many existing markets or applications for nickel which, in the past, have not been adequately promoted.

I feel we were fortunate. Better economic market conditions and increased research and market development activity have resulted in increasing demand for nickel and renewed growth of the market.

Slide 9: Three phases of growth (second time)

Market analyses indicate that during the present growth period one single factor, viz the tremendous evolution of stainless steel applications in modern technology, has caused the nickel market to grow faster than the general economic development.

Slide 10: 1987 Nickel Consumption, First-use Sectors

From this breakdown of nickel consumption by first-use we can learn certain facts:

- Stainless steel with 56 percent of the total is the biggest individual sector of nickel consumption. In the last 20 years stainless steels have consumed an ever increasing share of total nickel production and there are indications that this development will continue. Without any doubt, the fate of the stainless steel industry and the nickel industry goes hand in hand;

- Alloy steels and high nickel alloys have held their own in the race amongst materials;

- Copper-base alloys, electroplating and foundry applications are at the losing end. We at the Nickel Development Institute have embarked on a number of specific defense plans to keep these traditional applications of nickel in place.

Slide 11: Stainless Steel Production 1968 - 1988

What then are the reasons for the phenomenal growth of stainless steels from 4 million tons in 1968 to close to 10.5 million tons last year?

Slide 12: Reasons for Growth of Stainless Steel

Let me first give you some of the technical reasons why we believe stainless steels have become among the most versatile materials in modern technology:

- Corrosion resistance;
- Good mechanical properties over a wide temperature range;
- Special physical properties;
- Ease of fabrication and welding;
- Finishing characteristics;
- Excellent appearance.

For these reasons alone, stainless steel is today a leading material in process technology, refining, environmental control, food processing and catering as well as in consumer products.

There is, however, yet another reason why stainless steels have so successfully found new markets during the last 20 years.

Slide 13: Price Competitiveness of Stainless Steel

Stainless steel, as can be seen here from data for West Germany, has been over the last two decades an 'underpriced' commodity. Pricing of stainless has - contrary to aluminum or plastic materials - not or only to a small degree reflected the cost of living increase. Clearly, low raw material cost combined with ample stainless steel production capacity has kept the price of stainless low.

Has stainless steel, therefore, grown faster than plastic materials?

Slide 14: Stainless Steel versus Plastics

The answer is - NO!

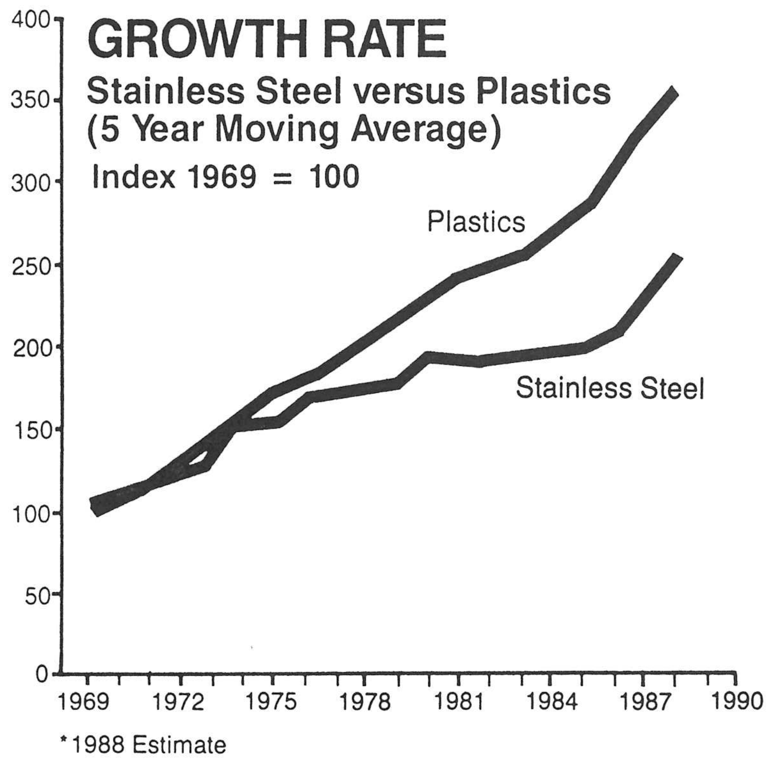
In other words, stainless steel has not yet reached its growth potential. Almost daily, we see new applications developing in the industrialized world but more importantly, in the emerging industrial countries of the developing world such as Taiwan, Korea, Brazil, South Africa and India, just to mention a few.

