



**Making the
Impossible...
Possible**



 **Servometer**[®]
PRECISION MANUFACTURING GROUP, LLC

ISO 9001:2000 Certified

**Precision Bellows
and
Electroforms**



Servometer®

Servometer® designs and manufactures precision electrodeposited nickel bellows, bellows assemblies, flexible shaft couplings, electrical contacts and lightweight structural electroforms.



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Reflections of the Past and A Vision for the Future

Servometer® was founded in 1957 when two engineers, Morris Holowachuk and Fredrick Kelly, decided to create an improved “servometer” for instrumentation and related industries.

Finding only a limited market for their “servometer” design, the two men changed their business focus and developed and patented a unique method to manufacture miniature bellows. These ultra precise electrodeposited bellows would soon become Servometer’s core product.

In 1962, Servometer relocated from a small factory in Passaic, NJ to larger accommodations in the neighboring town of Clifton. The Company continued to grow and expand, and in 1974 moved to its current state-of-the-art location in Cedar Grove, New Jersey.

In 2001, Servometer Corporation became Precision Manufacturing Group, LLC; continuing the business as Servometer – PMG, LLC. Servometer is a global leader in the design and manufacture of custom designed electrodeposited miniature metal bellows, bellows assemblies, and other bellows related products.

In 2007, Servometer – PMG, LLC acquired BellowsTech, LLC of Ormond Beach, Florida. BellowsTech is a premier manufacturer of edge welded bellows and assemblies, encompassing a wide array of alloys and dimensional configurations.

Precision Manufacturing Group, LLC continues to perfect its technical expertise while “making the impossible, possible”, and is focused on providing the means and the opportunities to grow and improve. Together, as one united team, we will go above and beyond the expectations of our customers.

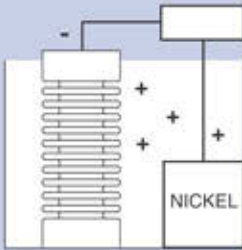
“We are proud of our past, excited about our future and confident of our continued success.”

Electrodeposited Nickel Bellows

SERVOMETER'S PROCESS OF ELECTRODEPOSITION



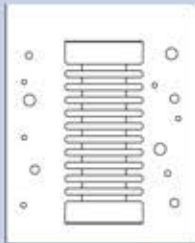
Machine Mandrel



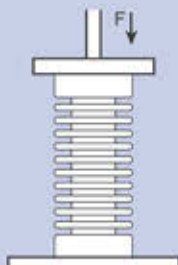
Electrodeposit Nickel onto Mandrel



Trim Plated Mandrel



Dissolve Mandrel



Spring Rate Bellows To Check Wall

Servometer miniature metal bellows can be used for metallic hermetic seals, volume compensators, pressure and temperature sensors, flexible connectors, and countless other applications where quality, dependability, reliability and long life are critical requirements.

There are five major types of metal bellows: rolled, hydroformed, welded, chemically deposited and electrodeposited.

Electrodeposited bellows are manufactured by forming a mandrel to the shape of the inside of the bellows, depositing the proper thickness of spring quality metal onto the mandrel, trimming the plated mandrel to define the ends, and finally dissolving out the mandrel. This leaves behind a thin convoluted tubular shell of plated metal which is the bellows. Servometer is the foremost manufacturer of electrodeposited nickel bellows. Bellows made of copper, silver and gold are also available. Electrodeposited nickel bellows have the following advantages over the other types of bellows:

1. The electroplating process allows us to carefully control the wall thickness of the bellows. Because the bellows walls can be made thinner than the other types (down to .0003 inch), they are extremely sensitive. This makes them excellent for very accurate instrument applications requiring a high degree of sensitivity. They can provide large deflections with only very minute forces. Servometer has manufactured a custom bellows that can fully compress with as little as 4 grams of force.
2. Electrodeposited nickel bellows are the most flexible bellows. They offer superb performance in applications such as hermetic sealing of switches and circuit breakers, and other applications requiring a reliable, dependable, dynamic hermetic seal.
3. They can be designed for compression strokes up to 60% of their free length, and combined with a greater I.D./O.D. ratio, giving them a volume displacement capacity equal to or larger than most other types.
4. Servometer bellows can be designed for "infinite" (100×10^6 cycles) life expectancy and have a normal minimum life of 100,000 cycles.
5. They are seamless and non-porous. No dust, dirt or moisture can lodge in seams and cause contamination in critical applications.
6. Servometer bellows are leak tight to 1×10^{-9} std. cc/sec. by helium mass spectrometer.
7. Servometer bellows can be made in sizes smaller than any other bellows. Many of today's sophisticated applications require a miniaturized bellows. Servometer bellows can be made as small as .020 in. in diameter and still retain full sensitivity and flexibility.





