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CAREERS/DEVELOPMENT NEWS AND APPLICATIONS FOR DESIGN ENGINEERS

OCTOBER 2, 1989

DESIGN NEWS

ANNUAL LAUNCH ISSUE

*Technical advances in the '90 models
Readers sound off on car trends*

*Inside story on Eaton-Ford supercharger
Editors test drive the passenger*



Mazda Miata: Overnight Sensation

ESIGN ENGINEERING SHOW EAST/NEW YORK



SMART SUSPENSIONS FOR THE IDEAL RIDE

New technology could produce
the comfort of a Cadillac and the handling of a Porsche

Keith Stuart, Aura Systems, Inc., Los Angeles, CA

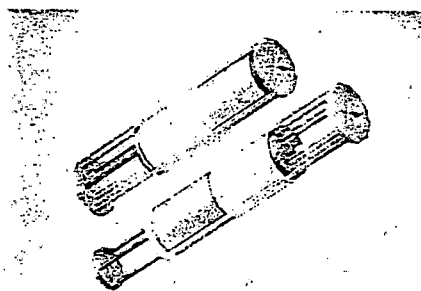
Imagine designing a car that combines the snappy handling of a sports car with the smooth, quiet ride of a luxury sedan? A new active suspension system, based on magnetic principles rather than hydraulics, may be the answer for that ever elusive suspension system.

Today, the consumer's desire to have it all is spurring more design engineers to take a hard look at the commonly used passive automotive suspension, and even the basic technology behind the new active suspension systems.

Several automotive designers are turning from traditional systems which consist of coil or leaf springs and hydraulic or gas shock absorbers to more "intelligent" active suspension systems.

Active systems use sensors to continuously monitor the car's wheel position, body position, and vibration levels. This sensed information is fed into a microcomputer that commands a force transducer or actuator, which in turn applies the force to each wheel for the instantaneous ride performance.

Such systems offer tremendous improvements in ride and handling over the passive spring-damper systems. To the consumer, they prom-



By creating a force from electricity, the new actuator provides an active suspension system that is fast and energy efficient. Prototype assembly is set, and the new design should be ready for commercial use soon.

ise smoother, safer rides by providing increased ride control, plus much faster response times to changing road surface and driving conditions. For example, an active system can simultaneously keep the car level when turning corners or breaking, and still provide superior vibration isolation from bumps and other road hazards.

Currently, several companies are basing their active system design on an hydraulic actuator that creates the force needed for the improved performance. However, Aura Systems has developed a force transducer based on magnetics. Instead of the microcomputer commanding hydraulic pumps and

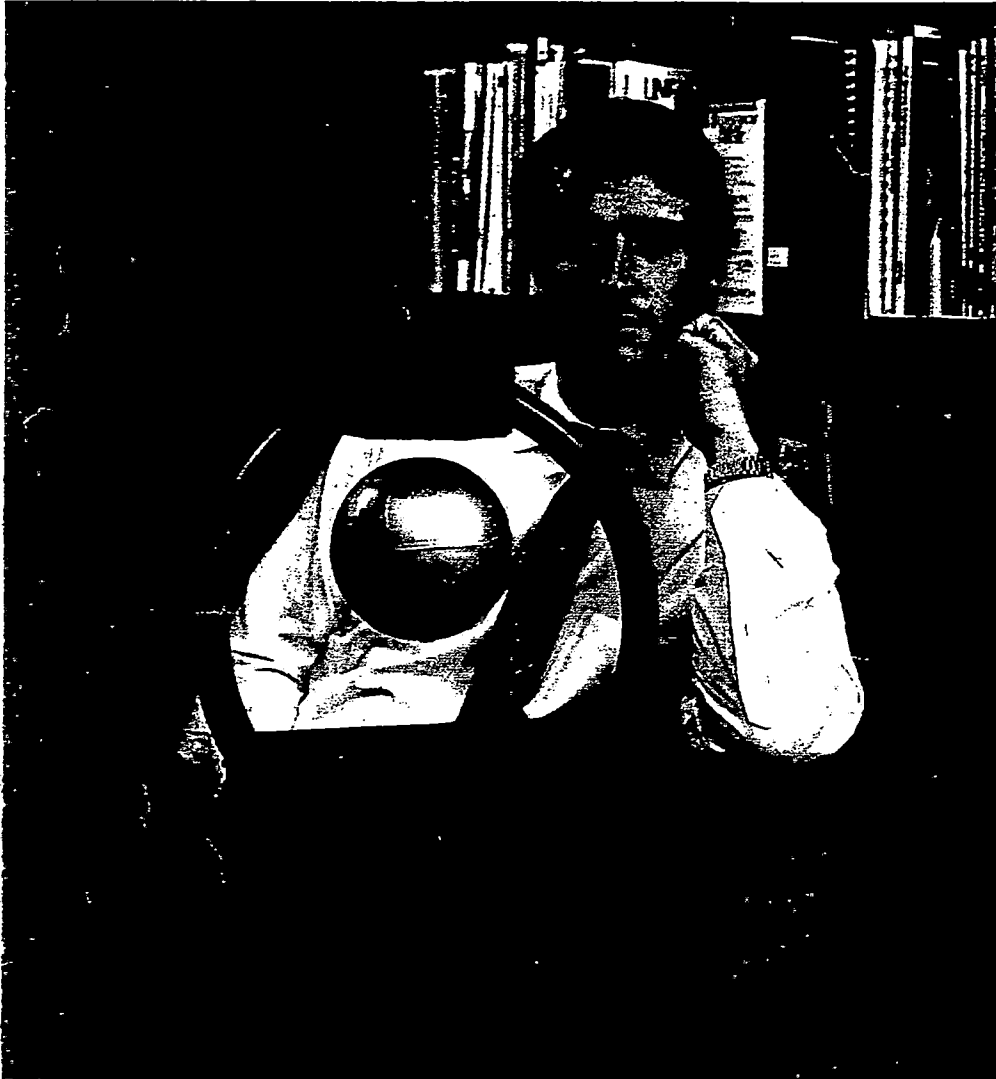
valves, the company's magnetic actuator can be commanded electronically. The result is a faster, quieter, and more efficient operation.

Why magnetics?

Suspension systems in luxury cars concentrate on controlling wheel motion, while those in sports cars emphasize body motion. A luxury car's lightly damped, softly sprung, passive suspension system is excellent for maintaining a smooth, soft ride over random road bumps—effects that exhibit high-frequency vibrations. However, such a system is inadequate for keeping tight control of the car's lower frequency body motion when cornering at medium to high speeds. That's where sports cars have the advantage.

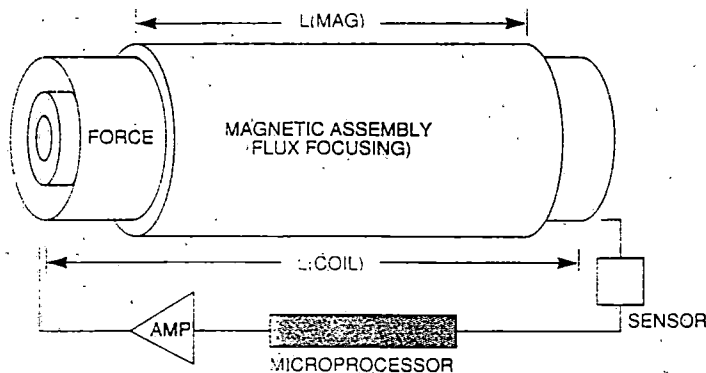
The ideal suspension system would simulate the soft springs of luxury cars for high-frequency wheel motion, and the modified response of sports cars for low-frequency body motion.

Aura Systems started perfecting magnetic suspension technology for a number of defense applications. Based on proprietary digital electronics and advanced magnetics, this technology eliminated the mechanical links and supports needed in a wide variety of machinery and



Stuart illustrates the power and advantages of magnetic suspension technology by levitating a revolving ball.

COMPLETE SUSPENSION SYSTEM



Besides magnetics, the smart suspension system incorporates electronics, sensor, and microcomputer technology. Its benign failure mode provides a margin of safety not possible with active hydraulic systems.

equipment. By "free floating" or levitating an object and allowing it to move with 3 to 6 deg of freedom, magnetic suspension technology minimizes—or virtually eliminates—friction, wear, noise, and vibration, as well as excessive heat to moving parts. The overall benefits included lower system cost and weight, and longer lasting units.

Basically, the magnetic actuator has two major assemblies: a magnetic assembly, to be mounted on the car body; and a coil assembly to be mounted on the wheel. By commanding current through the coils, a force is produced axially between the coil and magnetic assemblies. This force allows the microcomputer to manipulate the wheel in order to provide a superior ride. By contrast, an hydraulic automotive actuator relies on high-pressure oil and sophisticated, high-speed mechanical valves to produce the same relative force.

This breakthrough in actuator technology provides the efficiency and "travel"—the distance the actuator can move—required for automotive suspension applications. The key is in the advanced magnetic design that focuses on the magnetic fields or flux on the coil in such a way as to maximize the work performed by the current flowing through the coils.

In order to maximize the work, we had to examine the basic equation that governs all linear actuators—Lorenz' Law:

$$F = iL \times B$$

Where:

F is the relative force (in Newtons)
 i is the current (in amps)
 L is the length of wire in the magnetic field (in meters)
 and B is the magnetic flux density (in teslas).

After months of finite element magnetic analysis, we optimized the relationship between the current, the length of wire coil, and the flux,



to produce an actuator strong enough—and inexpensive enough—for an automotive suspension application. The efficiency or force-to-current ratio is increased substantially. The result is an actuator that achieves up to 560 lbs of force at an efficiency of 25 lb/amp. It is 6 inches in diameter, and provides 8 inches of “throw.”

Testing it out

The actuator is used in conjunction with a coil spring, and is sized as a direct replacement part, with a slightly larger diameter to current passive shock absorbers. The spring provides the force required to hold up the automobile's weight. Under normal driving conditions, the microcomputer monitors the changing road conditions. It commands the actuator to minimize the level of vibration passed from the road through the spring, and to keep the wheels rolling smoothly.

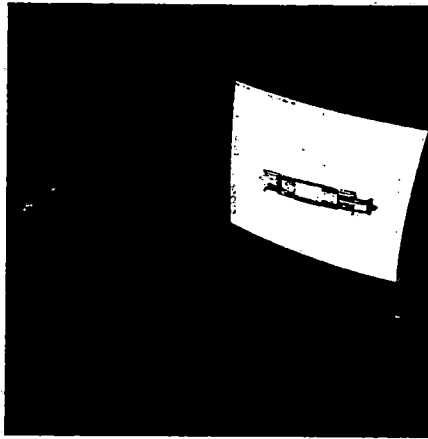
At the same time, the car body is monitored to keep it level at all times. This control not only prevents the boat-like feeling one gets in some luxury cars, but also improves handling during sudden turns, stops, and accelerations.

The system weighs about 200 lbs, and runs directly off the alternator. Under normal driving conditions, no more than 0.25 horsepower (hp) is consumed. During a severe maneuver, such as a panic stop, about 3 hp is drawn from the engine through the alternator.

Besides four magnetic actuators, Aura's suspension system requires an electronics module containing the microcomputer and actuator power drivers. This module can easily fit into the trunk of the car and is larger than a trunk-mounted, stereo power amplifier.

Safety conditions

A major concern of automotive equipment designers is safety. When working properly, an active suspension system improves safety



Using finite element analysis, Aura optimized the relationship between the current, coil length, and flux. Here, Stuart examines magnetic actuator design.

by increasing stability, even during panic situations. But what happens if the system fails during one of those panic situations?

Under no power, the magnetic actuator, due to an actuator phenomenon called back-EMF, behaves like a light passive damper. Back-EMF is a voltage developed in a coil when the coil moves through a magnetic field. It is directly proportional to the speed at which the coil moves. The voltage creates current which, by Lorenz' Law, creates a force to oppose the velocity. Therefore, under failure mode, the magnetic actuator reverts back to a passive damping system similar to that of luxury cars. All that is lost is the ability to keep the car level during a maneuver.

By contrast, an active hydraulic system becomes rigid during failure making the car undrivable.

A strong market

Aura's developments in magnetics, we feel, have led to several achievements in miniaturization, extremely accurate pointing, and very precise control of magnetic devices. And in several cases, this magnetic suspension technology provides the only solution to the vibration problems and line-of-sight requirements of military sensors.

New defense applications include

magnetic suspension equipment that tests missile seekers without destroying them, and magnetic gimbals that isolate delicate sensor systems from vibration, such as airborne reconnaissance cameras.

The military is not alone in recognizing the benefits of this technology. Analysts are predicting a strong market for commercial applications such as “frictionless” low maintenance, long lasting motors, pumps, and compressors. And, high-speed motors may expand the applications into more advanced areas, such as computer disk drives and fiber-optic guided missiles.

Active suspension systems for automobiles have a very promising future. According to the University of Michigan's first Automotive Electronic Delphi study, which comprises of the opinions of 100 automotive engineers, 20% of all cars built in 1995 will contain electronically controlled active suspension systems.

We believe the cost to the consumer for a magnetic active suspension will be about \$2 000. By contrast, active suspension systems based on hydraulics, are expected to be substantially more expensive, even in production quantities. And, if developments proceed as planned, magnetic active systems will be available in a few years.

Will they eventually replace all shock absorber systems? Probably not. In many situations, normal shock absorbers do the job, and their cost will undoubtedly remain quite a bit lower than active suspension systems. Nevertheless, many people still want to pay the extra price for an automobile that rides like a luxury car, and corners flatter than any sports car. □

An electrical engineer, Stuart is vice president, magnetics, at Aura.

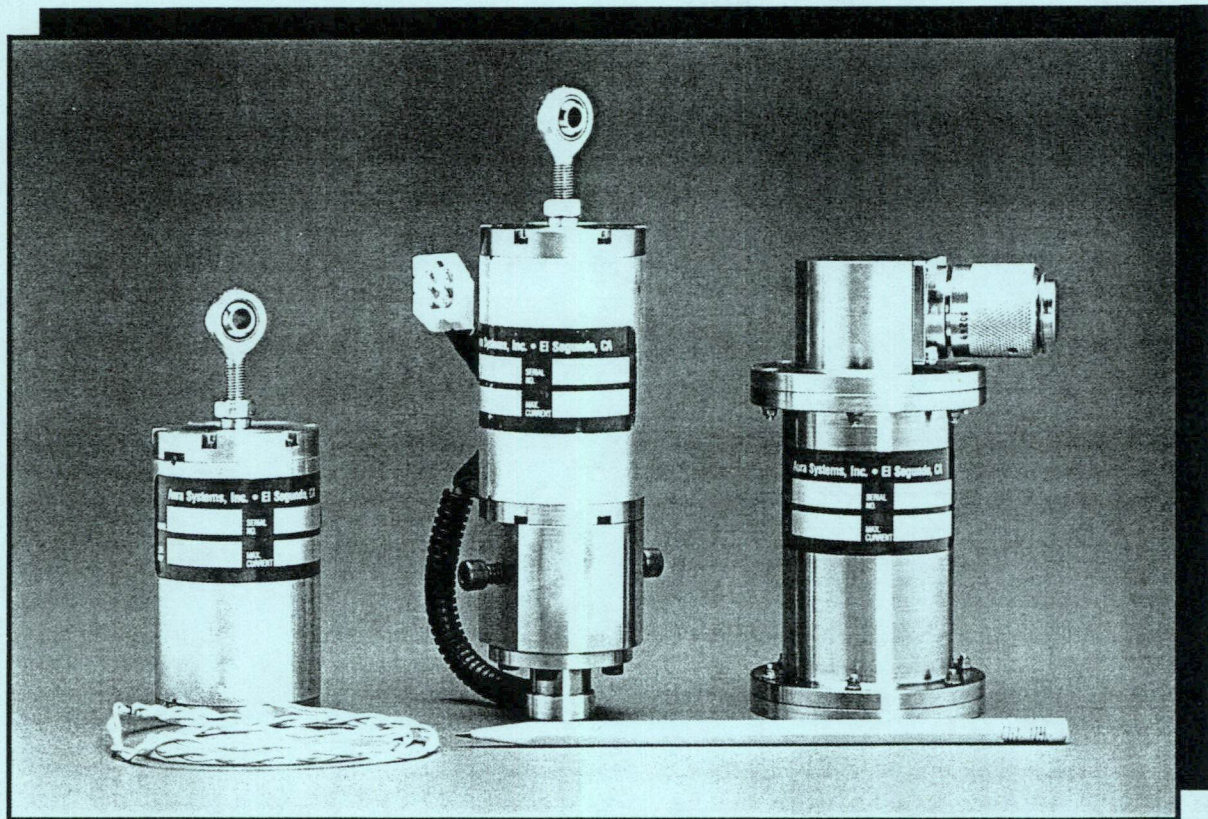
aura

Systems, Inc. Magnetics Division

ELECTROMAGNETIC LINEAR ACTUATORS

SERIES 10/0.5

10 LBF \pm 0.5" STROKE

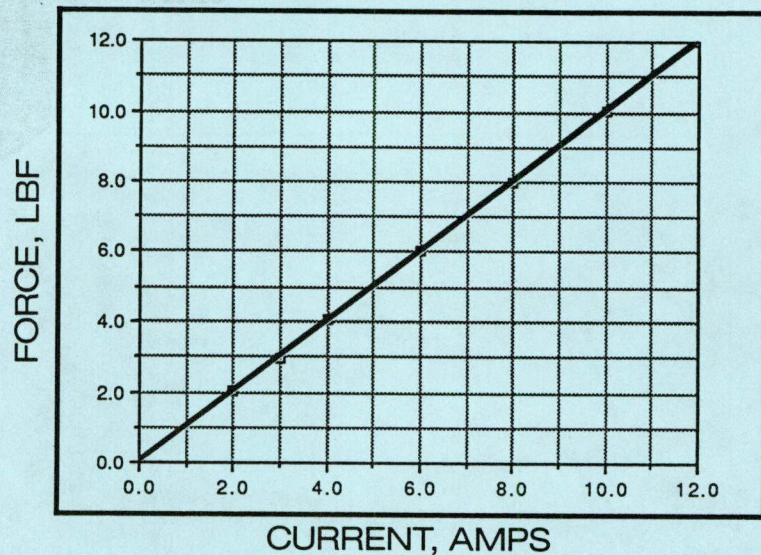


SERIES 10/0.5 FAMILY HIGHLIGHTS

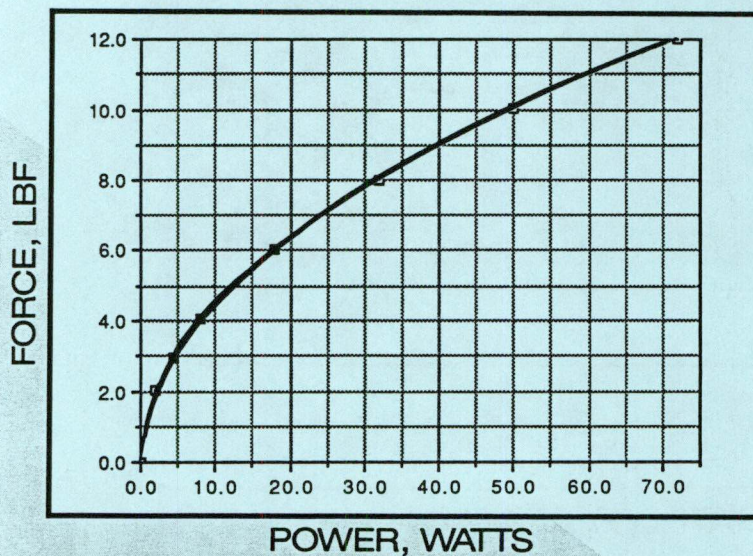
- 10 POUND BIDIRECTIONAL RATED FORCE
- 0.5 INCH TOTAL STROKE
- FORCE LINEARITY GUARANTEED OVER FULL STROKE
- 1000 HZ FORCE BANDWIDTH CAPABILITY
- AVAILABLE WITH INTEGRAL POSITION SENSOR
- CAN BE PULSE OVERDRIVEN TO 10 TIMES RATED FORCE
- SUBMERSIBLE MODEL OPERATES TO 15,000 FT. DEPTH

SERIES 10/0.5 FAMILY CHARACTERISTICS STATIC (STALL) CONDITIONS

FORCE VS. CURRENT



FORCE VS. POWER



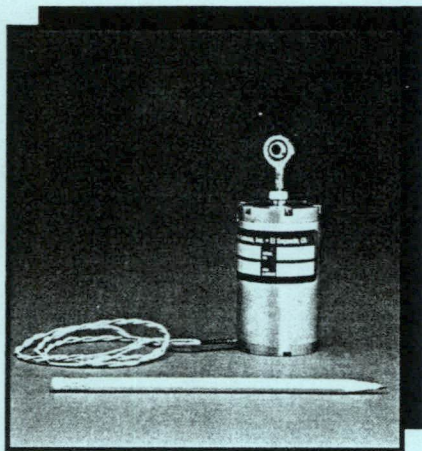
APPLICATIONS INCLUDE:

- PROPORTIONAL VALVE CONTROL
- PRECISION POSITIONING
- SHAKER TABLE ACTUATION
- MECHANICAL VIBRATION CANCELLATION
- ACOUSTIC FIELD GENERATION
- HYDRAULIC ACTUATOR REPLACEMENT/AUGMENTATION

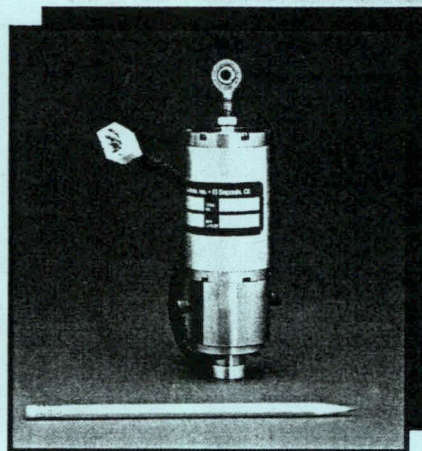
CUSTOM DESIGNS AVAILABLE

SERIES 10/0.5 FAMILY OF HIGH FORCE

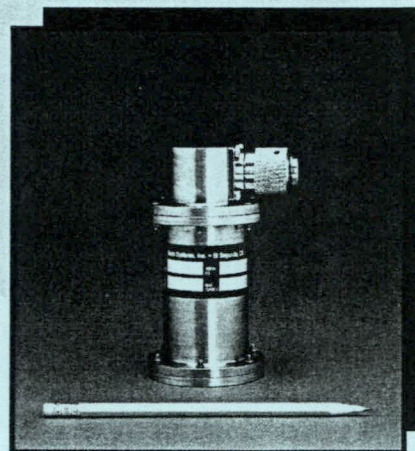
**ELECTROMAGNETIC
LINEAR ACTUATORS**



10/0.5 B
BASIC



10/0.5 P
WITH BUILT-IN
POSITION SENSOR



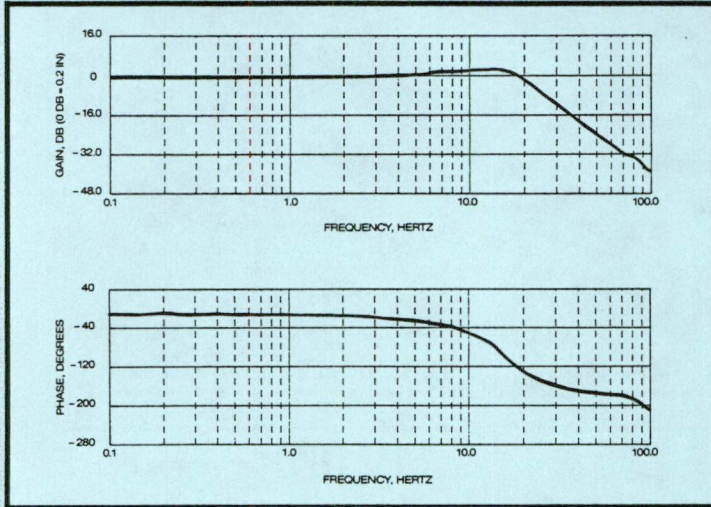
10/0.5 SP
SUBMERSIBLE
WITH BUILT-IN
POSITION SENSOR

PERFORMANCE DATA

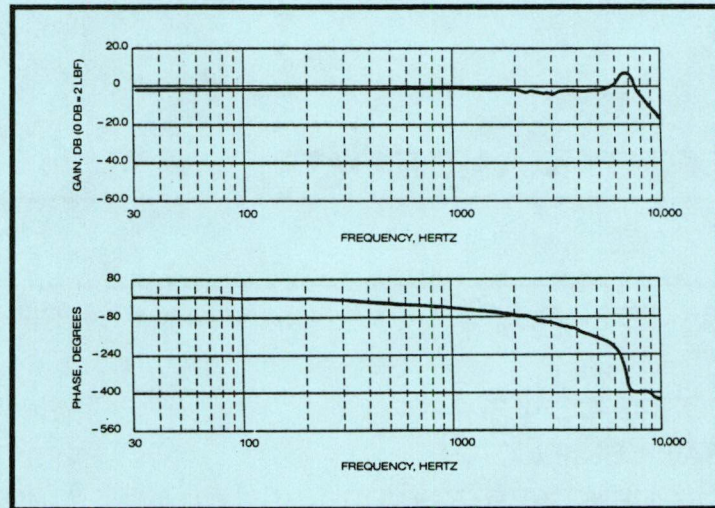
MODEL		10/0.5 B	10/0.5 P	10/0.5 SP
RATED FORCE	LBF	10	10	10
STROKE	± IN.	0.5	0.5	0.5
FORCE CONSTANT	LBF/AMP	1.0	1.0	1.0
BACK EMF CONSTANT	VOLT/M/SEC	4.5	4.5	4.5
CURRENT AT RATED FORCE	AMP	10	10	10
POWER AT RATED FORCE	WATT	50	50	50
RESISTANCE AT 25°C	OHM	0.5	0.5	0.5
INDUCTANCE	MILLIHENRY	0.9	0.9	0.9
MAXIMUM OPERATING TEMPERATURE	°C	80	80	80
WEIGHT OF MOVING MEMBER	LB	1.0	1.0	1.0
TOTAL WEIGHT	LB	2.5	3.0	5.2
LENGTH	IN.	3.5	6.0	5.5
DIAMETER	IN.	2.0	2.0	2.9
POSITION ACCURACY	± IN.	—	.002	.002
POSITION REPEATABILITY	± IN.	—	.001	.001
DISTORTION (ACTUATOR ONLY)	% THD	—	—	<1.0

SERIES 10/0.5 FAMILY CHARACTERISTICS DYNAMIC CONDITIONS

POSITION VS. FREQUENCY



FORCE VS. FREQUENCY



OTHER ACTUATOR PRODUCTS (AS OF MARCH, 1991)

MODEL	4/0.2 P	50/1.0 P	100/6.0 P	500/8.0 P	1500/5.0 P
RATED FORCE	4 LBF	50 LBF	100 LBF	500 LBF	1500 LBF
TOTAL STROKE	0.2 IN.	1.0 IN.	6.0 IN.	8.0 IN.	5.0 IN.
FORCE CONSTANT	4.0 LB/A	5.0 LB/A	4.5 LB/A	5.5 LB/A	25.0 LB/A
POWER @ RATED FORCE	1.8 W	450 W	750 W	2500 W	3000 W

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Systems, Inc.

