NICKEL

SPECIAL ISSUE

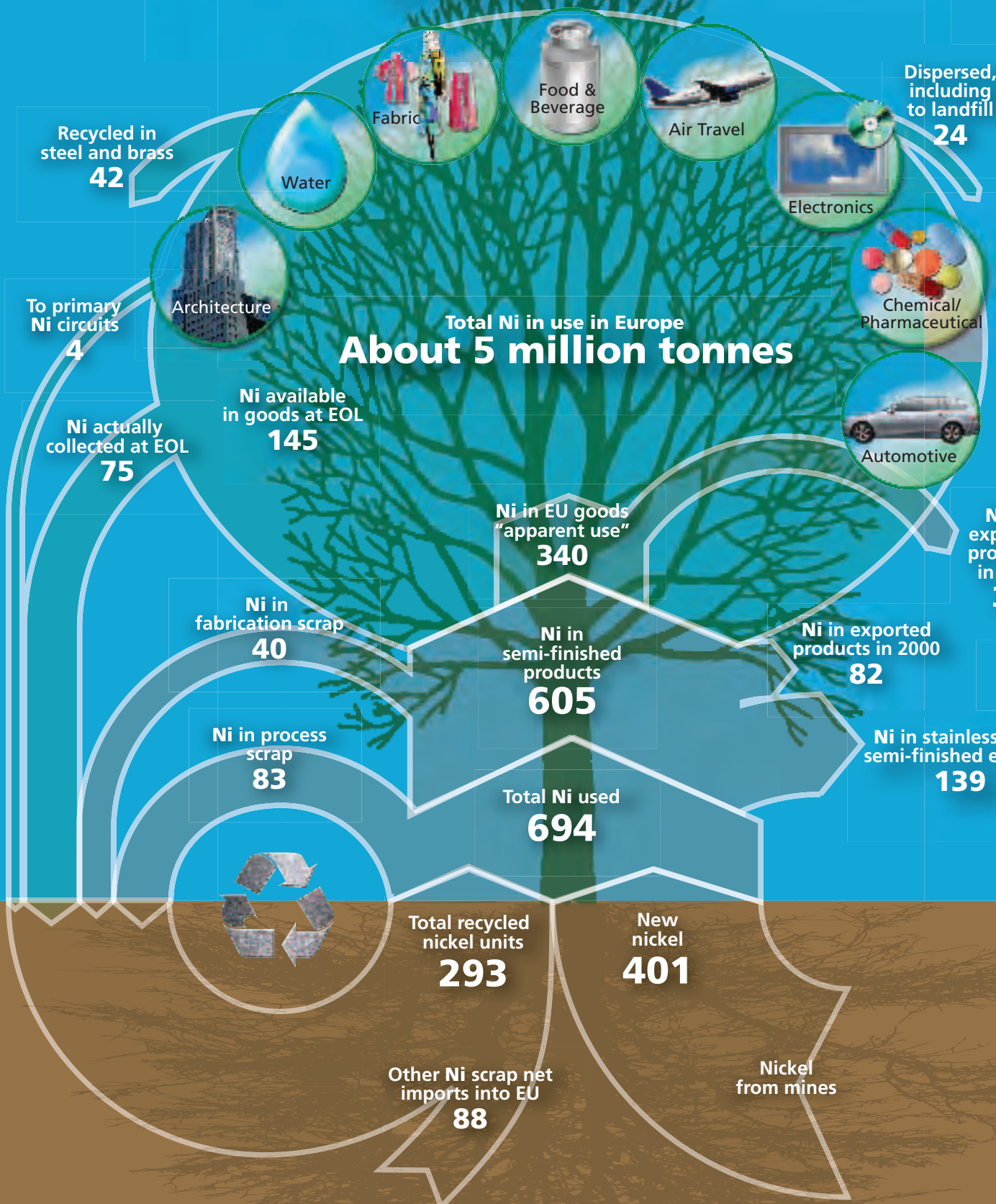
MAY 2006 VOLUME 21, NUMBER 3 THE MAGAZINE DEVOTED TO NICKEL AND ITS APPLICATIONS

ENHANCING THE QUALITY OF LIFE IN EUROPE

FIVE APPLICATIONS OF NICKEL THAT MAKE IT POSSIBLE

How Nickel Flows in Europe (2000*)

Figures in thousands of tonnes per year



European Nickel Industry Association. For more information please visit:

www.enia.org/flow

*Assumed average 25-year life cycle; available data do not reconcile, so numbers do not always balance.

NICKEL

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The Magazine Devoted to Nickel and its Applications

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CURIOUS TO LEARN?

I HAVE A CONFESSION TO MAKE: When I was studying geology and mine engineering in the 1980s, I had little appreciation for how, why and where the metals I was learning to mine from the Canadian Shield were being used in society. I learned that demand for metals grew as the global economy developed and that prices rose if supply fell short of demand. Why demand increased was immaterial; all that mattered to a recently graduated mining engineer was to get the sulphide ore safely to the mill at the lowest possible cost, preferably well below the going market price for the contained metal. Otherwise, he'd be out of a job.

My first job was designing underground mining stopes using vertical-crater-retreat technology at the Copper Cliff South and McCreedy West mines in the Sudbury area of Canada, and yet, at the time, I was unaware of the vast number of end-use applications for the copper and nickel that were being mined. I had a vague notion of the use of nickel in stainless steel and high-temperature superalloys (as used in the airline industry), but my interests were more in the area of spherical explosive charges, load factors and rock mechanics.

It's safe to say most nickel miners in Sudbury in the 1980s had little knowledge of the important role nickel plays in our lives, and while the internet makes it easier to obtain such information today, the situation probably hasn't really improved much.