Servometer®

Electrodeposited Nickel Bellows

TYPICAL BELLOWS APPLICATIONS

- Pressure responsive devices, as the sensing element in pressure switches, pressure gauges, pressure actuators, pressure transducers, aneroid and volume compensators
- Athermalization Bellows assemblies where changes in temperature are translated into linear displacement or motion
- Flexible seals
- Flexible shaft couplings
- Vibration Isolation

METAL COMPOSITION

Servometer's standard material is an electrodeposited Nickel alloy. Other materials include, but are not limited to: Copper, Gold and Silver.

Servometer bellows typically have a .0001 in. lamination of copper between equal thicknesses of nickel.

Servometer electrodeposited nickel alloy has a chemical analysis similar to that of commercial "A" nickel (with the exclusion of the copper lamina).

Nickel plus cobalt:	99.8%
Interstitally deposited impurities: (Oxygen and carbon)	.05%

Three grades of nickel are supplied as required:

Regular Nickel:

This metal is bright and high in yield strength. However, it cannot be welded or brazed because it contains .04% maximum sulfur which causes it to embrittle when heated above 350°F.

Low Sulfur Nickel:

This metal is "satin" finish, equivalent to regular nickel, except it contains only .02% maximum sulfur and is much more corrosion resistant. It can be soldered or brazed without embrittlement, but care must be taken to avoid annealing of the convolutions.

Weldable:

Equivalent to low sulfur nickel with .02% maximum Sulfur, but it can be welded or brazed without embrittlement.

Mechanical Properties of Servometer Nickel Alloys:

- Tensile strength = 125,000 psi
- Yield strength = 110,000 psi
- Elongation = 1.0%
- Hardness = 270 Vickers, (100 gms load)
- Young's Modulus = 23,350,000
- Metal hysteresis within stress limits is very low
- Specific Weight = .321 lb/in.³

SURFACE FINISHES

Servometer bellows normally have a bright corrosion resistant surface, but the following finishes are available:

1. Gold plate (24 carats), per ASTM B488-01. Gold plate is normally supplied to allow soft soldering without flux, or to provide a surface for microwave fields.
2. Silver plate which is usually applied where a bellows is used for a microwave waveguide.
3. A parylene conformal polymer coating can be supplied for certain corrosive conditions.

LEAK TIGHTNESS

All Servometer bellows, so specified, are leak tested 100% on a Helium Mass Spectrometer leak detector, 1×10^{-9} std. cc/sec. This rate amounts to one cubic centimeter of helium in 32 years.

ENVIRONMENTAL TOLERANCES

Temperature Tolerances:

Servometer nickel bellows are ideal at low temperatures such as liquid oxygen or liquid hydrogen points, where they retain toughness and gain some 30% in strength.

At high temperatures, the limit is about 350°F, above which regular nickel embrittles and sulfur free nickel anneals. In certain instances higher temperatures are attainable. Our engineers are ready to discuss your requirements.

Magnetic Properties:

Servometer's electrodeposited nickel is ferromagnetic. Electrodeposited copper is non-magnetic and can be utilized for special applications.

Corrosion Resistance:

Nickel is more resistant to corrosion than brass or bronze, but not as much so as stainless steel. Nickel bellows will not oxidize in air nor be affected by liquids that are alkaline, but will not withstand acids. In sea water, nickel bellows are attacked after a few weeks because of electrolysis where dissimilar metal fittings are used. Sulfur free bellows are much more corrosion resistant than regular nickel bellows. As in all corrosion problems, each situation must be evaluated alone. Many corrosive conditions are successfully handled by nickel bellows, and the customer should request data and operate prototypes under his environmental conditions before adopting a design.