It would, however, be a mistake to believe that nickel-stainless steels and other nickel-containing alloys are without competition.

Slide 15: Substitutes for Nickel-containing Alloys

It is true that ferritic, nickel-free stainless steels present a viable alternative to austenitic, nickel-containing steels. However, it is also a fact that on a worldwide basis, in the last 25 years, the ratio between austenitic and ferritic steel has not changed. Today, as in the past, some 73 percent of all stainless steels produced are nickel bearing and there is no reason - except a physical nickel shortage - why that situation should change. In fact, steel plants on average prefer to

SLIDE 14



SLIDE 15

SUBSTITUTES FOR NICKEL-CONTAINING MATERIALS

- Nickel-free (ferritic) stainless steels
- Coated steels
- Aluminum
- Copper-alloys
- Titanium
- Fibre-reinforced plastics (FRPs)
- Glass
- Ceramics

produce austenitic steels since they require less furnace time, less pickling effort and are usually the preferred option of the customers.

The slide lists other substitutes for nickel-containing steels and alloys such as coated steels, aluminum, copper alloys, titanium, fibre-reinforced plastics (FRPs), glass and ceramics. In certain areas of the market all of these alternatives have found their niche, but it appears that nickel-containing materials have taken more market away from other materials than vice versa.

As I have said, whether or not in a particular application nickel-containing materials will be employed depends entirely on their competitiveness both technically and commercially. It is my firm conviction that the future of nickel-containing materials, and in particular stainless steel, continues to be promising.

Summary

In summary, ladies and gentlemen, I believe there are strong arguments to support an optimistic forecast for nickel demand and a promising future for the industry. The world faces many pressures, but several priorities stand out, including the need for more efficient and reliable plants for the production and utilization of energy; the need to conserve the environment, and to improve health and safety standards; the need to use leisure time more constructively; and above all, the need to increase food and other essential supplies for the vast undernourished populations of the world.

All these needs offer important opportunities for nickel but, of course, these opportunities cannot be taken for granted - as mentioned, many important applications for nickel are vulnerable to competitive materials, notably plastics, coated mild steel, aluminum and others.

Obviously, it will take ongoing, well co-ordinated market development support to convince engineers, designers and specifiers that they can do no better than nickel steels and alloys for reliability, cost effectiveness and long life.

Thank you for your attention.

SESSION III - DISCUSSION

"THE NEED TO DEVELOP MARKETS FOR FERROALLOY PRODUCTS - THE EXPERIENCE OF THE NICKEL INDUSTRY"

Q. J.F. Collins, SKW Alloys, Inc. - USA. What is the budget of the Nickel Institute, and what is the size of the staff that you have?

A. J.P. Schade, Nickel Institute - Canada. We spent this current year $5,000,000 U.S. dollars world-wide, and the budget for next year will probably go up by 20%. I think the ultimate goal is to spend one cent per pound of nickel consumed or sold by the industry on research and development, so you can say that the budget can grow by another 50% eventually. We have a very small staff. We only have virtually five employees. We work exclusively with consultants, with institutes, with universities. We have 52 consultants under contract at the present time in the United States, Europe, some in Japan, and even the people who are running our offices, like the Tokyo, are on a consultancy basis because it is not a full time job, and if the man serves two or three days a week for us it is perfectly all right. You save a lot of money by not going into pension plans and employee benefits, etc. So we have right from the beginning said there is so much intelligence and expertise out there in the market, and we would like to capitalize on that.