Indeed, the populations of advanced industrial societies the world over are still largely unaware of the necessity of nickel. To improve the general knowledge of nickel will require a monumental effort. But such an effort is needed, most pressingly in the European Union, where a chemicals policy known as REACH is about to change the way nickel is used, reused and even perceived – and not necessarily for the better. If the positive role nickel plays in society is not communicated effectively, the export of this policy (via the OECD) throughout the rest of the world could potentially damage nickel's justified good reputation and therefore market demand.

Having worked in communications for the Nickel Development Institute and now the Nickel Institute over the past seven years, I can safely say I've gained a much greater appreciation of nickel. I've learned that there is virtually no limit to its versatility and seemingly essential uses. To get this information across to those in need of it, or who are at least curious, my challenge now is to remember what it was like not to know, and to present the available information in a way that's engaging and compelling.

WHY IS IT IMPORTANT TO KNOW that the dairy industry can deliver healthy milk at low cost because of stainless steels?

PHOTO: DELAVAL INTERNATIONAL

That's why this special issue of Nickel Magazine is designed the way it is. We've attempted to highlight five essential uses of nickel in the every-day lives of people the world over, and in Europe in particular. By highlighting these uses – in the fashion, home entertainment, airline and dairy industries – we hope to demonstrate the societal value of this unique natural resource. There are literally thousands of applications of nickel and nickel-containing materials; the five you'll read about in these pages are only among the most essential ones. We invite you to visit the sources of online information provided throughout this publication to find out more, and as always, we welcome your comments.

Patrick Whiteway

Patrick Whiteway
Editor

PURE PERFORMANCE

Delivering 120 Billion Litres Of Safe And Healthy Milk Every Year

Most of us are confident that pasturised milk is hygienic. However, without the use of stainless steel in the milk production process, it is doubtful that this would be the case.

The use of nickel-containing, austenitic stainless steel in the dairy industry can be traced back to 1913, though it didn't became widespread until the 1940s. By facilitating the efficient, safe handing and processing of milk, stainless steel has helped reduce the baseline cost of the product to 55 in the year 2000 from about 100 in the 1920s.

The success of Europe's dairy sector, which employs thousands, can be attributed to stainless steel. Among those employed in the industry is James Tallon of County Meath, Ireland, whose 300 Holstein cows produce more than two million litres a year for the liquid milk market in Dublin. Tallon is also one of 1,500 Irish farms that supply milk to R&A Bailey, makers of Baileys Irish Cream liqueur.

A visit to Tallon's farm is a lesson in the ubiquity of stainless steel in Europe's 20-million-cow dairy industry: S30400 stainless steel, containing 8% nickel, is used in the equipment that milks Tallon's Holstein cows, the lines through which the milk travels to the 18,000-litre bulk tank, and the tank itself. What's more, the washing-out vessel is stainless, as is the plate cooler that reduces the temperature of the milk by 15 °C before it goes into the tank for further cooling. Even the storage tanks on the lorry that collects the milk are made of stainless steel, not to mention the milk-packaging equipment.

Inside the plants, everything that comes into contact with the milk is stainless steel, except for rubber joints. The stainless steel must be inert not only from the point of view of the milk, but the cleaning chemicals and the local water too, the quality of which varies from place to place; 1000 litres of produced milk will use between 750-3000 litres of water.

Tetra Pak, which provides processing and packaging solutions for food, uses stainless steel grade S31600 for all items in chilled liquid milk processing plants, with the exception of the tanks, because of its greater corrosion resistance. It is also better suited to the hot milk, hot cleaners and sterilant chemicals used to clean the machinery; dairy farmers warm milk at blood heat and use cold cleaners, for which S30400 provides adequate corrosion resistance, according to Alan Stack, manager of component sales of Tetra Pak Processing equipment in the UK.

Stainless steel pipework delivers milk from the trucks to coolers that cool the milk to less than 4 °C, then onward to storage silos with capacities ranging from 100,000 – 250,000 litres. Afterward it is piped to a milk separator, where at 50-65 °C the cream is separated from the skim milk.

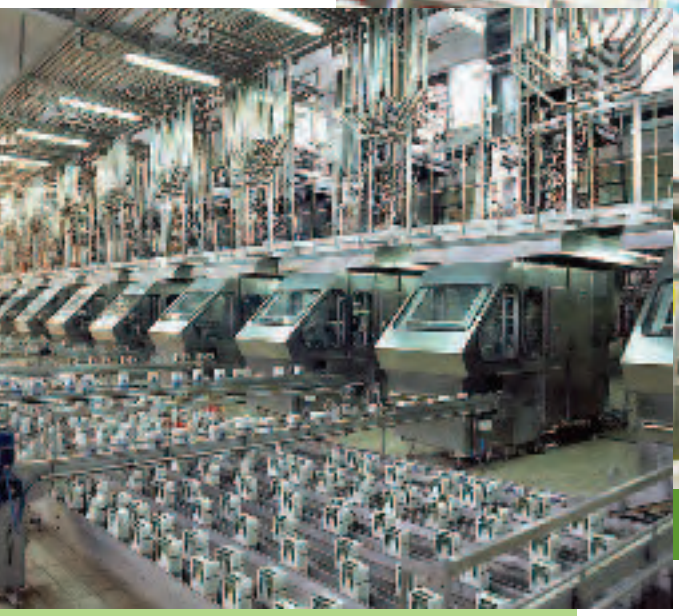
"The cream going back into the milk is homogenised to keep it

QUALITY CONTROLLED

HIGHEST PURITY STANDARDS

NEWEST TECHNOLOGY

PHOTOS: TETRA PAK, DELAVAL INTERNATIONAL AND GETTY IMAGES



MODERN MECHANIZED MILK PACKAGING

FROM FIELD TO TABLE, STAINLESS STEEL MAKES IT POSSIBLE

from separating out after it is mixed back in. The milk is pasteurised at 72-75 °C, as is the surplus cream, then cooled to between 2 ° and 4 °C. Then it normally goes into finished milk silos, with capacities ranging from 15,000 to 60,000 litres," says Stack. "From there it goes through all stainless steel pipework and is packaged in glass or plastic bottles or cartons for the consumers."

