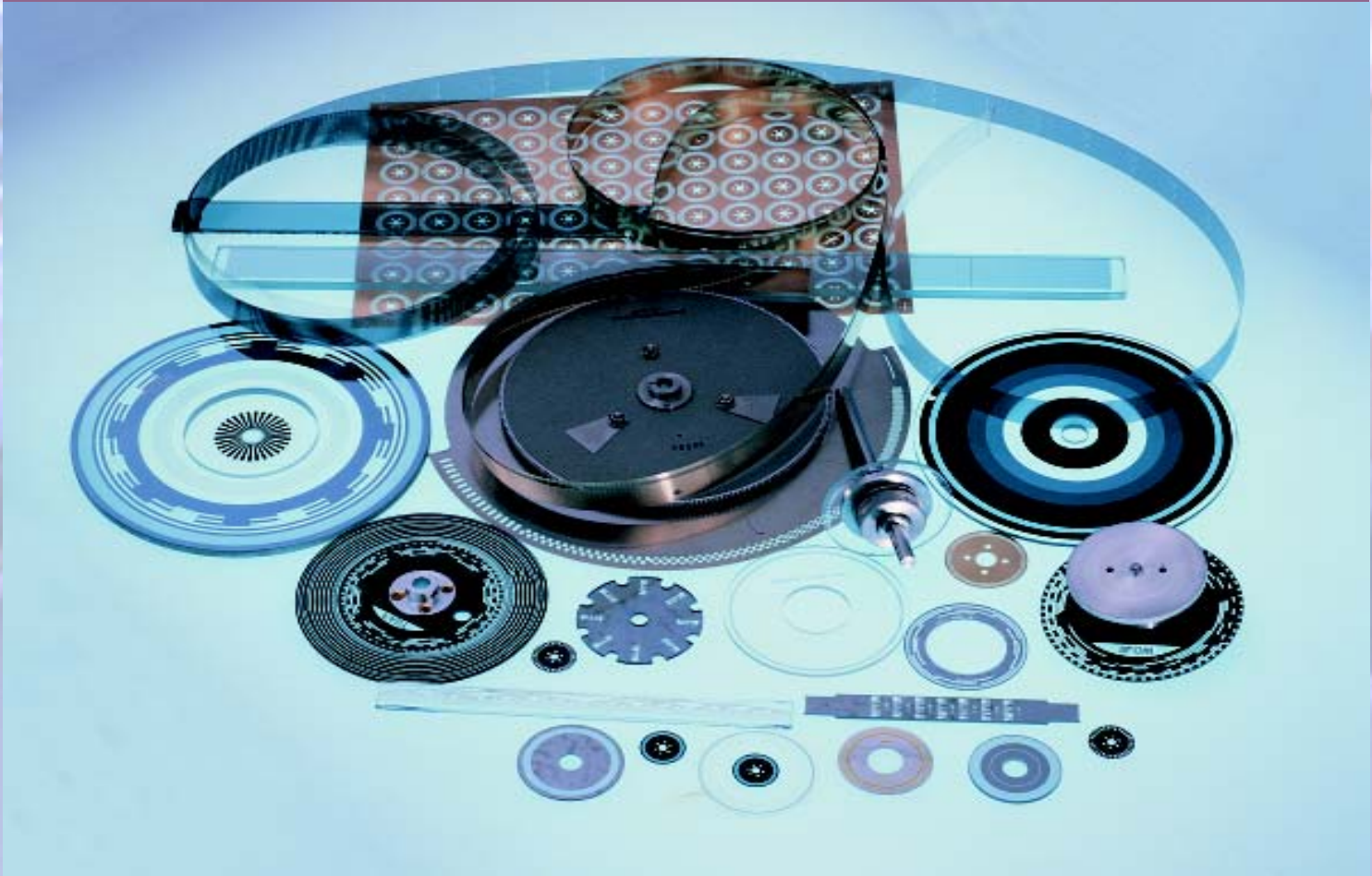
MAX LEVY AUTOGRAPH

PRECISION ENCODER SCALES, DISKS, AND READING RETICLES

BULLETIN 2200



MAX LEVY AUTOGRAPH manufactures custom **ENCODER SCALES, DISKS AND COMPANION READING RETICLES** for **OEM CUSTOMERS.** We will also custom configure **Encoder Scales, Reading Reticles, Mounts** and **Read Heads** for specific **CUSTOMER APPLICATIONS.** Types of **ENCODER SCALES AND DISKS** produced include both **INCREMENTAL** and **ABSOLUTE PATTERNS.**

INCREMENTAL ENCODER SCALES and **DISKS:** The **PATTERN** is a series of equally spaced **LINE PAIRS.** In the case of a power or other system failure the **ABSOLUTE POSITION** of the **DEVICE** being **CONTROLLED** is dependent on the resident memory capability of the **ELECTRONICS** associated with the **ENCODER READ HEAD.** A **START** or **REFERENCE PULSE** is normally provided as an **INDEX MARK** with this type of **ENCODER PATTERN.** The **READING RETICLE** is usually **QUADRATURE** with additional resolution enhancement provided by the selected **ANALOG/DIGITAL CONVERSION ELECTRONICS.**

ABSOLUTE ENCODER SCALES and **DISKS:** The **PATTERN** is a **BINARY PATTERN.** This requires **MULTIPLE TRACKS** and associated **READ HEAD EMITTERS** and **DETECTORS.** The cost of this type of implementation is higher; however, for many critical applications, such as **VALVE POSITIONS** in **NUCLEAR REACTOR PIPING SYSTEMS,** where **"LAST POSITION"** must always be known, this **PATTERN TYPE** is indicated.

MATERIALS: There are numerous materials that can be used to produce both **INCREMENTAL** and **ABSOLUTE ENCODER SCALES** and **DISKS.** Some of these are:

PLASTIC FILM: The use of MYLAR film is the least cost method of manufacturing. The disadvantage of film is its lack of dimensional stability/rigidity with changes in temperature/humidity. The **EMULSION** is also easily damaged by solvents. In PRINTING SYSTEMS, where overall size is not critical, one **LINEAR FILM ENCODER** can be tensioned and used to register all Print Engine colors simultaneously. Another application where small diameter **FILM ENCODER DISKS** have been used successfully is in low cost, slow speed, room temperature office equipment such as paper money counters.

The **RESOLUTION** of **PLASTIC FILM ENCODER SCALES** and **DISKS** is limited to the resolution of the **FILM EMULSION.** In general this limit is in the order of **40 LINE PAIRS/mm.** (A line with of 12.5 microns and a line space of 12.5 microns.) **PLASTIC FILM ENCODER SCALES** and **DISKS** are not suitable for **CLEAR OPTICAL PATH APPLICATIONS. PLASTIC FILM LINEAR ENCODERS** with **LENGTHS** to **72"** or greater can be manufactured in our current production facility.

RIGID PLASTIC: The use of **RIGID PLASTIC** is usually associated with applications where temperature cycling is modest and light weight and shock are both factors. The **PATTERN MATERIAL** is usually chrome, low reflection chrome, protected aluminum or silver. The protected aluminum or silver are used in reflective applications and gold is usually used in long wavelength reflective applications. **FLATNESS, BOW** and **SUFRACE FINISH** are not as good with **RIGID PLASTIC** as they are with **GLASS. PATTERN RESOLUTIONS** with **RIGID PLASTIC** are close to the **RESOLUTIONS** of **GLASS ENCODER SCALES AND DISKS.**