J.E. Gomersall, Middelburg Steel and Alloys - South Africa. Looking very briefly at your outlook of a 5.2% growth in demand for nickel and hence a 5.2% growth in austenitic stainless from the period 1985 through for the next ten years means something like an extra 200,000 tons of nickel capacity that has to come on-stream in the world. The nickel producers have been saying that at the current price levels of that kind of new investment does not look too rosy. And therefore, this could be a significant limiting factor on the growth of stainless, and that perhaps the 5% growth that you are looking at might be optimistic.

J.P. Schade. I do not want to go on record that the nickel market will grow at whatever the figure is. This was a very short trend. The situation is such, when you look at what we call the "first use," where is nickel going when it goes out of the smelter or out of the refinery? Sixty percent goes into stainless steel. And this is really where the growth of the nickel market is. All the other applications, maybe with the exception of high Ni alloy grows with the general economy, so you are talking about 2 or 2 1/2% growth. This is the sector in the foundry industry, the electro plating market, catalysts and so on. But you have the phenomena of stainless steel. Stainless has exploded in terms of production world-wide, and experts predict that that growth is going to continue. Now you can discuss until the cows come home whether that will grow at 3% or 4% or 4 1/2%. Whatever the figure might be, at some point in time you are going to reach the limit of the presently installed nickel capacity, I would think that that will probably be in the mid 90s. I think the nickel producers know that quite clearly, and I hear noises that they are looking at expanding production and probably going into new mines. There is not a lack of nickel ore, it is just a lack of investment in the nickel industry. But if the market continues to be attractive you will see further investment. On the other hand you have a braking factor, and that is the price. I have gone on record that I think the threshold of pain is somewhere in the order of $5.00 per pound of nickel. This is in constant 1987 dollars. We are above that threshold of pain, and we are beginning to see substitution of 3 or 4 grades in stainless steel going to 200 series, for example, at a lower nickel content. We see the US automotive industry using the 400 series for the exhaust systems, and we have to be very careful. I make it absolutely clear to people who finance the institute that they understand this very dramatic relationship between the price and the future application of nickel particularly in the stainless steel sector. I don't have a big concern about the future of availability, but the price is a definite concern.

Q. J.A.F. Vall, Marta Nickel Company - Brazil. I understand perfectly well that as president of the Nickel Development Institute you have to speak about nickel, but as ferronickel producers can you give us some figures about the ever increasing demand of ferronickel in the nickel world?

A. J.P. Schade. Basically, technology, particularly since the AOD process was invented, and I am only talking about the steel sector which as I say is 60% of the total, our technology today is so perfected that you can virtually produce a fine grade of stainless steel with any raw material you have available, and it starts with nickel containing scrap and goes to highly refined nickel. In the last analysis it is a question of price. Now the industry, and I am an old fashioned metallurgist and I like to work with chunky materials, the old fashioned metallurgist liked ferronickel. There is no question, provided that the ferronickel product is offering the same type of advantages, not only the free iron if you like, but also analytically the same advantages as some of the higher refined nickel grades that are sold at a charge nickel price, and I am talking in particular about the carbon content. You know there is a permanent battle to reduce the carbon content. There are low carbon ferronickels on the market today by several producers, and that is a very preferred material for the stainless steel people to work with. As far as the other applications are concerned, there is hardly any application of ferronickel with the exception of the foundry industry, maybe. So that will remain a market for more highly refined nickel grades, but if you have a good ferronickel that is a good product to work with in the steel plant.

Q. A. Arnesen, Elkem - Brazil. You showed that after the oil shock in 1973 the nickel consumption increased very little, and then around 1983 it started to grow more. To what extent do you attribute the activities of the Nickel Development Institute to this increase to growth again?

A. J.P. Schade. When my bosses ask me, I say that is all due to us. I more or less have to believe that we have done a little bit in terms of supporting the market, in terms of education, in terms of better knowledge about the material, better fabrication methods, and that results in business. I can give you at least ten examples where we have actually created new business for stainless steel or for a catalyst. We have one figure that the minimum affect of Nickel Development Institute would be 50,000,000 pounds of additional nickel that were otherwise not there. The industrial development in the last four years, of course, has been so fast that these 50,000,000 have disappeared like sugar in the coffee. But I think there is the real chance, not only to create new markets, and of course that is the big goal, but in my opinion the bigger emphasis is on defending existing markets because this is something the industry has not done, and I think that is something you should look at. When the industry uses its defence mechanism, it is totally open to substitution . You have to have a hand in things. I remember the old Union Carbide slogan "A hand in things to come." I think you have to help steering that market vehicle into the right direction.