Stainless steel has a number of properties today's dairy farmers could not do without, chief among which is cleanability: "We do a hot water wash once a day, and stainless steel is ideal for this," says Tallon. "It's certainly easier to clean than rubber."

The ability to quickly and thoroughly clean equipment is essential for the profitability of European dairy farmers. Lower bacteria contents mean higher prices for their milk. Cleaning removes milk deposits that would otherwise lower the quality of subsequent batches of milk that pass through the equipment. Stainless is easily able to withstand the mechanical forces, as well as the corrosive nature of detergents (both alkalis and acids) and disinfectants. These are used to clean away everything from fats and proteins to "milk stone" (formed from calcium), and micro-organisms.

Tallon previously used glass lines in his milking parlours. "But the lines had rubber joints that were hard to keep clean," he recalls. "There were also breakage problems and protein buildup, and glass is notoriously hard to clean. Stainless [by comparison] can handle higher washing temperatures and stronger detergents than glass and rubber."

Stainless steel is also preferred for its low maintenance requirements and resistance to corrosion. The latter is especially advantageous in Ireland's damp climate, says Tallon, who adds: "My new plant is stainless steel; there's nothing that can rust, so corrosion is not a problem."

Nickel is metallurgically locked into the crystal structure of stainless steel, and a microscopically thin surface layer of chromium oxide helps prevent corrosion. As a result, virtually none of the nickel in stainless steel is transferred to the milk during production, storage or delivery. However, cow's milk, like most foods naturally contains small amounts of nickel.

The advantages of stainless steel are well-known to DeLaval International, the world's largest manufacturer of dairy equipment. DeLaval's units can be found in 40 percent of the dairy farms in the European Union. "Stainless can be welded on-site and adapted to the building; it's easily installed and repaired," says Pat O'Shea, DeLaval's manager of the milking parlours and milk extraction. "It's a well-established technology and available in many kinds of stock, and unlike other materials, you don't have to paint stainless. That's a real advantage."

In addition to milk-handling equipment, DeLaval makes the devices used to secure and manage cows while they're installed in the milking parlours, including neck rails, manure gutters, butt pans and skirting. A milking parlour has to suffer many indignities: A 600-kilogram Holstein will not only jostle its stall as it moves about; it sometimes leans on the rails as it is milked. Stainless steel is strong, and if repairs are necessary, on-site welding is easy; it also resists the corrosive effects of the ammonia in cattle urine.

Today's milking parlours are a sight to behold, largely due to the ease with which stainless allows them to be kept clean and shiny.

Says O'Shea: "If people come to your farm from the city, you want them to return home saying 'We want to drink more milk.' Increasingly, it's producers who need to promote the consumption of dairy products. That means they have to keep the parlours clinical-looking, and stainless steel meets the bill.

MORE INFORMATION:
www.nickelmagazine.org/dairy

FASHIONABLE FABRICS

Helping Design Materials For A More Beautiful World

The manufacturers of textiles supply an industry where trends come and go, fashions change with every season, and competition is fierce. That means speed, precision and versatility are essential, whether the fabrics printed are destined for fashion-show runways or clothing-store racks.

"New designs must be available rapidly under the influence of constantly changing fashion trends," says Arno Vonk, spokesman for Stork Prints B.V., the world's largest supplier of nickel-mesh rotary screens to the textile industry.

Global production of printed textiles amounts to some 18 million kilometres of cloth a year – enough to stretch from the Earth to the Moon and back almost 25 times. "By far most of this volume is produced using rotary screen printing technology," notes Vonk, whose Boxmeer, Netherlands-based company produces more than half of the printing machinery in use worldwide.

Stork Prints, with a stable of 60 companies and annual revenues in the €2-billion range, pioneered rotary screen printing in the 1960s. Electroforming is used to create precise, finely patterned nickel screens, which in turn transfer intricate and colourful patterns to cloth, wallpaper, labels and packaging materials.

In the electroforming process, which was perfected in Germany in the mid-1800s, nickel or other metal in solution is electroplated onto a mandrel in order to reproduce the pattern on the mandrel's surface. Nickel, deposited from a solution of nickel sulphamate, has become the metal of choice to produce the seamless mesh screens used in rotary printing.

Nickel is easy to electroform, and thanks to its corrosion resistance, mechanical strength and stability, ease of welding, and heat-resistance, it is the logical choice for making screens.