Servometer®

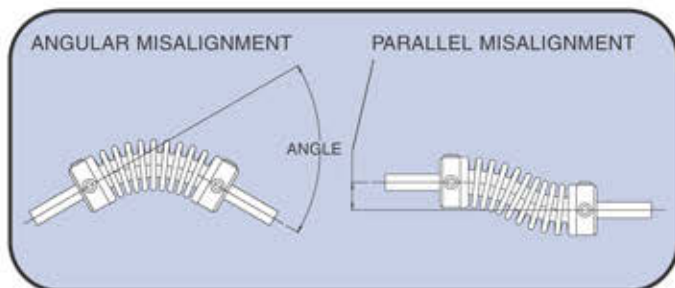
Flexible Shaft Couplings

Precision motion control applications require mechanically tight systems, especially between motors, driven loads, and feedback devices, to ensure accurate positioning. Such systems often require shaft couplings that are both torsionally rigid, to accurately transmit rotational position, and laterally flexible to accommodate shaft misalignment.

Light industrial precision applications, for example, often include bellows-type flexible couplings to connect power transmitting devices, such as step motors or servomotors; or positioning mechanisms, such as ball screws or lead screws; to motion control feedback devices.

The feedback devices are usually of two types: position sensors, such as optical encoders, resolvers, and potentiometers, and velocity sensors, such as tachometers. In a typical system, a motion controller translates the sensor feedback into instructions for the motor.

Servometer flexible shaft couplings provide torque capabilities from 2 oz.-in. to 20 lb.-ft. for shaft sizes ranging from .090 to 1 inch. Because of their flexibility, the low torque couplings can handle angular misalignment up to 31 degrees or parallel misalignments (shafts parallel but offset) up to .076 in. In general, as flexibility increases, torque capacity decreases.



Servometer couplings exhibit both low wind-up, due to torsional rigidity, and low side thrust because of lateral flexibility. Other coupling types have either low windup or low side thrust; but not both.

Servometer flexible shaft couplings are precision electrodeposited nickel bellows-type couplings, made using Servometer® brand precision electrodeposited nickel bellows. Bellows couplings are indispensable for use on critical applications such as resolvers, encoders, servos, motion control devices, and computers.

The unique characteristics of the bellows couplings are:

1. Zero Backlash
2. Very low elastic wind-up
3. Zero Cyclic Speed variation during 360° rotation
4. Low side thrust on bearings
5. Vibration damping capability

In addition, flexible bellows couplings with specialized dynamic requirements can be custom designed to fit customers specifications.

For attachment to shafts, the following hub styles are available: standard set screw type hub, split hub with clamping collar or the integral clamp hub.



SERVOMETER SERVOMETRIC® METRIC FLEXIBLE SHAFT COUPLINGS

In response to a growing global demand for highly accurate, highly reliable precision flexible shaft couplings, Servometer now offers the Servometric® line of Metric Flexible Shaft Couplings.

Servometric® Flexible Shaft Couplings are designed to absorb angular and parallel misalignments in combination with axial movements, while precisely transmitting torque.

The Servometric® line of bellows type flexible shaft couplings have zero backlash and extremely low windup (as low as 4.4 arc sec/Ncm), making them ideal for critical precision positioning applications. Since the flexible element is a bellows, the coupling can absorb parallel shaft misalignments up to 1.73 mm, angular misalignments to 31°, and axial movements of 5.84 mm, or a combination of all three, while precisely transmitting torque loads.

Servometer's stock line of flexible shaft couplings have a torque range from 1.4 Ncm to 198 Ncm. Outside diameters range from 6.4 mm to 61 mm and overall lengths from 12.7 mm to 62 mm. Larger sizes and greater torque capabilities are available on a custom basis.



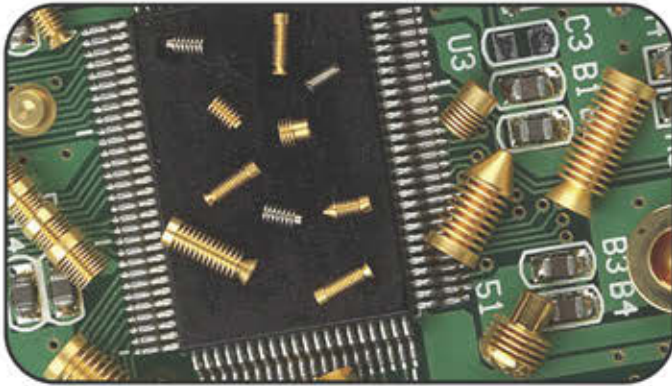
Bellows Contact Springs

SERVOMETER GOLD PLATED BELLOWS CONTACT SPRINGS

Servometer's line of miniature flexible gold plated bellows contact springs insure reliable electrical continuity, with a lifetime of spring and force repeatability, in applications where tolerance buildup, vibration, and thermal expansion would otherwise be problematic. Their spring flexibility allows them to minimize shock and vibration in dynamic applications.

