

Oxygen Free Copper Wire Casting Technology

Rautomead breaks the mould

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Continuous Casting Since 1978

The Rautomead Story



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Throughout the copper wire industry, the trend is for higher quality 8.0mm diameter feedstock for the drawing process. Over recent years,

Rautomead International Limited has become a world leader in continuous casting technology with innovative solutions that truly break the mould.

From its headquarters in Dundee, Rautomead specialises in the design and manufacture of continuous casting equipment for processing non-ferrous metals. The company's vast expertise in Graphite Crucible and Electrical Resistance Heating is being found to offer significant quality benefits and major cost savings to cable and wire producers.

WIRE BREAKS MINIMISED

By applying graphite-casting technology to the production of fine and superfine copper wires, Rautomead can ensure that costly wire breaks are minimised in the multi-strand drawing process.

THE OXYGEN-FREE SOLUTION

Residual oxides frequently provide the potential for wire breaks during drawing. Rautomead's integral graphite

filter technology, however, overcomes this problem by providing a naturally reducing environment in which the oxygen reacts with the graphite containment system to result in the production of oxygen-free quality copper wire rod. Non-metallic inclusions – another potential cause of wire breaks – are also minimised in the Rautomead process.

For full details, turn over now...

It's Pure and Simple

Rautomead breaks the mould in casting technology for "Oxygen Free" Copper Wire Rod.

Since its formation in 1978, Rautomead International Limited has become a leading specialist in the design and manufacture of continuous casting equipment for processing non-ferrous metals.

In fact, today, its Dundee headquarters is recognised as a world-centre for continuous casting technology.

The company's wide-ranging expertise in Graphite Crucible and Electrical Resistance Heating Technology is being found to offer significant quality benefits and major cost savings to the international wire and cable industry.

Rautomead's unrivalled expertise in this area is perhaps nowhere better illustrated than by the application of its graphite casting solutions to copper wire production.

With an industry wide trend towards higher quality 8.0mm diameter wire rod for feedstock to the drawing process, Rautomead's know-how facilitates the production of fine and superfine wires whilst minimising the frequency of wire breaks in multistrand drawing machines.



A naturally reducing environment

One of the potential causes of breaks in copper wire during drawing can be residual oxides present in the molten metal during the casting process. Rautomead's unique integrated melting and casting graphite crucible (incorporating a graphite filter) overcomes this problem by providing a naturally reducing environment in which the oxygen reacts with the graphite containment system to produce oxygen free copper wire rod.



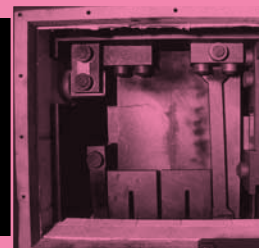
Eliminating breaks through non-metallic inclusion

Non metallic inclusions in the rod, resulting from the use of refractory lined crucible and launders in induction systems, is also a cause of wire breaks. Rautomead eliminates this problem with the use of a graphite crucible combined with an electric resistance heating and integrated melting & casting system.



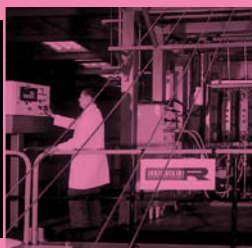
Heating technology leads the way

The Rautomead furnace uses high intensity - low voltage electrical resistance heating is safe to use and provides a high degree of power and temperature control. In combination with the graphite crucible, it provides a large 'heat sink', generating highly accurate and very stable melt temperatures.



24 applications worldwide

Rautomead have already introduced 24 Upward Vertical continuous casting machines in 11 different countries around the world. Consequently, the Rautomead range of machines is becoming a by-word for reliable, economic and efficient production of high quality copper rod. Machines are available for the production of between 2,000 and 20,000 tonnes per year.



A test of excellence

All Rautomead machines are fully installed, tested and operated, casting metal, prior to packing and shipping. Customers' engineers are invited to attend to receive initial "hands on" training and to witness pre-shipment casting demonstrations. An extensive and worldwide customer care programme also comprehensively supports Rautomead products.



A Total Control Refinery to Special Cable

A Growing Concept in the Copper Industry

The meteoric development of the information technology industry – with servers, LANs, PCs, laptops, palm-tops, printers, scanners and the accompanying miniaturisation of so many electronic components – is creating a rapidly increasing demand for finer and finer wires.