PRINTING FABRICS AT MARIMEKKO IN FINLAND

A FINELY PATTERNED PURE NICKEL SCREEN

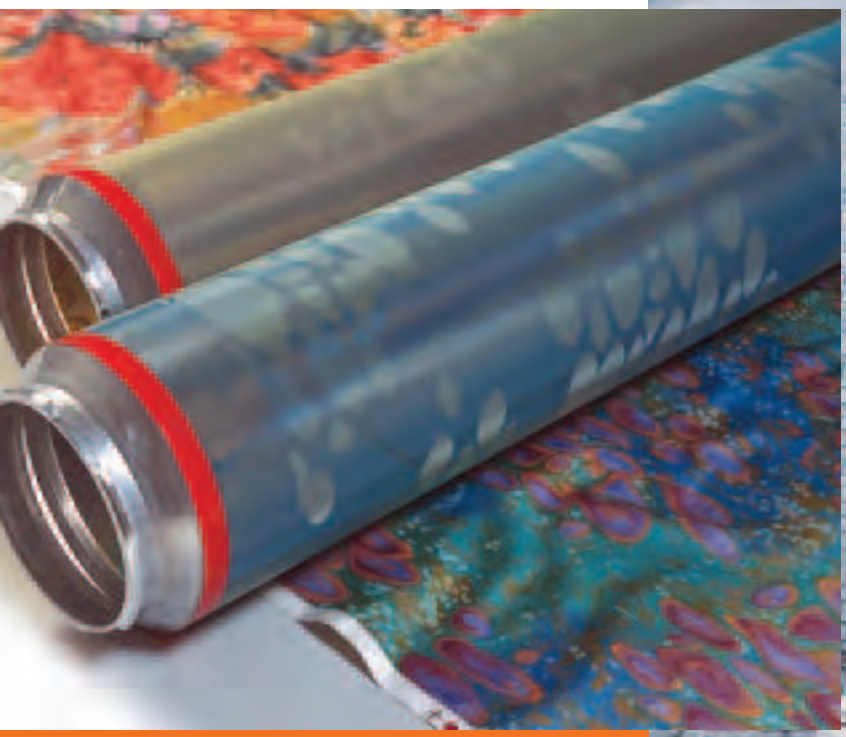
Electroformed nickel screens are extremely durable. One of Stork Prints' versions, marketed under the brand name RotaMesh, has a lifespan of 500,000 metres of printed substrate and a new pattern can be used up to 15 times. Stork uses 99.95% pure nickel to produce its cylindrical textile printing screens, which have high mesh counts of between 23 and 75 per linear centimetre. The high mesh counts minimise the space between holes, allowing colour to be transferred quickly and easily and fabric to be printed at higher speeds.

Speed and flexibility are essential in the highly competitive fashion industry, which generates roughly €200 billion a year in the European Union and employs more than two million people or 7% of the region's manufacturing workforce (2003 estimates).

But the removal of import restrictions on textiles and clothing in 2005, under a World Trade Organization agreement, is bringing increased competition from China and other Asian producers. Stork Prints estimates that China now accounts for between 30 and 40% of the world's textile production, and its share of the global market is growing.

Holger Bollmann, a division manager with Saueressig GmbH, a German screen manufacturer, stresses that pure nickel is ideal for the production of textile printing screens. "Nickel is 100 per cent resistant against corrosion," he says, adding that its hardness, strength and durability are essential to the performance of print screens.

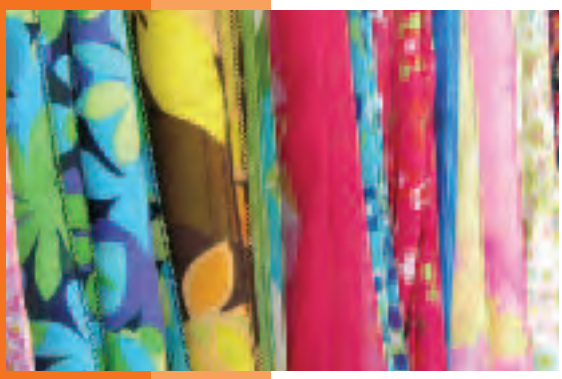
Rotary nickel-mesh screens have various applications. Saueressig's screens, for example, are used to print clothing, household textiles, curtains and carpeting. "There is almost no



NICKEL-MESH ROTARY SCREENS

NICKEL MAKES A STATEMENT

SCREEN PRINTING



A MYRIAD OF CHOICES

limit on the shapes of patterns that can be printed," says Bollmann. And since the screens can lay thin layers of print, they're applicable not only to textiles but to graphics, labels, packaging, wallpaper, coatings, decorations, and even the metallic foil used as a security device on banknotes.

"Rotary screen printing techniques offer enhanced aesthetic appeal because they can create three-dimensional effects and also allow varnishes to be applied easily," adds Vonk.

Stork Prints also produces high-speed scanners, computer-assisted design and laser engraving systems to transfer digital designs directly to printing screens, and ink-jet printing systems for textiles.

"Stork is the only manufacturer to develop and supply systems and technologies for every stage of textile printing," says Vonk. "As a result, printers can carry out their work efficiently and profitably."

MORE INFORMATION:
www.nickelmagazine.org/fashion

PHOTOS: STORK PRINTS B.V., MARIMEKKO, HOLGER BOLLMANN, CORBIS AND ISTOCK PHOTO

DEFINING DISPLAY

Enhancing Our View Of The World

Despite the growth of new flat-panel display technologies such as liquid-crystal-display and plasma, most television sets in use today rely on a device known as the cathode ray tube. In 2005, an estimated 145 million of the 175 million TVs shipped worldwide were cathode ray tube-based products, representing about €120 billion in value, compared with €63 billion in 2000. Clearly this technology is still in demand, and that means greater demand for the nickel alloys that play an essential role in tube technology.

Indeed, the Weinberg Group's Final Report on Valuable-Use Scenarios for Nickel, prepared for the European Nickel Group at the end of 2003, states that nickel-iron alloys are "irreplaceable" in the CRT television industry and assist in the high quality mass production of cathode ray tubes.

The reason is that nickel-iron alloys have an extremely low coefficient of thermal expansion, and that allows for an undisturbed TV picture independent of the temperature of the cathode ray tube, which heats up during service. The alloy family with this property was discovered by C. E. Guillaume in France in 1896.

When you switch on your TV, the cathode ray tube converts an electrical signal into visual information using an electron beam, intensity-modulated and deflected, to impinge on a cathodoluminescent screen surface in a glass envelope under vacuum.

The cathode ray tube comprises four principal elements: a glass panel, a shadow mask, three electron guns (one for each colour) and a glass funnel. Of these, the shadow mask is most dependent on nickel-iron alloys.