Due to their very low spring-rates, force requirements of .04 oz. (1.13 gms) per .001 in. of travel are available. This allows designs to be made where contact with a delicate component or material is required.

Servometer bellows contact springs are manufactured from electrodeposited nickel alloy and gold plated to enhance their conductivity. Most of the end cups are designed to fit over standard sized pins or into recesses, connecting them to other components without the necessity of soldering.



Bellows type contacts provide the following benefits.

1. They have a minimum of self inductance.
2. They have extremely low DC resistance.
3. They have a minimum of insertion loss.
4. They have lifetime spring repeatability.
5. They require moderate forces to insure good contact between the two mating parts.
6. They can be, if required, packaged in anti-static (ESD) packaging.

With outside diameters ranging from .037 in. (1 mm) to .245 in. (6.22 mm), they are available and in stock from Servometer.

LIFE EXPECTANCY

Servometer contacts can be designed for life expectancies ranging from 100 to 100×10^6 cycles.

ENVIRONMENTAL TOLERANCES

Servometer contacts listed in this catalog can be safely used up to 260°F and maintain their full spring qualities. There is no low temperature limit. Servometer bellows are presently operating at temperatures of -423°F below zero.

METHODS OF MOUNTING

In many applications it is possible to simply insert the open end of the bellows onto a pin and press assemble into place. Alternative methods include spot welding, soldering or a conductive epoxy.

CURRENT RATING

Servometer contacts are rated for a maximum current of 4 amps.

CUSTOM MADE CONTACTS

If one of Servometer's standard contacts does not meet a customer's requirements, Servometer's experienced design engineers will design a custom contact to the customer's unique specifications. Custom contacts can be designed with bellows diameters as small as .020" (.5 mm).

BELLOWS CONTACTS FOR RELIABLE INTERCONNECTIONS

Servometer's Interconnectic line of miniature gold plated bellows contact springs were designed for flexible interconnections. Their diameters range from .037 in. (.94 mm) O.D. to .125 in. (3.18 mm) O.D. These unique contacts come with either a convex conical or concave conical tip, which will allow them to be used in critical interconnection applications where reliability, flexibility and low force are a must. These contacts can be used individually or in pairs. When misalignment is a problem, the unique pairing of a contact with a convex conical tip with a contact with a concave conical receptacle tip allows them to self align as they make a connection.

These contact springs are manufactured from electrodeposited nickel alloy and gold plated to ASTM B 488-01, to enhance their conductivity, and provide extremely low DC resistance with a minimum of insertion loss. They are designed to provide lifetime spring and force repeatability. These interconnect contacts will:

1. Minimize shock and vibration in dynamic applications.
2. Help overcome tolerance buildup and misalignment problems in critical assemblies.
3. Allow the designer a less expensive alternative to high cost assembly components with tight tolerances.





Servometer is a world leader in the custom design and manufacture of precision electroforms.

Servometer electroforms can be found in critical high tech aerospace, electro-optic, EMI, medical and military applications.



THE ADVANTAGE OF SERVOMETER ELECTROFORMS

The technique of making parts by electrodeposition is over 150 years old, yet it is only in the last 50 years that this method has been used successfully to make extremely intricate parts with deep crevices or odd shapes.

Servometer is capable of manufacturing many specialty electroforms which normal electroplating companies cannot produce. Servometer electroforms can be made with unusual shapes, close tolerances and are light weight with a rugged structural rigidity.

Servometer electroforms are produced by electrodepositing a thin layer of nickel alloy onto an aluminum mandrel of any shape – then chemically dissolving the aluminum, leaving behind a thin shell of tough nickel alloy, which is the electroform. (This electroplating process has been perfected by Servometer over the years while manufacturing millions of metal bellows, using the same technique.)

The advantages that Servometer electroforms offer are:

- extreme light weight, yet tremendously rugged.
- unusual shapes which can even be made with varying cross sections.
- very small sizes.
- surface micro-finishes as fine as 4 R.M.S.
- extreme close tolerances.
- varying wall thickness on a single part (if required).
- can be made as an intergral unit with a bellows, eliminating welding and soldering.
- can withstand extreme temperatures, even down to -423°F.