Yet while building wires are conventionally used at gauges of 0.5mm to 0.20mm, these new products call for wire gauges in the range 0.05mm to 0.02mm – 1/10th of the diameter, but only 1/100th of the surface area.

OXIDE INCLUSIONS

As a consequence, fine and superfine multi-wire drawing equipment has been developed to process 16 to 32 strands simultaneously. However, brittle copper oxides – resulting from impurities in the matrix – can result in both cup and cone wire-breaks. And conventional CCR rod, often made from cathode from a variety of sources, frequently fails to meet the exacting performance requirements.

A NEW APPLICATION, A NEW LEVEL OF QUALITY

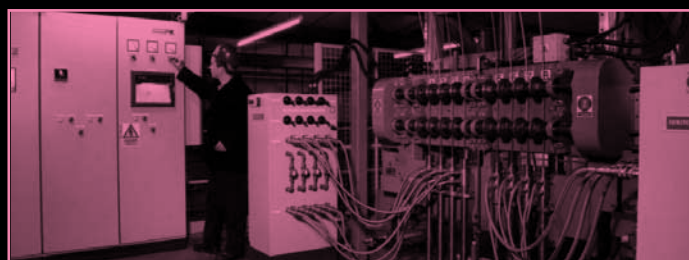
For these new high-tech applications, the normally accepted Grade A classification is not sufficient to ensure acceptable performance and economic production.

An impurity level (excluding silver) of 7 parts/million is equivalent to a purity of 99.9993% and this is the area of quality essential to achieve a wire-break performance in drawing at 0.050mm (50 microns) or better than 200 kg per break.

Such applications of refined copper call for a radical re-appraisal of relationships within the copper industry to achieve a position where, for example, the



manufacturer of special cables has full control over purity of the cathode used and control over the whole rod casting and wire drawing sequence.



A FINE SOLUTION FROM RAUTOMEAD

Rautomead specialises in the design and construction of continuous casting machines of small to medium capacity for the conversion of high quality cathode into copper re-draw rod with typical annual output capabilities

from 2,000 tonnes to 18,000 tonnes.

Rautomead machines are compact and are designed to be installed in wire and cable factories where the redraw rod

can be fed straight to the rod break-down machine.

ELECTRICAL RESISTANCE HEATING – VERTICAL CASTING

The Rautomead proprietary process is designed to melt, hold and cast the cathode copper in

a single graphite furnace. The furnace is heated by electrical resistance and is protected in an inert nitrogen gas atmosphere, the rods are cast vertically upwards from the machine to form coils of 4-5 tonnes weight.

The graphite furnace represents probably the most metallurgically clean environment in which to handle copper in the molten state, it also serves to reduce oxygen from 80-100 parts/million common in good quality cathode to less than 5 parts/million in the cast rod.

WORLDWIDE ACCLAIM

Already 27 systems have been sold in 12 countries around the world. Whilst the production of 8mm re-draw rod is the main application of this equipment, it has also found applications in the production of special conductor alloys, such as CuAg, CuSn, CuMg and CuCd.