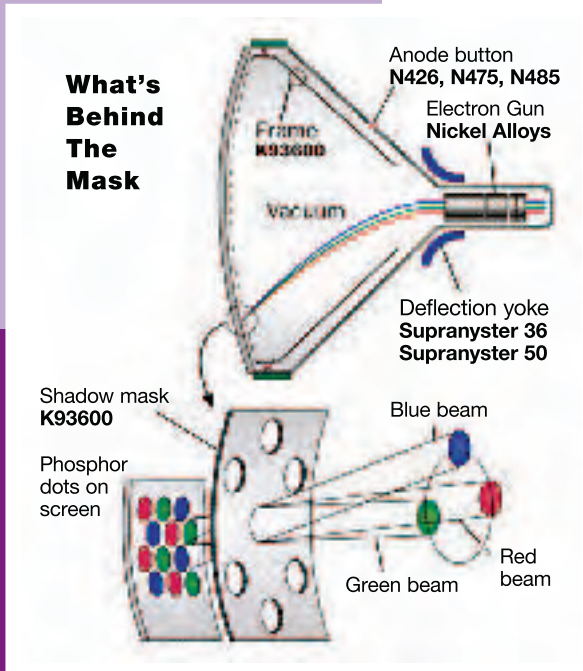
A grid that sits just behind the TV screen, the shadow mask is etched with many small holes or slits and supported by a metal frame (see illustration). The mask is moulded to match the contour of the interior surface of the glass panel. As the Weinberg Report explains: "An important function of nickel-iron alloys is the matching of metallic materials to the thermal expansion behaviour of various grades of glass and ceramics. Nickel-iron is an ideal sealing alloy, because it enables excellent surface joints to be created between glass or ceramic material and metal. Glass grades and nickel-iron alloys can be matched, according to their thermal expansion behaviour, to suit a variety of applications."

The report goes on to say that the use of nickel-iron alloy in the mask allows for the display of purer whites on the screen and improves colour reproduction and heat resistance (compared with iron masks). By ensuring that the electron beam hits the right phosphor dots on the screen, the mask maintains the integrity of the picture.

Principal European manufacturers include ThyssenKrupp VDM GmbH of Germany and, until early 2006, Imphy Alloys of France.

NICKEL ALLOY K93600

PHOTOS:THYSSENKRUPP VDM GMBH, AND BANANA STOCK IMAGES



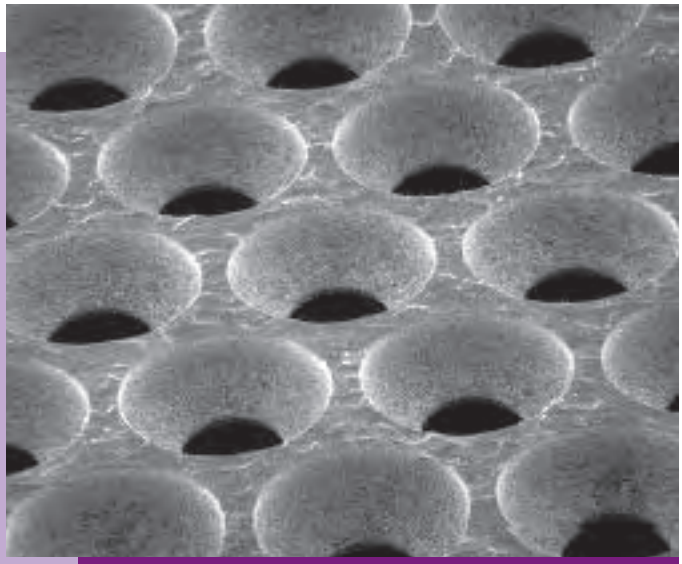
ThyssenKrupp VDM's Pernifer 36® alloy is used in shadow masks and shadow mask frames. "For this application, we supply several material grades which differ in the etching behaviour - that is, the etching of the pixels into the mask," says Dr. Bernd de Boer, ThyssenKrupp's manager of magnetic and controlled expansion alloys.

Pernifer 36 contains about 36% nickel and boasts an extremely low coefficient of thermal expansion between -250 and +200 °C. The coefficient of thermal expansion of Pernifer 36 nMn is even lower, owing to a lower manganese and residual elements content.

The range of cathode ray tubes stretches from 'fat' to 'slim', including larger dimensions, flat face-plate and 'High Definition Ready'. Invar® (K93600), the nickel-iron alloy originally used in bimetals and thermostats, as well as improved versions such as Inovar®, allowed tube makers to meet technical challenges. More precisely, they were ideal for the shadow mask since they ensured a perfect convergence of the electrons to form the image on the TV screen.

"Lower-end products may use less expensive metals for the mask," says Imphy's former communications manager, Sylvie Gindre, "but they don't allow for an acceptable picture quality for larger formats than 66 centimetres. When heat builds up during the TV set's working time, the shadow mask expands, generating what's known as 'doming'. K93600 keeps this doming phenomenon under control."

NICKEL IN YOUR HOME



SHADOW MASK MAGNIFIED 150 TIMES

Among the cathode ray tubes currently being marketed are 'slim tubes,' which are only two-thirds as deep as traditional ones. These tubes, which are available in large formats are top-quality specifications (100 Hz, High Definition Ready), cannot be manufactured with masks other than those made with nickel alloys such as K93600.

K93600 contains 36% nickel and has a low coefficient of thermal expansion between -100 and +200 °C. All of the above-mentioned alloys are easily weldable.

Nickel-iron is also used for numerous parts of the cathode ray tube apart from the shadow mask. The manufacturers of new display technologies such as organic light emissive displays are also looking at low-expansion alloys to provide a stable material for silk-screening meshes and similar requirements. And because display applications usually involve heat created by electrical power and require stable quality, manufacturers are naturally inclinded to look to low-expansion nickel alloys as potential building blocks.

MORE INFORMATION:
www.nickelmagazine.org/tvs

PRECISE PERFORMANCE

Enabling Inexpensive Replication Of Digital Entertainment

Nickel is expected to play a vital role in the growth of the digital entertainment industry as consumers in Europe and the rest of the world embrace a new generation of electronic devices.

Factory sales of consumer electronics reached €160 billion in 2005, up 11% from the previous year, according to Charles Van Horn, president of the International Recording Media Association (IRMA). He considers the products IRMA members produce – namely CDs and DVDs – to be an integral part of the electronics industry's growth.

