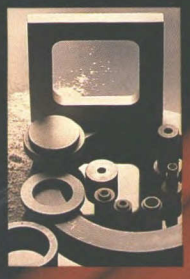
Advanced Materials

Enhancing Industry's Competitive Edge





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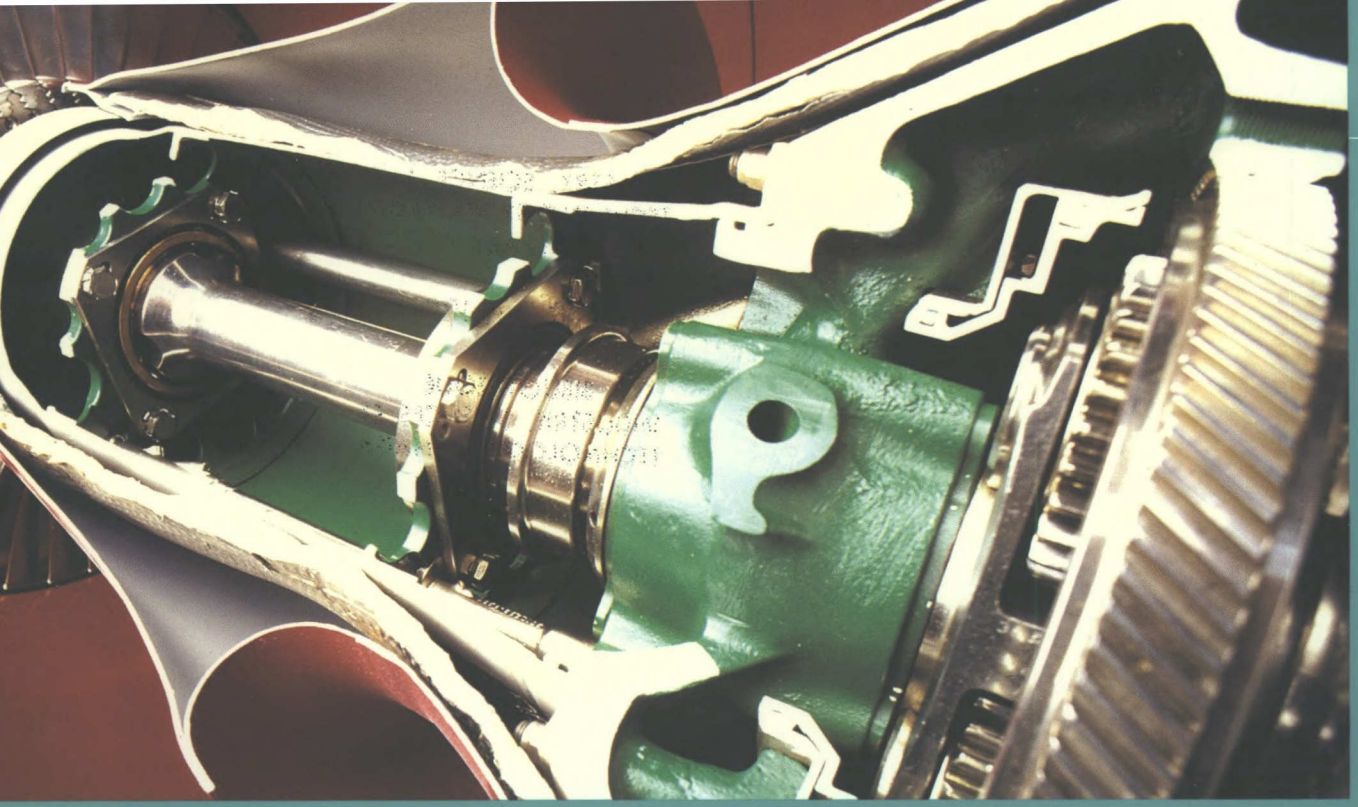
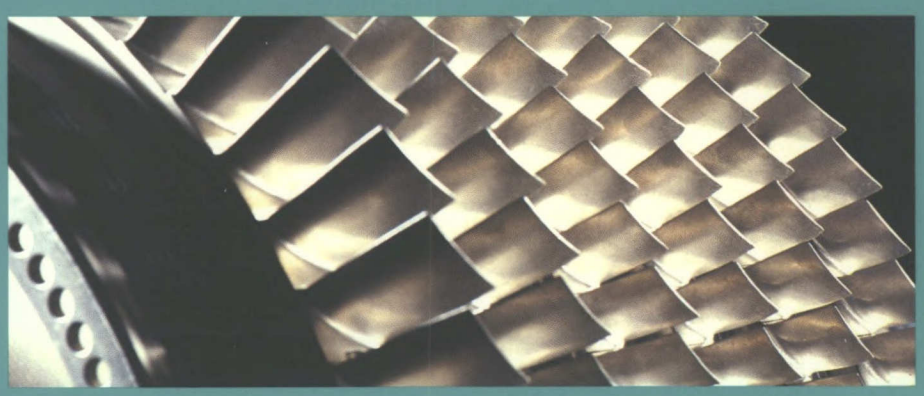