Vertically Challenging

The unbeatable Rautomead RS upwards-vertical Casting Machine

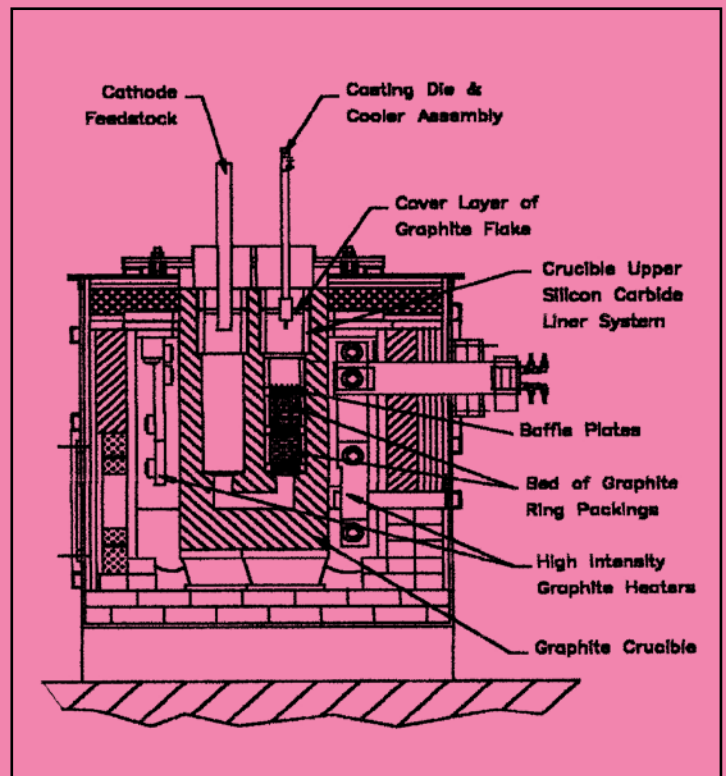
Since 1978, Rautomead has built continuous casting machines to its own proprietary design, incorporating electrically heated furnaces, solid graphite crucibles and submerged casting dies. During the 1980s, machine design was refined, some downwards vertical machines were also built for tube work, and customers were given the option of using the machine either as an integrated melting, holding and casting unit – or feeding the machine from a separate melting furnace.

In 1991, Rautomead took the decision to adapt its well-tried and proven continuous casting process to upwards vertical casting, with the specific objective of enabling the process to produce oxygen-free copper rod.

This had not been possible in horizontal casting and the adaptation of the process to upwards vertical casting gave immediate advantages of higher casting speeds, rapid casting die change times, improved consistency of product quality and higher production efficiency. The upwards-casting technique is also inherently safer.

Element	Symbol	Grade A Spec	Proprietary Brand
		ppm	ppm
Bismuth	Bi	<2.0	<0.2
Selenium	Se	<2.0	<0.3
Tellurium	Ti	<2.0	<0.2
group		<3.0	<0.6
Arsenic	As	<5.0	<0.1
Cadmium	Cd		<0.1
Chromium	Cr		<0.1
Manganese	Mn		<0.1
Phosphorous	P		<0.1
Antimony	Sb	<4.0	<0.1
group		<15.0	<0.5
Lead	Pb	<5.0	<0.1
Sulphur	S	<15.0	<4.0
Cobalt	Co		<0.1
Iron	Fe	<10.0	<0.7
Nickel	Ni		<0.1
Silicon	Si		
Tin	Sn		<0.1
Zinc	Zn		<0.1
group		<20.0	<1.0
Silver	Ag	<25.0	<5.0
Total		<65.0	<15.0

Sectional View of RS Model



UPWARDS AND ONWARDS

The first 8-strand upwards-vertical machine for production of 8mm diameter rod in oxygen-free copper was sold in 1995. Since then, Rautomead has built and sold a total of twenty one upwards machines for oxygen-free copper rod and six similar machines for copper alloy rod production.

COPPER BASED BENEFITS

Several of the key advantages of upwards casting apply equally to many copper-based alloys. The totally enclosed nature of the process lends itself particularly to the production of copper alloyed with reactive elements, such as magnesium and phosphorous, where

accurate control of the alloying additions was necessary in proportions of less than 0.5%.

LESS THAN 4PPM OXYGEN

In terms of product quality, the results achieved have fully fulfilled Rautomead's expectations. Oxygen-free copper rod is normally sold to a specification of less than 10ppm oxygen. Using a grade A cathode feedstock, the actual oxygen-levels achieved in the Rautomead rod are typically 3-4ppm. Customers are drawing the rod to 0.10mm on a routine basis with a better wire break performance than when using conventional CCR rod.

Never before has Casting Been So...

...ADVANCED

Rautomead equipment makes use of high-grade graphite and low thermal mass insulation materials initially developed for the nuclear and aerospace industries.

...ECONOMICAL

Rautomead equipment eliminates many intermediate metal making processes – allowing manufacturing enterprises to achieve cost-effective production.

...PRECISE

Rautomead equipment is capable of producing semi-finished products across a broad range of sizes – flats up to 750mm widths, rounds up to 300mm diameter, as well as small sizes such as 1mm by 2.2mm strips and rods of 1.5mm diameter.

...VERSATILE

Rautomead equipment allows casting dies, cooling systems and product withdrawal to be changed and adapted to suit specific applications. This can be of great benefit to customers in adapting to new products in changing market conditions.