That's where nickel comes in. Every CD and DVD is manufactured using a mould, which is electroformed from pure nickel. Nickel electroforming employs electro-deposition technology similar to that used in decorative nickel plating. Electroforming is by far the most precise means of replicating the surface of any object, including CDs and DVDs, and nickel is the only metal suitable for this because of its unique physical properties, namely hardness and resistance to heat and corrosion.

Although gold, silver and copper can all be electroformed, nickel is by far the metal of choice. That's because it is economical (relative to precious metals), versatile, has excellent heat, corrosion and abrasion resistance, and can be electro-deposited quickly.

Nickel electroforms are also 100% recyclable and melting them down at the end of their useful lives – usually a result of damage rather than wear – is common practice, according to Cinram, one of the world's largest manufacturers of pre-recorded DVDs, CDs and audio and video cassettes.

In 2004, 17.4 billion CDs and DVDs were produced worldwide, according to the IRMA. Each mould can produce in the order of 100,000 discs. That's a lot of moulds, and a lot of nickel.

"If you're selling a recording of an obscure string quartet, you'll probably only make a few thousand moulds," says Dr. Tony Hart of U.K-based Hart Coating Technology, which provides materials for CD electroforming facilities. "But if it's the latest hit record, you might need to make a hundred thousand or more mouldings."

The technology works like this: First, a laser burns billions of microscopic shallow depressions into a photosensitive film made of an organic resin. Their dimensions and position create a pattern that is used by a CD player to reproduce the music or visual images. The resin is then made electrically conductive by covering it with an extremely thin layer of pure silver metal. Nickel is then "grown" onto the silver surface by electro-deposition, a process in which nickel ions in solution are converted into atoms that build up, layer upon layer, to produce a uniform deposit. This deposit perfectly replicates the original surface.

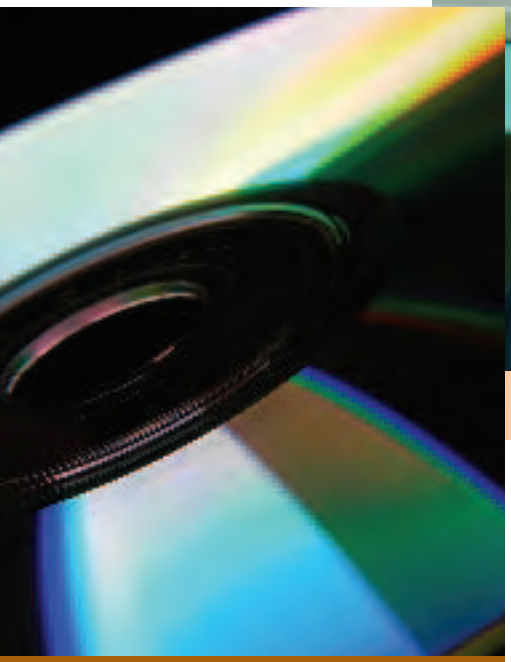
The resulting electroform is then separated from the original, or "master," with every surface detail, including the billions of sub-

NICKEL MOULDS

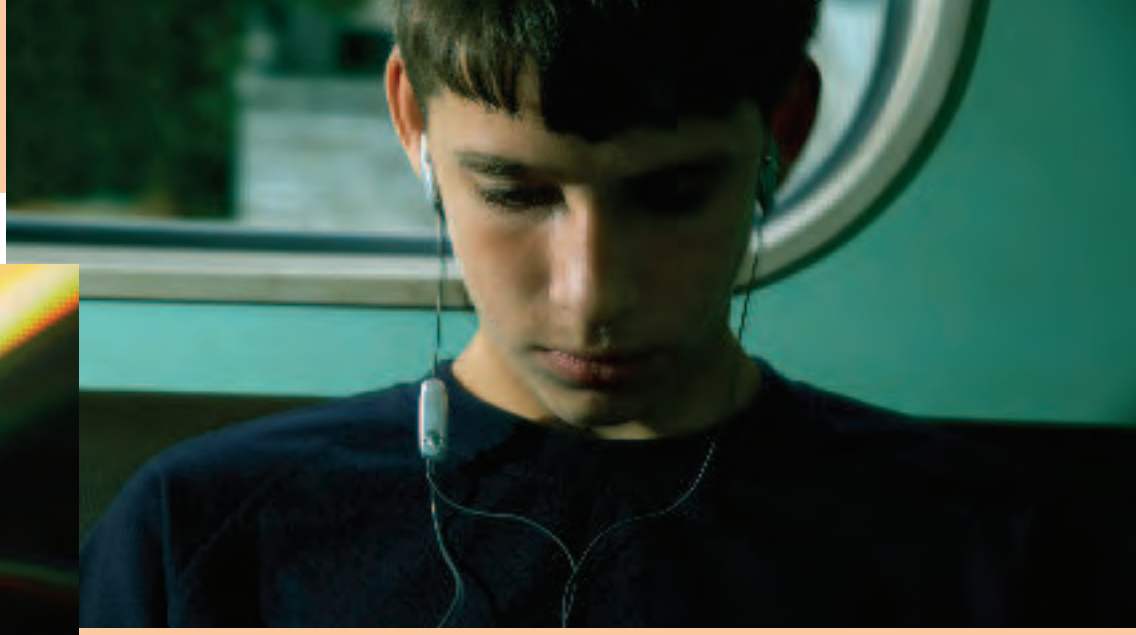
HIGH-SPEED DISC STAMPING

NICKEL ELECTROFORMING

PHOTOS: LOUIE PALU FOR NICKEL INSTITUTE, AND BIG STOCK PHOTO



BILLIONS PRODUCED EVERY YEAR



ENJOYING HIGH-QUALITY SOUND REPRODUCTION

micron sized pits, perfectly replicated. Actual production moulds are made from the original 'master' is a series of three subsequent nickel electroforming operations.