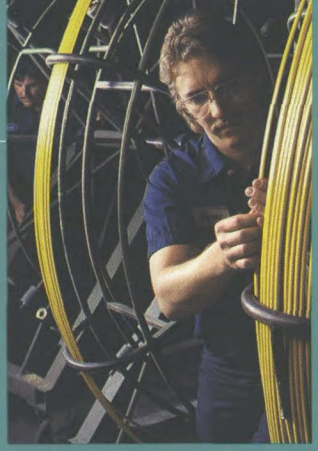
THE CHALLENGE AND THE OPPORTUNITY:

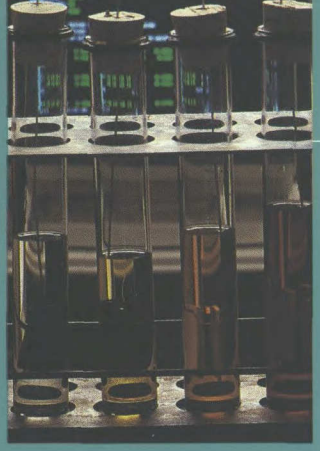
Keeping Up with the Rapid Pace of Change

People have always worked with the materials around them. Often, these efforts grew from a desire to lighten the burden of labour or to make life a little more comfortable. Plastic and aluminum, though common now, were once considered "new materials". In today's world, new materials have become much more complex, involving everything from programmable medical implants with timed-release medication to laser-treated skate blades that maintain their edges 10 to 100 times longer than conventional steel.

Today, an explosion of scientific knowledge is accelerating the pace of discovery. Materials are being advanced that can improve the quality of manufactured goods, reduce costs, modernize industrial plants, and open new avenues for both product and process development. By precise manipulation at the molecular level, high performance materials can be created to meet the specific needs of a host of applications.







The electronics, automotive, aerospace, human health, biotechnology, energy and defence sectors, among others, are already taking advantage of materials that are stronger, more corrosion-resistant and more durable than ever. There are also environmental benefits. Because these materials are often much lighter than their conventional counterparts, transporting them consumes less fuel.

Some of the products arising from these new materials are already familiar. Long-lasting ceramic-coated drill bits and lightweight tennis rackets, golf clubs, and surfboards made of fibre-reinforced composites have been commercially available for some time. But the full impact of advanced materials is yet to be realized.

Material innovations such as the following can affect the very way we live: plastic automotive gears and parts, buildings made of free-standing glass fibre and resin towers that are 75 percent lighter than steel, adhesives so strong they eliminate the need for welding, high temperature electrical superconductors and memory alloys that assume a particular shape at a particular temperature.

Processing innovations are critical in moving new materials into the marketplace. Today, the careful choice of materials is an integral part of many manufacturers' engineering, design and production activities. A higher level of "material literacy" can make every industry more internationally competitive.

The market for advanced materials is enormous. As industry and consumers become aware of new developments — whether in semiconductors, advanced solar cells, or magnesium bicycles — the demand is expected to reach hundreds of billions of dollars. In Japan and the U.S. alone, the demand for advanced metal alloys and composite materials is expected to reach $25 billion by the year 2000.

This technological revolution offers exciting opportunities for Canadian industry. Never before has the ability to manipulate materials to meet specific requirements been so great. Never before has the opportunity to increase competitiveness through integrated design and production been so apparent. Canadian industry has begun to recognize the new materials trend and has seized upon this challenge for the 1990s and beyond.