...PURE

Rautomead equipment is highly accepted in high prestige industries such as precious metals, bullion, coinage, jewellery and electronics.

...SAFE

Rautomead Equipment is electrically heated by either graphite resistance elements or an induction coil and enclosed, thus reducing fume emission to a minimum. Ceramic fibre installations ensure a clean, safe working environment.

Rautomead Equipment is designed for simple operation, with Rautomead undertaking full customer training in safety and operational procedure before commissioning.

All Part of *the Service*

Rautomead place great emphasis on both technology transfer and training. Customers are encouraged to send their key personnel for training at the Rautomead factory in Dundee, with follow-on training taking place on site by the commissioning engineer.

Installation

All Rautomead machines are fully installed, tested and operated, casting metal, at the Rautomead factory in Dundee prior to packing and shipping.

Commissioning

On-site commissioning is carried out by Rautomead's experienced engineers, who then provide a full training programme.

Training

Customers' engineers are invited to receive initial hands-on training and to witness pre-shipment casting demonstrations.

Support

Rautomead products are comprehensively supported by an extensive and worldwide customer care programme, including the supply of spare parts held in stock in Dundee, engineering support and application development.



Precious Metals mean Golden Opportunities

Introducing the *Jewel in the Crown* of Casting Technology

Rautomead's continuous casting machines for precious metals are engineered to deliver high quality semi-finished products, from bullion coins, medals, and jewellery, to dental alloys, brazing alloys and sputtering targets.

The equipment, redesigned to include more user-friendly features for Y2K, is tailor-made to customer's individual requirements and supplied in over 35 countries worldwide. It is also supported by a comprehensive service package that includes trial and demonstration facilities, pre-shipment testing with molten metal, installation

and commissioning supported by engineer training.

PRECISE CONTROL

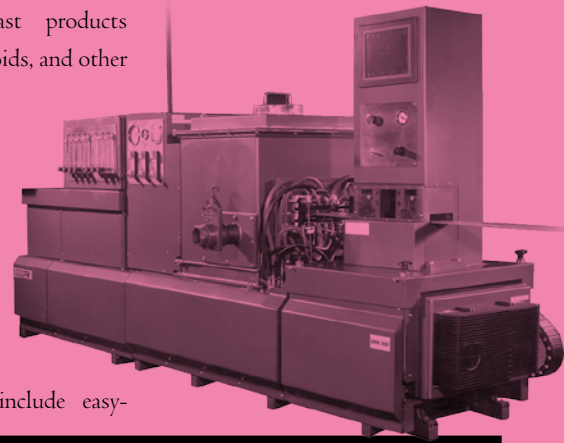
Rautomead equipment is specially designed to combine top quality continuous cast material with accurate control and repeatability of production parameters. These include a safe, easy-to-use resistance

heating system that operates at low voltage, and a unique graphite containment system that provides a naturally reducing environment, producing clean cast products without inclusions, voids, and other internal defects.

THE HEIGHT OF DESIGN

Designed to offer the optimum performance and operational simplicity, features include easy-

to-read eye-level controls, better operational, maintenance and safety features and a highly efficient cooling system.



Going for Gold

Rautomead goes for *Olympic Gold* in Sydney

Its not just athletes who win at the Olympics. Perth Mint chose Rautomead's continuous casting technology to mint the historic set of 52 commemorative coins to mark the occasion of the 2000 Olympic Games. The Rautomead equipment was used to cast the 99.99% gold strip 54mm x 10mm thick for subsequent rolling and blanking. And the complete set included eight \$100 gold coins, sixteen \$5 silver coins

and twenty-eight \$5 bronze coins - as well as all the gold and silver medals awarded to the athletes.

Mintage of the gold coins - which are legal tender - was restricted to 30,000 of each design. And the silver coins were limited to 100,000 of each design. In addition, the Perth Mint produced a \$30 I Kilo Olympic Masterpiece coin in fine silver and a special 10 oz. silver coin for the Paralympic games - all minted to proof quality.



Precious Metals

Manufacture in Algeria

One of the most unusual contracts to be completed by Rautomead involved the supply of two continuous casting machines for production of gold and silver alloys in Algeria.

The company, AGENOR of Baraki, was experienced in the processing of gold and silver, but operated old, traditional production methods, involving static casting of the metals into ingot moulds. Acting on the recommendations of an independent international consultant, AGENOR selected Rautomead as the basis for their modernisation programme.