Servometer can supply electroforms which range from .020 in. (.5 mm) to 9 in. (229 mm) in diameter. Larger parts are also practical in certain instances. The basic electroform material is nickel, but copper, silver and gold are also available, either as a complete part or as a surface finish.



Servometer®

Complete Bellows Subassembly Services

WHY OUR CUSTOMERS LEAVE SUBASSEMBLY TO US

1. To get a specialized job done right.
2. To focus on our core competence.
3. To reduce parts count.
4. To simplify assembly, purchasing, scheduling.
5. To reduce scrap rate on high added-value parts.
6. To improve process control.
7. To reduce total part costs.



With over 50 years of subassembly know-how, combined with necessary leading-edge technologies, we'll get your job done exactly right – on spec, on time, every time. Our experienced design engineers will work with you to value engineer your custom application for manufacturability. The result...a high quality product, at the most economical cost.

Outsourcing this very specialized job to Servometer subassembly specialists benefits you in several ways. Mainly, what loomed as a troublesome variable or bottleneck in your operation becomes a reliable constant you can depend on. You will also reduce your parts count and scrap rate and simplify assembly, scheduling and purchasing. Improve your process control and risk management, too.



What makes bellows subassembly so specialized? The ultra-thin walls make bellows vulnerable to damage, especially heat damage, unless handled expertly. Even the "cool" area of the tiniest soldering flame can overheat a 0.001-inch bellows wall to 1000°F, ruining an expensive part in the blink of an eye. In a brazement, a void no bigger than a dust mote can trigger a leak in an avionics instrument at 50,000 feet. And the tiniest speck of residual flux can eat through the wall of a nickel endoscope component during a diagnostic procedure.

We understand the problems, and have developed the proprietary solutions. And given the critical nature of so many medical and aerospace applications for bellows, we certainly understand what's at stake for you.



Servometer has done literally tens-of-thousands of subassembly jobs for demanding bellows customers. In fact, more than half of our bellows customers have us handle the subassembly as well. Many who once did it themselves now leave the whole job up to us.

APPLICATION SUPPORT/VALUE ENGINEERING

Contact us with your design or concept questions. Servometer's experienced design engineers are on staff and waiting to work with you to create an innovative design solution, that meets your requirements at a reasonable price.



With Pro/ENGINEER CAD/CAM software, our design engineers will transform your requirements into accurate parts with re-liable performance. Collaborating with you, they will also suggest improvements to enhance manufacturability and consistency while preserving functionality.

SUBCOMPONENT SUPPLY AND LOGISTICS

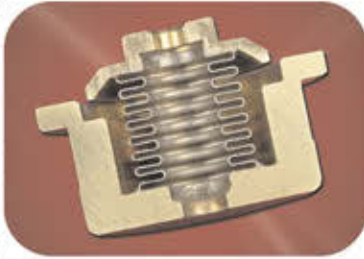
Servometer can manufacture or procure all the necessary sub-components for your assembly requirements, to save you the expense of handling the supply logistics yourself. Servometer will assume single-source responsibility for quality, delivery and price of the finished subassembly.

TORCHLESS BRAZE

Servometer does not usually suggest brazing the precision electrodeposited nickel bellows to custom end pieces due to the heat involved and the difficulties protecting the bellows material from overheating. Servometer employs brazing two joint subassembly end pieces together with a proprietary induction brazing process using an induction machine, so that they can be subsequently soft soldered to a bellows or an electroform.

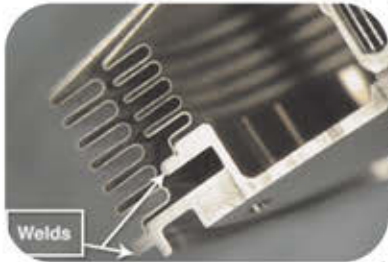
FLAMELESS SOLDER

Servometer's assembly personnel are experts in soldering Servometer miniature metal bellows and electroforms to custom end pieces. To avoid overheating the bellows, Servometer's assembly experts do all the soldering by hot irons or custom hot plates, never with flame, employing time-tested proprietary processes. Servometer's solder joints are leak tight and can be tested to 1×10^{-9} cc He/sec. By practice, Servometer employs only ROHS compliant solders, unless otherwise specified by your requirements.