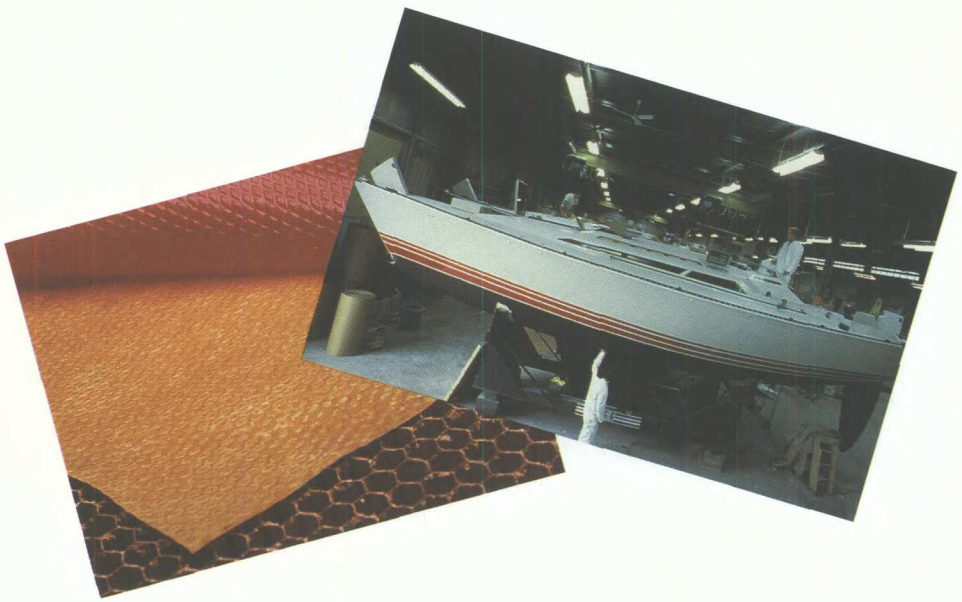
PLASTICS:

Profoundly Changing Our Material World

Today, 60 000 different plastics compete for a place in the market. Every year, hundreds of new varieties are introduced. Manufacturers have enhanced plastics with one property after another — stiffness, toughness, flame retardation, lubrication, colour — and it's only the beginning. Their potential is almost limitless.

Compared with metals, plastics are in their infancy, but they are already more complex and are extremely versatile. Inherent strength and rigidity coupled with low density makes some plastics as strong or stronger than common structural metals. They can also be shaped more easily.

Already, car manufacturers are regularly using plastics for parts such as gears, fittings, headlamp covers and radiator tanks. In the years ahead, plastics may also be used in body implants, super light-activated switches, membranes to desalinate sea water and ultra-light batteries for electric cars.

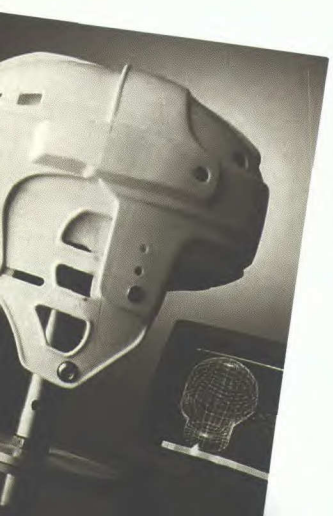


YACHTS

Advanced plastic composites are gradually replacing aluminum as the preferred material in the manufacture of high performance racing yachts. Fibre-reinforced plastic boats are lighter and their hulls flex less under load. The yachts are constructed with carefully oriented fibres of carbon and aramid encased in epoxy resin. Precise fibre orientation is important if the structure is to carry the design loads.

TORNAC RUBBER PRODUCTION

Tornac rubber is an advanced material developed to extend the life of car tires, hoses and belts, particularly at high temperatures.



HOCKEY HELMETS

These days, even hockey equipment is going high technology. Using lasers, plastic injection moulding and three-dimensional computerized design programs, there is a never-ending quest for a better hockey helmet.

SPECIALIZED CERAMICS PRODUCTS

Specialized ceramics products include brake rings, high temperature gaskets, insulators and seals.

ALUMINUM BICYCLE

The frame of this mountain bike is made of an extrudable, weldable aluminum ceramic composite that provides a unique combination of lightness and stiffness.

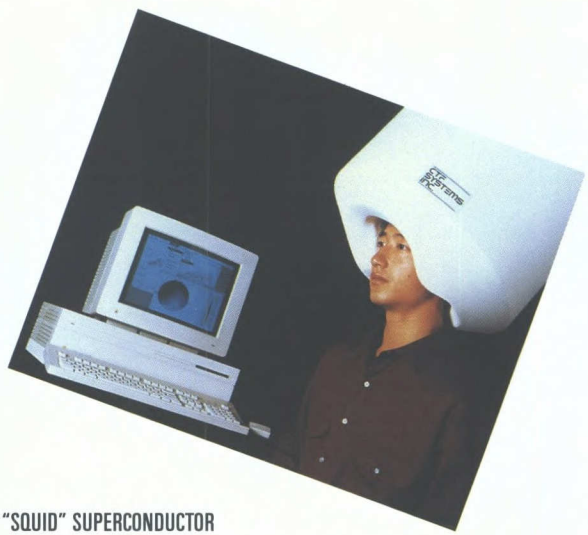
CERAMICS:

Renaissance of an Ancient Technology

Today, some 13 000 years after ceramic pottery was first discovered in Japan, ceramics is the subject of renewed scientific interest. Compared with steel, ceramics can be harder, lighter, stiffer and more resistant to heat and corrosion. Ceramic engine parts, for example, perform efficiently and can withstand heat levels that would melt their metal counterparts.

Even the age-old problem of brittleness is being overcome. As never before, scientists are working to toughen ceramics with fibres, crystals, and surface coatings. Most of us are already familiar with automobile catalytic converters and Corning Ware dishes — two advanced ceramic products.

In recent years, new ceramic materials have demonstrated superconductivity at higher temperatures than had been thought possible. Applications could include magnetically levitated trains and ball bearings that operate with no friction.



"SQUID" SUPERCONDUCTOR

The instrument pictured here makes use of superconducting micro-electronic devices to measure the magnetic fields of the human brain. Known as the whole-cortex MEG (magneto-encephalography) system, it is currently under development for use in human brain function analysis and performance evaluation. The MEG system will contain up to 100 niobium-based superconducting channels.

METALS AND ADVANCED ALLOYS:

Maintaining their Role through Innovation

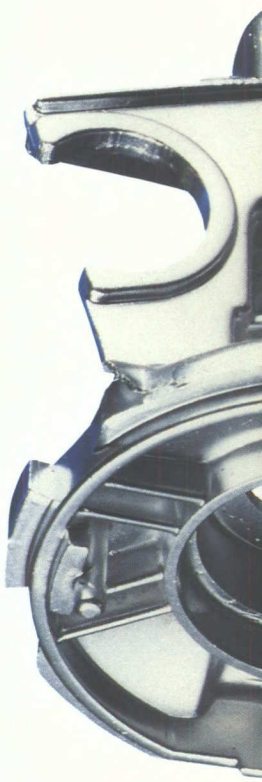
With so many new materials flooding the market, it might appear that metals are on their way out. Not so. New superalloys offer lightness, stiffness, corrosion resistance and high service temperatures. Steel has maintained its dominant role in the automotive industry because of new alloys so stiff that car parts can be made much thinner, reducing weight.

Similarly, aluminum can compete with new, lighter plastics and composites when it is alloyed with the metal lithium, the third lightest element. Other superalloys — based on nickel, cobalt and iron — are so heat-resistant they are being used in the hot sections of turbojet aircraft engines.

New processes — such as superplastic forming, rapid solidification and mechanical alloying — can transform familiar metals into metals with new structures and new properties of magnetism, strength, stiffness, and heat and corrosion resistance.

ORTHODONTIC BRACES

Since their invention in 1930, orthodontic braces had not changed significantly. However, these orthodontic braces are one-third smaller than conventional braces, making them easy to keep clean and comfortable to wear. They can also reduce treatment time by one third and patient visits by 40 percent. The basis of the new brace is a small leaf spring that stores and continuously releases energy. The spring, which wraps around the tooth bracket, is deflected when the tooth is not properly aligned. The spring gently releases its stored energy to move the tooth faster and with less pain than more bulky, conventional ties.