The semi-finished products to be made include strips, rods and anode sections in a range of gold and silver-based alloys for use in the jewellery, electronics and dental industries and also as brazing alloys.

A GOLDEN OPPORTUNITY

As a result AGENOR is enjoying greater flexibility in matching the characteristics of the casting machines to a wide range of product requirements.

EXTENSIVE TRAINING

Training of AGENOR's technical personnel took place in Dundee prior to shipment of the machines. With French being the Algerian's native language, all training and technical documentation was adapted accordingly.

The two Rautomead machines selected were:

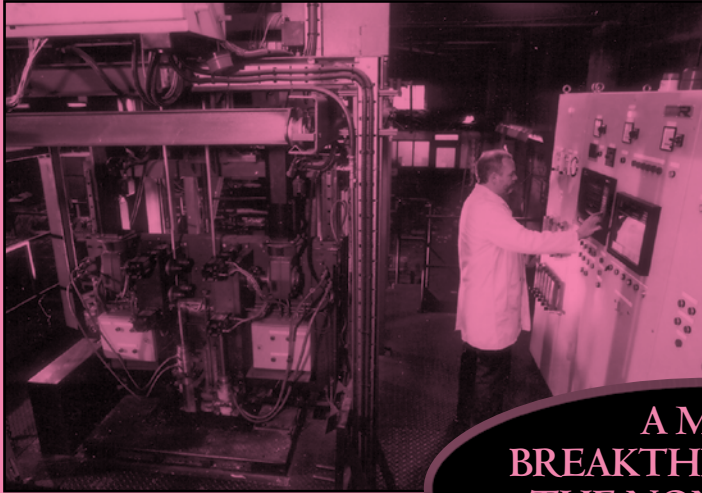
Model RMJ/H025 a 45 KVA horizontal casting machine that is used principally in production of strip sections. The machine can make strip up to 125mm wide.

Model RVSIIIIV (v), a 15 KVA downwards-vertical machine that is used principally to make rod products. It is also well-suited to production of hollow sections.

The Only Way is Up

Continuous Casting of Bronze Bars and Hollows

“Vertical” means new heights in continuous casting technology



A MAJOR BREAKTHROUGH FOR THE NON-FERROUS FOUNDRY INDUSTRY

Thanks to Rautomead, the non-ferrous foundry industry can now enjoy significant cost and quality advantages through the upwards-vertical continuous casting of straight length bars and hollows. Indeed by adopting the

process through the Rautomead's RSL machine series, foundries could make substantial savings in capital investment and reap the benefits of improved safety and product quality benefits.

NO SPECIAL STRUCTURES REQUIRED

Installation of traditional down casting machines for bronze bars and hollows has always been expensive because the equipment requires a substantial assembly structure and often involves considerable civil engineering work. Unlike traditional systems, Rautomead's equipment requires no special foundations or superstructures and is safely mounted at floor level.

NO GRAVITATIONAL PULL

The Rautomead system also scores over traditional methods by alleviating the gravitational effect of the weight of molten metal at the point of solidification. This means handling metal from its molten to solid state is a far safer procedure.

LOWER OPERATING COSTS

Requiring low capital investment, the Rautomead system can also help manufacturers to eliminate some of the traditional, intermediate metal-making processes, creating substantial savings through investment in smaller scale production facilities.

GREATER FLEXIBILITY

Flexibility is another bonus offered by Rautomead. Much quicker, more convenient upward casting die changes also enable users to achieve higher degrees of concentricity when casting hollow sections.

DUAL USE DOUBLES THE ADVANTAGE

Rautomead machines may be used as either melting - casting machines (single furnace) incorporating an automatic ingot feed system, or as holding - casting machines, fed with liquid metal from a separate pre-melting furnace. No matter which option is required, product quality is enhanced by the use of graphite in the production process.

ELECTRICAL RESISTANCE MEANS SAFER OPERATION

Unlike ceramic-lined induction heated furnaces, the Rautomead system processes the metal melt with high intensity electrical resistance heating. This offers low voltages that are far safer to use, whilst providing a high degree of efficiency and control. Combined with the graphite crucible, a large 'heat sink' ensures stable, more accurate melt temperatures.