"THE RECOVERY AND SOLUTION RATE OF FERROALLOYS"

Q. F. Sadler, Frank Sadler Associates - USA. I would like to ask a two-part question. First of all, what was the grade steel that you used for emersion of the various ferroalloys?

A. S.A. Argyropoulos, University of Toronto - Canada. The carbon was an Armco iron with a carbon of about .04%.

Q. F. Sadler. Would you expect a different set of solution parameters for various carbon levels?

A. S.A. Argyropoulos. In the range of below .1% I don't expect a very big difference in the solution rates.

Q. F. Sadler. How about the higher carbons?

A. S.A. Argyropoulos. I found the most important parameter there is the super heat. It depends on the particular ferroalloy you want to examine. Which ferroalloy are you talking about?

F. Sadler. Primarily the most common ones, manganese and ferrosilicon.

S.A. Argyropoulos. I do not expect a big difference apart from the fact that for a steel which has above .1% carbon, the super heat changes. This in turn affects the solution rate slightly.

Q. R.C. Urquhart, Fenco Lavalin - Canada. Have you tried metallized pellets, iron pellets or ferrochrome pellets, and if not, would you speculate as to what might happen where you have a case of endothermic reactions and slag formations?

A. S.A. Argyropoulos. I have not tested pellets, but I believe the way in which we have examined the compacts we can examine the pellets too. In the event that we have an endothermic reaction you might see the mass transfer rate slow down. How much depends on the particular environment which we have and the slag. The slag might act as a barrier for the whole mass transfer. It depends on the convective characteristics of the liquid steel.

"ADVANCEMENT OF CORED WIRE APPLICATIONS WITHIN THE STEEL AND CAST METAL INDUSTRIES"

"THE CORED WIRE ASPECT OF IN-LADLE METALLURGY"

Q. J.F. Collins, SKW Alloys, Inc. - USA. Have either of you had experience with cored wire applications in the production of ferroalloys? You have talked about steel and cast iron, but not about ferroalloy production.

A. D.B. Marsh, Miller and Company - USA. No, I can't say that we have, but during the last two days I happened to think of a potential application regarding the addition of magnesium in the production of magnesium ferrosilicon. We have to do some work on getting magnesium in fast enough in large enough quantities, possibly a four-strand machine could be entertained. I think time would potentially be a problem, but the possibility would certainly be there. And I think, also, there was mentioned the dephosphorization of manganese, this might be another possible utilization of cored wire.

Q. J.F. Collins. Mr. Simmons do you have any comments on this?

A. J. Simmons, Affival, Inc. - USA. My comments are the same based on previous experience. The introduction of calcium, magnesium or strontium into ferrosilicon for the manufacturing of innoculents, the introduction of magnesium into manganese for dephosphorization are all very practical applications of corred wire technology.

Q. J.T. Jennings, Shieldalloy Metallurgical - USA. Mr. Marsh, you said that four pounds per ton of calcium carbide injected in the form of cored wire effected desulphurization. What was the base sulphur and what was the final?

A. H. Mair, Odermath Stahlwerkstechnik GmbH - West Germany. The sulphur content to begin with is about 110 and we get down to 78. This is the lowest.

"THE INFLUENCE OF THE SOLIDIFICATION PROCESS OF SILICON-RICH FERROALLOYS ON PRODUCT QUALITY"

Q. K.S. Chopra, Elkem Metals Company - USA. With regard to the manganese silicon system that you showed, Mn_5Si_3 phase goes through a phase transformation during the process of cooling.

There is micro cracking because of that, and sometimes this is noticed in the decrepitation process. Do you have any comments on this?