"Every one of those pits in the mould surface must be exactly the right size, in exactly the right place, and in exactly the right shape, or it won't sound right or look right," says Hart.

The degree of accuracy and reliability achieved through three stages of replication has enabled the CD/DVD industry to grow to the point where many plants are routinely producing more than 100 million discs per year. Technicolor, the world's leading manufacturer of CDs and DVDs, with plants in Europe, North America and Australia, has the capacity to produce 1.7 billion DVDs and 175 million CDs annually.

Western Europe is among the world leaders in CD/DVD replication, with about 26% of the market, according to 2003 statistics from the IRMA. North America and Asia each have 30%.

The industry does face challenges from a glut of product, pirating, and competition from digital downloading of music and film. Earlier this year, TDK Corp. announced it would shut down its European CD and DVD production facilities as part of a larger decision to withdraw from the manufacture of recordable discs. The decision was based on a sharp drop in the market prices for CDs and DVDs and higher costs.

Van Horn acknowledges there is "major consolidation" going on as optical media adjust to new technology but believes the industry can capitalize on the move toward high-definition (HD) DVDs and Blu-ray discs.

"Those buyers of flat-screen TVs are going to want a step up in the quality of image they receive from their recording media," he told the audience at the recent IRMA Recording Media Forum, held in California. "They are going to need a storage device to record their HD programs."

As for competition from downloadable music and film, Van Horn suggests the CD/DVD replication industry take a lesson from other industries where consumers have been convinced that value-added products are better than what can be obtained from other sources free of charge.

"We need to tell our story over and over again until it sinks in. DVD looks better and sounds better. Better picture and sound make for better entertainment.

The industry's best hopes may lie in HD-DVD or Blu-ray disc technology. The latter takes its name from the blue laser used to read much smaller and higher-density pits, and thereby providing much greater storage capacity. Just as DVDs had roughly five to ten times the storage capacity of CDs, so Blu-ray is expected to increase DVD capacity by a similar amount. Both HD-DVD and Blue-ray technology will be totally dependant on the nickel electroforming process.

Starting this year, U.S. consumers will be able to access some Blu-ray disc products from among the players, recorders, high-definition computer drives, recordable media and PC applications now in development.

HD-DVD is battling with Blu-Ray to see which will become the dominant technology to replace CDs and DVDs. Microsoft and Intel have both announced support for HD-DVD, while others are looking to Blu-Ray for higher storage capacity. Some Hollywood studios have said they'll publish films in both formats.

Whatever the outcome, the optical media replication industry stands to benefit from increasing consumer interest in high-definition products, and nickel electroforming will continue to play an essential role in this compelling growth story.

MORE INFORMATION:
www.nickelmagazine.org/entertainment

FARTHER, FASTER AND SAFER

Making Air Travel Cleaner, Quieter And More Fuel Efficient

Every year, nickel makes it possible for roughly two billion people and 34 million tonnes of cargo to take to the skies.

Aluminium, because of its low density, is normally associated with aircraft. However, it is the unique properties of nickel alloys, such as resistance to heat and corrosion in some alloys, and nearly zero expansion and contraction across temperature swings of hundreds of degrees in other alloys, on which the industry is highly dependent. That's because aircraft are becoming larger and aerospace engineers are striving to reduce airframe weight, engine noise and emissions.

For an example of nickel's vital contribution to modern aviation, consider the Airbus A380, the largest passenger aircraft built to date. History was made on April 27, 2005, when a gargantuan A380 began its four-hour maiden flight from Toulouse, France. The aircraft is manufactured by the French joint stock company Airbus S.A.S., which is 80% owned by the European Aeronautic Defence & Space Company and 20% by BAE Systems.

In its standard passenger configuration, the A380 will have 555 seats, weigh 560 tonnes on takeoff, and be capable of flying 15,000 kilometres at 85% of the speed of sound (Mach 0.85). Yet despite these record-setting figures, the A380 will burn 12% less fuel per seat than any other passenger aircraft – less than 3 litres per 100 passenger kilometres.

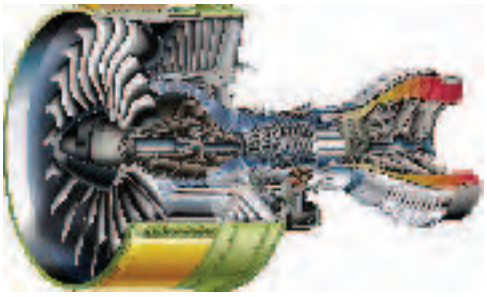
Today, skyrocketing fuel prices pose the single greatest threat to commercial aviation, and international transport in general. In 2005, 2.08 trillion litres of jet fuel were burned worldwide at a cost of €127 billion, more than double the cost reported for 2003.

Aside from improving airframe aerodynamics, there are two ways to reduce fuel consumption: create lighter aircraft and build more efficient engines. Since it takes about three kilograms of fuel per hour for an aircraft to carry 100 kilograms, weight reduction has become key.

Designers of the A380 minimised weight by using lightweight composite materials made of layers of carbon fibre cloth impregnated with resin (the same materials used to make lightweight sporting equipment). About 23% of the total airframe weight of the A380 consists of composites, including the centre wing box (the roughly-box-shaped section of the fuselage between the two wing roots), the rear pressure bulkhead, wing and tail ribs, trailing edges, and landing gear doors. Composite parts have bettered Airbus weight goals by as much as 25%.

A composite part is fabricated, or "laid up", layer by layer, on a nickel alloy mould milled to give the part a precise shape. Then the mould and part, impregnated with a resin (such as epoxy) are wheeled into an oven where the part is cured by heating it to temperatures ranging from 375 to 425 °C.