EASY OPERATION & MAINTENANCE

All Rautomead machines easily integrate into your production schedules. Machinery can be switched to standby at night or weekends and in emergencies can be run from a generator. The furnace is designed for a long operational life and may be run continuously for periods of up to six months between servicing.

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Phelps Dodge (Norwich, CT)

Commissioning of the two Rautomead RS machines, commenced in April 2001 after formal approval, in the form of an environmental licence to operate, was received from the local authority. The Rautomead machines will produce oxygen free copper wire rods using liquid metal fed from the shaft furnace.

Muller Fittings (Covington, TN)

RS2300, production commenced in summer 2000. Large diameter rods (3/4 - 1" dia) are used in the manufacture of copper water fitting components.

Italy

15,000 tonne per year, new model Rautomead RS8000 is under manufacture for delivery to a large

Italian company specialising in enamelled wire and electric motor manufacture. Installation and commissioning, 4th quarter 2001.

Taiwan

12,000 tonne per year, 8.0mm CuOF RS 6000/16/8 installation completed March, production commenced April 2001.

Second Rautomead RS 3000 at

Chien Ann Enterprise commenced production March 2001.

Sweden

Elekrokoppar (Helsingborg) have ordered a Rautomead RS Machine to produce high quality oxygen free copper alloy rods which will be used, within the group, as feedstock to continuous extrusion equipment.

Continuously Casting Since 1978

The Rautomead Story

Founded in 1978 by present chairman, Sir Michael Nairn, and other colleagues, Rautomead has established itself at the forefront of continuous casting technology of non-ferrous metals through its commitment to technical innovation and research.

Operating through a carefully selected network of sales agents – and with 90% of product destined for export – the company is a true global player and has installed machines in over 40 different countries, with on-site commissioning by Rautomead engineers.

WIDE RANGING APPLICATIONS

Rautomead continuous casting technology can be used to make semi-finished rods, sections and hollow bars in copper, and in a wide range of copper based alloys. Smaller machines can also be used in processing of gold and silver based materials.

IMPROVED OPPORTUNITY

Rautomead machines improve the economic viability of metal processing companies by enabling costly scrap and machining swarf to be recycled on site and by giving management a degree of autonomy in the supply of vital raw material.

DELIVERING RESULTS

With a single-minded focus to deliver innovation, product versatility, quality and value – and always meet a customer's most specific needs – Rautomead also places great emphasis on both customer training and customer service on a long-term and continuing basis.

SHARING SKILLS

Emphasis on technology transfer and training is integral to company philosophy and customers are actively encouraged to send their key personnel for training at the Rautomead factory in Dundee with training then continued on site by the Rautomead Commissioning Engineer.

COMPLETE SOLUTIONS

As a natural extension to its core business, Rautomead undertakes the management of complete turnkey projects, running from continuous casting processes to end product. This service includes initial planning and layout, the sourcing of ancillary equipment and staff training through to final commissioning of plant. Rautomead also maintains a range of in-house machines for trials on new alloys and sections, and for specialist demonstrations.



WELL-ESTABLISHED TECHNOLOGY

The Rautomead design process ensures the production of top quality continuous casting machinery, whilst offering accurate control and repeatability of production parameters. The resistance heating system operates at a safe, low voltage and is simple to maintain. Whilst the graphite containment system produces metallurgically clean cast products, without inclusions, voids or other internal defects.

Rautomead manufacture the following three series of machines as well as a series for casting precious metals.

THE R-SERIES HORIZONTAL

This is based on graphite containment and casting for reliable, economic and efficient production of rods, sections, flats and hollow bars in non-ferrous metals.

THE RS-SERIES VERTICAL

This provides compact, integrated plants for upward casting of oxygen-free high conductivity copper wire to British Standard 4109 C103 and American ASTM Specification B1, B2, B3, C10200. Machines also enable the economic production of conductor copper alloy rods.

THE RSL SERIES VERTICAL

A superb range of versatile upwards-casting machines for the manufacture of copper based alloy rods, section and hollow bars in straight lengths.

THE ALL-NEW RMK SERIES FOR PRECIOUS METALS

For precious metals, the Rautomead RMK Series is used to produce semi-finished bullion, coins & medals, jewellery, dental alloys, electronics, brazing alloys and sputtering targets.

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