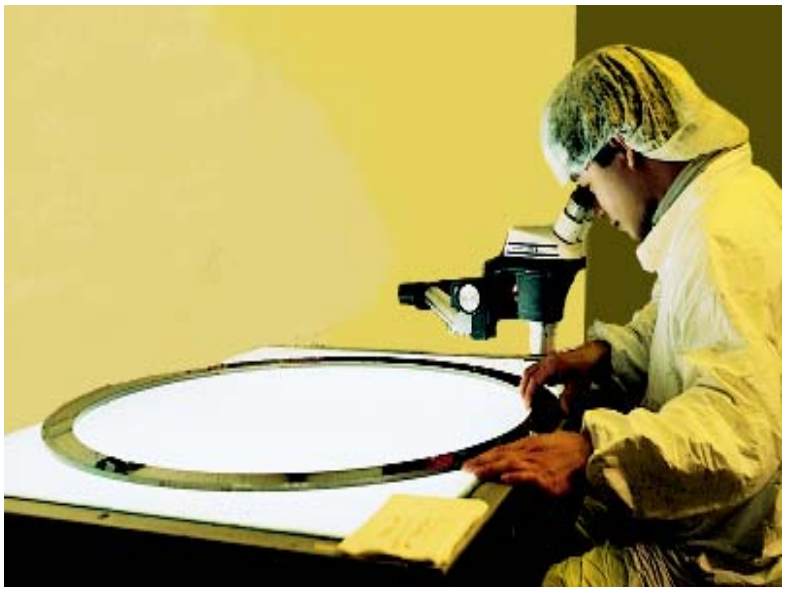
GLASS: Most **ENCODER SCALES, DISKS** and **READING RETICLES** are made from **SODA LIME FLOAT GLASS** or other **OPTICAL QUALITY GLASS.** The **PATTERN RESOLUTION** can be as high as **500-600 LINE PAIRS**/mm for **SMALL ENCODERS. LARGE GLASS ENCODER DISKS** to **60" DIAMETER** and **LINEAR SCALES** to **72"** can be manufactured in our current production facility.

NICKEL ELECTROFORMS: CLEAR OPTICAL PATH, HIGH PRECISION RADIAL and **LINEAR ENCODERS** with **RESOLUTIONS** as small as **20 LINE PAIRS/mm,** (25 micron line width and 25 micron line space.) can be manufactured by this method. When required, **LINE SPACE TOLERANCES** of **0.5 MICRONS** are also possible using our high precision manufacturing techniques. For a further discussion of our **ELECTROFORMING CAPABILITIES** see **BULLETIN 2100.**

METAL ETCHED ENCODERS: CLEAR OPTICAL PATH, MEDIUM TO HIGH PRECISION RADIAL and **LINEAR ENCODERS** with **RESOLUTIONS** as small as **10 LINE PAIRS/mm** can be manufactured by this technique. The **LINE SPACE TOLERANCE/EDGE ACUITY** is not as good as that achieved by **ELECTROFORMING;** however, **LINEAR ENCODERS** to **72"** in **LENGTH** can be produced using this method. For a further discussion of our **PRECISION PHOTOCHEMICAL MACHINING** capabilities see **BULLETIN 2400.**

PHASE DIFFRACTION ENCODER SCALES AND DISKS: These patterns are phase etched into glass and can be transmissive or reflective. They are normally tuned to a specific laser frequency.

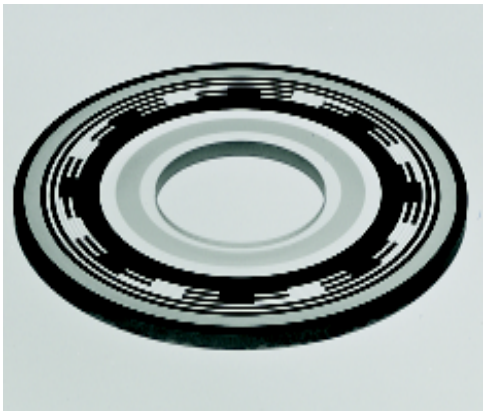
SPECIAL APPLICATIONS: Encoder tracks can also be etched into shaft diameters and shaft ends and filled with a high contrast epoxy.