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Aura Claims System Can Distribute Pix Electronically

By MORRIE GELMAN

Aura Systems Inc., a low-profile technology company based in El Segundo, claims to have come up with an electronic distribution system to replace the 75-year-old system of bicycling feature films from one theater to the next.

Via ongoing discussions with various studios, Aura is exploring various business strategies for beaming feature films and special pay-per-view events directly to theaters by satellite.

The Southern California company is suggesting that it become in essence a common carrier, or act like a phone company, for motion picture studios. The proposal is for Aura to convey films over a system of satellites to receiving stations at each of the 25,000 screens around the country.

Aura estimates that the motion picture industry spends about \$400 million annually on release prints and the infrastructure to support celluloid distribution.

Aura Distribution Systems Inc., a new company set up by Aura Systems Inc., would function as a one-stop service company for the motion picture distribution industry. ADSI is claiming it could effectively reduce motion picture distribution costs by 40-50%.

In a presentation that is currently being made to all of the major studios, ADSI also is promising greater studio control.

The company is asking the motion picture industry to install its projector system in all of the major theater screens in the U.S. by 1994-95.

The signal distribution to the screens would be scrambled and compressed. The actual transmission would be downlinked during the middle of the night and stored in the projector and, with studio authorization for the scheduled playdates, would be programmed to play back the film in its electronic

form during its various play times.

Aura is claiming that its UMTV (uniquely modulated) electronic movie projector will "shatter" the projection industry's current 20-foot screen limitation, allowing studios to abandon reliance on an "outmoded" and expensive celluloid distribution system in favor of a more cost-effective electronic one.

"The big breakthrough that we have achieved is the ability to configure video projection technology with higher-resolution and the equivalent brightness of film projection technology.

"That will now allow the movie studios to start beaming movies by satellite or by fiber optics or whatever distribution means directly to theaters," says Lawrence M. Shultz, Aura's senior management consultant.

Adds Aura exec v.p. Arthur Schwartz: "The dream of transmitting movies by satellites, beaming them down to theaters, has been with us for a long time, but the one weak link that has stopped this from happening is the projection technology.

"Hollywood is not going to approve a changeover to video distribution by satellite if the image looks worse than 35m film."

Aura Systems, which specializes in electromagnetics control and electro-optics technologies, is currently configuring its UMTV projection/display system to, in essence, provide a "filmless movie projector."

The company is already providing the U.S. Air Force with a very high resolution 3000-frame-per-second scene project for testing missile sensors in the infrared spectrum using lasers.

According to Schwartz, the essence of Aura's claimed breakthrough is an array of controllable mirrors in which each individual mirror reps a tiny point, or pixel, in the image. "We can literally fabricate devices which are many thousands by many thousands of pixels in size," Schwartz says. "That's what gives us the intensity."

Aura says it is able to take the pixels in an image — whether a high-definition tv image of 1200 pixels vertical or 2500 lines for motion pictures — and divide the picture into pixels, each with a corresponding mirror.

From a light source, Aura reflects, in varying intensities, the light on a pixel-by-pixel, mirror-by-mirror basis. The angle at which the mirror is controlled determines the intensity that goes out to the screen.

Schwartz won't cite a specific figure but says Aura so far has spent millions of dollars in research and development over the past two to three years.

Currently, Aura is developing a prototype of the system.

Aura has a couple of contracts with the U.S. Air Force to build full-scale devices for the military.

For motion picture application Aura is building a 3000-by-2500-pixel projection system, report Schwartz and Shultz. They claim it will produce a resolution that will surpass that of 35m film projected on a screen.

Scaled Back

For HDTV application, Aura says it can scale back this system to a little more than 1500 pixels by 1200 pixels. "This very high resolution display can be scaled down to NTSC quality if in fact HDTV broadcasting is not going to be happening in the near future," says Schwartz.

"We would still be able to build a 5- or 6-foot-wide tv set that surpasses the quality of current rear-projection systems at roughly a lower cost."

Aura doesn't care who wins the political argument of which HDTV system becomes the standard.

The company claims the UMTV system can be fabricated in quantities and at costs that are competitive with those of standard cathode ray tube television sets of today but can be made up to any size of display desired.

Aura has calculated details for displays of up to 100 feet for a massive-type movie projection system.

The cost of tv mass-produced types of products is estimated at less than \$1,000 wholesale.



75 Cents

28 Pages

Newspaper Second Class P.O. Entry

Los Angeles, CA 90036, Friday, Aug. 17, 1990

VOL. 228 No. 53

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SDI HIGH TECHNOLOGY UPDATE

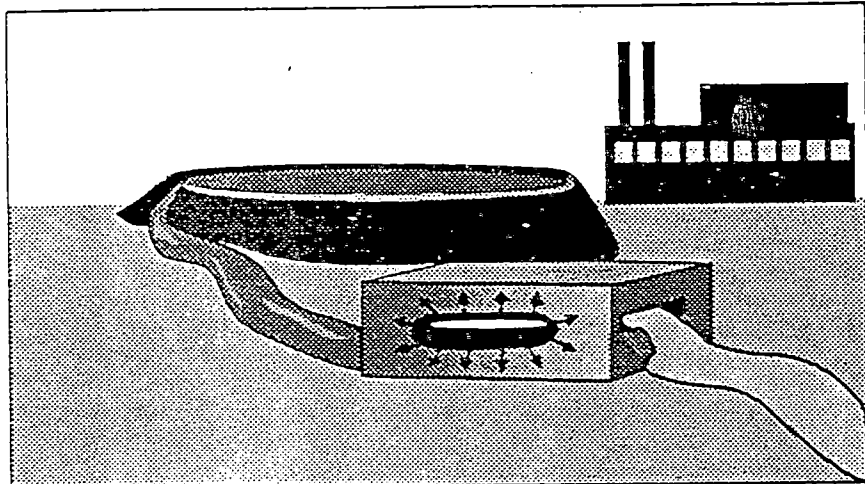
Update of the Technology Applications Office, Strategic Defense Initiative Organization

Vol. 1, No. 1

Message from SDI: Think Spinoffs!

The Strategic Defense Initiative (SDI) Office of Technology Applications was established to support the initiatives of the Congress and the President to make federally developed technology more accessible to American business in order to enhance America's international competitiveness. The SDI technology applications program sponsors reviews of SDI technology for commercial and other federal applications by experts from industry, federal laboratories and universities to determine other applications of the technology being developed for strategic defense. Access to the emerging technologies is made possible through the modern-accessible Technology Applications Information System (TAIS), which can be accessed by any American business or citizen certified to do so. For more information on the TAIS, see page 3.

This bulletin is another new initiative of the program to help facilitate technology transfer. If you want further details about the information in the articles, please call the SDI Technology Applications Office at (703) 693-1563 or mail back the Request for Information card at the back of this bulletin.



A linear accelerator could purify toxic water directly at any site.

Linear Accelerator May Help to Save the Environment

An Induction Linear Accelerator (ILA), devised by Lawrence Livermore National Laboratory with Strategic Defense Initiative (SDI) funding, may irradiate a wide variety of wastes, decomposing toxic substances. The ILA produces a high-energy stream of electrons, causing toxic substances to break down into compounds that are more easily handled by the earth.

The first spinoff application of an ILA was designed to irradiate sulfur and nitrogen compounds in the exhaust gas of coal burning power plants. The irradiation, combined with water vapor and ammonia, converts the sulfur oxides and nitrogen oxides into ammonium sulfate and ammonium nitrate, which can be sold as fertilizer. The process removes 90 percent of the sulfur and nitrogen oxides from high sulfur coal effluent—thus minimizing acid rain.

The accelerator can also treat both

ground and waste water, including sewage sludge. In sample testing, an ILA employing the energy of 100 kRad

continued on page 6

What's Inside . . .

Energy and Power

Linear Accelerator May Help to Save the Environment (Cover Story)

EM Coilgun May Launch Space Station Parts into Orbit, page 5

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Automotive and Aerospace

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Liquid Ceramic Process Moves into Cars and Cans, page 4

Medical and Health

Electromagnetic Suspension System to Remove Cataracts, page 6

MEDICAL AND HEALTH

Electromagnetic Suspension System To Remove Cataracts

Technology that was designed for an electromagnetic test stand to test SDI rocket thrusters is being incorporated into a surgical system to remove cataracts. The new surgical technique promises to reduce complications, shorten recuperation time, and be less invasive and traumatic than current techniques.

In the original SDI test stand application, a projectile was placed between two magnetic coils and suspended in an electromagnetic field. Thrusters in the field were fired, vibrations in the field were measured, and automatic adjustments were made to ensure the gap between the electromagnets and the projectile remained constant.

When ophthalmologist Dr. Charles Kelman read about the technology in *Forbes*, he saw its application in cataract removal. Several years ago, he developed the phacoemulsification cataract removal technique, in which an incision is made in the lens capsule, a probe is inserted, and the cataract emulsified. In the majority of cases, however, the muscles of the lens capsule are damaged, and the eye's focusing ability is lost.

In an attempt to avoid damaging the muscles of the lens capsule, Dr. Kelman developed a new surgical system. In the system, three magnets are placed around the patient's head, a tiny incision is made in the eye, and a magnetic bead (magnabit) is inserted under the lens capsule. A computer-controlled motion system, optical camera sensors, and a video camera give the surgeon control of the bead and a magnified view of the eye. The surgeon then rotates the magnabit, emulsifies the cataract, and removes the magnabit without severing the lens muscles.

Dr. Kelman and Aura Systems Inc. formed Aura Medical Systems, Inc. to refine and develop the technique. It has been tested on animals, and awaits FDA approval. The innovators also see other applications of the technology, including its use to break down plaque in arteries, remove obstructions from organs, and perform surgery on inaccessible parts of the body.

For Further Information

Return the Request for Information card on page 7 or call the SDI Technology Applications Office. ■

"In the long run, men hit only what they aim at. Therefore, though they should fail immediately, they had better aim at something high."

--- Thoreau

Linear Accelerator

continued from page 1

X-rays, reduces the trichloroethylene (TCE) concentration of ground water from 450 parts per billion (ppb) to less than 1 ppb. ILAs also decompose PCB in contaminated soil. Unlike most other methods, ILAs can treat "mixed" wastes.

Advantages of ILA

Incineration may handle mixed wastes, but it pollutes the air, while ILAs do not. Portable ILAs can be designed, allowing water or sewage to be treated directly at a remote site. Further, ILAs can process waste right "in the barrel"; products need not be removed from their container. Moreover, the design can be tailored to treat specific waste streams.

Compared to other systems, the ILA contains no moving parts, so it is more reliable and has a longer life. Further, a 250 kW electron-beam can process ground water at 1,800 gallons/min., 36 times faster than current 60 kW Mercury lamps.

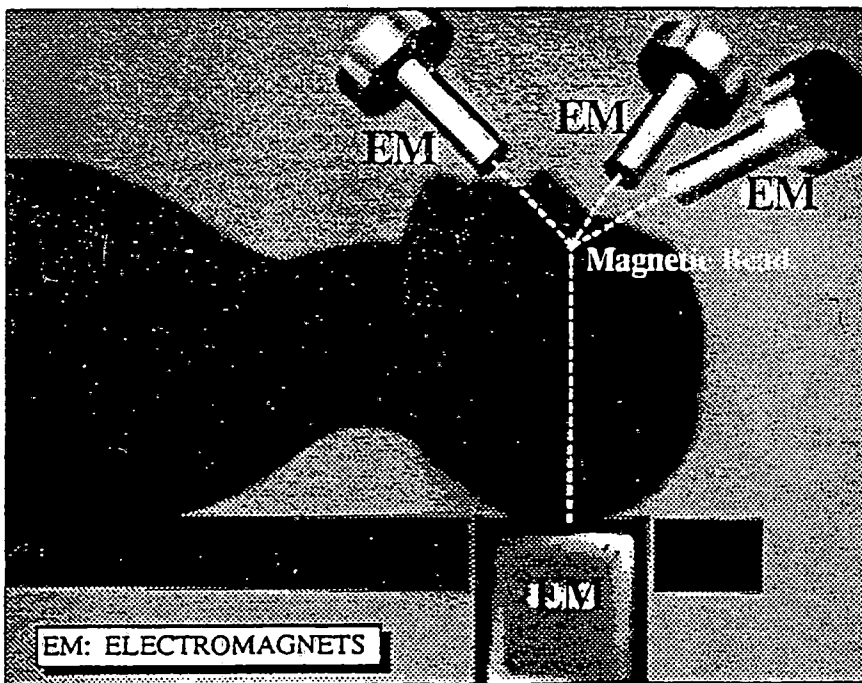
The ILA works at low pressures and generates very little heat; 2.5 Megarads heats water by only 6 degrees C, minimizing heat pollution. It requires less energy than many other methods, and produces only minor outgassing.

Other Applications

ILAs can irradiate food, killing bacteria, which keeps food fresh longer. ILAs can also sterilize medical products. And in the field of materials, ILAs accelerate electrons that rapidly cure plastics.

For More Information

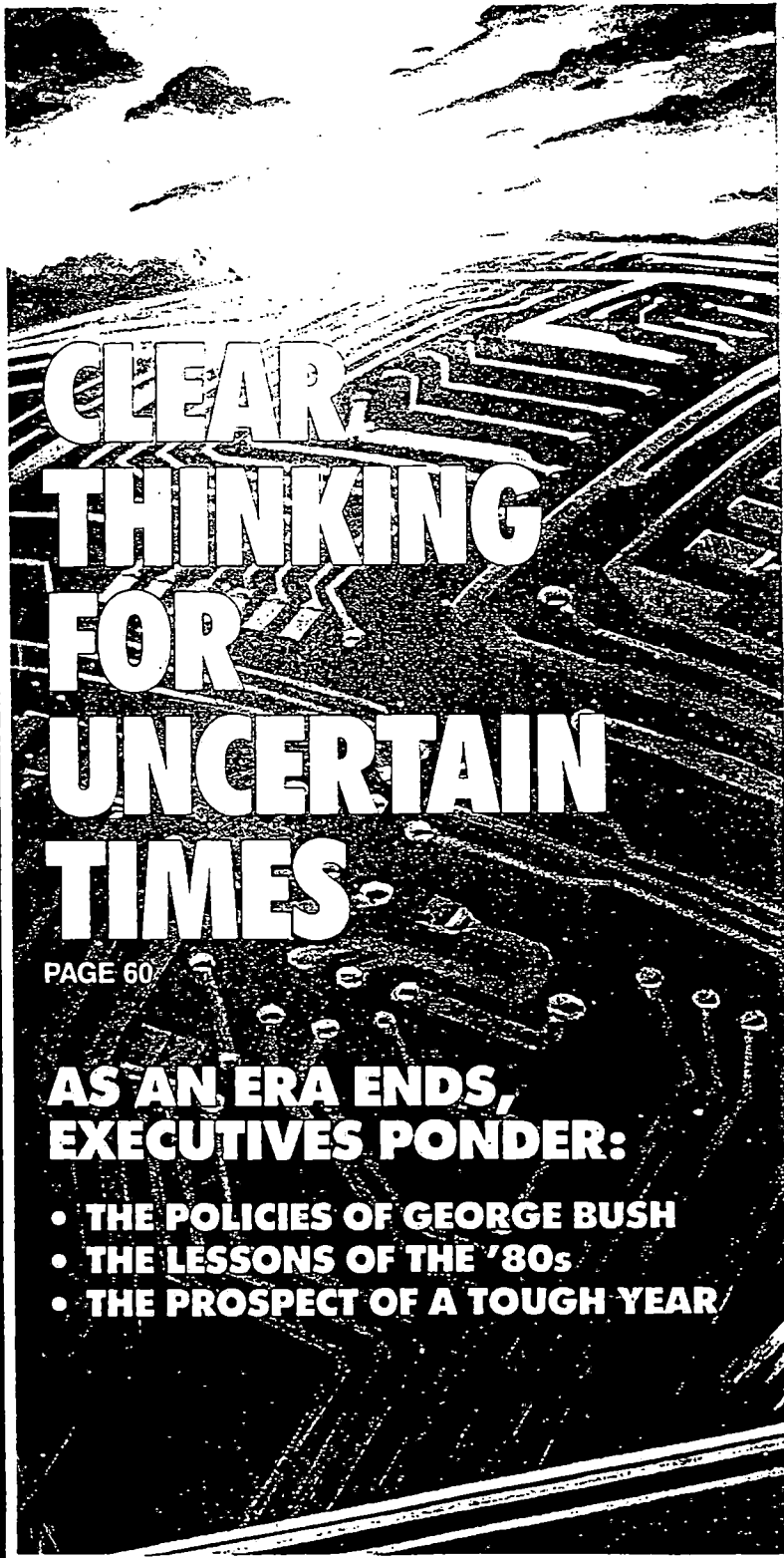
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**WHY CONTENT-ADDRESSABLE RAMs ARE CATCHING ON/82
MCC AT FIVE: NOW IT MUST LEARN TO EARN ITS KEEP/89**

DECEMBER 1988

Electronics®



CLEAR THINKING FOR UNCERTAIN TIMES

PAGE 60

**AS AN ERA ENDS,
EXECUTIVES PONDER:**

- THE POLICIES OF GEORGE BUSH
- THE LESSONS OF THE '80s
- THE PROSPECT OF A TOUGH YEAR



AURA BRINGS ESOTERIC TECHNOLOGY TO FRONT LINES

LOS ANGELES

With military procurement budgets either on hold or growing slowly, and with precious few new, big programs in the wings, conventional wisdom holds that these are the worst of times for a startup aiming at the military market.

But Aura Systems is bucking that trend with fast growth based on mastering a unique core technology—magnetic suspension—and recognizing that the absence of new funding has the defense community looking for some less expensive ways that they can use to deliver cutting-edge performance.

"There has never been more opportunity than now," says president Zvi (Harry) Kurtzman. Because the military cannot soon replace its workhorse aircraft, ships, and weapons platforms, it's receptive to ideas which lead to affordable hardware that will improve old systems' performance. Although such upgrading has always taken place, it has historically taken a back seat to spending sprees for new equipment. Now events have forced it to the top of the priority list, says Kurtzman, "to take existing systems and make them better."

The attraction of magnetic suspension is that it makes it possible for objects to be levitated, or "free-floated," in the magnetic field. The payoff comes from virtually eliminating effects such as friction, vibration, and heat. But while the technology has been known for much of this century, it has seldom been used because of difficulties in building, packaging, and accurately controlling it.

JUICY PROSPECTS. In the tough climate of slim defense budgets, Aura's record—skyrocketing to an approximately \$10 million annual sales rate from zero in 1987—will soon be attracting attention to the Los Angeles, Calif.-based company. And Kurtzman's assessment of the military's quandary is seconded by defense analyst Wolfgang DeMisch of the Union Bank of Switzerland in New York. Slashed budgets "mean they can't replace existing fleets," he says, "so the logical thing is... to juice them up."

Because Aura is still relatively unknown outside a handful of aerospace firms and a cadre of Pentagon procurement people, DeMisch has not yet studied it in depth. But he thinks the timing might be right for small companies with solid credentials to win a growing share of military work against some of the much larger competitors.

The award of a \$5.1-million contract in

September should earn Aura wider industry notice. The firm beat out a number of heavyweight rivals to build a facility for simulating incoming ballistic missiles and testing sensors for the Strategic Defense Initiative [*Electronics*, Oct. 1988, p. 62]. To be located at Eglin Air Force Base in Florida, the project initially will use a three-axis flight-motion simulator to position the missile. Later Aura will replace it with magnetic-suspension equipment.

Aura was quick off the mark from its founding in early 1987 to go after the wid-

Aura blends magnetic suspension with digital control for the military

ening niche, which seems particularly ripe for its specialty. Resulting from work performed over the previous five years at several tiny predecessor companies, the magnetic-suspension technology has the advantage of the latest digital techniques, developed by Aura to control objects suspended magnetically.

Aura scientists—who, like Kurtzman and his cofounders, mostly came from GMHE/Hughes Aircraft Co.—use off-the-shelf processing chips for the controls, packaged on a circuit card. But custom devices now being developed will cut the parts count to a few components. Development required a new kind of servo-mechanism control software, and the circuitry also includes a power amplifier to drive current through the electromagnet coils that generate the magnetic field.

Though magnetic suspension has long been regarded as something of a visionary field, with real uses remaining far in the future, Aura has been able to sell some tough military customers on it. For example, General Dynamics Corp. of St. Louis, Mo., picked the company to build a magnetic gimbal for its F-16 aircraft.

The goal is to improve the clarity and resolution of existing electro-optical sensors by floating them in the gimbal's magnetic field, thus isolating them from jitter or vibration. And Aura has teamed up with TRW Inc. of Cleveland, Ohio, in a proposal for an advanced technology system for submarines. Among other improvements, the system reduces vibration-related signature emissions, thereby decreasing the chance of the undersea craft's detection.

Because Aura's magnetic-suspension technology is now at hand and in the view of the U.S. aerospace community, there are nearly unlimited prospects for employing it, according to Kurtzman. "Aircraft, ships, subs, satellites, and missiles—all of them" are prospects, he says. Along with the core expertise, Aura has built related skills, notably computer simulation, artificial intelligence, and electro-optical scene generation. This electro-optical capability uses laser-based gear to create light patterns that can be projected onto missile detectors. With it, the military can realistically simulate targets in an overall scheme for the nondestructive testing of missile performance before actual flight.

Aura's momentum impresses industry veteran John M. Carter, president of Carco Electronics, Palo Alto, Calif., a leading supplier of motion-simulation equipment that has teamed up with Aura on the Eglin project. "For a small company, they're pretty far ahead in magnetic simulation; that's the key," he says. Carter is negotiating with Aura to use its technology.

The flurry of new contracts and word-of-mouth have combined to whip up intense interest in Aura, Kurtzman says, to the point where the 43-person company is pushed to the limit to respond. "We're getting calls from people we've never heard of, where last year we couldn't get past the door."

GROWING TOO FAST? If any roadblocks to Aura's future are in sight, it is this fast growth, which Kurtzman recognizes as "really our most difficult challenge." Present business will cause the company to double in size by February and again by June, and financing it is Kurtzman's top priority. He raised \$4.5 million in a private placement in recent months and will need more soon. The company's common stock became eligible last month for listing on the over-the-counter market.

But Aura already is looking past military customers at commercial vistas. "We're pursuing active-suspension systems for autos, which are perfect for magnetic suspension," he says, predicting production in the next decade. Even products based on superconductivity seem within reach, Kurtzman thinks, because some of the proposed applications involve suspending objects in a magnetic field. Superconductivity researchers "are still talking about doing it—and we can do it now."
—Larry Waller

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Short-Pulse Thrusters for SDI Require New Instrumentation

MICHAEL A. DORNHEIM/LOS ANGELES



Aura Systems magnetic suspension thrust stand (left) is shown supporting a cylindrical mass model of Air Force/Boeing LEAP guided projectile.

Stand provides an alternative to free-flight testing of SDI weapons that have thrust pulses too fast for conventional stands to measure.

The Air Force/Boeing lightweight exo-atmospheric projectile (LEAP) program will employ a magnetic suspension test stand to measure the rapidly pulsing thrust of its rocket engines, in what is believed to be the first use of a magnetically suspended thrust stand.

A conventional, mechanically suspended test stand will not respond rapidly enough to the brief pulses of the LEAP projectile. Anthony K. Goodfellow, Boeing Aerospace LEAP chief engineer, said. In a conventional stand, it is difficult to measure thrust changes in several axes faster than 50-100 times per second, which is not good enough to characterize LEAP's several-millisecond thrust rise time, he said.

The magnetic suspension test stand, developed and produced by Aura Systems, Inc., Los Angeles, can be used to measure thrust with 1,000-Hz. frequency response.

The test stand can measure forces independently in all six axes with little of the cross-coupling between sensors that occurs at high frequencies on mechanical test stands, Aura officials said.

LEAP is part of the Strategic Defense Initiative and is to be a space- or ground-based infrared-guided projectile launched from rail guns to kill missiles by impact (AW&ST Oct. 17, 1988, p. 24; Nov. 2, 1987, p. 46). Projectile weight is under 20 lb., putting it in a category between the heavier space-based interceptor program and the lighter "Brilliant Pebbles" concept. Since practical rail guns are not expected to be available in the near term, early versions of LEAP would use a rocket engine to gain their velocity. Both the Army and Air Force have LEAP programs.

To keep LEAP simple, lightweight and inexpensive, the weapon's infrared

seeker is mounted rigidly to vehicle structure instead of being suspended in a gimbal. The attitude of the projectile must then be carefully controlled for good seeker performance—a goal is to keep jitter to under one pixel on the seeker. Propulsion system performance has to be accurately measured for good attitude control.

The Air Force LEAP has lateral and attitude control hot gas thrusters made by Thiokol Corp. A solid propellant in a central chamber provides the hot gas, which has to be directed constantly to various thrusters for the system to operate properly, even when no change in course is desired.