A. O. Raaness, SINTEF - Norway. Yes, I agree with you. It is a phase transformation but on the other hand, this is a process that occurs over a period of two or three minutes during solidification. What kind of a phase transformation would that be? It would not be a phase transformation that includes any kind of diffusion of matter. But of course it could be possible that through reorientation some of the crystal could have a different phase. It is not a phase transformation in the normal sense which involves diffusion of material.

"CONTRIBUTION TO THE STUDY OF HYDROGEN CONTENTS OF FERROALLOYS AND ITS INFLUENCE IN THE STEEL'S QUALITY"

J. Elliott, MIT - USA. (Comment) This is a very interesting paper. It deals with the subject that was brought up early in the conference yesterday morning, and that is the quality control of products from the ferroalloy industry. There is a need for eternal vigilance in the business of control of hydrogen in all steel making operations, starting with the preparation of raw materials and also the ferroalloys that are added when the steel has come from the furnace and is to be alloyed and then solidified. The paper indicates very clearly that even though the solubility of hydrogen in iron-silicon alloys liquid is very low, the conditions of storage, handling, processing and so on can have a tremendous influence on the hydrogen that may be brought with the product through the process of handling from the producer through the distributor and the consumer due to contained water, to hydrated corrosion products perhaps, and also because of the dissimilar phases that we saw in the previous paper which could cause electrolytic charging of the alloy. So I think this contribution is important for the industry because it indicates clearly that one has to be careful with the quality of the product, not only as it is made, but as it is handled through the processing systems. Merely making sure that there isn't very much water in the ferroalloy is not sufficient. I tell my students that a glass of water dumped into steel ladle containing 100 tons of steel can provide sufficient hydrogen to make this steel unacceptable for forging quality steels. One has to keep in mind that very small quantities of hydrogen in the form of water are deleterious in the steel, and this ferroalloy source is one that must be considered.

Q. R.C. Urquhart, Fenco Lavalin - Canada. My question relates to the content of hydrogen in ferroalloy that has been water granulated. Have you measured the content of hydrogen compared with normal mold casting of ferroalloys?

A. W.F. Carmo, Companhia de Cimento Portland Maringa - Brazil. I don't have any data unfortunately.

Q. J. Finardi, ABRAFE - Brazil. My question is not related to hydrogen but to the even more problematic gas nitrogen. I would say that producing ferromanganese using coke, coal and mainly green coke, the nitrogen level must probably be far lower than for example charcoal produced ferromanganese. Do you have any experience on this subject?

A. W.F. Carmo. No, I do not have any experience in this.

"RECENT TECHNOLOGY OF LOW AND MEDIUM CARBON FERROMANGANESE MANUFACTURING"

Q. D.S. Kozak, Elkem Metals Company - USA. In your paper you mentioned that, at least for the data presented, the cost of silicon units prohibited its use to reduce manganese oxide out of the slag. In order to achieve the 92% recovery, I assume you must reduce the manganese units out of the slag. My question is what materials did you use to reduce the manganese units from the slag, and if you did not do this, what recovery would you expect?

A. S. Suzuki, Mizushima Ferro-Alloy Company, Ltd. - Japan. In order to get the 92% recovery they don't use any special flux or ferrosilicon.

Q. K. Festoy, Tinfos - Norway. I see that the limit for this process is to produce low carbon ferro-manganese down to .7% carbon. But I know the process you used before based on silico manganese could go lower. I wanted to know, are you still using the old process for lower carbon levels, or have you stopped the old process altogether?

A. S. Suzuki. Even with this new process they can have the 0.5 to 0.7% low carbon ferromanganese. That is similar to the old process using the silico manganese.

Q. C.N. Herman, Ferro Alloys Corporation - India. The loss of manganese is shown about 16%. Eighty-four percent is the recovery given. How much of the manganese is lost in fumes? How much is lost in slag? And whether there is any utilization of the manganese which goes to fumes?

A. S. Suzuki. Roughly speaking, fifty, fifty. So 50% if the manganese recovery is 92%; 4% for fume and 4% for slag.

Q. C.N. Herman. And what about the manganese in fumes? Is it recovered and utilized in any way?

A. S. Suzuki. The fume has about 98% part Mn_3O_4, so it is on sale as a high-purity manganese oxide.

Q. J.K. Tuset, Institute of Technology - Norway. Did the shaking take place during oxygen blowing? And what is the actual effect of this shaking? Is it just that it keeps down the temperature so that you can avoid super heat in the surface? Is that the main purpose of the shaking?