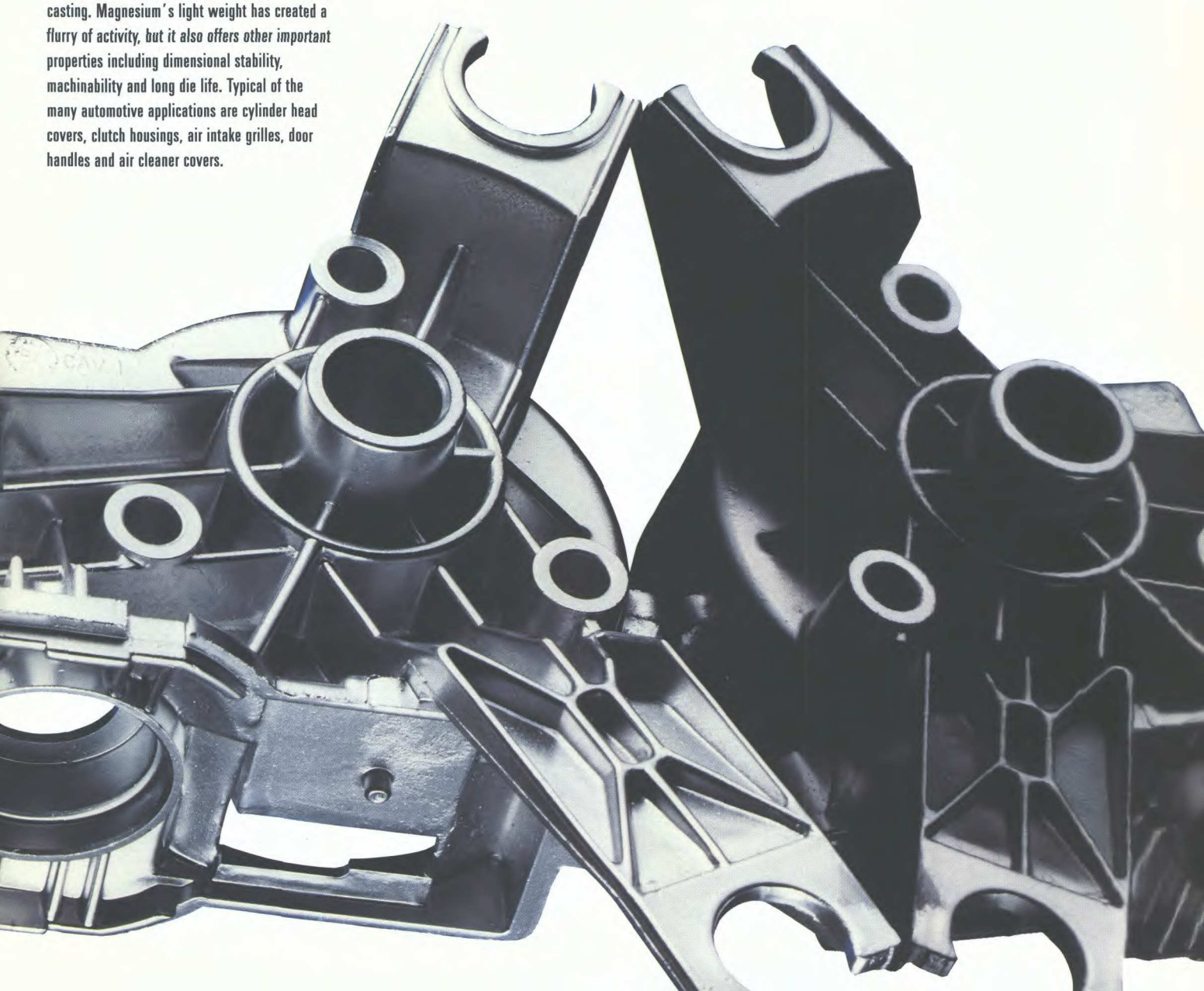


MAGNESIUM AUTO PARTS

One of the most common structural applications of magnesium is in auto parts and assemblies. The parts shown here include engine blocks and wheels, valve and air cleaner covers, brackets and wheel covers. Using magnesium not only saves weight but also can reduce or even eliminate machining costs because magnesium can be cast to closer tolerances than other metals.

MAGNESIUM DIE CASTING

The drive to produce lighter car parts, such as the wiper motor housing pictured here, has focused new attention on magnesium as a metal for die casting. Magnesium's light weight has created a flurry of activity, but it also offers other important properties including dimensional stability, machinability and long die life. Typical of the many automotive applications are cylinder head covers, clutch housings, air intake grilles, door handles and air cleaner covers.



SKI-DOO AND SEA-DOO

Moulded fibreglass provides maximum strength with minimum weight for many sports products.

DE HAVILLAND DASH 8

The de Havilland Dash 8, a highly successful passenger aircraft designed in Canada, makes extensive use of composite materials to reduce weight. For example, the nose bay, tail cone, landing gear doors, and wing leading edges all contain composite materials. The cabin interior is made almost entirely of fire-resistant composites.