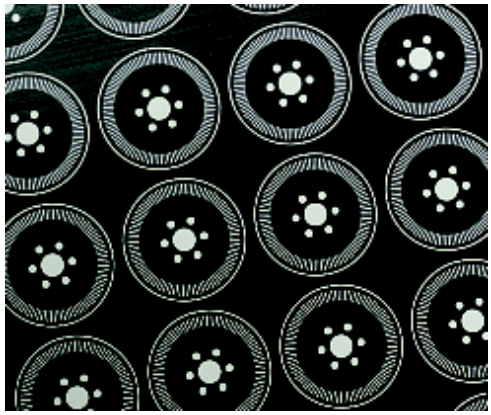
The photo above is of a **MAX LEVY TECHNICIAN** performing a **FINAL QUALITY INSPECTION** of a large **RADIAL ENCODER DISK** used to control the radial position of a **MEDICAL DIAGNOSTIC MRI MACHINE.**

The photo above is of a **STAINLESS STEEL 9" DIAMETER ENCODER DISK ASSEMBLY.** The entire assembly consists of four, .010" thick stainless steel disks, the .005" thick encoder track disk (pattern blow-up shown at right), and an aluminum drive gear. The interior disks are light weight patterned metal etched structures. The entire disk assembly is **VACUUM LAMINATED** by us using a high strength film thermosetting adhesive for maximum strength and minimum weight. The entire assembly is required to spin up to 6000 RPM within 1.5 seconds while slewing perpendicular to the center shaft axis at 30 degrees/second.

SAMPLE CONFIGURATIONS, MATERIALS, AND PATTERNS USED FOR LINEAR AND RADIAL ENCODER SCALES



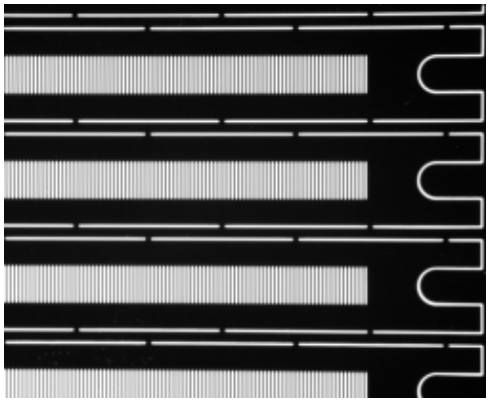
This **RADIAL/BINARY ENCODER** contains multiple tracks and illustrates some of the many options that can be custom designed into the pattern.



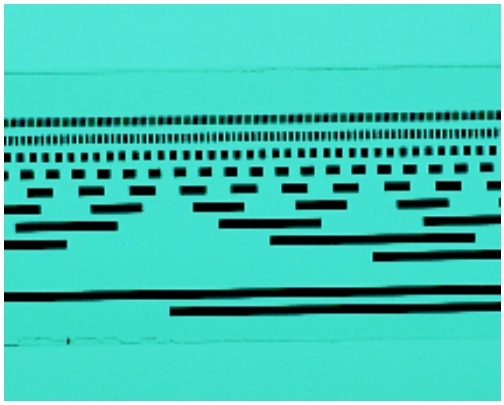
The **METAL ETCHED ENCODER DISKS** shown above are economically produced in a multiple up array in large sheets of BeCu and treated with Black Oxide for low reflectivity.

This **STAINLESS STEEL HUB/SHAFT** and **GLASS ABSOLUTE RADIAL ENCODER** designed and built by us for **NASA.**

This pattern shows some of the fine pattern detail of the chrome on glass tracks of the **BINARY/RADIAL ENCODER.**



This photo magnifies a small section of a 15 up, 10" long **ELECTROFORMED ENCODER ARRAY.** The clear optical path encoder frequency is 500 LPI (.001" lines and .001" spaces).