AIRBUS A380



NICKEL-BASE ALLOYS IMPROVE FUEL ECONOMY

NEW JET ENGINE: GP72000

PHOTOS: AIRBUS S.A.S. AND ENGINE ALLIANCE

AIRPORT IMPROVEMENTS NEED TO ACCOMMODATE THE NEW A380

LOWER EMISSIONS

The Evolution Continues

Nickel alloys have advanced the performance of aircraft engines since the 1930s, when new alloys were developed that could withstand the extreme temperatures and pressures of new engines.

This process continues today with the engines that have been developed for the A380. The GP72000 for example, developed by Engine Alliance, will have lower fuel burn emissions and far less noise than other aircraft. These improvements are designed to meet tougher noise restrictions at European airports.

Nickel alloys allow lower engine weights, even as they develop more thrust, and higher operating temperatures. Engine Alliance uses advanced nickel-base alloys such as Rene 104®. "This advanced alloy allows the disks to operate for long periods of time at temperatures 38 °C hotter than previous generation disk alloys," says Ken Bain, leader of the materials application engineering team for the GP72000 engine at GE – Aviation. "This improvement in temperature capability, to more than 704 °C, enables significantly more efficient engine cycles and improved fuel economy."

This alloy, known as Invar®, contains 36% nickel and has a particular property that's essential in the creation of composite components: a near-zero coefficient of thermal expansion, meaning it does not expand as it's heated or contract as it cools. As a result of this high stability, composite parts can be fabricated to the required tolerances measured in mere fractions of a millimetre.

Less weight means less fuel consumption, and that in turn means aircraft can carry more cargo and passengers. Our skies are vast, but capacity at many airports is strained to the point where runways are incapable of accepting any more aircraft. Gate space is often at a premium, and some airports have slot restrictions that make it impossible for airlines to add flights to their schedules. One solution to this exceedingly difficult problem is to put more passengers on fewer aircraft.

"Runway capacity ultimately determines airport capacity," says Robert Hornblower, assistant director of airport development with the International Air Transport Association. "It's expected the A380 will increase passenger throughput at airports with severe runway limitations."

By February 2006, Airbus had received 159 orders for A380s, including both passenger and cargo versions. Emirates, an airline headquartered in Dubai, has ordered 45, to be used primarily on its main trunk routes from Dubai to New York, Europe and Australia.

"Since the A380 is an aircraft with great passenger capacity, we'll use it on routes where we have slot restrictions," says an Emirates representative. "As things stand, Emirates serves a great many cities where we could offer more daily services; if we can't get these, then using an A380 on the route offers greater capacity."

Singapore Airlines will be the first to use the A380; its initial flight is scheduled for later in 2006. European customers include Air France, Lufthansa and Virgin Atlantic Airways, with combined orders totalling thirty-one A380s. Already more than 60 airports worldwide have made improvements to accommodate the aircraft, and in a few years it will be a common sight for international travelers.

MORE INFORMATION:
www.nickelmagazine.org/aircraft

MORE INFORMATION

This Special Issue of Nickel Magazine features five applications of nickel that are essential to the economy of the European Union. Read it online in these European languages*:

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There are thousands of other uses of nickel and nickel-containing materials in virtually every sector of the European economy. Nickel Magazine has been publishing articles on these applications since 1985 and you can read about them and more recent applications of nickel by going to **www.nickelmagazine.org/archive**

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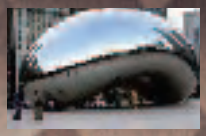

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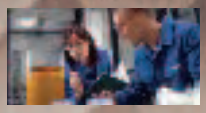

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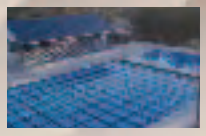

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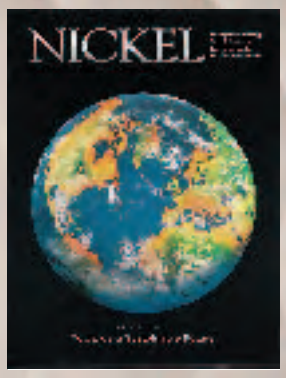

Restoring **Shine** To An Icon

WHY ELECTROPOLISHED STAINLESS STEEL WAS CHOSEN TO RENOVATE BELGIUM'S ATOMIUM

Built for the 1958 World's Fair, the Atomium depicts the body-centred cubic crystal structure of elemental iron metal. Originally clad in aluminum sheet, the structure was not intended to remain standing after the 1958 Exhibition, but its popularity endured, to the point where it has become a major landmark on the Brussels skyline.

During the intervening half-century, however, the nine 18-metre-diameter aluminum-clad steel spheres have lost some of their sheen. It was therefore decided in 2004 to re-clad the steel spheres and support structures with corrosion-resistant stainless steel sheet electropolished to a mirror finish so that the Atomium can remain a compelling tourist attraction for several decades. As a result, the Atomium was reopened in February, 2006, after nearly two years of renovation and a total investment of 25 million euros.

The aluminum cladding was replaced with stainless steel sheet because weather had dulled the surface appearance. Seventy tonnes of 1.2-mm-thick, electropolished S31603 stainless steel sheet were required. Cladding the curved surfaces of the spheres and support columns with stainless steel sheet was a major engineering challenge. The trick was to cut the sheet into triangles of different sizes.

INTERIOR VIEW ▲

THE SHINING ICON ▼

There were 720 triangles per sphere, and 15 of these were pre-welded together to form 48 larger, curve-formed triangles for installation on the spheres. By cutting the sheet into triangles, engineers were able to minimize the duration of installation work on the spheres, even though the large, 16-square-metre panels, each of which weighed 480 kg, required careful handling.

The triangles were electropolished, which resulted in a very thin but continuous surface oxide layer, thereby contributing to corrosion resistance.

MORE INFORMATION:
www.nickelmagazine.org/atomium

PHOTOS: ATOMIUM