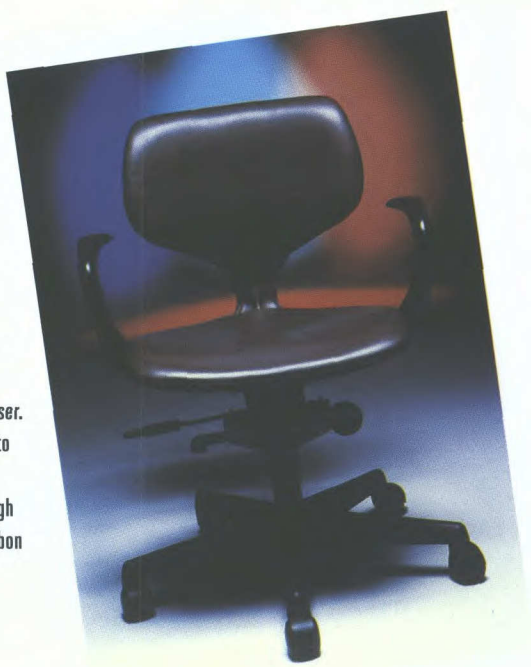
COMPOSITES:

Strongest of Materials by Weight

Many materials can be made stronger by adding fibres. Such fibre-reinforced materials are known as composites, and the most familiar of these is perhaps fibreglass.

Fibres may be embedded in a plastic, metal or ceramic matrix and may be arranged in various patterns: short, random fibres as in fibreglass boats or, for more strength, long parallel fibres as in skis and golf clubs.

Composites are now moving beyond specialty sports products to enter the domain of automotive, aircraft and space applications. As well as being strong, composites are light and exhibit excellent stiffness characteristics and good resistance to fatigue failure. As better automation is achieved, the high cost of producing composites is gradually diminishing.



COMPOSITE CHAIR

This composite chair adapts to the natural movements of the body. The narrow, yet extremely strong "waistline" of the one-piece moulded shell allows the backrest to move automatically, adjusting to the needs of the user. Specially moulded snap-on cushions conform to body contours without restricting blood circulation. The chair owes its structure to high performance polyurethanes encapsulating carbon and glass fibres.

CUTTING AND COATING

Improving Industry's Competitive Edge

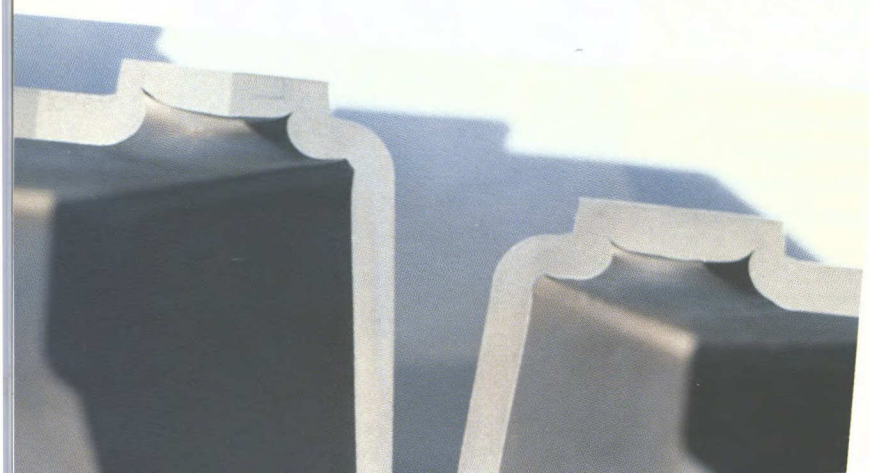
Faster, more precise methods of cutting are improving industry's competitiveness. With cutting speeds of up to 100 cm/s, laser cutters can be used on a wide range of industrial fabrics and plastics to cut the most intricate of shapes. Applications range from automotive trim, athletic wear and made-to-measure suits to signs and composites.

High speed water jets are another advanced cutting tool. Needle-thin jets of water forced out of sapphire nozzles at velocities approaching three times the speed of sound can be used to cut many materials precisely, including carpets, electronic circuit boards and fibreglass auto-body parts. Hard materials such as glass and metal may be cut by mixing fine grains of silica or other abrasives with the water.

Increasing Performance and Durability

Coatings and surface treatments can greatly extend the performance and durability of many tools and components, including high speed steel cutting and forming equipment, gas turbine vanes and blades, precision bearings, and semiconductors. For example, the cutting life of drill bits coated with titanium nitride (a ceramic) is five times that of regular steel bits.

There are many advanced coating processes and surface treatments, including ion implantation, sputter ion plating, laser plating, and hypersonic flame spraying. In the aerospace sector, plasma spray technology provides coatings that are light, yet extremely durable. In the field of superconductors and electronics, exciting advances are taking place in "thin film" coating processes.