Thrust pulses are as short as possible for fine control—on the order of 10 millisecond long—and are shorter than the pulses of previous generations of thrusters, which took at least 10 millisecond just to rise to full thrust. The Aura magnetic test

stand is designed for the measurement needs of the new thrusters.

Aura received a firm, fixed-price contract valued at several hundred thousand dollars from Boeing in May, 1988, to make the test stand. The stand was to have been delivered last January but development took longer than expected, and the stand is now scheduled to be delivered at the end of August to a Thiokol test chamber in Elkton, Md. The LEAP program is not affected since it is behind schedule as well, due largely to sporadic SDI funding.

The test projectile has aluminum interface rings at each end that connect it into the magnetic suspension. Each ring is inset with four pieces of vanadium Permanganate laminate, a dense material with a high magnetic saturation limit. Opposite each piece of vanadium Permanganate in the fixed bearing housings is an electromagnet that suspends the interface rings and the projectile.

Radial position of the bearing shaft with respect to the housing electromagnets is measured by four eddy current proximity sensors at each end. This is used by a digital controller to keep the shaft in the desired position by adjusting electromagnet current 3,300 times per second.

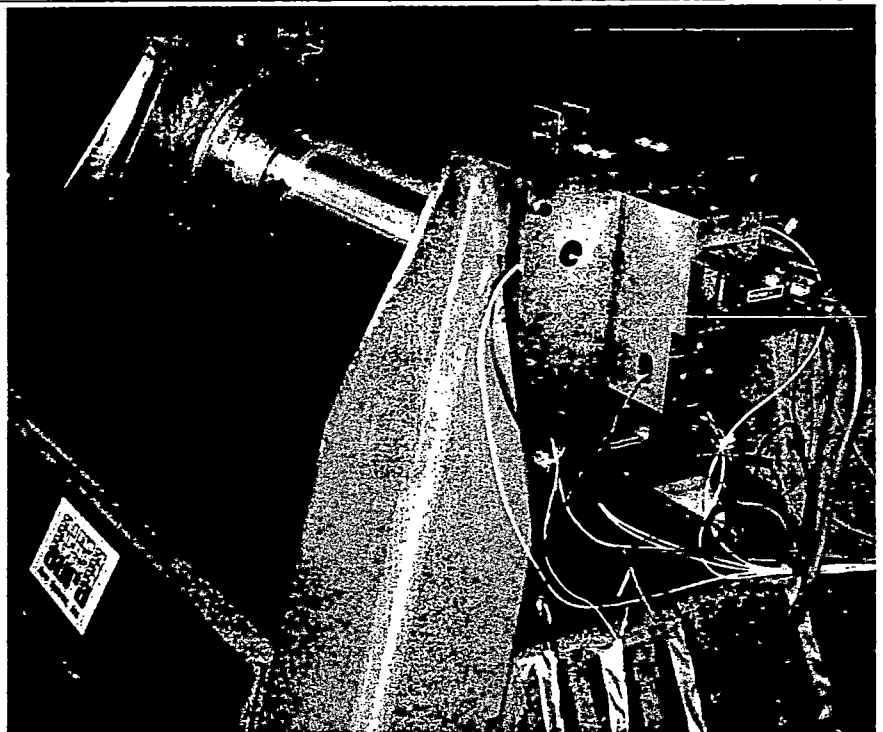
Axial position of the shaft is controlled by a moving coil magnet at one end, and shaft rotation is controlled by two more moving coil magnets on lever arms at the same end. Rotation is measured optically and is narrowly constrained by mechanical stops, though the company has built other magnetic suspensions capable of continuous rotation.

Thruster forces up to 100 lb. in the bearing radial direction can be measured with 0.5-lb. resolution. Axial forces up to 4 lb. can be measured to within a few tenths of a pound resolution. Rotary torque can be measured up to 200 in.-oz. with 5 in.-oz. resolution.

The LEAP projectile can change from zero to several g's acceleration in a few milliseconds. The projectile will move 0.007-0.008 in. in the suspension when it fires, compared with a normal radial gap of 0.020 in.

Two complementary methods are used to measure thruster forces—magnetic forces, and accelerometers on the interface rings. Magnetic force is calculated from electromagnet current and shaft gap, and is good for static and low-frequency measurements, with response starting to fall off at about 50 Hz. The accelerometers cannot measure static force and become more effective as frequency increases, and provide all the force measurement above 200 Hz. Response drops off above 1,000 Hz. from a sharp filter that avoids a structural resonance at 1,400 Hz.

Twenty-four channels of 16-bit data are sampled at 10 KHz., and 55 sec. of data can be recorded on a 40-megabyte hard



Each end of the thrust stand has magnetic bearings, and the near end has other magnets to control axial and rotational position, as well as an optical rotation sensor.

disk. Data reduction to forces about the test vehicle center-of-gravity is time-consuming on a personal computer, and takes about 15 min. for each second of test time.

The thrust stand is calibrated by applying forces through a single-axis load cell to various points on the test article. A single-axis load cell does not experience the cross-coupling problems of a multi-axis load cell at high frequencies.

*Recent development work
focused on devising an
accurate mathematical model
for the suspension system*

Besides measuring forces, the test stand can be used "backwards" to shake the test vehicle. It could be used to "play back" recorded thruster vibrations on a vehicle with a sensor to see how the vibrations affect the sensor. This would be especially useful on LEAP since the solid propulsion system can only be used once, making multiple powered tests expensive. However, Boeing is not now under contract to use the test stand in this manner, Goodfellow said.

Tests will be run in the Thiokol chamber at a simulated 100,000-ft. altitude though operational altitudes will be higher, since this is the maximum vacuum that can be maintained with the rockets firing.

The last several months of test stand development were spent devising an accu-

rate mathematical model for the suspension system. The payoff has been a stiffer suspension without the added noise that usually comes from increasing system gains. "We can now model to within 5% of reality. Before, we were 50% off, though the suspension worked," Keith O. Stuart, Aura Magnetics Div. vice president, said.

Aura also is studying a magnetically suspended force sensor for the Navy Skyray missile program at the China Lake Naval Weapons Center, Calif. This project is examining the use of a fiberoptic data link between a launch aircraft and an air-to-surface missile (AW&ST June 12, p. 275). Uneven payout of the fiber can cause poor data transmission or fiber breakage.

The sensor could gather high-frequency force data to better understand the mechanics of fiber payout. Aura has determined, under a China Lake contract, that high accuracy, high bandwidth accelerometers are the most crucial element to building the force sensor. The company is now under contract to survey available accelerometers and improve magnetic techniques of force measurement. The next phase would be to build a force sensor and test it on a payout simulator at Hughes Missile Systems Group in Canoga Park, Calif., and then possibly on a rocket sled at China Lake.

Going beyond a force sensor, China Lake officials envision a magnetically suspended payout spool that spins at high speed to reduce payout stresses, and measures payout forces as part of a closed-loop force control. □

has built systems capable of responding actively to inputs ranging from 0 to 20 cps. That hardware is heavy (in some applications weighing 300 pounds), power hungry, and, so far at least, too expensive and unreliable for mass production. On the Infiniti Q45, the active suspension option inflicts a 130-pound weight penalty. At 3,000 rpm, the Infiniti's power drain is three hp; at 6,000 rpm it increases to six hp. Significantly, an active suspension's constant power drain will extract a 1.5-mpg fuel economy penalty in the active-equipped Q45, Nissan estimates.

I compared an active-suspension-equipped Q45 with one without this option in a smooth medium-speed right-hand bend. The conventional Infiniti understeered a bit (the nose of the car drifting wide) during the first half of the corner and demonstrated a near-neutral attitude (both ends of the car sliding slightly) when I pressed the accelerator down during the last half of the corner. This is exactly how a properly tuned sport sedan should behave.

The active Q45 turned in toward the apex of the corner with superb stability. Through the middle and exit portions of the curve, it demonstrated a pronounced tendency to understeer no matter what I did with the steering wheel and/or the throttle. This I found disappointing; the keen edge of a fine-handling car has been blunted.

According to Nissan's experimentation, there's a 70 percent reduction in vibration levels with active suspension as long as the ride frequencies are

below two cps. By Nissan's own admission, between two and three cps, the Infiniti's new ride is marginally inferior to other cars in the luxury class. And beyond three cps, it responds to bumps in the road in a passive mode, relying entirely on the sub-accumulators at each wheel. Each of these is a small self-contained hydro-pneumatic suspension unit, similar in some respects to the system long used by French-built Citroens. In response to a sharp road impact, oil flows out of the actuator, through a damping valve, and into a gas-pressurized reservoir. Over moderately bad pavement at Tochigi, I found that an active suspension does deliver a slightly better ride. But as I increased the car's speed over the same bumps, there were instances when the car with a conventional suspension actually demonstrated superior ride isolation.

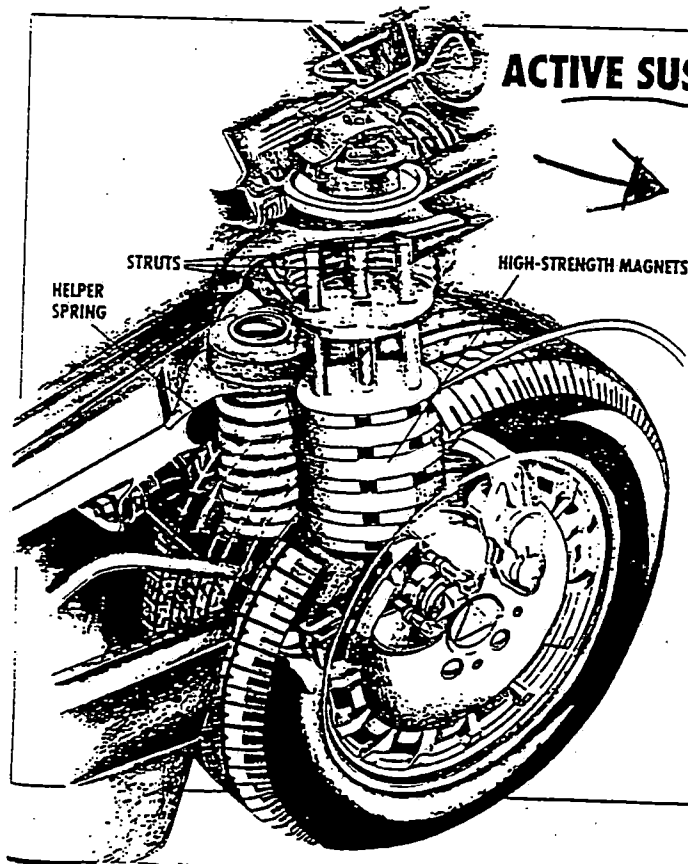
It is inevitable that many potential customers who hear of the Infiniti's expensive new computer-controlled suspension will expect this Q-ship to ride as if their private world were paved with whipped cream. They will be sorely disappointed. The Q45—with or without active suspension—is a 150-mph sport sedan with underpinnings tuned first and foremost for high-speed over-the-road competence. A truckload of computers and hydraulic actuators couldn't make this car glide over broken pavement with a magic-carpet ride.

Later I spent a few hours driving a

Toyota Celica Active Sports. Within a few miles I noticed various annoyances: a whir from under the hood that I assumed was the hydraulic pump hard at work, and rattles from unsecured suspension components. On the freeway, ride motions were abysmal. Over major bumps, the active Celica rocked diagonally like a crazed hobby horse. In the safe confines of a hotel parking lot, I discovered some bizarre handling. In response to a sharp steering input at moderate speeds, the Celica Active Sports turned smartly with virtually no body roll...for a second or two. Then, it felt as if its hydraulic muscles gradually went limp. The body heeled over, and the car assumed a slightly different trajectory.

In my opinion, this Japanese-market-only suspension system is not sufficiently developed to satisfy a broad base of customers.

At this juncture, I wouldn't rush out to buy active suspension as most of its considerable potential is yet to be exploited. General Motors' cancellation of the active suspension planned for the 1991 Corvette underscores these difficulties. "We were in the glide path for production," says Don Runkle, vice president in charge of General Motors' Advanced Engineering Staff. "We had some problems with impact harshness and reproducibility, which we are working on. Sometimes you get enthusiastic about the promise of a new technology, and then some area you didn't think about comes back and bites you."



ACTIVE SUSPENSION: AN ELECTRIC ALTERNATIVE?

If frequency response is one of the basic problems with the development of an active suspension, how about high "C"?

An all-electric approach to powering suspension struts is the research goal of California-based Aura Systems, which claims to have developed an electromagnetic linear actuator capable of generating 500 or more pounds of thrust and responding at a 500-cycles-per-second frequency. It is, in effect, an enlarged version of a speaker coil, and Aura demonstrates it by generating sound of reasonable fidelity with a plate attached to one end.

The Aura strut derives its power from magnets inside a coil. Sets of coil windings are energized by a sliding switch similar to an electric motor commutator. The construction of the coil is a flat spiral aluminum strip, wound like a child's Slinky toy and insulated by aluminum oxide. The result is a coil with the appearance of a thick-walled tube, and the robust construction is one reason the coil can handle the power loads.

Aura claims the device could be used for engine valve actuators, power steering motors, or active suspension systems, though the company has not yet demonstrated prototypes. As a suspension strut, the main advantage would be simplicity and extremely high frequency response. The power draw would be high, however, although power draw at the alternator would be about the same as the pump for hydraulically operated struts.

Although the device's application in a suspension system is strictly theoretical at this time, the Aura research explores a significant alternative to the complex hydraulic mechanisms of current active-suspension designs.—Dan McCosh

High-tech engine mount may quiet inline 4 and 6 bangers, cut costs

By Jack Keebler
AUTOMOTIVE NEWS STAFF REPORTER

A new type of computer-controlled, "active" engine mount promises to make shaky inline four-cylinder and V-6 engines as quiet and vibration-free as a V-8.

The development of active engine mounts could give new life to aged four-cylinder engines, save vehicle weight, increase fuel economy and conserve billions of dollars in engine development costs.

Until recently, increased competition and harshness has been pushing makers away from four to smooth-running inline six, V-6, V-8 and even V-12 engines.

But the threat of tougher fuel economy standards, chassis weight-reduction programs and consumer anxiety about rising fuel prices beg engineers to reconsider

the low weight, mechanical simplicity and thermal efficiency of four-cylinder engines. And this engineering breakthrough would eliminate the four-cylinder engine's greatest disadvantage.

Three companies claim to have arrived at the new engine-quieting technology independently. Lotus Engineering of Norfolk, England in conjunction with engine mount maker Carl Freudenberg of West Germany; Noise Cancellation Technologies Inc. of New York; and Acura Systems Inc. of El Segundo, Calif., have all recently claimed development of an active engine-mount system.

Lotus and Noise Cancellation Technologies claim their electronic systems are far more effective than engine-powered balance shafts because the additional power required to smooth the engine is less

— 0.1 horsepower for engine mounts versus approximately 1.0 to 3.0 horsepower for a balance shaft.

Active mounts weigh less (5 to 10 pounds vs. 20 pounds). They could also reduce engine-packaging problems by eliminating bulky balance-shaft systems. And finally, because they are computer controlled and programmable, they are adaptive to a much wider range of engine speeds and loads.

Balance-shaft systems provide their vibration reducing benefit in a relatively narrow range of engine speeds and loads.

Wilhelm Cashen, an Acura Systems representative, said his company is currently developing an electro-magnetic version of an active mount for automotive applications. The Lotus and Noise Cancellation Technologies, see MOUNT, page 41

MOUNT

FROM PAGE 6

Noise Cancellation Technologies mounts utilize electrical or hydraulic actuators, but the electronics software and hardware are basically similar. Acura says it has installed its active-mount system in some Navy ships and some military aircraft. Details on the Acura system have not been released.

Lotus predicts that active engine mounts will be in an up-market European sedan within two years. Noise Cancellation Technologies said it has successfully demonstrated an active engine-mount prototype developed under contract with Chrysler, and "a major European car manufacturer."

And General Motors is expected

to announce a contract with Noise Cancellation Technologies.

"NCT's active mount impressed us all by far out-reaching the level of vibration reduction that any of us expected," said Christopher A. Wolfe, a product engineer for Jeep/Truck Engineering at Chrysler, in a Noise Cancellation Technologies press release. "At the beginning of the project we had no idea the results would be so dramatic."

A spokesman for Lotus said the active mounts would likely be about twice as expensive as the most sophisticated hydraulic mounts. That would mean a single mount would cost about \$75. All systems would require at least two of the mounts to be effective. The

control electronics would also add approximately \$10 to \$20 additional cost. But the electronics could cost considerably more depending upon their sophistication.

Michael J. Parrella, president of Noise Cancellation Technologies, said the cost of his mounts would be similar.

High-revving four-cylinder engines of modest displacement can reliably make 200-plus horsepower with supercharging, turbocharging and multi-valve cylinder head technology. But four cylinder use has been limited — with some significant exceptions — to low-budget cars and trucks or sporty models where vibration and noise are more readily tolerated by

buyers.

The traditional methods of damping powertrain vibrations are engine-powered balance shafts and heavy damping weights. Balance shafts, which weigh approximately 20 pounds, are currently used in the engines of General Motors, Ford Motor Co., Chrysler Corp., Mitsubishi Motors Corp., Porsche AG, Saab Scania AB and Volvo Car Corp.

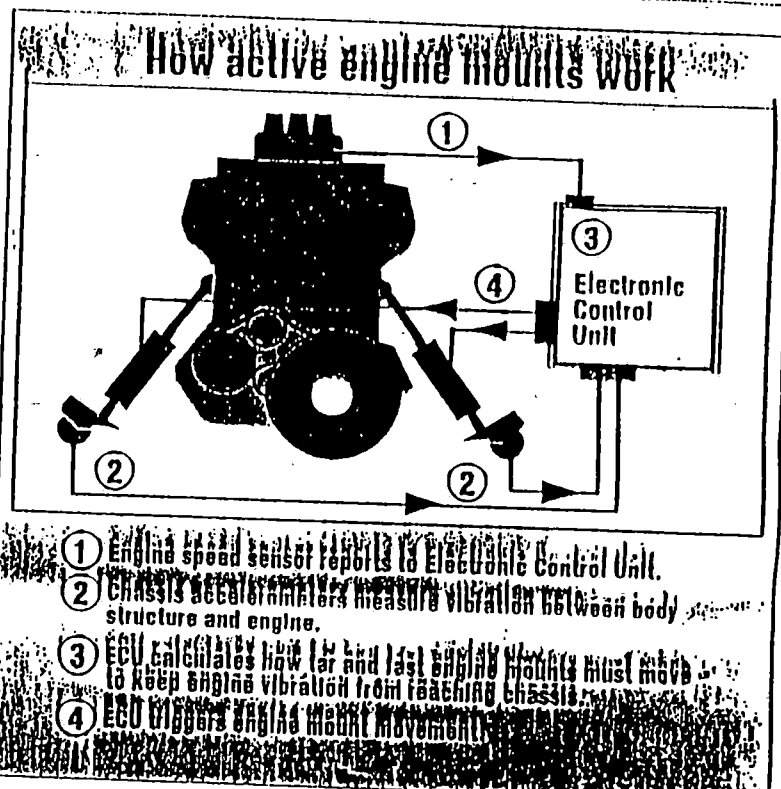
Damping-weight systems, which modify the resonant frequencies of body, chassis and powertrain components, are even more widely used than balance shafts. These range in weight from 5 to 25 pounds.

The Lotus-Freudenberg system

consists of conventional hydraulic engine mounts adapted to house an electrical actuator that is controlled by a computer. The actuator is controlled so that the force from the moving engine mass is not transmitted to the body or powertrain cradle.

The actuator's movement is determined by the system's computer using chassis-mounted accelerometers and an engine-speed sensor. The computer then shortens or lengthens the mounts in order to minimize the input from the vibrating engine.

Special Correspondent Ian Adcock in Norfolk, England contributed to this report.



AUTOMOTIVE NEWS / DAVID L. BURMAN

ROA NATIONAL SECURITY REPORT



Cold War May Be Over, but Iraqi Aggression Threatens World Peace

By Vice President Dan Quayle

Since the onset of the Cold War, the United States has had three strategic objectives in the Middle East region. The first objective was to contain Soviet expansionism.

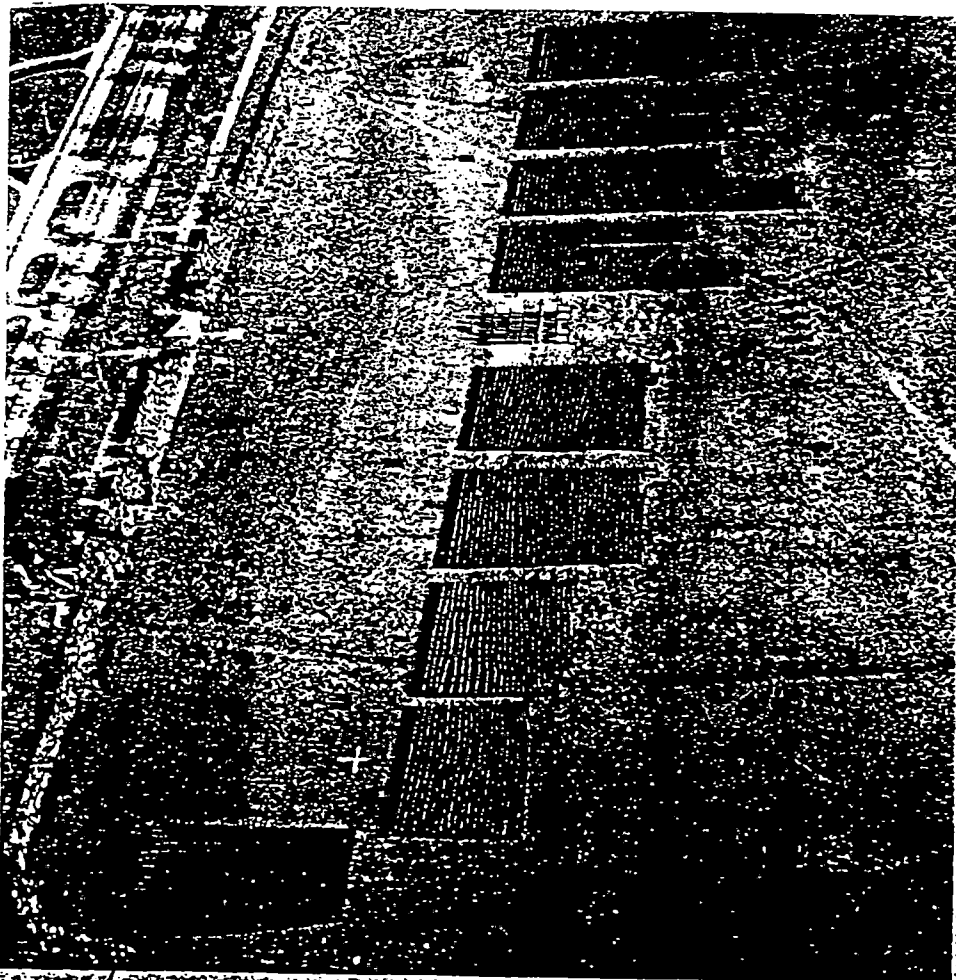
In 1947, the Soviet threat to one regional state, Turkey, played a role in President Truman's decision to issue the doctrine that bears his name. Thirty-three years later, the threat of Soviet encroachment on another region of the Middle East — the Persian Gulf — led President Carter to proclaim the equivalent of the Truman Doctrine for the Gulf.

The Carter Doctrine, which was also reinforced by President Reagan, warned, "Any attempt by any outside force to gain control of the Persian Gulf region will be regarded as an assault on the vital interests of the United States of America, and such an assault will be repelled by any means necessary, including military force."

Continued on next page.



This text is excerpted from an address 29 November by the Vice President to Selon Hall University, South Orange, N.J.



Muster of the 24,000 Marines of the Second Marine Expeditionary Force (II MEF) took place 10 December at Camp Lejeune, N.C., preparatory to their departure for Saudi Arabia. Marine Commandant Gen. Alfred M. Gray addressed the assembled "warriors" of the Second Marine Division, Second Marine Air Wing, and supporting units from Fleet Marine Force Atlantic. Most were to be in Saudi Arabia by the end of the month. ROA National Security Report photograph.



and willing to help. President Bush has urged the international community to help these countries, hurt by the loss of export markets and rising energy costs at a time when they can least afford it.

The recognition that our economies have become increasingly interdependent marks a turning point in our understanding of both national and international security.

Understanding regional and global trends and their implications for our nation is the job of intelligence. Reporting on instability worldwide, whether that instability is caused by blatant aggression or is the result of changing internal forces, will also remain the task of intelligence.

Intelligence will continue to track the transnational issues of weapons proliferation, terrorism, and narcotics. And intelligence will continue to advise on the military, political and economic forces abroad which affect our nation.

This article has discussed two regions of the world which have undergone dramatic change in the past year. What has occurred in both regions — democratic change in eastern Europe and international support in opposing the invasion of Kuwait — would have been impossible without the changes in the relationship between the United States and the Soviet Union, without the continued vigilance of the past decade and without the strength of an international community of nations.

We are all of us standing at the threshold of a new era. We bring with us the knowledge of past events: of wars, aggression, influence and power; of technological advances that have changed our communication and changed the nature of conflict. We bring with us a determination to safeguard the future.

In the months ahead, as we continue to monitor the situation in the Gulf and as we watch the nations of eastern Europe re-enter the world economy, those in intelligence will have an unparalleled privilege: advising our policymakers in times of unprecedented change and unprecedented opportunity.

SDI Research from Innovation to Application

By Carol A. Valentine

When we hear the words "Strategic Defense Initiative" how many of us think of cataract surgery, integrated circuit design and manufacture, toxic waste disposal, cancer treatment, leg braces and artificial veins?

Yet technological innovations developed by SDI funding have potential application in these disparate fields, and have been incorporated in products and processes far removed from the original SDI purpose.

How many who have operated sophisticated military systems realize what has evolved from the research and development behind them?