ULTRA CLEAN WELD

Servometer's assembly personnel are experts in electron beam welding of Servometer miniature metal bellows and electroforms to custom end pieces. Electron beam welding enables Servometer to weld electroformed nickel components in leak-tight assemblies with state-of-the-art computer process control. Electron beam welding imparts only localized energy to the work piece, minimizing distortion of thin parts. It also produces exceptionally clean welds in parts that cannot tolerate contamination. Servometer produces a precision sensor assembly for a military aerospace application by e-beam welding a bellows less than .001 thick to a stainless steel end piece. With a properly designed weld joint, Servometer can e-beam weld parts from .03" to 8" in diameter.



SECONDARY ASSEMBLY

Servometer can also supply your next level assembly requirements. Let Servometer take care of screw insertion and other secondary operations. You'll get a complete sub-assembly. We're doing it for others, so we can do it for you.

ENGRAVING

Our computerized engraving services handle part identification and serialization for production lot control. Due to the thin walls of electrodeposited bellows and electroforms, we do not suggest that these components be serialized, but that the engraving be applied to the custom end pieces assembled to these electroformed components.

ADHESIVE BONDING

We're specialists in close-tolerance adhesive bonding with epoxy, anaerobic or cyanoacrylate adhesives. The adhesive application area and thickness are closely controlled for cleaner, sounder assemblies.

POST ASSEMBLY SEALING, BACKFILLING, COATING

Servometer subassembly services can provide sealed, evacuated, or backfilled (with gas or liquid) bellows assemblies for pressure and temperature responsive applications.

Servometer can also provide specialized coatings, gold, silver, copper, or parylene copolymer coatings for custom requirements.



MACHINING

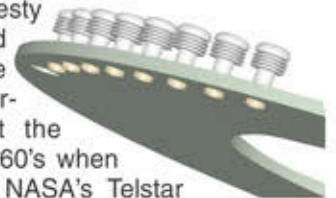
Our experienced machinists in our fully equipped machine shop will fabricate any necessary machined subcomponent. Leading edge CNC workstations use Pro Engineer CAD/CAM software to faithfully reflect your custom design in every finished component. Our experienced design engineers will work with you to design custom precision components to your exacting specifications.



TESTING

Servometer is fully equipped to handle life cycle fatigue, pressure response, and helium leak testing, as well as dimensional inspection. Our Helium Mass Spectrometer leak detects any leakage beyond 1×10^{-9} std cc/sec – less than 1 cc in 32 years.

Our tradition and history are built on a fundamental philosophy of hard work, honesty and teamwork. Dedicated people providing innovative solutions to serve ever-changing times have built the company. From the early 1960's when our products were part of NASA's Telstar Satellite Program, until today, providing precision parts for the United States Air Force air combat missiles and the Space Shuttle Program, Servometer has remained the benchmark of the industry.



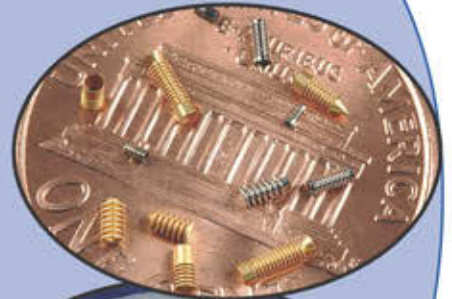
We are proud of our past, excited about our future and confident of our continued success.



*"Precision
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MINIATURE METAL BELLOWS

Servometer custom designed, electroplated, nickel alloy metal bellows serve a variety of needs in aerospace, medical devices, instrumentation and related critical fields. Key attributes are extreme sensitivity and long fatigue life.



COUPLINGS

Servometer zero-backlash, flexible shaft couplings meet rigorous needs in precision rotary positioning systems, where high flexibility, sensitivity, and extreme accuracy in dimensional tolerances and concentricities are critical.

CONTACTS

Servometer self-aligning spring contacts meet critical solderless connection needs in miniature electronic applications, and feature negligible insertion and inductance loss. They are ideal for repetitive connect and disconnect.



ELECTROFORMS

Servometer lightweight, structurally rigid electroforms are the ideal solution for needs involving unusual shapes, close tolerances, high strength and ultra-thin walls. Servometer manufactures many specialty electroforms which other electroplating companies cannot produce.