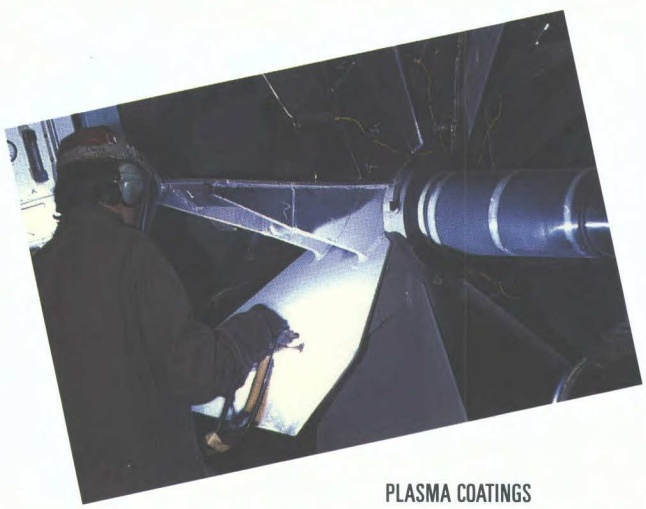


NICKEL VAPOUR DEPOSITION TECHNOLOGY

Nickel vapour deposition moulds, such as the one pictured here, can be manufactured with a deposition thickness ranging from a few thousandths of a centimetre to three centimetres. The deposit is 99.9 percent pure nickel.

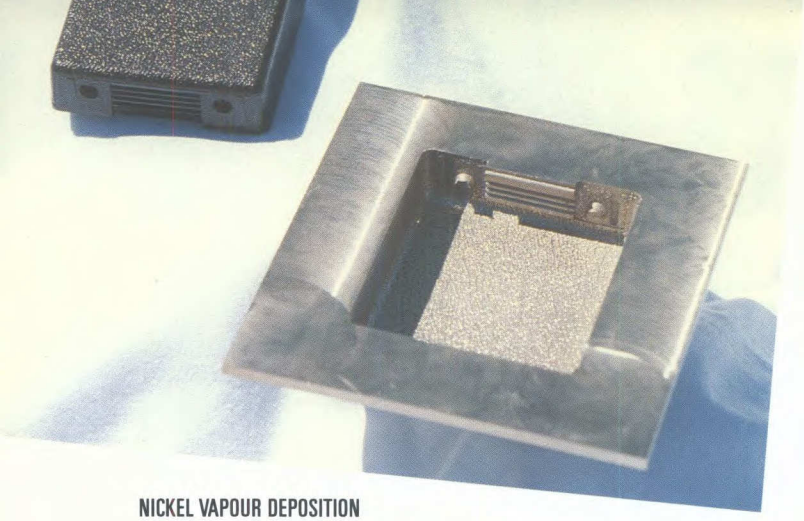
CERAMIC CUTTING MACHINE

This ceramic cutting machine, which uses silicon-nitride composites to cut tool inserts for cast-iron machining, is extremely wear-resistant.