Radar developments led to the microwave in the kitchen; artillery shell fuze spinoffs now trigger air bags in automobiles; Navy anti-submarine technology now resides in Magnetic Resonance Imaging diagnostic equipment in hospitals; even the photosensitive windshield material developed to protect B-58 crews from nuclear flash found its way into the photogray eyeglass lenses many wear today.



Mrs. Valentine works to promote technology transfer with the Technology Management Division of Systems Engineering and Management Associates, Inc., Falls Church, Va., a contractor with the Strategic Defense Initiative Organization (SDIO).

Technology transfer — the application of ideas and technologies from the sphere in which they were created to other fields — has taken place with military technology for decades and is an integral part of the SDI program today.

Federally developed technology has been the subject of a host of Congressional initiatives designed to make this technology more accessible to American businesses and government agencies.

In response to these directives, a special office within the Strategic Defense Initiative Organization, the Office of Technology Applications, was set up in 1986. This office uses a variety of approaches, including database access, people-to-people contact, and publications to make US corporations and citizens aware of the SDIO technology that is available to them.

The SDIO Technology Applications Office supports a user-friendly, modern accessible database which contains over 1,400 abstracts of SDI funded technologies, covering 20 industrial and technological categories. The abstracts cover subject matters ranging from advanced materials to electronics, computers, energy, optics, navigation, guidance and control systems, biotechnology, and others.

The unique concept behind this system is that it was not designed as much to provide detailed technical information as it was to put potential users directly in touch with the scientist who is doing the research and is developing the technology.

The database also provides referrals to

Continued on page 31



more than 175 federal and 450 state and regional sources of financial and technical assistance. American corporations and citizens can access the database after a simple, straightforward certification administered by the Defense Logistics Agency to ensure that military critical technology will be properly protected.

On the people-to-people level, the SDIO hosts meetings between SDI scientists and experts in technology applications. These Technology Applications Review meetings are held about ten times a year, with major review areas in advanced materials, optics, electronics, power, biomedical applications and others.

Other outreach efforts include networking with universities, professional associations, federal laboratories, corporations, and other institutions within the tech transfer community. Finally, SDIO produces a variety of written informational materials, including press kits, brochures, annual reports, and articles for technical and professional journals. The goal of these outreach efforts is to accelerate the transfer of SDI technology to the commercial marketplace.

What kind of spinoffs have been generated from the Strategic Defense Initiative? Let's look at some.

Technology that was designed to be used in an electromagnetic test stand to test SDI rocket thrusters is being incorporated into a surgical procedure to remove cataracts. The new surgical technique promises to reduce complications, shorten recuperation time and be less invasive and traumatic than techniques currently being used.

In the original SDI test stand application, developed by Aura Systems, Inc., of El Segundo, Calif., a miniature thruster is suspended in a strong electromagnetic field established with magnets. The thrusters are fired, and automatic adjust-



Technological advances coming from Strategic Defense Initiative (SDI) research are explained to Deputy Secretary of Defense Donald Atwood during a recent visit to an Air Force base. USAF photo from DoD Still Picture Collection.

ments are made to ensure the gap between the electromagnets and the vehicle remain constant. In this manner, precise thrust

"Technology that was designed to be used in an electromagnetic test stand to test SDI rocket thrusters is being incorporated into a surgical procedure to remove cataracts."

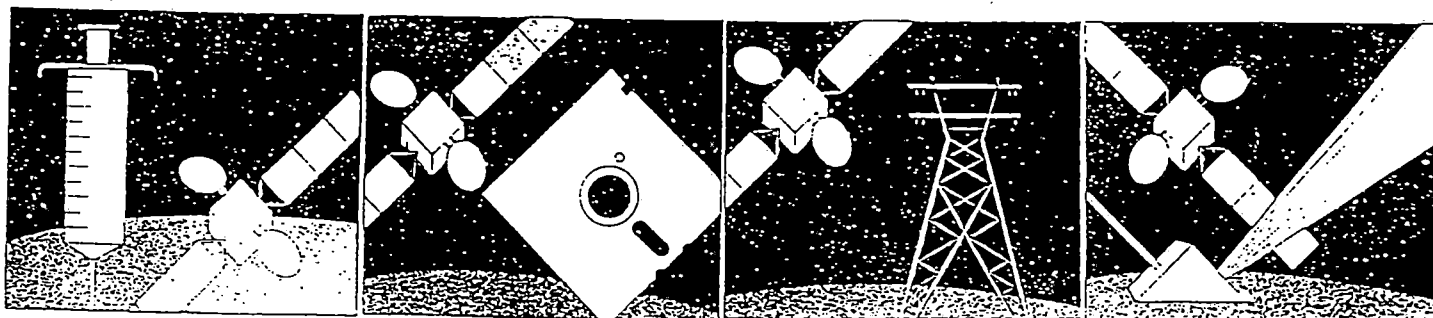
measurements can be obtained for relatively small thrust levels.

When New York ophthalmologist Dr. Charles Kelman read about the technology

in *Forbes*, he saw its application in cataract removal. Several years ago, Dr. Kelman developed the widely used phacoemulsification cataract removal technique, in which an incision is made in the lens capsule, a probe is inserted, and the cataract emulsified. In the majority of cases, however, the muscles of the lens capsule are damaged, and the eye's focusing ability is lost.

Dr. Kelman reasoned that the Aura technology could be used to avoid damaging the muscles of the lens capsule. He and Aura engineers developed a surgical system in which three magnets are placed around the patient's head, a tiny incision is made in the eye, and a magnetic bead (a magnabit) is inserted under the lens capsule.

A computer-controlled motion system, optical camera sensors and a video camera



give the surgeon control of the bead and a magnified view of the eye. The surgeon then rotates the magnabit, emulsifies the cataract and removes the magnabit and the emulsified material without severing the lens muscles.

Dr. Kelman and Aura Systems Inc. jointly formed Aura Medical Systems, Inc. to refine and develop the technique, which has been tested on animals. FDA approval for limited testing on humans will be requested. The Aura innovators also see other applications of the technology, including breaking down plaque in arteries, removing obstructions from organs, and performing surgery on inaccessible parts of the body.

In another spinoff, a laser developed to gauge the location of enemy space vehicles is now being used to make microchips. The laser, made by Lightwave Electronics in Mountain View, Calif., is compact, lightweight, and thus easily deployable.

In the SDI application, a deployed laser would emit a very short burst of light at the target vehicle. The light would reach its target and be reflected back to its source just like a conventional radar. The distance of the target from the laser would then be calculated as a correlate of the time interval between initial firing and receipt of the reflection. For increased accuracy in pinpointing targets, the laser was designed to emit short bursts of energy (the shorter the burst of energy, the higher the resolution in range finding).

How does this relate to microchip manufacturing? Well, at the time the

Lightwave laser was developed, manufacturers of integrated circuit (IC) manufacturing equipment were using lamp-pumped lasers to burn patterns into the IC mediums. The lamp-pumped lasers were large and expensive to operate, needed to be cooled with water, and were incapable of shorter bursts of energy.

Today the Lightwave laser has replaced the lamp-pumped lasers in this market. The shorter bursts of energy and the finer resolution they produce mean finer and more precise patterns can be burned into the IC medium. Compactness and economy of operation are also attractive commercial features.

In another spinoff, the Lightwave laser is being used by a power plant customer to test for electrical overload in cables. In this application, the power plant ran an optical fiber along the length of copper cable.

"The Aura innovators also see other applications of the technology including breaking down plaque in arteries, removing obstructions from organs, and performing surgery on inaccessible parts of the body."

When a pulse of laser energy is sent down the fiber, some is scattered back.

The scattered light is measured, and variations in intensity have been correlated to variations in temperature. Should any variations occur during actual testing, the sites of the variations can be located by calculating the speed at which the light travels and the time taken to return.

Lightwave Electronics sees other future applications of the laser to include spotting fires in buildings, boats, and airplanes, and thermal control in space vehicles.

Other spinoffs of SDI research include:

- A miniaturized linear accelerator which can potentially make toxic wastes, including nuclear wastes, inert; developed at Lawrence Livermore National Laboratory.
- Cancer treatment. A Los Alamos linear accelerator has been integrated into the proton cancer treatment facility at Loma Linda University Hospital. The first patient was treated on 27 October 1990.
- A method of manufacturing biomedical grade elastomers with microscopic pores. Tubes made with the material can support living tissue and be used as artificial veins and blood vessels; developed by Sandia National Laboratories.
- A software program that creates design layouts for integrated circuits; developed by Silicon Designs, Inc.
- Leg braces made of an advanced carbon-based composite material, which is two times stronger, weighs two-thirds less, and is 40 percent more rigid than steel.

Further information on the program can be obtained from the Technology Applications Office, Strategic Defense Initiative Organization, OSD/SDIO/TNO, The Pentagon, Washington, D.C. 20301-7100; phone (703) 693-1563. □

MAGNETIC BEARING INSIGHTS

Volume 1, Number 2

June, 1991

NEWSBRIEFS

GREENIDGE FEEDPUMP UPDATE

The magnetic bearing feedpump currently being demonstrated at the New York State Electric and Gas Company's Greenidge plant was recently taken out of service to correct a minor problem, following an observed reduction in hydraulic performance. The reduction in performance, which was not related to the magnetic bearings, has been traced to deterioration in one of three Graphalloy sleeves, which function as auxiliary bearings in the event of magnetic bearing failure. The bushings have been replaced by hard-faced metallic sleeves which should prevent a recurrence of the problem.

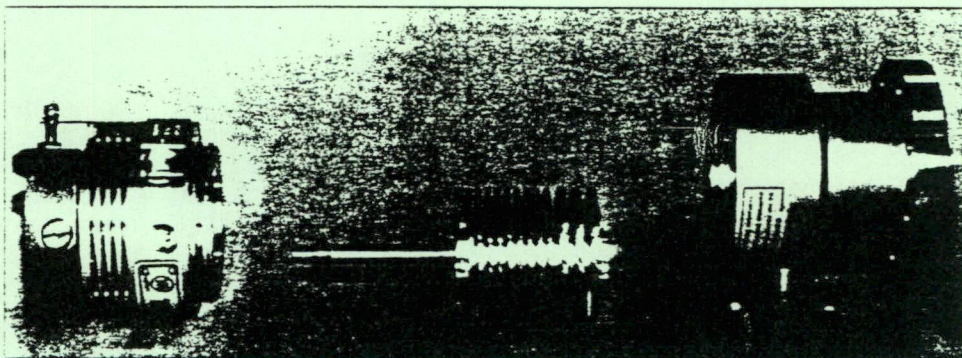
KINGSBURY ANNOUNCES JOINT PROJECT

Kingsbury Bearings of Philadelphia, Pennsylvania and BW/IP International of Vernon, California are joining forces to develop a new class of magnetic bearing-equipped pumps. The new pump design eliminates both face

(Continued on page 2)

INSIDE:

- ❑ Breaking The Cost Barrier
- ❑ The University of Virginia: A Center for Magnetic Bearings
- ❑ Novacorp: Focus on Gas Pipeline Compressors
- ❑ Evaluating Magnetic Bearing Applications - Part 1 of a 2-Part Series
- ❑ Future Events



AURA will provide magnetic bearings for this Varian turbomolecular pump.

AURA MOVES INTO PRODUCTION PHASE

The active magnetic bearing technology developed by Aura Systems of El Segundo, California has taken a major step from the laboratory to the marketplace with the announcement of a multi-year contract from Varian Associates. The contract, which has a minimum value of \$4 million, was awarded for the production of magnetic bearings for turbomolecular pumps. Under the contract, Aura will provide at least 6,750 bearing sets over a five-year period. The Varian award represents the first production run contract for Aura, which was founded in 1987.

A second contract, worth approximately \$1 million was also announced by Aura. The latter is for approximately 100 magnetic actuators to be used in wave generators for large modeling tanks simulating open ocean conditions. The modeling tanks are used to support the design of ocean drilling platforms and similar applications. The actuator contract was placed by Davis Engineering Ltd. of Montreal, Canada on behalf of the Korean and French Governments.

Turbomolecular pumps are high vacuum producing devices that typically operate in the range of 1 Pa to 10^{-4} Pa. The bearings to be provided by Aura for Varian's turbomolecular pumps will feature full five-axis active control (two radial bearings and two single-acting thrust bearings). This is a departure from other magnetic suspension systems for turbomolecular pumps, which have typically relied on passive magnetic bearings, employing permanent magnets, to control one or more axes. In a recent paper presented at the ROMAG '91 conference, Aura engineers Sortore and Bartosh suggested that stiffness, damping and overall dynamic stability could be improved by a change to all-active magnetic bearings. To prove their concept, Aura modified a commercially available Varian turbomolecular pump to incorporate their five axis bearing system. Production units are designed to operate at speeds up to 60,000 rpm for indefinite periods, without bearing related failures.

EDITORIAL: BREAKING THE COST BARRIER

Given the many advantages of magnetic bearings in rotating machinery, it seems strange, at first, that this technology, which has been in development for over 50 years, has not already made a larger impact in the marketplace. The answer, of course, may be found in the technical and economic barriers that were faced by its developers.

Early technical barriers included the need to develop the fundamental principles of magnetic suspension and the associated development of practical control schemes. Other problems related to the resolution of rotor dynamics issues and the development of suitable auxiliary bearing systems. With many of these technical challenges having now been resolved, practical applications of magnetic bearings began to appear as early as the 1970's.

The early applications of magnetic bearings tended to be in areas of unique capability (e.g.: space applications, turbomolecular pumps). In such applications, the use of magnetic bearings resolved serious shortcomings in conventional equipment and cost considerations were of secondary importance.

At the current stage of market development, however, magnetic bearings are being evaluated for applications in which conventional bearings have a proven track record of generally satisfactory, if

not ideal, performance. In such a market, economic factors become the dominant issue, and the last major barrier to the wide-spread use of magnetic bearing technology.

As noted in the accompanying educational series article, a careful evaluation of prospective magnetic bearing applications can already produce a positive economic result in many instances. This is especially true in those cases where performance or reliability can be enhanced in large, high cost machines. The current trend toward reduced magnetic bearing prices will further expand the dimensions of this specialty market. For smaller, high volume applications to be feasible, however, new approaches must be developed that would drastically reduce the costs of such systems.

The most significant impediment to reduced cost is the current generation of analog control systems which require a labor intensive tuning process for each individual installation. With the advent of self-tuning digital systems, this expensive process should soon be eliminated from the pricing structure. Standardization and volume production should then be possible, thus opening the door to new high-volume low-cost market strategies.

In contemplating this last, and difficult, barrier to the wide-spread use of magnetic bearings, we are encouraged by the recent emergence of practical digital control systems which are under development by several vendors. We also note with interest the high-volume, low-cost marketing strategy adopted at Aura. We believe that both trends portend a bright future for magnetic bearings. ■

Readers are invited to contribute articles of general interest to MAGNETIC BEARING INSIGHTS. If interested, please contact the editors at the number provided.

NEWSBRIEFS

(Continued from page 1)

seals and contact bearings, which are major sources of outages in conventional equipment. The objective of the joint project is to provide a standard line of pumps for petrochemical refinery applications, which meets the requirements of API Standard 610. The pump design incorporates standard API product line components for the impeller, volute case and wear rings. The motor is based upon existing Byron-Jackson submersible motor design and canning technology which is currently used in naval and petroleum refining applications. A prototype of the new pump is currently being tested at BW/IP's facility in Vernon. The motor being tested within the prototype pump is rated at 125 hp.

RESEARCH CONTRACTS AWARDED TO CREATE

Creare, of Hanover, New Hampshire, was recently awarded two follow-on (Phase II) Small Business Innovative Research (SBIR) contracts for the development of magnetic bearings. The first contract was awarded by the U.S. Air Force, in November 1990, for the development of high temperature bearings for the Expendable Turbine Engine Concept (ETEC) Program. Creare is teamed with Williams International, an established manufacturer of small turbine engines for that effort. According to Dr. Victor Iannello, the goals of the Phase II contract include bearings and sensors capable of operating at 70,000 rpm at 800°F and a miniaturized control system that significantly reduces weight and volume relative to current systems.

Creare was also awarded a Phase II SBIR contract by NASA Goddard. The second award is for development of magnetic bearings to be used in a miniature high speed compressor. The compressor is part of a space-borne cryocooler system that is used to maintain components of infrared sensors at cryogenic temperature levels. The compressor shaft has a diameter of 1/4 inch and the target speed is approximately 500,000 rpm. In Phase

(Continued on page 11)

MAGNETIC BEARING INSIGHTS

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EVALUATION OF MB

(Continued from page 10)

It is a challenge, then, to devise a structured evaluation framework that would encompass a broad range of possibilities.

From our own experience, we believe that a two-step evaluation process comes closest to meeting the mark. The first step involves a qualitative assessment, which is accomplished using the framework of Table 3. Table 3 is an extension of the methodology used in the utility evaluation outlined above, which takes into account the additional decision factors that were identified through this survey of current applications. In the qualitative assessment, two questions should be asked regarding each evaluation item. The first is whether there are any important technical differences that would distinguish a magnetic bearing solution from that of its conventional counterpart. Where found, such differences should be noted. The second question to be addressed for each item is whether that issue can and should be included in an economic assessment to follow.

In some cases, the initial assessment may conclude that magnetic bearings provide the only practical technical solution. In such cases, no further comparative evaluations may be necessary, and the question reverts to whether the application itself offers sufficient incentive. In other cases, where the technical issues are not compelling, the economic differentials of the competing solutions should be explored in the areas identified as important. The economic evaluation is the second step of the evaluation process, and its nature will vary considerably from application to application.

NEXT MONTH: AN EXAMPLE

In this month's article, we have looked at diverse range of magnetic bearing applications that are currently deployed or under development and have identified the key decision elements that have led to their selection. A proposed methodology and framework has been developed as a more general approach to evaluation. In next month's issue, we will apply this methodology to a new application of

magnetic bearings, large centrifugal fans for fossil boilers in utility power plants.

REFERENCES

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3. R.B. Zmood, et al, *ibid*, p 123.
4. G. Genta, et al *ibid*, p 65.
5. R. Siegart, et al, *ibid*, p 197.
6. M. Ota, et al, *ibid*, p 205.
7. S.O Uptigrove, et al, ASME Gas Turbine Conference and Exhibition, May 31-June 4, 1987, Anaheim, CA.
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NEWSBRIEFS

(Continued from page 2)

I, Creare successfully demonstrated a preliminary design at 250,000 rpm. Dr. Iannello noted that both awards are consistent with Creare's focus on specialized applications of magnetic bearings at high rotational speeds and extreme temperatures.

NOVACORP DEVELOPS THRUST BALANCER

Novacorp has announced the availability of a patented device to reduce the end loads in gas-compressors incorporating overhung shaft designs. The "Thrust Reducer" which can be used with both radial and axial compressor inlet configurations, incorporates an active control system to regulate pressure in two concentric gas chambers, effectively isolating the inlet gas forces which normally are exerted on the end of the compressor

shaft. By significantly reducing the end thrust loads, the Novacorp device allows magnetic thrust bearings to be applied in certain machines where high thrust loads previously excluded their use. The prototype thrust reducer has been operating in a Novacorp compressor for three years.

JOINT MAGNETIC BEARING CONFERENCE ANNOUNCED

The Center for Magnetic Bearings at the University of Virginia announced that they will host the Third International Conference on Magnetic Bearings which will be held in Alexandria, Virginia during July 29-31, 1992. Since the International Conference will be held in the U.S. for the first time, it will be joined in 1992 with the industrially oriented MAG '92 conference (a follow-on to ROMAG '91). Professor

Paul Allaire of the University of Virginia will be the Conference Chairman for the joint meetings. ■

CORRECTION: MBI REVISITED

In the May NEWSBRIEFS, we incorrectly reported that Magnetic Bearings, Inc. (MBI) had been acquired by John Crane, Inc. Actually, a majority (60%) interest in MBI was acquired by the TI Group of England, which is also the parent of John Crane. MBI has an agreement to utilize the marketing organization of John Crane to support their U.S. marketing activities, but is otherwise independent of that organization. The remaining 40% of MBI is held by S2M of France.

FUTURE EVENTS

1991

- JUN 26-28 EPRI Power Plant Pump Symposium, Tampa, FL
Susan Bisitti
(415) 855-7919
- AUG 19-23 International Symposium on Magnetic Suspension Technology
NASA Langley, Hampton, VA
Emily Kornegay
(804) 864-6606
- SEP 17-19 Turbomachinery Symposium, Texas A&M
Dallas, TX
Julie Blasingame
(409) 845-7417
- OCT 13-16 ASME STLE Conference
St. Louis, MO
(212) 705-7057

1992

- APR 6-9 REVOLVE '92
Calgary, Alberta
Novacorp
Marie Lentsch
(403) 261-7526
- JUL 29-31 3rd International Conference on Magnetic Bearings
Alexandria, VA
University of Virginia
Sandy Maslen
(703) 924-3292
- OCT 18-21 ASME/STLE Tribology Conference
San Diego, CA
ASME
(212) 705-7057

AURA SYSTEMS

(Continued from Page 1)

According to President and CEO Harry Kurtzman, the Varian contract is consistent with Aura's strategy to focus on production run applications, as opposed to custom engineered, single use applications. With quantity production in mind, Aura has focused their development efforts on compact, low cost bearings, using customized proximity sensors and a digital control system with self-tuning and self-monitoring capabilities.

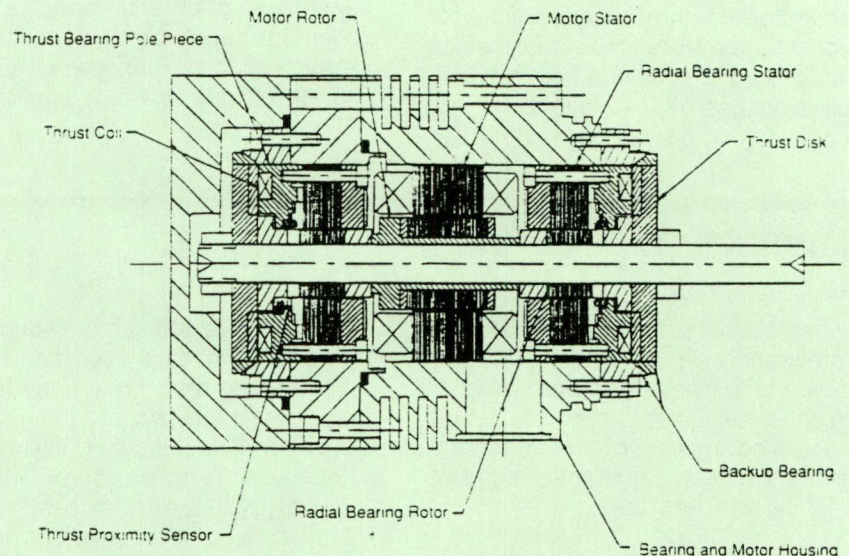
The digital control system is an adaptation of digital signal processing technology which was initially designed for telecommunications applications. The control system can be applied, without physical change, over a range of sizes, thus enhancing standardization and reducing unit costs. The cost of power amplifiers has also been addressed through the use of higher frequency (81 kHz) pulse width modulated amplifiers to replace the larger



Magnetic Bearings for Varian Pump

and more expensive linear amplifiers that are often used.

If the Varian contract is a true indicator, the cost reductions already achieved by Aura should open significant new market possibilities for active magnetic bearings. Kurtzman stated that even further reductions in cost appear possible with the employment of modern high volume production technology. ■



Magnetic bearing layout for Varian turbomolecular pump

READER'S FORUM

In future issues of MAGNETIC BEARING INSIGHTS, we plan to include a Reader's Forum. We would invite readers to submit questions and comments on magnetic bearing topics that are thought to be of general interest. In the case of questions, we will provide an answer or obtain an answer from a knowledgeable expert and print the answer, along with the question. Alternatively, we may print the question and solicit input from readers for publication in later issues. We encourage our readers to take advantage of this potentially valuable communications vehicle.

POWERCONVERSION & INTELLIGENT MOTION

THE FUSION OF POWER & MOTION TECHNOLOGY & APPLICATIONS

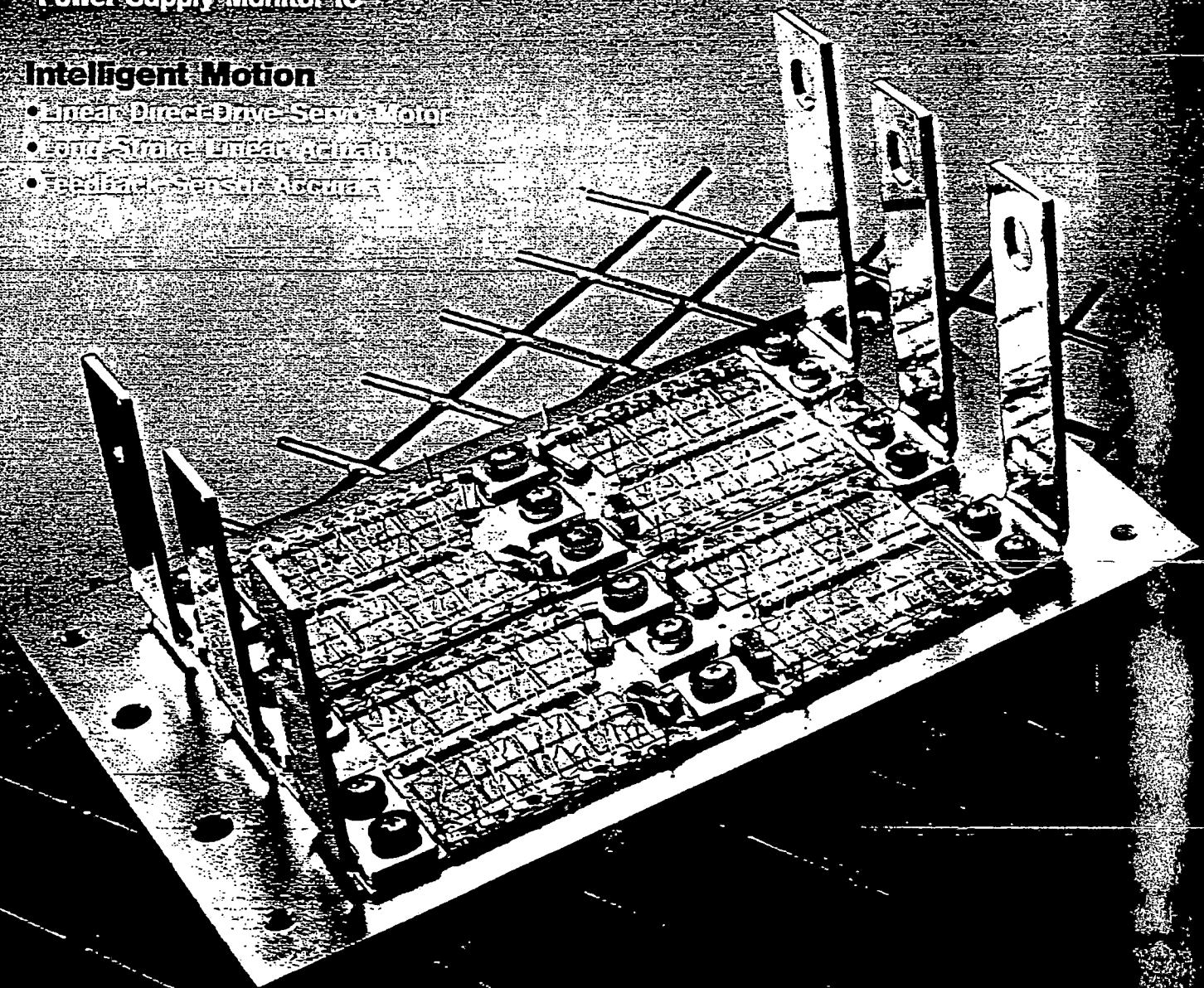
OCTOBER 1991

Power Conversion

- Thermal Modeling
- Power Hybrid Thermal Characteristics
- Power Supply Monitor IC

Intelligent Motion

- Linear Direct Drive Servo Motor
- Long Stroke Linear Actuator
- Feedback Sensor Accuracy



positioner is again useful in automotive applications such as flow rate control. Of interest to the off-road diesel engine equipment manufacturers is servo-controlled throttling using such a system.