This photo shows an enlargement of an **ABSOLUTE LINEAR ENCODER.** The magnification permits a clear view of the design of the pattern.

MANUFACTURING METHODOLGY: MASTER PHOTOTOOLS are **PROGRAMMED** in **AUTOCAD,** converted to a suitable **MACHINE FORMAT** and **PLOTTED** on either **FILM** or **CHROME. SMALL ULTRA-PRECISION TOOLS** are plotted using **ELECTRON BEAM** Technology. **LARGER PRECISION TOOLS** are plotted using **PATTERN GENERATORS** and our own **LASER INTERFEROMETRICALLY CONTROLLED AUTOGRAPH.** These **MASTER TOOLS** are in turn replicated to make **WORKING MASTERS** which are used to image the pattern onto the production parts. See **BULLETIN 1100** for a more detailed discussion of **PHOTOTOOL** manufacturing options.

We can accept almost all graphical formats for conversion to a plot format suitable for programming the **PHOTOTOOL.** In order for the replication process to achieve the desired final part dimensions, specific line width and other compensations must be built into the **FILM** or **CHROME ON GLASS PHOTOTOOL.** This precludes the direct use of the original customer CAD files to directly generate the **PHOTOTOOL.** For extended life, some **WORKING PHOTOTOOLS** are also made in the **ETCH & FILL PROCESS** as explained on the last page of this Bulletin.

PHOTOTOOL AND SUBSTRATE COATINGS - EVAPORATIVE OR SPUTTERED

Phototool and Substrate Coatings are selected based on the density and/or reflectivity required over a specific wavelength range. Coating adhesion, durability, and substrate compatibility must also be considered.
MAX LEVY AUTOGRAPH maintains both evaporative coating and sputter coating facilities. Some of the available coatings, general specifications, and uses are as follows:

CHROMIUM: STANDARD 55% REFLECTIVITY
Opaque, dense and very durable inert coating. Used extensively for Phototooling and Replications as material of first choice. For minimum pinholes and a density greater than 3.0, two layers of about 750 Angstroms each are applied.

CHROMIUM: LOW REFLECTION, 1 TO 5%
Can be made low reflection looking at the substrate and either standard or low reflectivity looking through the substrate. Very good for critical Phototooling and Reticles and Targets used in optical systems to reduce retro-reflections and stray light.

TITANIUM
High density coating. Good for long wavelength applications and as an adhesion layer for Gold on certain substrates. Very resistant to most chemicals.

ALUMINUM - SiO
Used where high reflectivity (above 80%) is required. Not as durable as chromium. Relatively inexpensive.

SILVER AND ENHANCED SILVER
Silver is used where high reflectivity (above 92%) is required over a broad spectrum. Enhanced silver reflectivity is above 97% from .45 to 12 microns. Regular silver tarnishes unless overcoated.

GOLD
Used for long wavelength reflective mirrors and conductive grid and circuit applications. It is soft but stable.

INDIUM TIN OXIDE
Used for conductive transparent circuits.

COPPER
Used for electrical circuits and thermal conductivity.