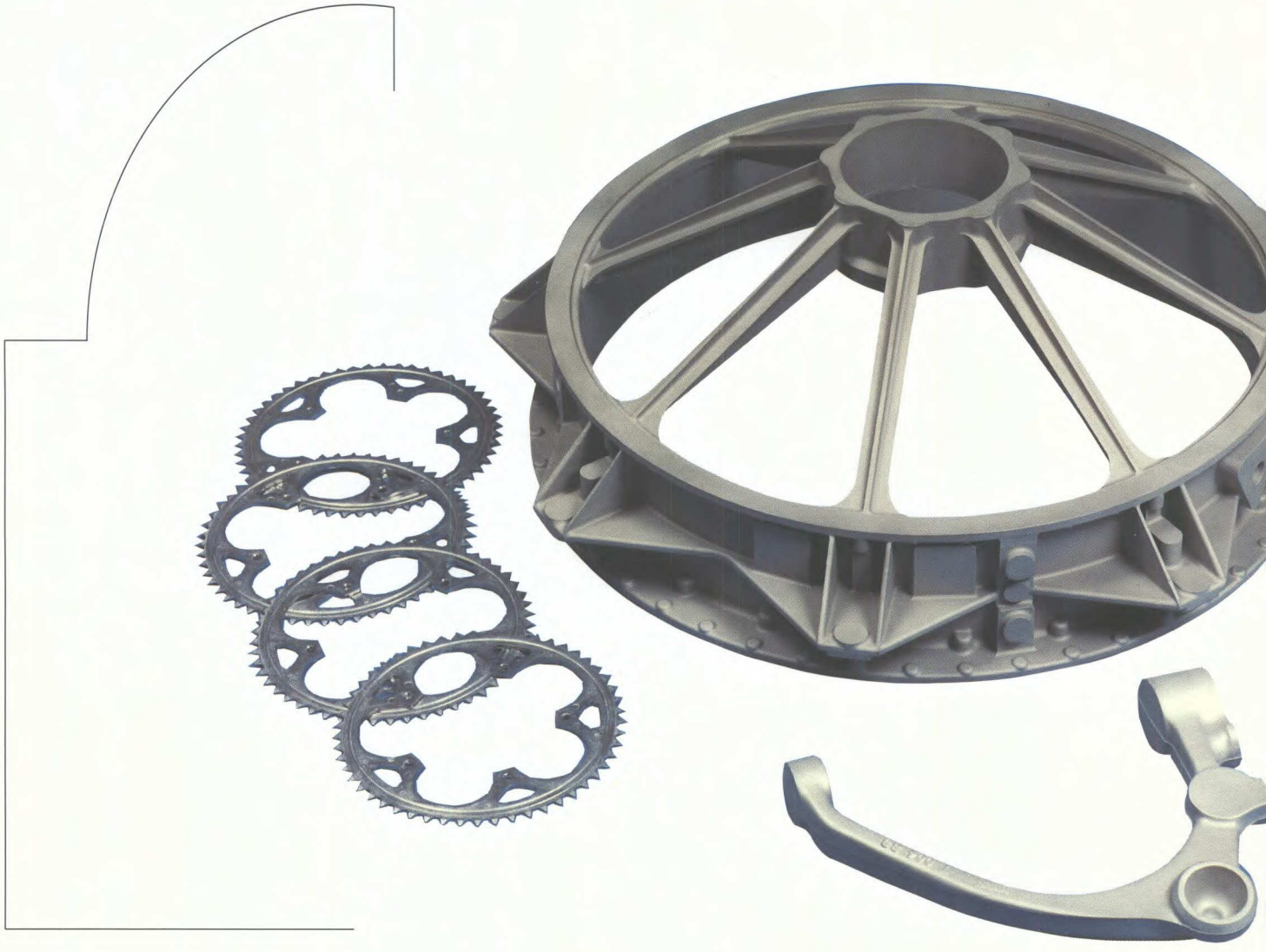
PLASMA COATINGS

Plasma coating of industrial parts and components provides wear and abrasion resistance under severe operating conditions. Both high and low velocity coatings can be adjusted for thickness and quality.



NICKEL VAPOUR DEPOSITION

High technology precision moulding is making use of an important Canadian resource – nickel. A new moulding process, nickel vapour deposition, can exactly duplicate surface textures such as leather grain, engravings and optical quality surfaces. Nickel moulds are also stable, strong and heat- and corrosion-resistant. They have important applications in many areas, including the plastics, automotive, defence and aerospace industries.



SILICON-CARBIDE PLATELETS

Increasingly, silicon-carbide platelets (magnified above) are being used as reinforcing materials in ceramic and metallic composites. The black free-flowing powder improves strength, fracture toughness, hardness and high temperature creep resistance. When incorporated in light metals such as aluminum and magnesium, silicon-carbide platelets improve high temperature properties. Current applications include wear parts, cutting tools, heat exchangers, engine components and sporting goods.

ADDING VALUE TO CANADA'S RESOURCES:

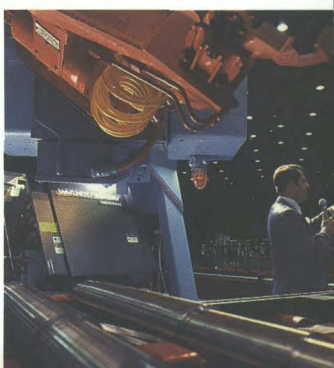
Building on Our Strengths

Canada's resource-based industries are entering the advanced materials age. In the search for innovative products and new markets, traditional materials such as nickel, aluminum and steel are being coupled with high technology processes to create completely new products that are of higher value. Advanced metal composites and high precision moulds and castings are but a few of the promising new applications.

Canadian industry's current research and development investments will lead to employment and manufacturing benefits tomorrow and in the future. To achieve these benefits, the human and financial strength of large, resource-based firms is being combined with the advanced processes and innovation of smaller high technology companies. These alliances will add value to our resources, lead to new product development and make Canadian companies more competitive internationally.

COMPOSITE CASTINGS

A variety of aluminum composite castings are shown, including aircraft camera gimbals (centre) and (clockwise from upper right) an automobile brake rotor, pistons, an automobile control arm and bicycle sprockets.



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