These linear actuators employ relatively simple mechanical components and assembly procedures as well as low-cost materials. This results in low production costs compared with other types of mechanical actuation methods. For example, the automotive industry requires actuation of door locks, remote mirror positioning, and flow control valves. The linear actuator has one moving part and is no more bulky than electro-mechanical systems now used, so it can replace the more expensive gear-and-motor mechanisms. Also, it can provide low-cost precision flow control when driven by the automobile's microprocessor.

Why should an "old" technology like the linear actuator or solenoid become so attractive today? First, the technology has recently undergone an evolution that had previously been stymied by low engineering interest. Second, the parallel advancement of permanent magnet materials has made the newer designs realizable.

Based on flux focusing, the new design achieves the highest magnetic

flux density possible, with little flux leakage. This is accomplished in an area contained by the entire coil, producing highly efficient and linear actuation (*Figure 2*). The increased efficiency occurs because the flux is focused on the coil and is not lost in wayward paths; i.e., there is minimum flux leakage. The high degree of linearity occurs because the flux paths are completely encompassed by the coil, so fringe effects are negligible.

Flux focusing is based on a patented concept that uses radially magnetized, permanent magnets formed in arc segments. Availability of high-energy rare-earth permanent magnets has made it possible to generate extremely high forces from a compact actuator assembly.

Further developments in coil forming and insulation have also contributed to the new actuator capabilities. Flat wire, which allows higher packing density, permits more turns per inch, thus increasing the force developed for an equivalent actuator coil constructed with round wire. Another advantage of the flat wire is increased current-carrying capability, which is due to its larger cross-sectional area compared with round wire. Whereas larger round wire gauges take a toll on the turns per inch in the coil, flat

wire thickness is held constant, with its width selected for the required current-carrying capacity. Unique methods of wire insulation have been developed that withstand the coil forming process and high temperature actuator operation.

Linear actuators are available in various configurations, each having its own application niche. These include moving magnet, moving coil, brushless and brushed designs.

In a moving magnet linear actuator the magnet structure, which rides on some type of bearing or bushing, moves within a stationary coil. Usually, the coil is mounted in intimate thermal contact with the actuator casing, which aids cooling during heavy-duty operation.

In contrast, the coil of the moving coil linear actuator physically moves within a stationary magnetic field, produced by the permanent magnet structure. This actuator provides higher bandwidth than the moving magnet design, due to the reduction of moving element mass. The coil structure is typically lighter than the magnet structure.

Depending on the stroke specification, the actuator design can be brush or brushless. A brushless design is desirable for construction simplicity. The breakpoint for determining what method to use, brushed or brushless, is a function of stroke, force and linearity. As a rule of thumb, use a brushless design for strokes less than two inches. The tradeoff is the amount of magnet material used, which must be able to generate enough flux to create forces with reasonable coil currents. This directly affects the weight and cost of the actuator assembly. The rare-earth permanent magnets represent the highest component cost in actuator production.

A further tradeoff is the electrical characteristics of the actuator. For longer strokes, a brush design yields a lower coil resistance and inductance to the power driver. Because brushes energize a specific section of coil, the power driver need only be sized to

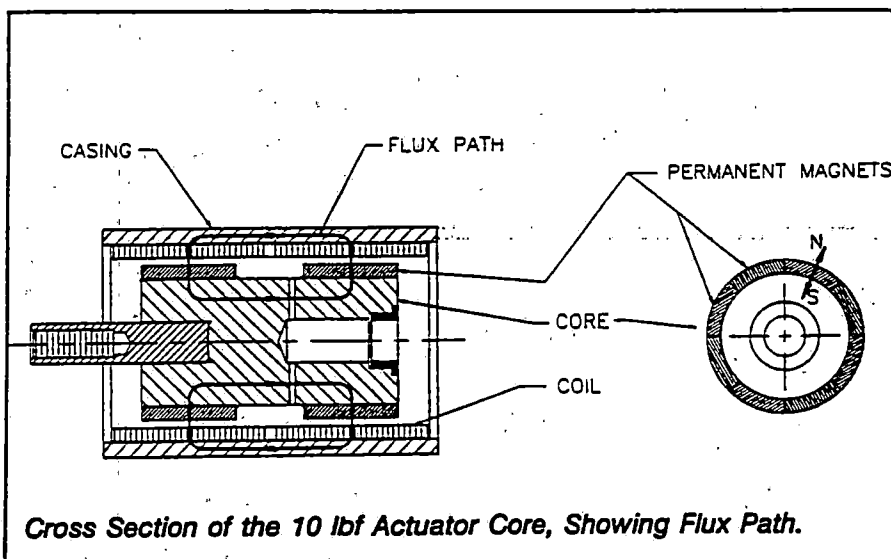


Figure 2. Radially Magnetized Permanent Magnets Focus Flux Into the Coil.

drive that section of coil, not the entire coil.

Some applications require the linear actuator to respond to high frequency currents, so in these cases the reduction of coil inductance is important. Power drivers have real limitations in terms of their voltage, current, and bandwidth capabilities.

Returning to the applications side of this discussion, the various types of linear actuators have found homes in many different applications of force generation and motion control. One interesting application makes use of the mass of the moving magnet actuator design. The momentum developed by the moving magnet structure can be used to counteract vibrational energy of another system.

In an application known as vibration cancellation, a moving magnet actuator is mechanically mounted to a surface that could be part of a vibrating machine. The desired effect is to cancel the machinery's vibrations by applying reaction forces. The reaction forces are generated out of phase with the machinery vibration, as measured by accelerometers. The actuator's force output is proportional and linear with coil current. Applying an amplified and inverted accelerometer signal as the coil current waveform causes reaction mass acceleration within the actuator. This movement causes equal and opposite reaction forces to be exerted against the surface of the machinery to which the actuator is mounted. The result is quieter machinery, with the vibration energy transferred into actuator heating and electronic power driver losses.

Because the actuator's output is through momentum transfer in this application, no output shaft is present. The actuator is completely sealed, and has even been designed for submersible operation.

The vibration cancellation application demands a high precision of force reproduction. Distortion in the force reproduction would result in generating unwanted vibrational energy, and possibly negating the

Combining the new linear actuator's long stroke with a precision position-sensing device, such as a linear voltage differential transformer (LVDT), provides a replacement for ball-screw and lead-screw type positioners.

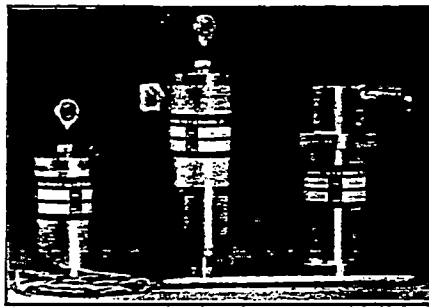


Figure 3. Similar 10 lbf Linear Actuators With Different Characteristics; Left: The Basic Unit, With Output Shaft; Middle: With Integral LVDT Position Transducer; Right: Submersible Reaction Mass Device for Vibration Cancellation.

desired vibration cancellation. The highly linear characteristics of the new actuator designs result in high fidelity force reproduction. In fact, currently produced designs achieve better than -40 dB total harmonic distortion, referenced to the full rated output over the device bandwidth. This fidelity of force reproduction has been verified in actuators with force outputs ranging from 10 lbf to 1500 lbf and over frequency ranges from 5 Hz to 500 Hz.

There are many benefits to the motion control aspect of the new linear actuator application. Combining the new linear actuator's long stroke with a precision position-sensing device, such as a linear voltage differential transformer (LVDT), provides a replacement for ball-screw

and lead-screw type positioners (*Figure 3*). In currently produced hardware, the position transducer is integrated completely within the actuator's mechanical assembly. The electrical connections to the position transducer and the actuator coil are in a single convenient connector.

Figure 4 shows the curves of position vs frequency (*6a*) and force vs frequency (*6b*). These characteristics allow the actuator to provide precision positioning via a classic controls implementation to eliminate backlash and increase bandwidth. The accuracy with which the actuator can position its output shaft is related to the position transducer accuracy, which can be better than 0.001-in. Backlash is eliminated by eliminating the lead screw. Stiction induced dither is eliminated through use of quality shaft bushings or bearings in the linear actuator construction. Bandwidth is increased because of the direct actuation of the shaft in a linear actuator, compared with the indirect, slow actuation of ball-screw and lead-screw positioners.

Another application of such a device is in precision vibration of shaker heads, where the actuator is used to induce predefined vibrational profiles to a component under environmental test. For acoustics applications, the new actuator design is perfectly suited for speaker drivers. The highly linear characteristics of the actuator provide low distortion sound reproduction. Another benefit of the flux focusing aspect of the new actuator design is elimination of stray magnetic fields. Speaker systems are now being required to operate near television screens, which are highly susceptible to magnetic interference. The result of magnetic interference on a CRT is improper color and image distortion. Conventional speakers use an inefficient magnet structure that exudes sufficient flux for CRT distortion from many feet away. These speakers require magnetic shielding that is costly and often ineffective.

The new actuator, with its highly efficient flux focusing approach, can be operated within a few inches of a CRT without any distortion. The magnet structure captures all flux, so stray fields are nonexistent. Furthermore, the application of the flux focusing technique can be applied to speakers over a variety of ranges and bandwidths.

The first application of the new

actuator to speaker design was as a subwoofer, which had a cone diameter of 15 in. and a throw of 1 inch. This throw has been previously considered unachievable with conventional voice coil approaches. The next application was to an 8 in. low to mid frequency driver with a 0.5 in. throw. Initial testing indicates exceptional linearity and efficiency. The cost of the new speaker systems is identical

or cheaper than existing systems, due to the use of ferrite permanent magnets instead of the rare-earth magnets in related designs. The flux focusing technique works for all types of permanent magnet materials.

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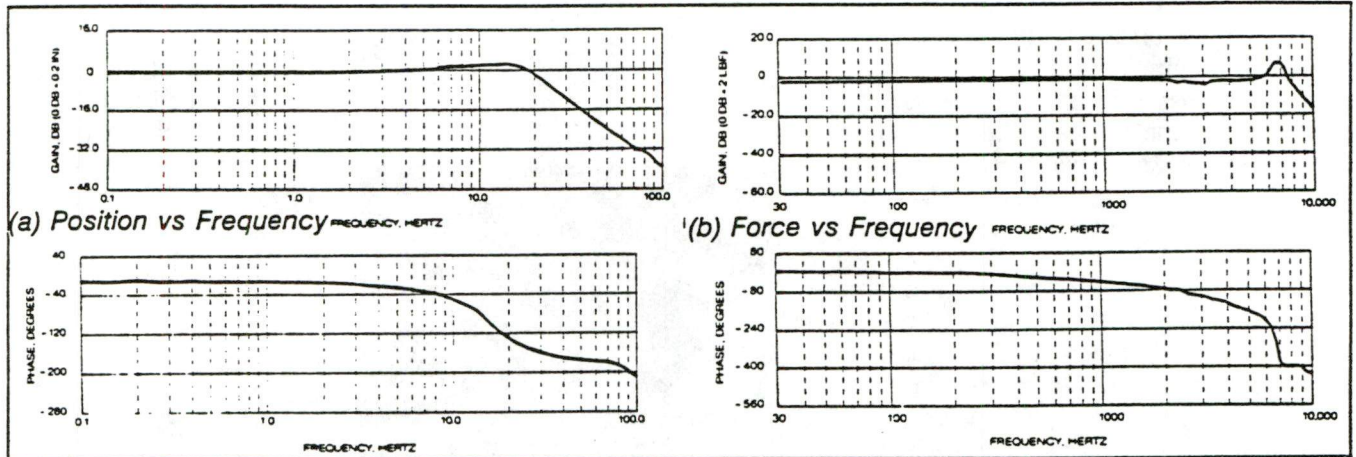


Figure 4. Linear Actuator Characteristics.

FABRICATION of "PRACTICAL" MAGNETIC BEARINGS

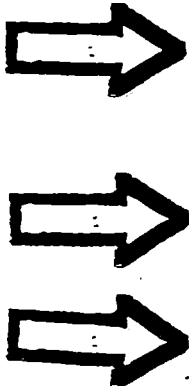
CORPORATE OFFICE: 2335 Alaska Ave • El Segundo, CA 90245 • (213) 643-5300

THE "PRACTICAL" MAGNETIC BEARING



- MUST BE SMALL, LIGHT, RELIABLE AND LOW COST

- MAGNETIC BEARING COMPONENTS
 - Magnetic Assembly: Rotor and Stator
 - Proximity Sensors
 - Controller
 - Power Amplifier



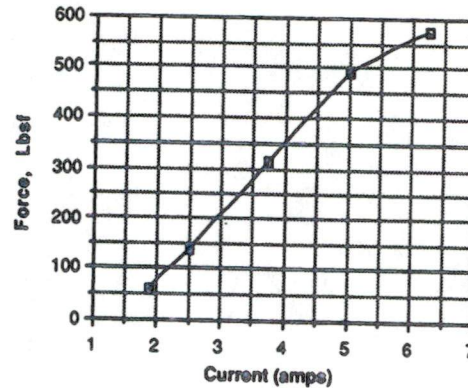
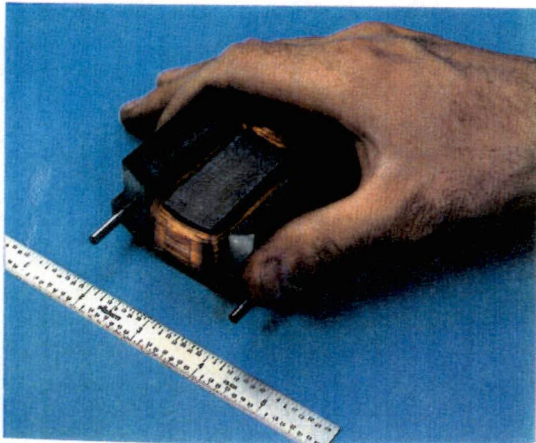
1. Mag. Gimbals for Isolation, Pointing and Tracking	
Application	Benefits
<ul style="list-style-type: none"> • Airborne Cameras • Linear Vibration Isolation • Missile Sensors 	<ul style="list-style-type: none"> • Precision Pointing • Protect Delicate Equipment • Micron level position control
2. Mag. Suspension for Test and Measurement Equip	
Application	Benefits
<ul style="list-style-type: none"> • Force and Torque Measurement • Flight Motion Simulation 	<ul style="list-style-type: none"> • 6 DOF, High Bandwidth • Simulate High Frequency Jitter
3. Magnetic Bearings for Rotating Machinery	
Application	Benefits
<ul style="list-style-type: none"> • Turbo-Molecular Pumps • High Speed Motors • Precision Gyros 	<ul style="list-style-type: none"> • Ultra-High Speed, No Lubrication • No Friction, No Lubrication • Ultra-Quiet, Long Life
4. High Force Actuators	
Application	Benefits
<ul style="list-style-type: none"> • Active Automotive Suspension • Naval Applications 	<ul style="list-style-type: none"> • High Force, High Bandwidth • Large Throw, Quiet, Fast Response
5. Medical Equipment	
Application	Benefits
<ul style="list-style-type: none"> • Cataract Surgery 	<ul style="list-style-type: none"> • 1 mm Incision, accommodation

In developing this technology, Aura has maintained focus not only on performance, but also weight and power efficiency, manufacturability, reliability and cost effectiveness (Table 1).

TABLE 1: AURA'S MAGNETICS FOCUS:

- | | |
|--------------------------|-----------------------------|
| 1. Dynamic Control | 7. Size Reduction |
| 2. Control Precision | 8. Weight Reduction |
| 3. Responsiveness | 9. Power Efficiency |
| 4. Digital Control | 10. Manufacturability |
| 5. Vibration Isolation | 11. Reliability |
| 6. Force-to-Weight Ratio | 12. Installation Simplicity |
| | 13. Cost Effectiveness |

RADIAL MAGNETIC BEARING ELECTROMAGNET



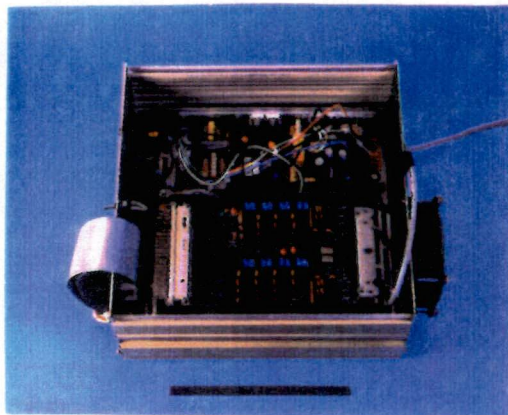
- **LOAD CARRYING CAPACITY:** 450 Lbs @ 4.75 amps, 10 mil gap
- **MAXIMUM FORCE:** 600 lbs @ 6.5 amps, 10 mil gap
- **TOTAL WEIGHT:** 1.5 LBS
- **SIZE:** 2.75 in. wide, 1.5 in high, 1.9 in. deep
- **POWER DISSIPATION:** 47 watts at 4.75 amps (2.1 ohm resistance)
- **MATERIAL:** Vanadium permendur

L0747-6/90

HIGH SPEED DIGITAL CONTROLLER FOR MAGNETIC BEARINGS



- **USE DIGITAL SIGNAL PROCESSOR (DSP) TECHNOLOGY**



- **50 MHz, 32 Bit DPS**
- **Processor Module Size:** 4in x 6 in x 2.5 in
- **Overall Size (with supply):** 10 in x 10 in x 4 in
- **Real number operation, programmable in "C"**
- **Average servo computation time = 20 μ Sec**
- **Can control 12 channels simultaneously**
- **Includes 12 bit digital to analog converter**

L0750-6/90

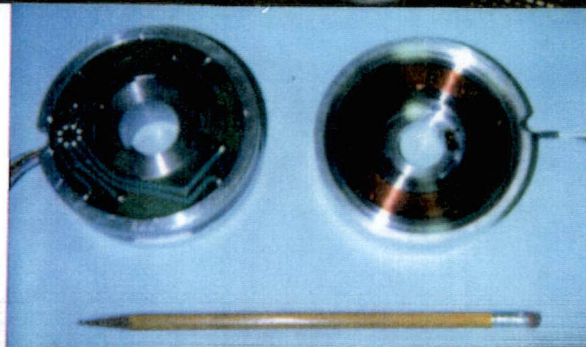
High Speed Pump Production

This turbomolecular pump is one of several series being produced in minimum guaranteed quantities of 6,500 over the next five years for Varian Associates. The nominal maximum steady state and peak dynamic load specification for this MBS Series 30R90T-4.06D 1.7ID appear to meet many different type of pump cases.

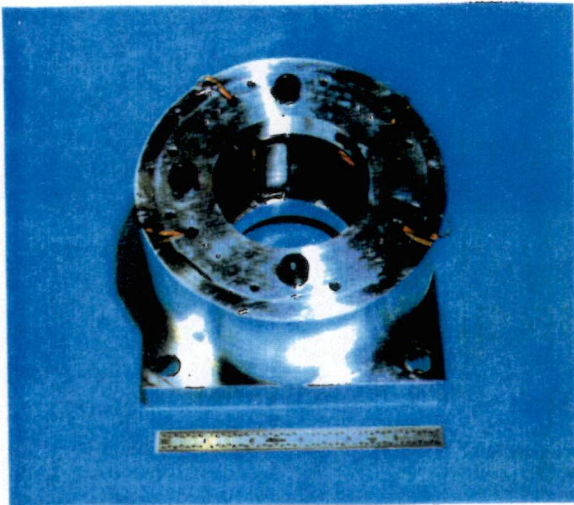
TABLE 1: Preliminary Bearing Dimensions and Performance Characteristics

Table 2: Bearing Power Requirements

	Radial bearing		Thrust bearing			
*Outer stator diameter	103 mm	(≤4.06 in.)	≤103 mm	(≤4.06 in.)	Mag. brg. controller no load power (when controller is switched on, but mag. brgs. are switched off)	60W
*Length	25mm	(0.984 in.)	40 mm	(1.575 in.)		
*Outer rotor diameter	43mm	(1.693 in.)	≤103mm	(0.0138 in.)	Total maximum required power (during a high load transient)	150W
Magnetic bearing clearance	0.25mm	(0.00984 in.)	0.35mm	(0.0138 in.)		
Backup brg. clearance (for V-100 pump)	0.15 mm	(0.00591 in.)	0.25mm	(0.00984 in.)	Total maximum steady state power (for V-1000 pump)	100W
Peak dynamic load capacity	200N	(44.94 Lbf)	1800 N	(404.46 Lbf)		
Steady state load (for V-100 pump)	22 N	(4.94 Lbf)	44 N	(9.88 Lbf)		
Maximum allowable steady state load	130 N	(29.21 Lbf)	400 N	(89.89 Lbf)		
Peak current (transient)	5.0 A		5.0 A			
Steady state current (for V-1000 pump)	1.0 A		0.6 A			
Maximum allowable steady state current	2.7 A		2.0 A			
Steady state (for V-1000 pump)	1.0 W		1.7 W			
Maximum steady power	7.2 W		18.6 W			

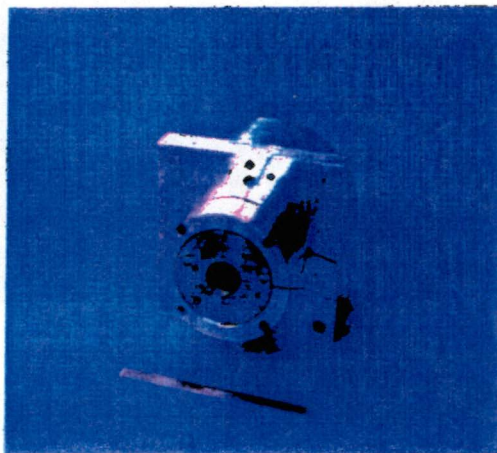


MAGNETIC BEARING ASSEMBLIES TO SUPPORT 600 LBS SHAFT



RADIAL ASSEMBLY
Peak Force 600 lbs

AXIAL ASSEMBLY
Peak Force 900 lbs



L0760-6/90

OVERALL MAGNETIC BEARING SYSTEM WEIGHT/POWER



- TWO RADIAL, ONE AXIAL MAGNETIC BEARING SET PLUS ALL ASSOCIATED ELECTRONICS

(= 2,000 LBM @ 0.1g) * (=2,000 LBM @ 0.1g) *

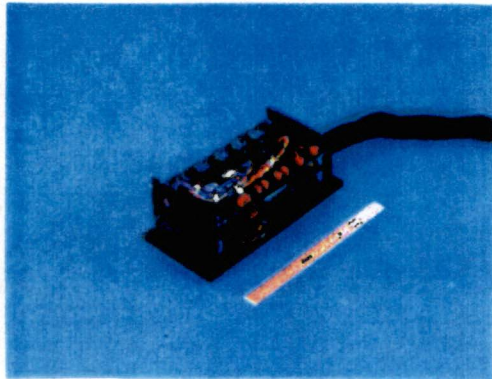
COMPONENT	600 LBM SHAFT (ACTUAL)	200 LBM SHAFT (ESTIMATE)	200 LBM SHAFT (LIGHTWEIGHT MECHANICAL AND ELECTRONICS) (ESTIMATE)
Performance Notes: (A) Not to Exceed 1 urad (B) Degrees/Sec Slow (C) random G's of Force			
RADIAL MAGNETIC BEARING ASSEMBLY (LBM, FOR TWO BEARINGS)	16.8	5.5	4
AXIAL MAGNETIC BEARING ASSEMBLY (LBM)	7.1	2.5	2
PROXIMITY SENSOR ELECTRONICS (LBM, IN ENCLOSURE)	1.4	1.5	0.5
PROCESSOR ELECTRONICS (LBM, IN ENCLOSURE PLUS POWER SUPPLY)	7	7	2.5
POWER ELECTRONICS (LBM, IN ENCLOSURE)	8.1	3	2
TOTAL MASS (LBM)	40.4	19.5	11
MAXIMUM POWER (WATTS)	1200	400	250
AVERAGE POWER (WATTS) -- 10% Duty Cycle	120*	40*	25*