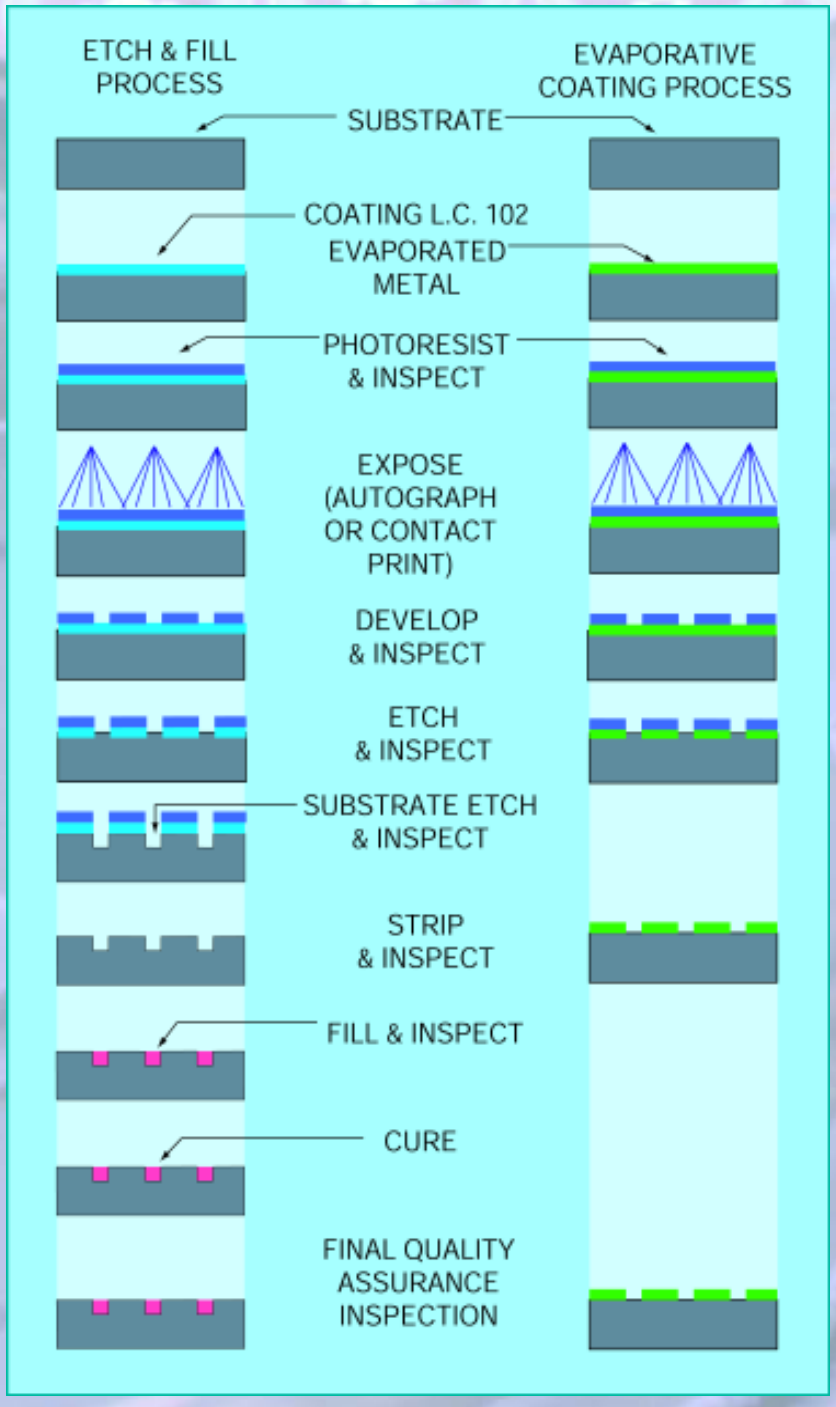
INCONEL
Used where neutral density patterns are required.

MAGNESIUM FLUORIDE
MIL-C-675 antireflective coating. 1.5% average reflectivity, 400 to 700 nanometers. Wavelength band is adjustable.

HIGH EFFICIENCY BROADBAND ANTIREFLECTIVE COATING
Provides less than 0.5% reflectivity over the visible range of 400 to 700 nanometers. Expensive when compared to MgFl. Wavelength band is adjustable.

CREATING THE PHOTOTOOL

MASTER PATTERNS and **REPLICATIONS** are produced by either:
1. Etching the pattern into the substrate, then filling the etched areas with an opaque fill.
2. Evaporative or sputter coating the substrate with chrome or another metallic, conductive, or opaque material, then etching away the areas that are to remain.



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