A. S. Suzuki. It is carried out, shaking during oxygen blowing. Second question, carrying out the shaking heat loss increased so the temperature maintained lower.

Q. R.H. Kaiser, Elkem Metals Company - USA. You indicate you have a tapping temperature of about 1600°C. What sort of materials do you tap into?

A. S. Suzuki. It is made of cast iron.

Q. Y.E. Lee, Elkem Metals Company - USA. At the end of your operation, apparently you are also lowering the nitrogen and iron, by doing so I would expect that you would pick up nitrogen in the alloy. How much nitrogen was it?

A. S. Suzuki. Nitrogen pick up is about 400 ppm; Kawasaki steel specification is 500 ppm.

Q. S. Camacho, Plasma Energy Corporation - USA. Your original premise is that you wanted to reduce the energy consumption of ferromanganese production. And you compared it, I heard, with the electric arc furnace and developed this process instead. Can you comment on how much energy you have saved, or let's say maybe the ratio of energy consumption on the electric furnace vs. your process for low carbon ferromanganese?

A. S. Suzuki - Unfortunately we do not have a figure now.

"THE ROTARY HEARTH FURNACE DIRECT REDUCTION PROCESS"

Q. W. Dai, Jilin Ferroalloy - China. My first question is, would you please compare your process with SRC Process? My second question is, do you have any trouble with the sealing of your rotary hearth furnace?

A. G. Rath, Mannesmann Demag Huttentechnik - West Germany. Let me start with the second question first. There is actually no problem with sealing. The sealing takes place in the way that the stationary roof penetrates in a well sealed water pad located on the rotary hearth. First question - What is the process you asked me, the SRC?

W. Dai. It is a rotary kiln process. Used by Showa Denko, Japan.

G. Rath. The difference, in general, is of course the equipment from the rotary kiln to the rotary hearth, but there are some basic differences regarding the final degree of metallization. At least, up until now, the

SRC process is limited in the metallization up to, I would say, on a large-scale plant, 50-60%. The reason why it is limited is in the pellet itself. To achieve a high degree of metallization, you need a certain amount of carbon in the pellet. On the other hand, when you add the carbon required, that is up to 20% in the pellet of the total weight, the strength of the pellet drops. Then it becomes difficult to charge this type of pellet in a rotary kiln. Because in the rotary kiln the pellet always moves and is subjected to mechanical stresses which can destroy the pellet. In the rotary hearth furnace the pellet rests. So the strength of the pellet is not so important, and you can add more or less the amount of carbon required and even more if necessary. That is in principle, the basic difference. This limitation of carbon in the Showa Denko process, at least up until now limits the degree of pre-reduction.

Q. A. Arnesen, Elkem - Brazil. Apart from the obvious advantage that you have in this rotary hearth with a very gentle mechanical treatment of the charge, how would you compare this process with a rotary kiln process in terms of fuel efficiency, maintenance and availability?

A. G. Rath. Starting again with the last one first, due to the design there are no sticking problems, at least no sticking problems could be found. I think, in general, the maintenance problem is less. Regarding the energy efficiency, kiln and hearth furnaces heated with gas, oil or other resources like coal, have a bad thermal efficiency. You have to think of what to do with the hot gases in both processes. One of the easiest things is to preheat your combustion air, and the second step further on is to produce steam, hot water or whatever. But thermal efficiency in both units is not good.

Q. A. Arnesen. One short additional question. In terms of the same capacity, how would you compare the investment cost in the rotary hearth with the rotary kiln?

A. G. Rath. The hearth is, in general, much cheaper. I would say a third. But on the hearth you have also the need of certain raw material treatment. You have to grind the material and make pellets; the Showa Denko process needs the same raw material handling. The Krupp process allows the use of run-of-mine ore. When this works, as it is foreseen, you save the whole part before the rotary kiln. And so in this respect I would say it ends up in the same investment.