*System Note: Total Mass Net **= (+ Mag Bearing Set) - (Savings in Total S/C ACS/Structure/Innover/Station Keeping Mass)

*Analogous Experience Est. = 6 to 10% Savings in Total

L0935-9/90

AURA'S MULTI-CHANNEL PROXIMITY SENSOR

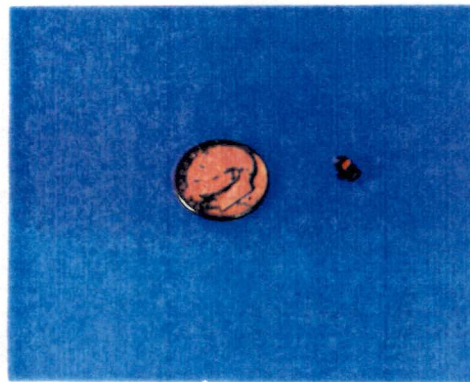


ELECTRONICS

- 5 Channel (needed for a set of 2 radial, 1 axial bearings)
- 12 Bit Resolution (2 μ inch resolution with 10 mil gap)
- 5 kHz bandwidth
- Differential probe operation provides excellent temperature/time stability

PROBE TIP

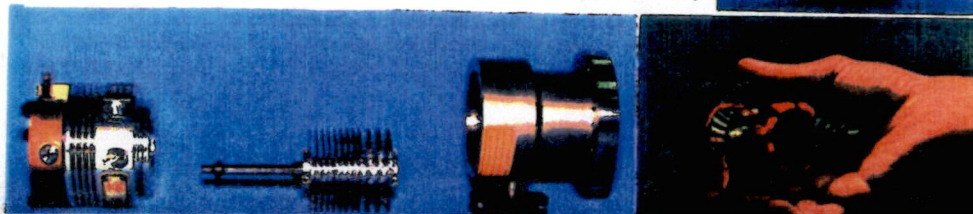
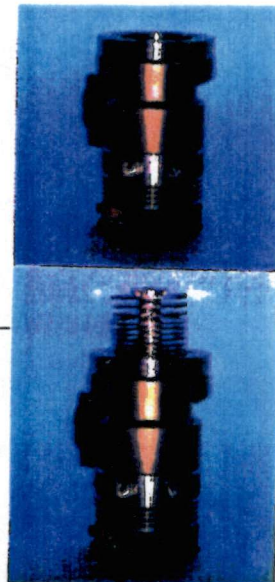
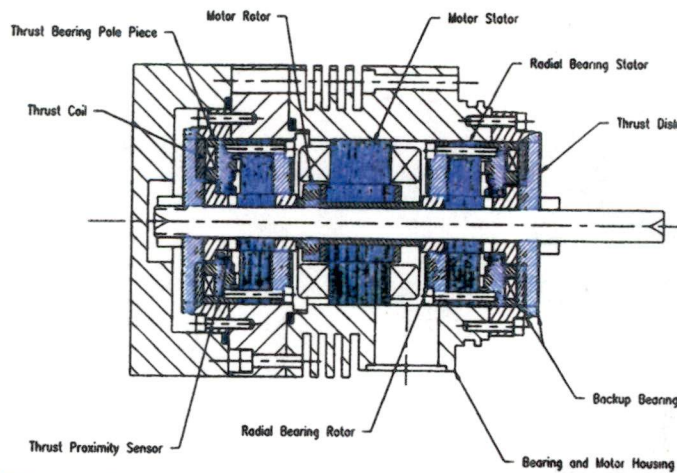
- Inductive
- Uses High Mu 80 for superior frequency response



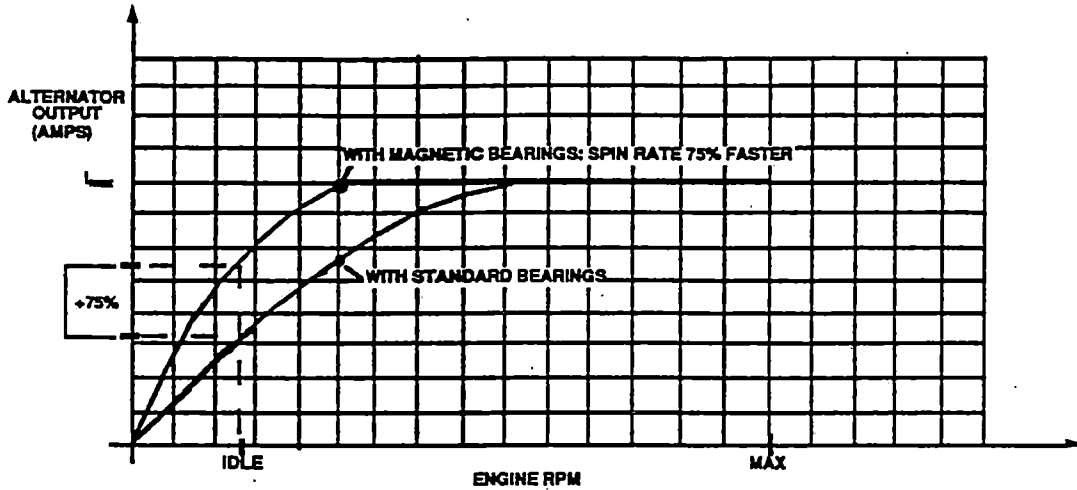
High Speed Pump

Aura has retrofitted the mechanical bearing--and lubrication and coding subsystems--of a turbo-molecular vacuum pump with a magnetic bearing. The unique integrated design of both a radial and thrust bearing (only 2" in diameter, 1.5" in height, and weighing less than one pound) can counter forces of 22 lbs radially and 27 lbs axially, and yet still rotate at a speed of 60,000 rpm--using only 1 watt of power, and accommodating both rotor and external disturbances. Advantages over a mechanical bearing include greatly increased longevity (due to wear-less bearings), oil-free performance (important for purity requirements in high vacuum), and a fully suspended shaft which eliminates vibration.

TURBOMOLECULAR PUMP



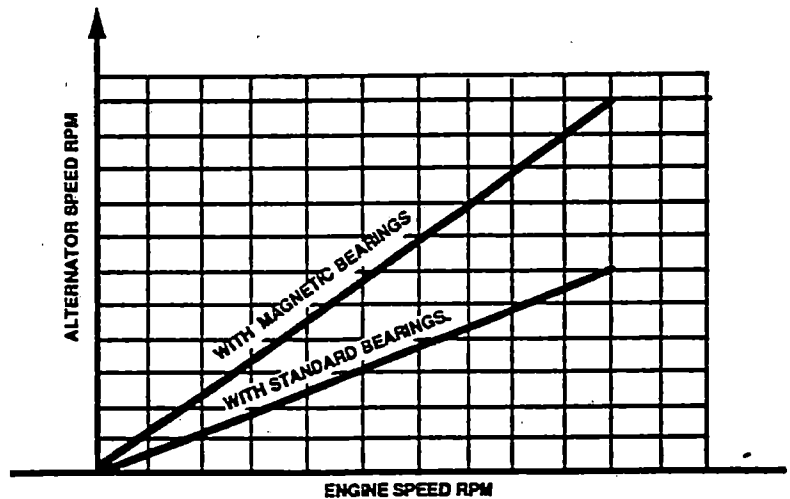
ALTERNATOR WITH AURA MAGNETIC BEARINGS - BENEFITS



Resulting output alternator with magnetic bearings when speed is 75% faster.* At low RPM, Alternator can produce 75% more current. At high RPM, Alternator core saturates, so no additional current is generated.

Because magnetic bearings are frictionless, no wear occurs; therefore reliability and longevity are not effected by higher average operating speeds.

In automotive quantities, cost of magnetic bearings with electronics approximately \$75 each.



*75% faster speed for example only; actual speed increase dependent on current draw requirements for specific applications.

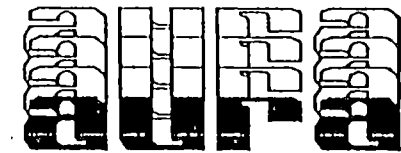
MAGNETICS FACT SHEET:

BREAKTHROUGH CAPABILITIES ENABLED



1. Dynamic Control
2. Control Precision
3. Responsiveness
4. Digital Control
5. Vibration Isolation
6. Force-to-Weight Ratio
7. Size Reduction
8. Weight Reduction
9. Power Efficiency
10. Manufacturability
11. Reliability
12. Installation Simplicity
13. Cost Effectiveness

- (1) Respond to: Complex six degree-of-freedom commands in milliseconds.
- (2) Act with: Several thousand pound forces under complex multidirectional control commands.
- (3) Maintain: Dynamic separation distance of mils under acceleration of 10,000 degrees/sec², with forces noted, and with static positional precision of 0.1 mil or better.
- (4) Maintain: Microradian line-of-sight rotational accuracies for 10s of milliseconds, under at least random 10 gravity loads while slewing over 5 degree or greater angles within 120 millisecond responses.
- (5) Isolate from: Vibration by 80 or more decibels from at least 10 gravity external forces with millisecond rise times.
- (6) Induce, while suspending: Vibration spectra of several kilohertz bandwidth.
- (7) Suspend and differentially spin: Rotors at tens to hundreds of thousands rpm with no bearing wear or lubrication.
- (8) Linearly or Rotationally actuate: Over large--essentially unlimited--throw distances or rotational angles/directions with tens to thousands of pounds of force with milliseconds responsiveness and 0.1 mil or better position precision; tractor motor or columns extension implementation available.
- (9) Drive, as a motor, with: High Torque at any RPM, without gearing.
- (10) Use typically: Less power and weigh less than comparable force hydraulic, pneumatic or electric systems.
- (11) Install without: Pumps, hoses, fluids, pressure, valves, seals, mechanical drives, lubrication, noise or large control boxes.
- (12) Assure reliability and safety with: No mechanically touching parts; "fail safe" or "fail to" design alternatives; lightweight digital control/electrical backup redundancy; and flexibility of electrical routing alternatives.



Aura Systems, Inc

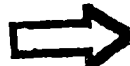
TYPICAL AURA HIGH FORCE ACTUATOR
PERFORMANCE PARAMETERS



TABLE 1: AURA'S MAGNETICS FOCUS:

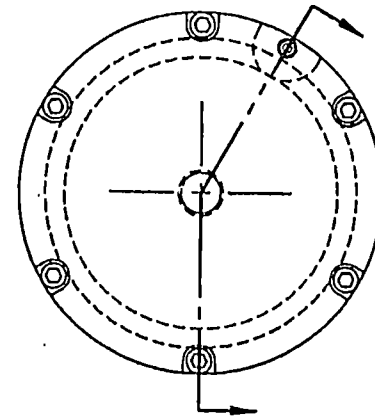
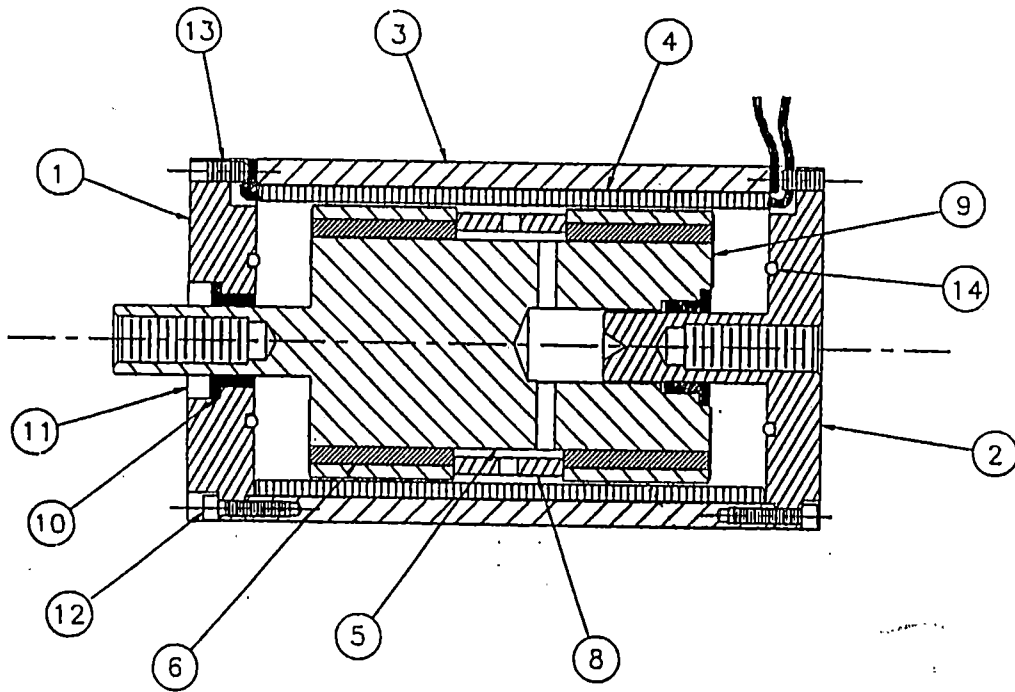


1. Mag. Gimbals for Isolation, Pointing and Tracking	
Application	Benefits
<ul style="list-style-type: none"> • Airborne Cameras • Linear Vibration Isolation • Missile Sensors 	<ul style="list-style-type: none"> • Precision Pointing • Protect Delicate Equipment • Micron level position control
2. Mag. Suspension for Test and Measurement Equip	
Application	Benefits
<ul style="list-style-type: none"> • Force and Torque Measurement • Flight Motion Simulation 	<ul style="list-style-type: none"> • 6 DOF, High Bandwidth • Simulate High Frequency Jitter
3. Magnetic Bearings for Rotating Machinery	
Application	Benefits
<ul style="list-style-type: none"> • Turbo-Molecular Pumps • High Speed Motors • Precision Gyros 	<ul style="list-style-type: none"> • Ultra-High Speed, No Lubrication • No Friction, No Lubrication • Ultra-Quiet, Long Life
4. High Force Actuators	
Application	Benefits
<ul style="list-style-type: none"> • Active Automotive Suspension • Naval Applications 	<ul style="list-style-type: none"> • High Force, High Bandwidth • Large Throw, Quiet, Fast Response
5. Medical Equipment	
Application	Benefits
<ul style="list-style-type: none"> • Cataract Surgery 	<ul style="list-style-type: none"> • 1 mm Incision, accommodation



- | | |
|--------------------------|-----------------------------|
| 1. Dynamic Control | 7. Size Reduction |
| 2. Control Precision | 8. Weight Reduction |
| 3. Responsiveness | 9. Power Efficiency |
| 4. Digital Control | 10. Manufacturability |
| 5. Vibration Isolation | 11. Reliability |
| 6. Force-to-Weight Ratio | 12. Installation Simplicity |
| | 13. Cost Effectiveness |

In developing this technology, Aura has maintained focus not only on performance, but also weight and power efficiency, manufacturability, reliability and cost effectiveness (Table 1).



Maximum Continuous force: 10 lbs
 Maximum Power (@ 10 lbf): 50 watts
 Maximum Current: 5 Amps
 Stroke: ±0.25 inches
 Type: Brushless, force linear with current

UNLESS SPECIFIED: DIMENSIONS IN INCHES TOLERANCES ARE ANGLE ± .35 D.D. ± .01 C.D.C. ± .001 FINISH PER PREPARED EDGES	DRAWN: Eric S. Lewis 8/4/99 CHECKED: APPROVED:	PROJECT: DTAR: Actuator Assembly CHANGE NO.: SIZE: C DRAWING NO: 4510 0000.00-2.01								
<table border="1"> <thead> <tr> <th>LETTER</th> <th>DATE</th> <th>REVISION</th> <th>BY</th> </tr> </thead> <tbody> <tr> <td> </td> <td> </td> <td> </td> <td> </td> </tr> </tbody> </table>	LETTER	DATE	REVISION	BY					El Segundo, California	
LETTER	DATE	REVISION	BY							

Using technologies developed by Aura, an actuator was designed that meet all these requirements. Figure 2 shows this actuator and its constituent parts. The unit measures 2" in diameter by 3.5" in length and generates 10 lbs of force. It is a robust design with only one moving part.

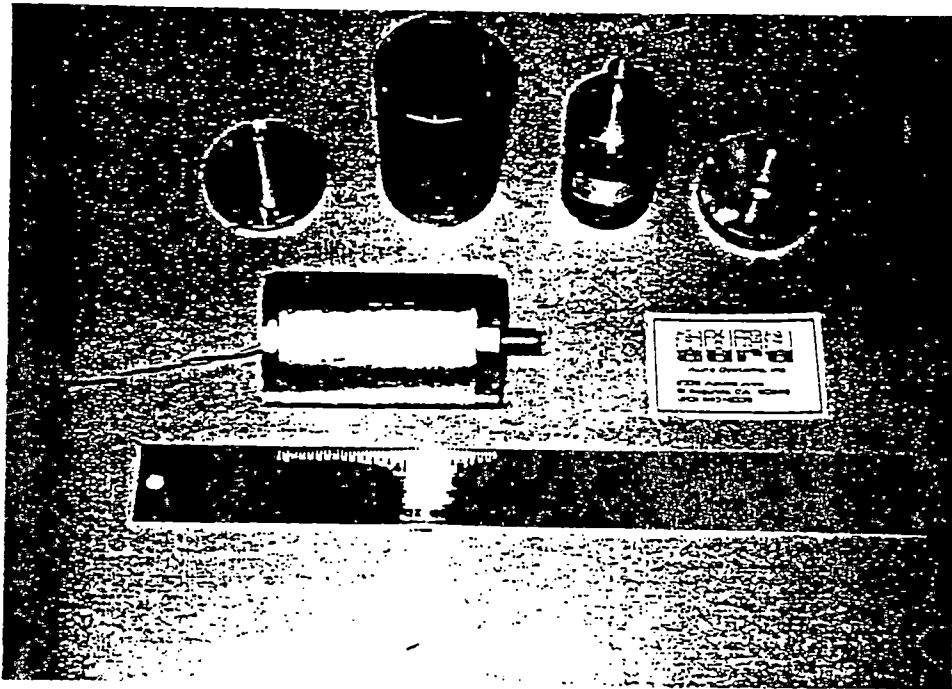


Figure 2. Aura Actuator and Components

Having met all imposed requirements, the actuator was then installed in the power steering system. This necessitated the design and fabrication of a variable flow orifice that served to couple the two systems. Figure 3 illustrates the orifice and the interface between the power steering and the actuator. The power steering fluid union can be seen in figure 4.

BASIC SPECIFICATION (Always include units!)

Maximum Req'd. Force: 10 lbf Max. Stroke: \pm 0.25 inch
Maximum Power: 50 watts Duty Cycle: 100% = 10 lbf; 25% = 20 lbf
Maximum Current : 10 amps Coil Resistance: 0.5 ohms
Minimum Voltage Rqd: 5 volts Back-EMF: 4.448 V/m/sec
Force Gain (lbs/amp): 10/10 = 1 Mag. Location (inside or outside): Inside
Brush or Brushless?: Brushless Frequency response: Linear, 0 to 7 KHz (power amp spec. limit)

Frequency response: 13.97 Hz +/- 0.25

in. (unloaded) stroke at 10 lbf (100% duty); 19.76 Hz at 20 lbf (25% duty); 197.62 Hz +/- 0.0025 in stroke at 10 lbf (100% duty).

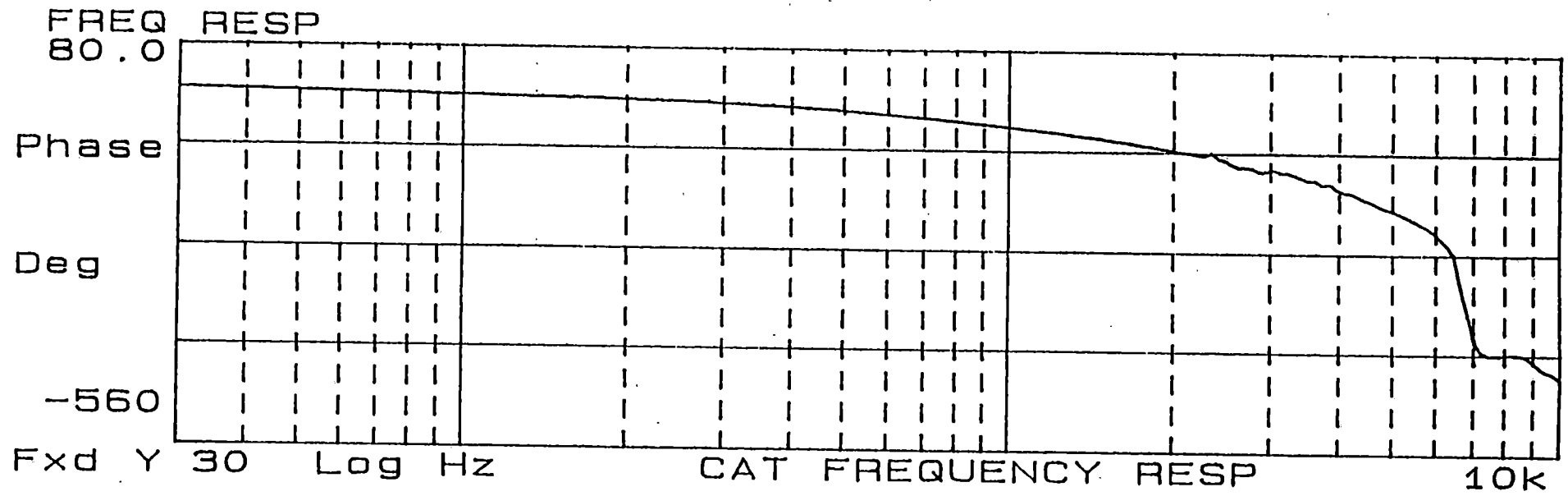
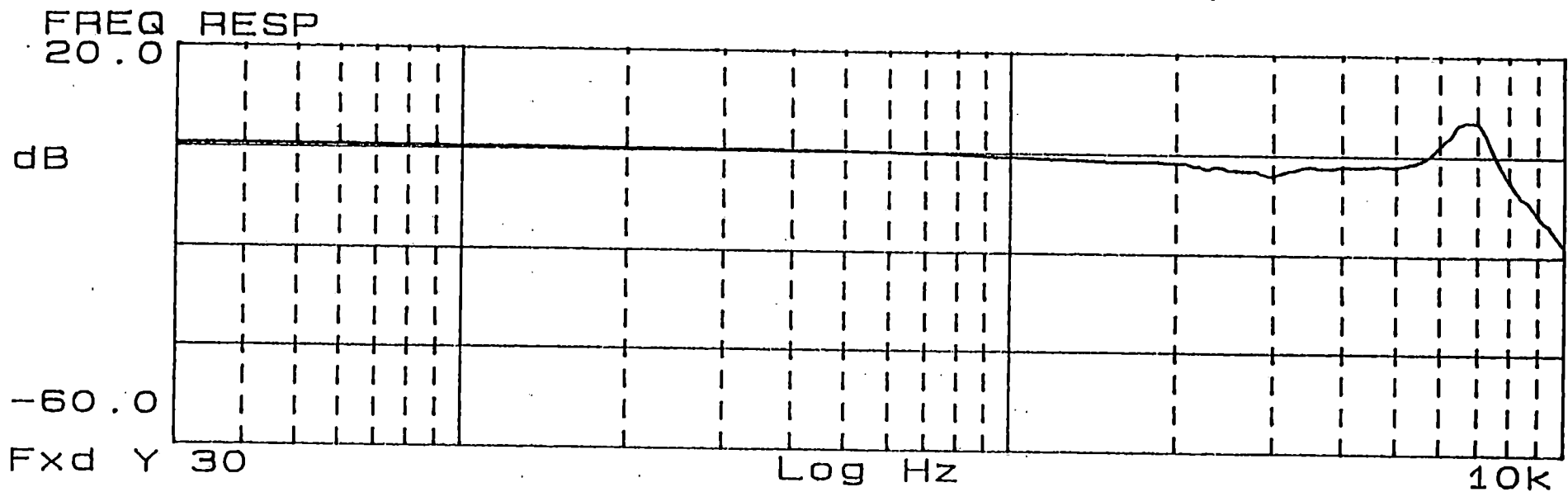
Size, Weight

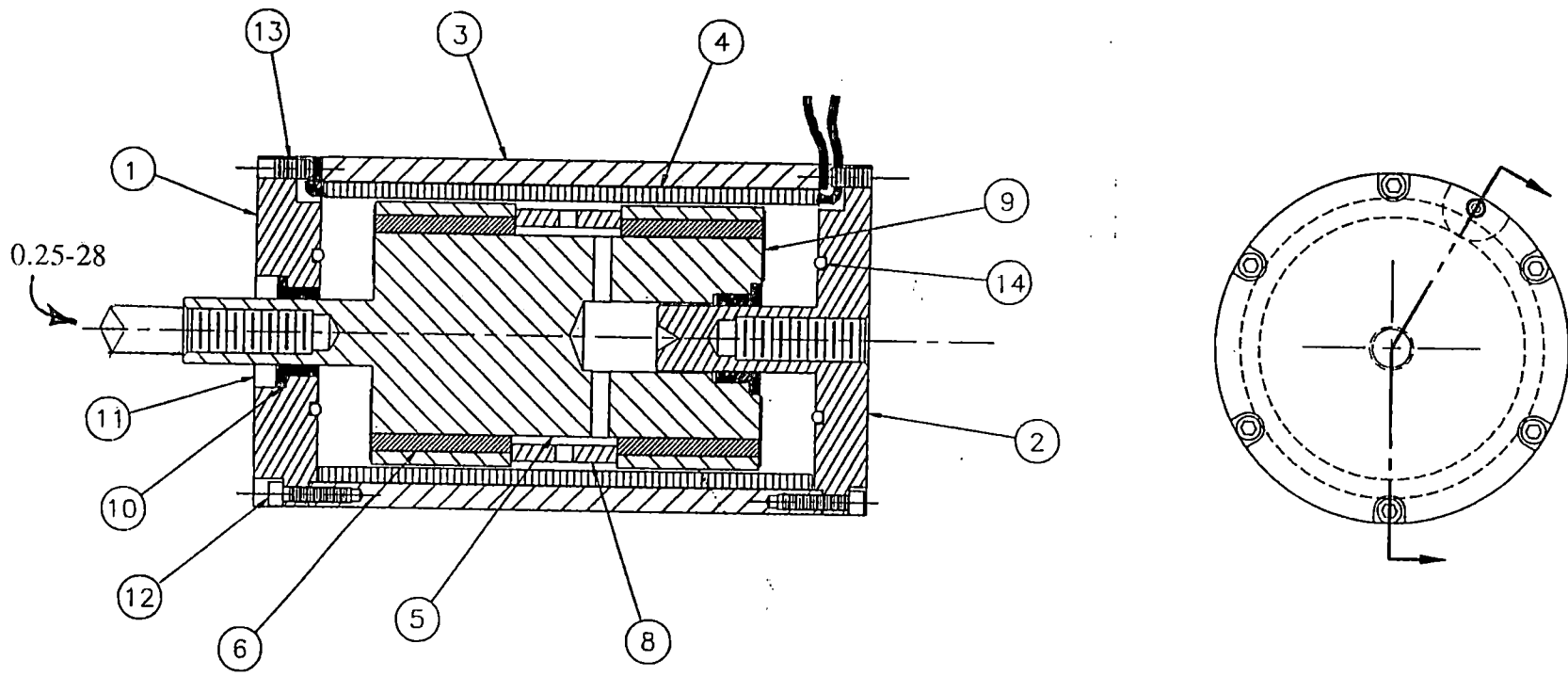
Outside Diameter: 2 in. (50.8 mm) Weight of magnets: 0.2 lbm
Length (unextended): 4 in. (101.6 mm) Weight of coil: 0.4 lbm
Length (mid-stroke): 4.3 in. (109.22 mm) Weight of iron/VP (Note one): 1.3 lbm
Shaft Diameter: 0.375 in (9.525 mm) Weight of other materials (Al, etc): 0.6 lbm
Weight of moving mass: 1 lbm Overall Weight : 2.5 lbm

Environment

Max Operating Temperature: 80 deg. C Ambient (outside) temp Range: 20 - 30 deg.

Special environmental considerations (sea-water, chemical, etc):



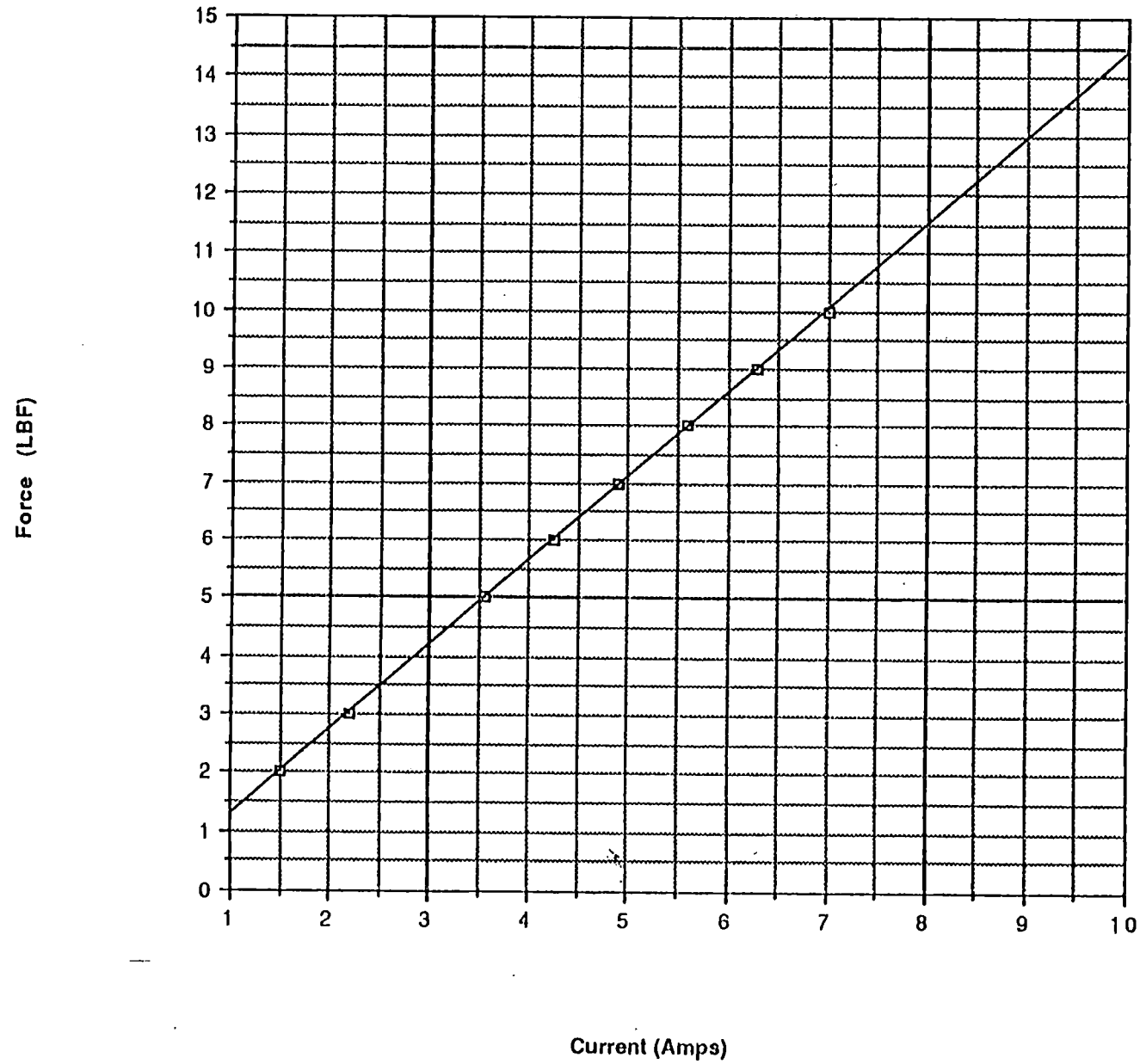


Maximum Continuous Force: 5 lbs
 Maximum Power @ 5 lbf): 5 Watts
 Maximum Current: 3.5 Amps
 Stroke: ± 0.25 in.
 Outside Diameter: 2 in.
 Length: 3.5 in.
 Type: Brushless, Linear (force vs. current)
 F/I: 1.4
 Mass: 2.5 LBm

LETTER	DATE	CHANGE	C.O. #

UNLESS SPECIFIED: DIMENSIONS IN INCHES TOLERANCES ARE ANGLES ± 0.5° 0.00 ± 0.01 0.000 ± 0.001 FINISH: PLAIN PRICE: 4.0 EDGES	DRAWN: Chris Swire	8/4/91	PROJECT:
	CHECKED:		DETAIL:
	APPROVED:		Actuator Assembly
 systems, inc El Segundo, California		CHARGE NO.:	
		SHEET: C	DRAWING NO. 4510.0000.00-2.01

Force Performance



BASIC SPECIFICATION (Always include units!)

Maximum Req'd. Force:	<u>5 lbf</u>	Max. Stroke:	<u>0.25 in.</u>
Maximum Power:	<u>25 watts</u>	Duty Cycle:	<u>100 %</u>
Maximum Current:	<u>3.5 amps</u>	Coil Resistance:	<u>2 ohms</u>
Minimum Voltage Req'd:	<u>7 volts</u>	Back-EMF:	<u>6.3 N/A</u>
Force Gain (lbs/amp):	<u>1.4 lbs/amp</u>	Mag. Location (inside or outside):	<u>Inside</u>
Brush or Brushless?:	<u>Brushless</u>		

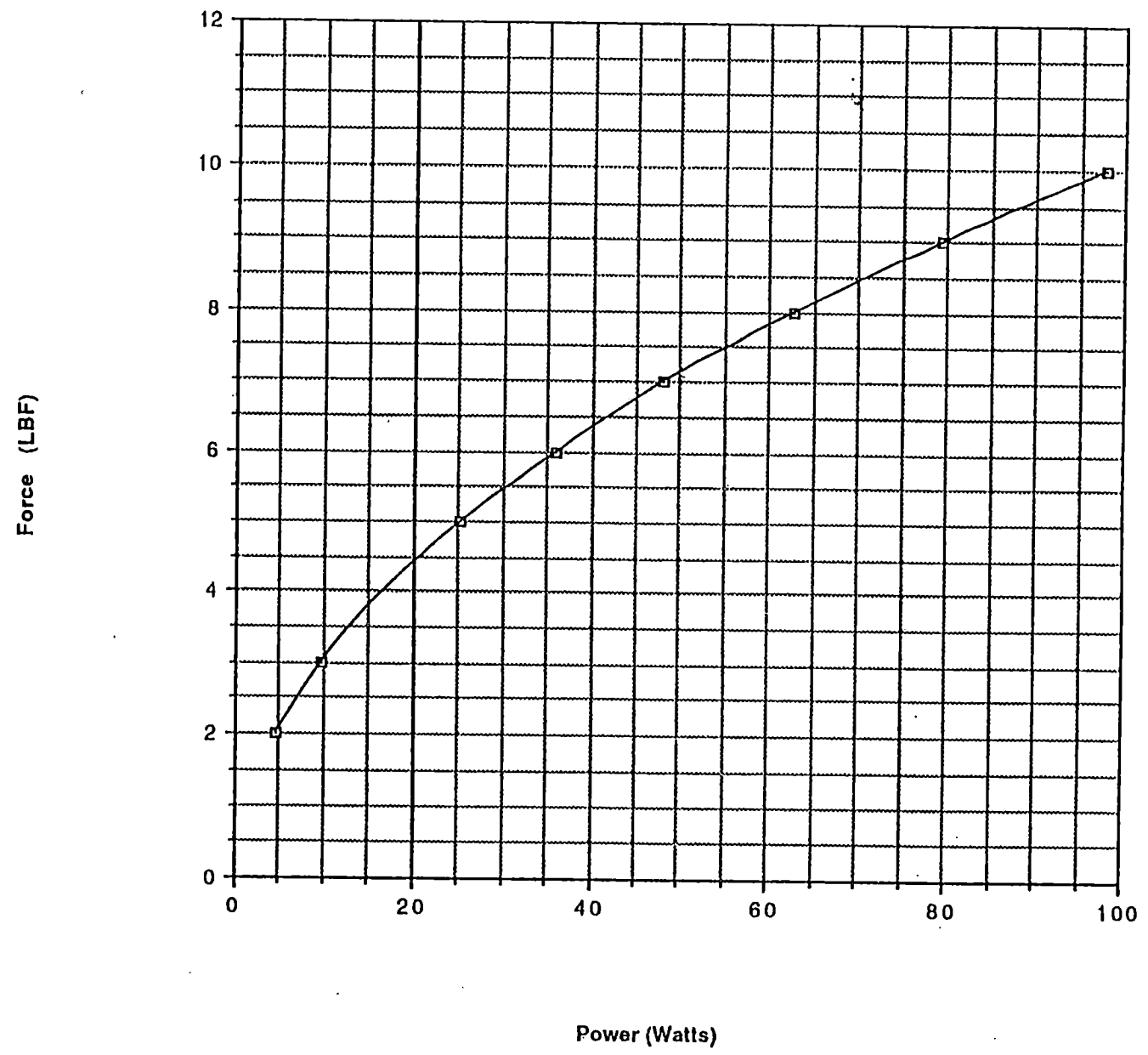
Size, Weight

Outside Diameter:	<u>2 in.</u>	Weight of magnets:	<u>0.17 lbs</u>
Length at mid-stroke:	<u>3.8 in.</u>	weight of coil:	<u>0.24 lbs</u>
Weight of moving mass:	<u>1.0 lb</u>	Weight of iron/VP (circle one):	<u>1.5 lbs</u>
		Weight of other materials (Al, etc):	<u>0.6 lbs</u>
		Overall Weight:	<u>2.5 lbs</u>

Environment

Max Operating Temperature: 100 deg. C Ambient (outside) temp Range: 20 deg. C
Special environmental considerations (sea-water, chemical, etc): _____

Force vs Power Performance



The controller generates actuator commands that are sent to the servo amplifier. These commands are boosted by the amplifier to drive the actuator. The amplifier is operated in the current mode, thereby commanding the actuator force. This allows quicker response of the actuator and the system. Integration and testing of the amplifier and actuator has already been completed. Figure 6 illustrates the frequency response of the actuator driven by the servo amplifier.

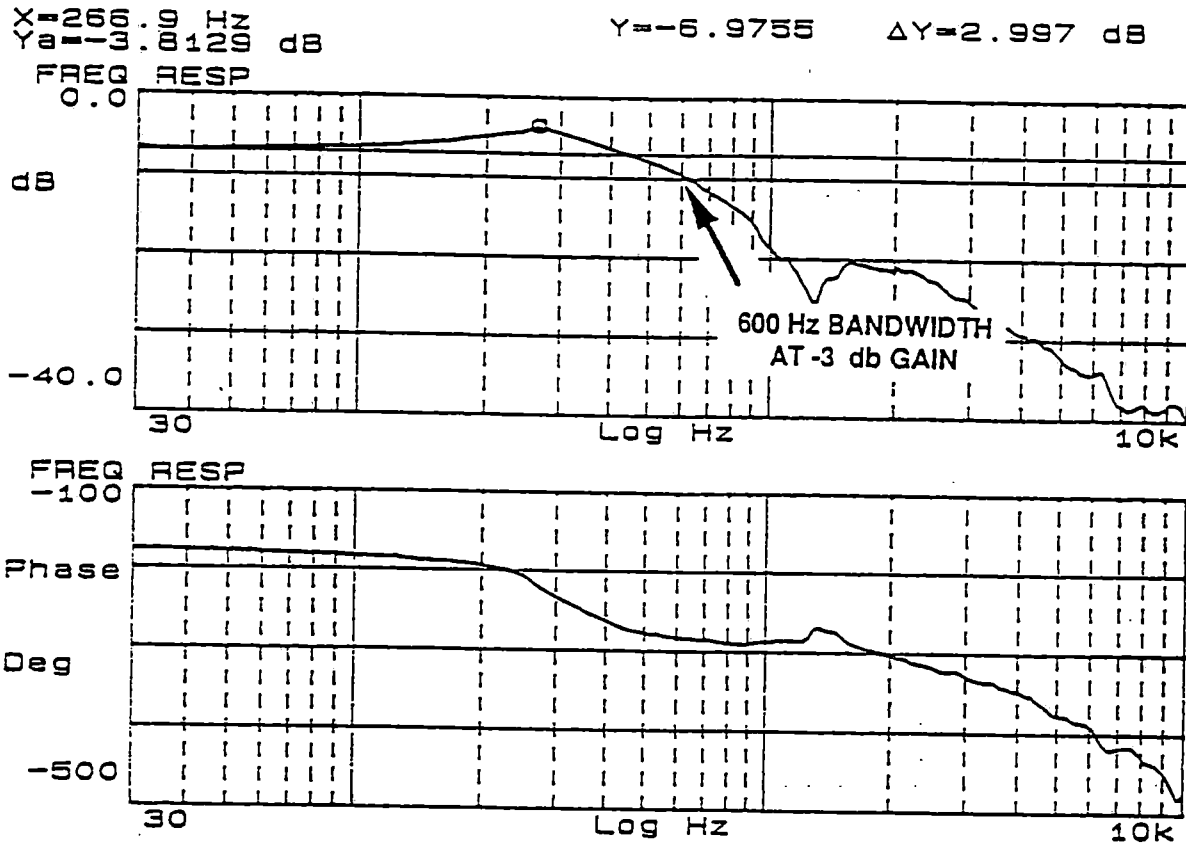
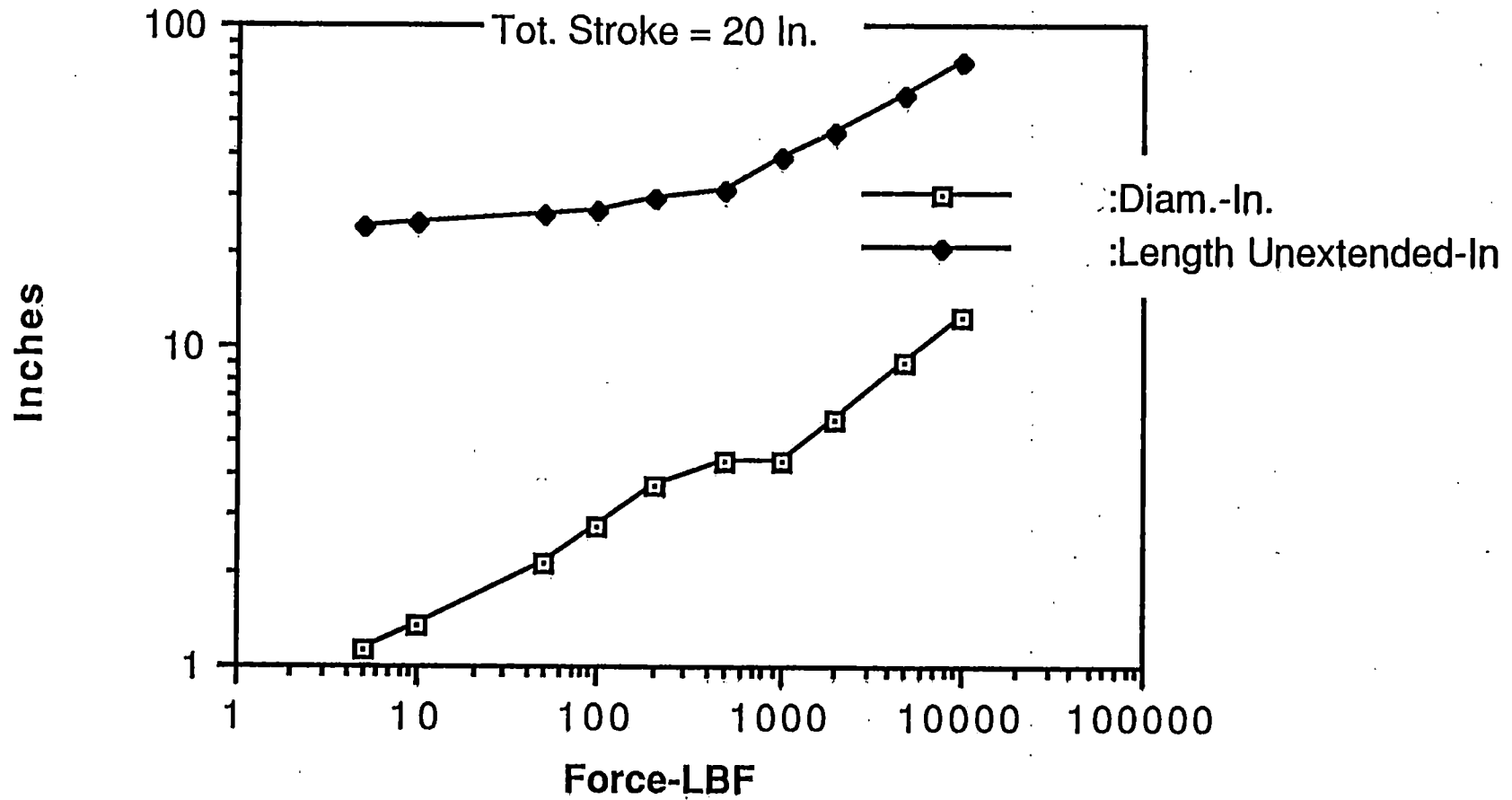


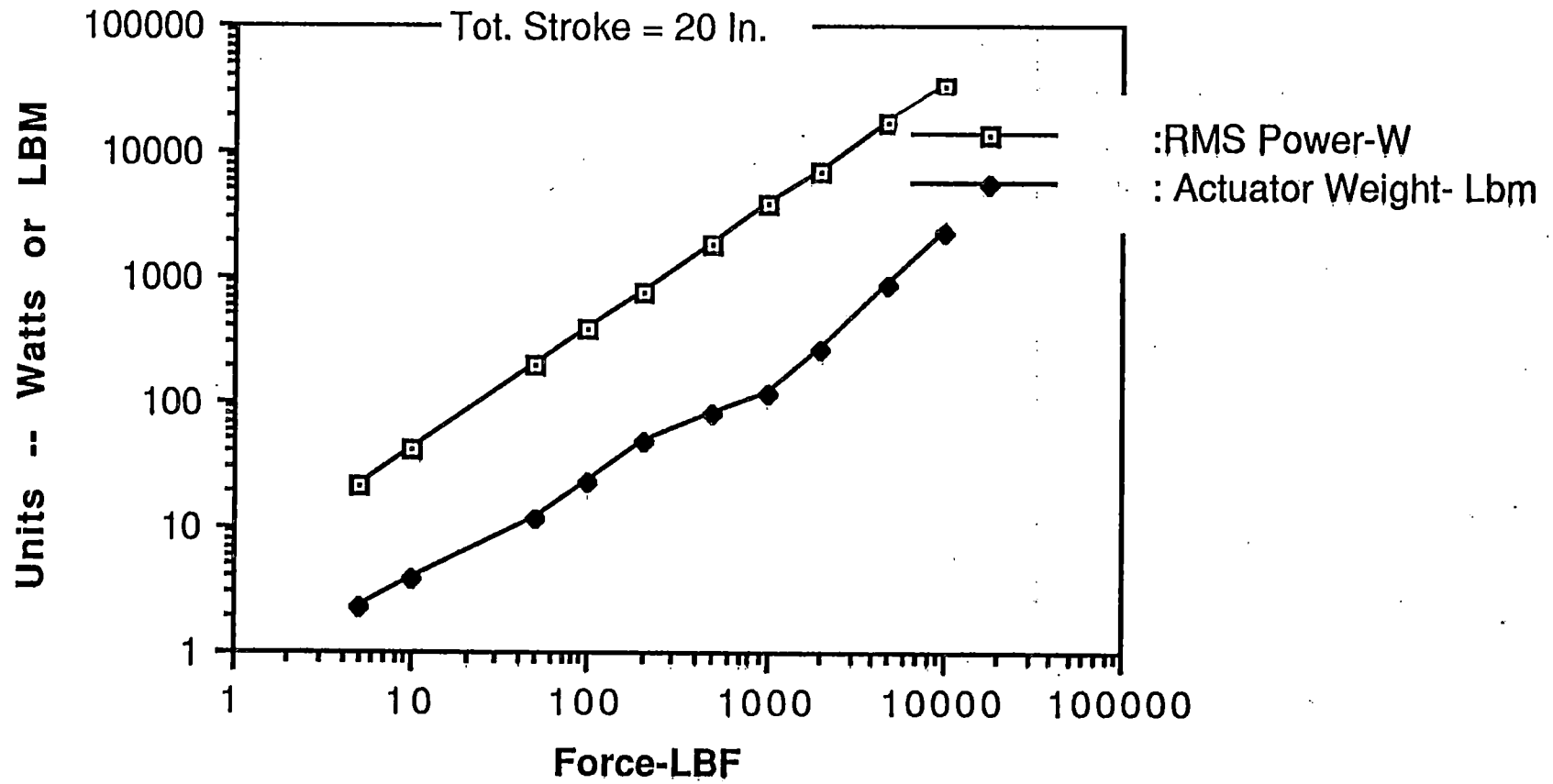
Figure 6. Frequency Response of the Actuator and Servo Amplifier
(Commanded Force / Actuator Acceleration)

Inspection of Figure 6 verifies the large bandwidth of the actuator, 600 Hz at the -3 db gain point. For our application, a 600 Hz bandwidth is much more than adequate. The actual bandwidth of the actuator is much higher (>8KHz). The gain rolloff is a result of low-pass filtering within the amplifier. The amplifier filtering prevents the introduction of high frequency noise.

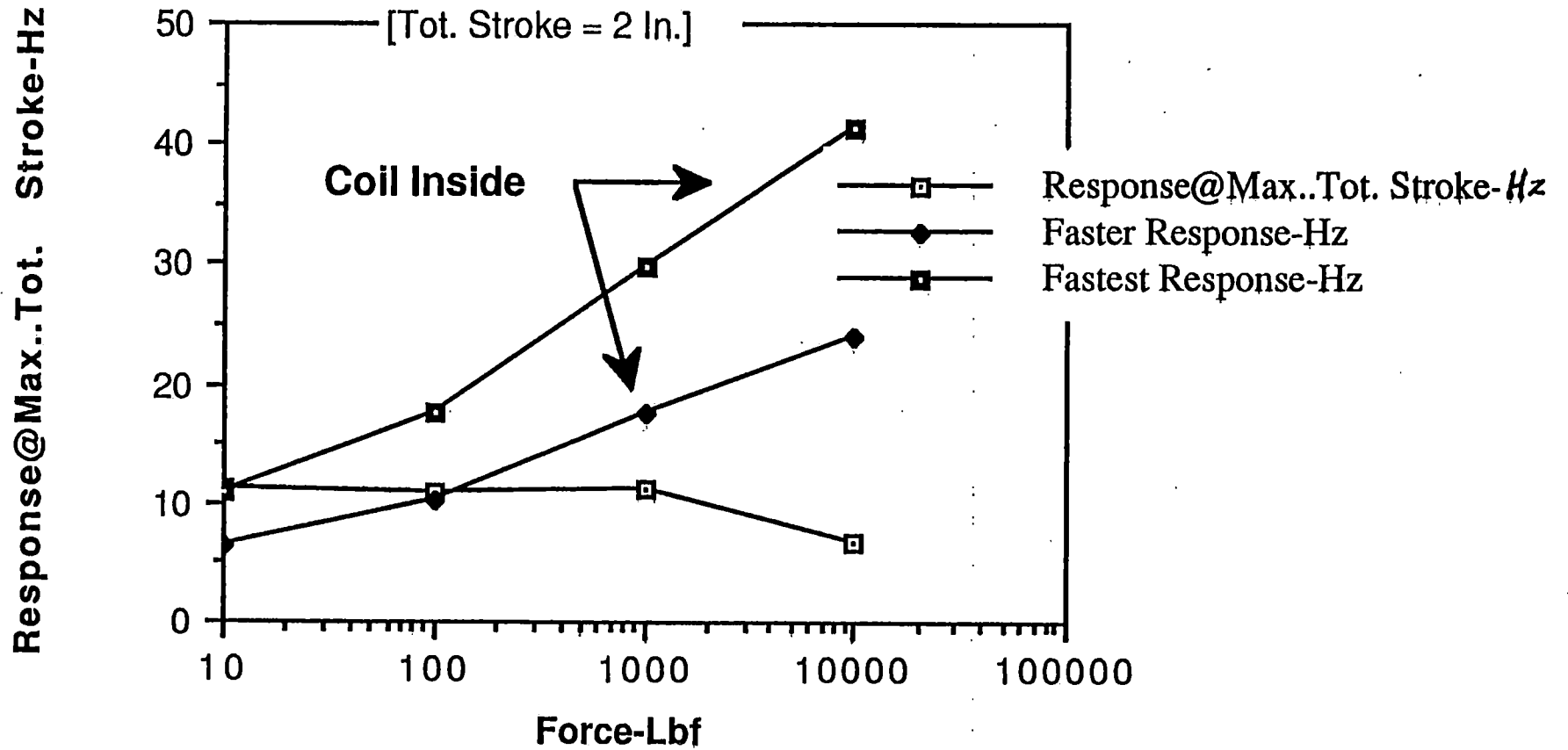
Aura HFA: Force vs. Diameter vs. Length



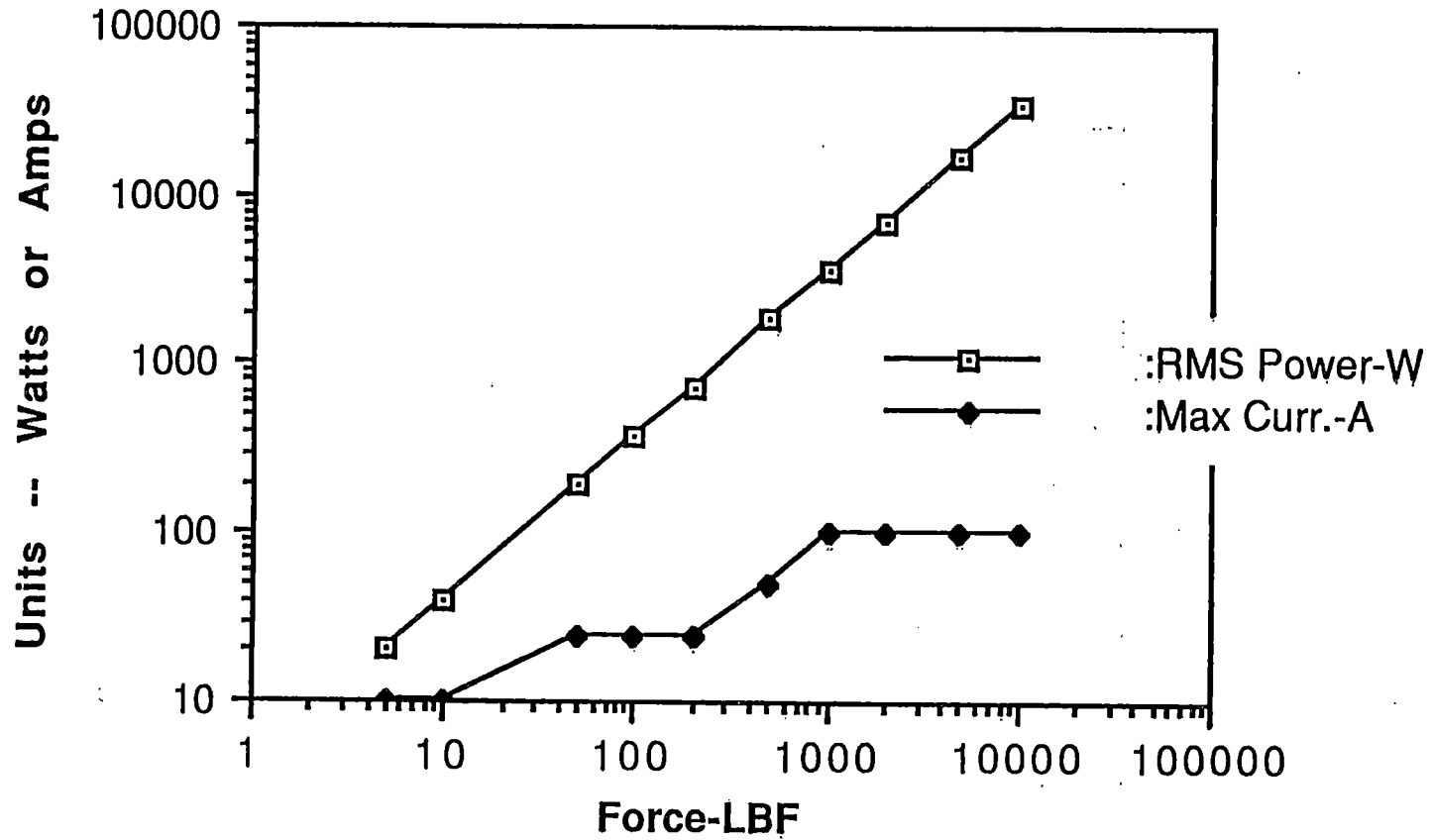
Aura HFA: Force vs. Power vs. Weight



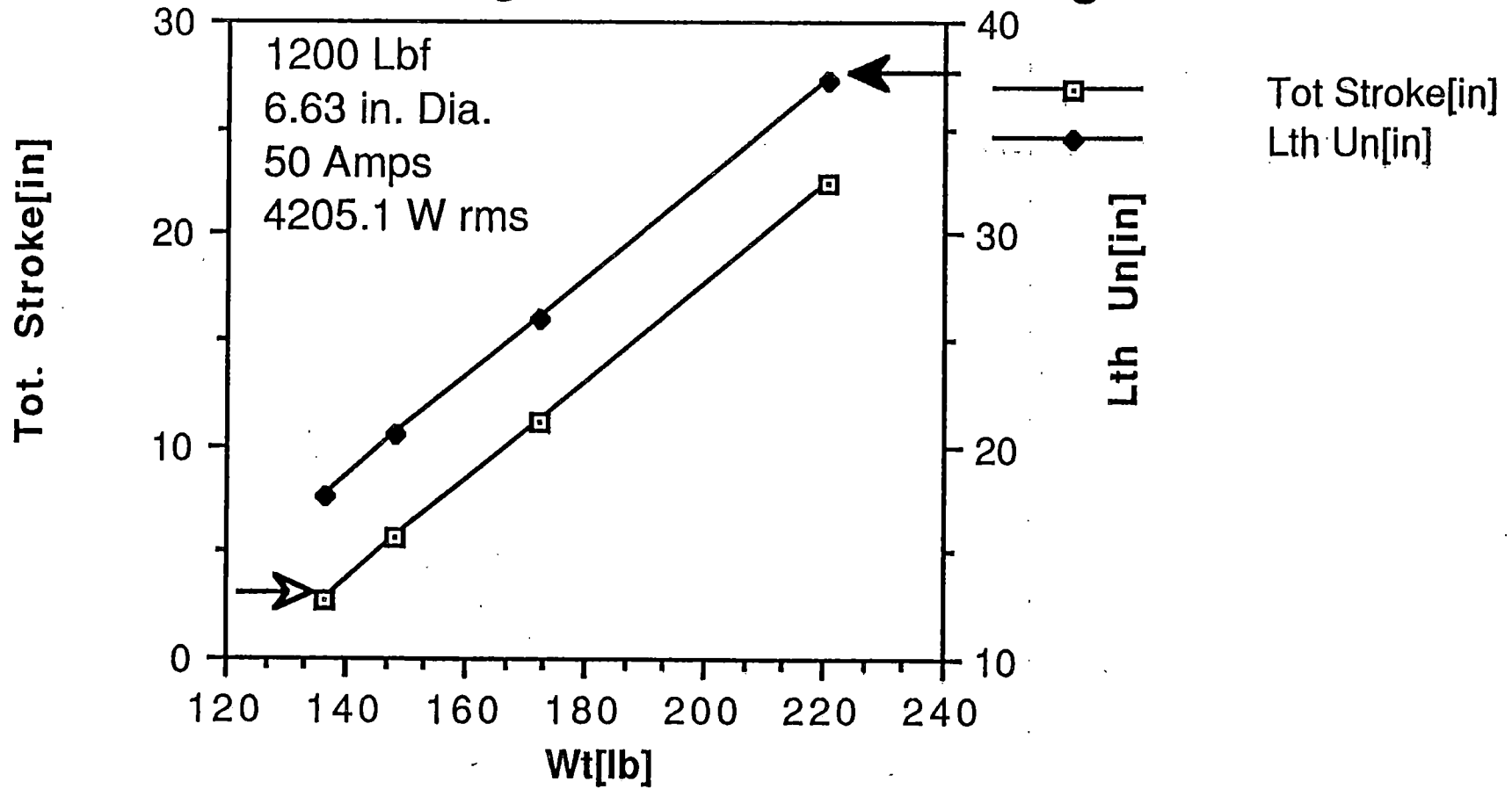
Aura HFA: Force vs. Response[±1 In.]



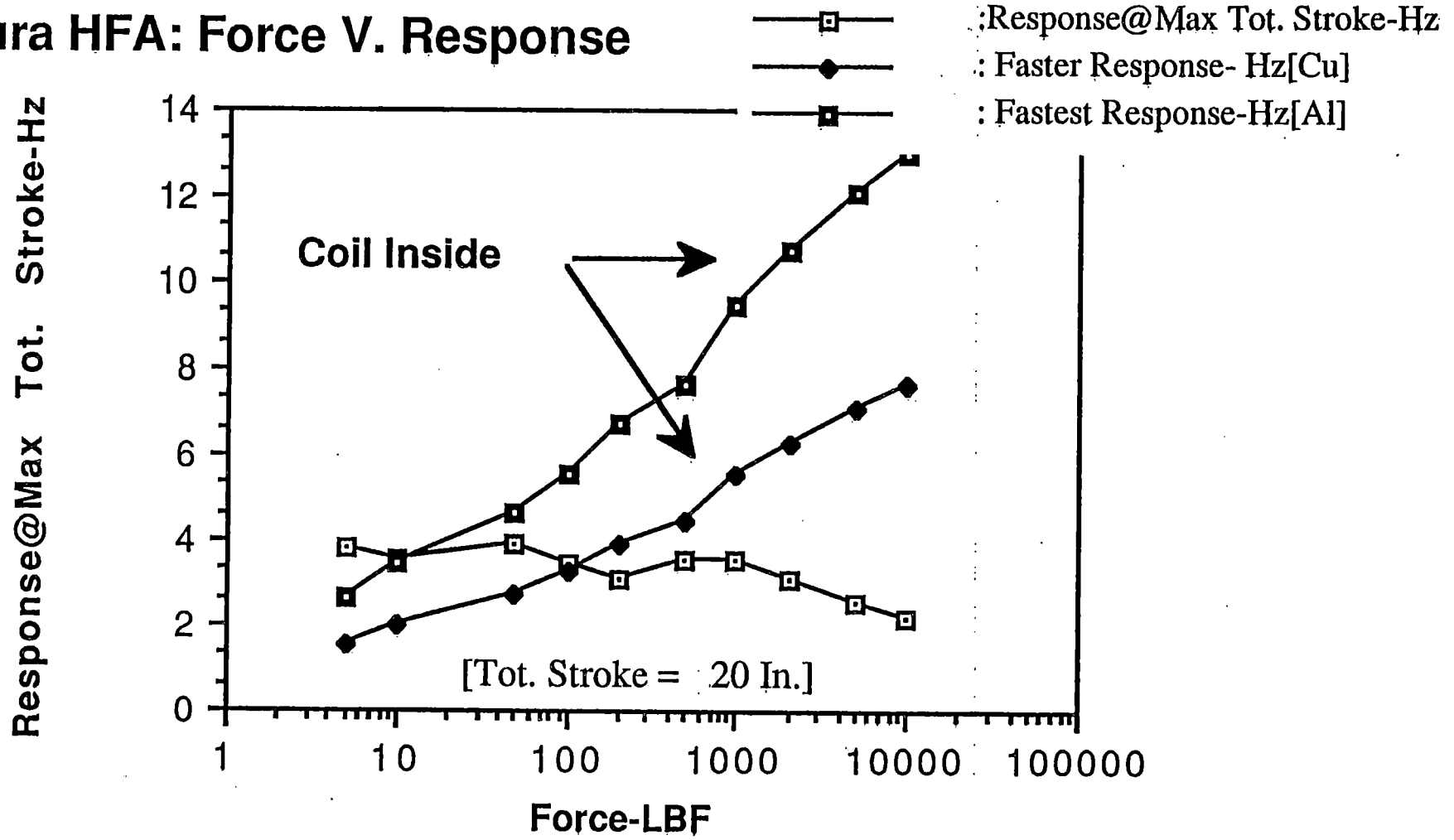
Aura HFA: Force vs. Power vs. Current



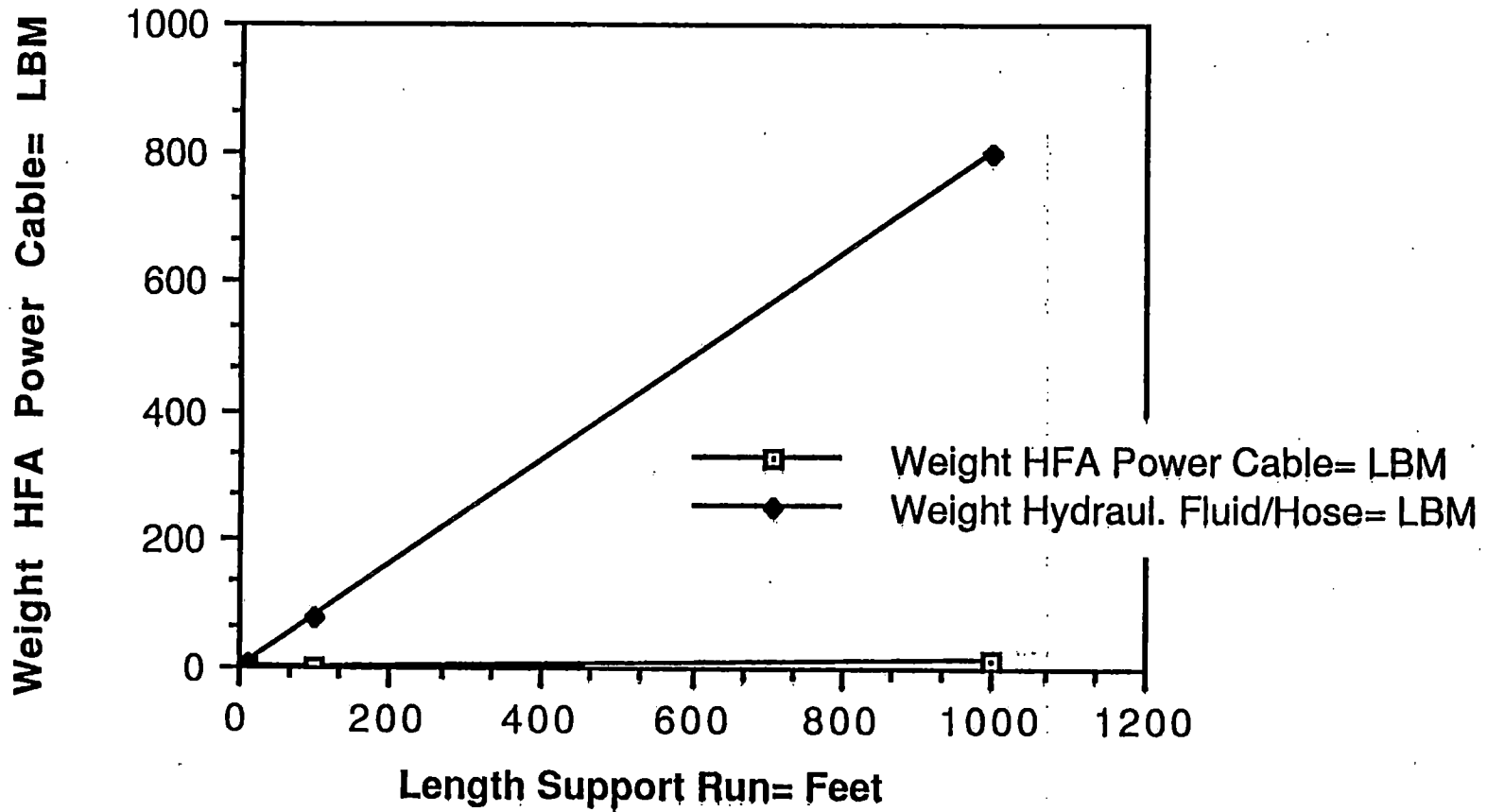
Magnetic High Force Actuator Example: Total Stroke vs. Weight vs. Unextended Length



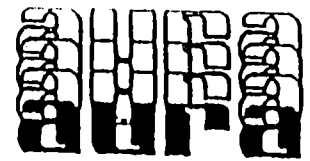
Aura HFA: Force V. Response



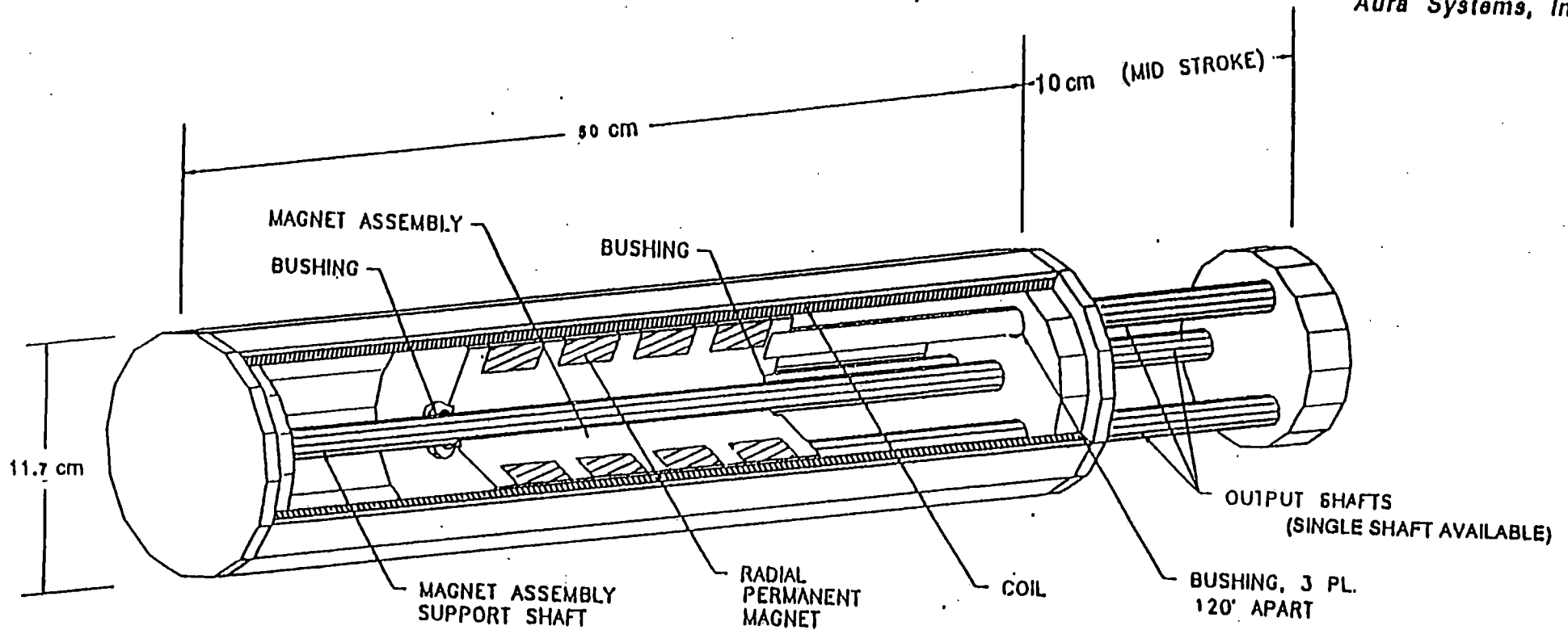
Support Equip. Wt: Power Cable vs. Hydraulic Fluid/Hose



500 POUND FORCE ACTUATOR: EXAMPLE CONFIGURATION



Aura Systems, Inc.



MÁX. FORCE	2225 N	OUTSIDE DIAMETER	11.7 cm
STROKE	±10 cm	LENGTH AT MID-STROKE	50 cm
MAX. CURRENT	85 Amps	OVERALL WEIGHT	24 kg
MAX. VELOCITY	1.3 M/Sec	MAX. OPERATING TEMP.	70°C
BANDWIDTH	100 Hz	AMBIENT TEMPERATURE	-30°C TO +40°C
MAX. VOLTAGE (@0 M/Sec)	24 Volts	HEAT DISSIPATION	FORCED CONVECTION (10 M/Sec AIR VELOCITY)
MAX. VOLTAGE (@1.3 M/Sec, MAX FORCE)	60.4 Volts	DUTY CYCLE	25%
BACK EMP	28 V/M/Sec	TYPE	BRUSHED, LINEAR
MAX. DISSIPATED POWER	1,890 Watts		

**MAGNETICS FACT SHEET:
BREAKTHROUGH CAPABILITIES ENABLED**



- 1. Dynamic Control**
- 2. Control Precision**
- 3. Responsiveness**
- 4. Digital Control**
- 5. Vibration Isolation**
- 6. Force-to-Weight Ratio**
- 7. Size Reduction**
- 8. Weight Reduction**
- 9. Power Efficiency**
- 10. Manufacturability**
- 11. Reliability**
- 12. Installation Simplicity**
- 13. Cost Effectiveness**

- (1) Respond to: Complex six degree-of-freedom commands in milliseconds.
- (2) Act with: Several thousand pound forces under complex multidirectional control commands.
- (3) Maintain: Dynamic separation distance of mils under acceleration of 10,000 degrees/sec², with forces noted, and with static positional precision of 0.1 mil or better.
- (4) Maintain: Microradian line-of-sight rotational accuracies for 10s of milliseconds, under at least random 10 gravity loads while slewing over 5 degree or greater angles within 120 millisecond responses.
- (5) Isolate from: Vibration by 80 or more decibels from at least 10 gravity external forces with millisecond rise times.
- (6) Induce, while suspending: Vibration spectra of several kilohertz bandwidth.
- (7) Suspend and differentially spin: Rotors at tens to hundreds of thousands rpm with no bearing wear or lubrication.
- (8) Linearly or Rotationally actuate: Over large--essentially unlimited--throw distances or rotational angles/directions with tens to thousands of pounds of force with milliseconds responsiveness and 0.1 mil or better position precision; tractor motor or columns extension implementation available.
- (9) Drive, as a motor, with: High Torque at any RPM, without gearing.
- (10) Use typically: Less power and weigh less than comparable force hydraulic, pneumatic or electric systems.
- (11) Install without: Pumps, hoses, fluids, pressure, valves, seals, mechanical drives, lubrication, noise or large control boxes.
- (12) Assure reliability and safety with: No mechanically touching parts; "fail safe" or "fail to" design alternatives; lightweight digital control/electrical backup redundancy; and flexibility of electrical routing alternatives.

(Hinchliffe/Gershowitz)
June 17, 1992 6 p.m.
DOD Draft Four

**PRESIDENTIAL REMARKS: INDUSTRIAL LEAGUE OF ORANGE COUNTY
FRIDAY, JUNE 19, 1992 1 P.M.
IRVINE HYATT, IRVINE, CALIFORNIA**

Thank you, Reed [Royalty]. Senator Seymour; Mayor (Sally) Sheridan and the other Orange County mayors; Todd Nicholson and everyone from the Industrial League. I identify with so many of you small businessmen -- not only did I start up my own business years ago, but I guess you could say Barbara and I still run a "Mom & Pop operation" -- we live above the store. \\ I've heard a lot of terrific things about your group's work to strengthen the economic health of Orange County -- and I'm particularly pleased with the business-education partnerships you sponsor. I've also heard about your annual Golf Tournament. How come I'm not invited -- has my reputation with a five-iron even reached this coast? \\

I'm proud to work with three solid, strong leaders not only for Orange County, but for this country: two are here today. Bob Dornan couldn't be here, but he's a real champion of American values, at my side in every election, an aggressive spokesman for the things we believe in. Chris Cox is an innovative, creative Congressman who embodies the vibrant, entrepreneurial spirit of this area -- he's pushing great new ideas like Turbo Enterprise Zones, and is dedicated to budget reform. And Dana Rohrbacher, fresh off his surfboard: he's deeply involved in what I want to talk to you about today -- our nation's transition into the post-Cold War era, and what this means to a competitive economy.

Three days ago I met at the White House with Russia's freely

elected President, Boris Yeltsin. We rejoiced at the new breeze of freedom which has swept the globe, scattering the last dust of grim totalitarianism. And we spoke of the dreams we share for our people. [ADD ANECDOTE/DETAIL FROM PRIVATE TIME WITH YELTSIN]

It was an extraordinary moment in history. We stood next to each other in the Rose Garden and together announced the end to a generation's nuclear nightmare. Our agreement will lead to the greatest arms reductions of the nuclear age -- reductions far deeper than we could have hoped for even six months ago. Think of what that means -- not for presidents, not for heads of state, not for historians -- but for parents and for their children. It means a future free from fear -- a miracle for mankind. \\\

As I travel across this country after this historic summit, I see what our nuclear agreement means in the daily life of every American. With the threat of the Cold War behind us, we now have the freedom to focus on the concerns that trouble us at home. And with the new partnership of peace we've forged with Russia, we have the chance to expand trade -- to create jobs and opportunities that will benefit both our nations.

But while we look ahead to these exciting new horizons there is one critical element we must never forget. Just because the Cold War is over doesn't mean that our need for the strongest defense is over, too. That need may change, but it will never disappear. Look at the threat posed by terrorists -- by renegade regimes -- by global uncertainties. We will continue to invest in military R&D. And we will depend upon companies like many in

Orange County, who will continue to develop and use technology that was begun for defense, but will now be used for commercial products as well. As a result, our next generation of the military will find that they have the technology they need. We need not fear for our defense; for our children; for our future.

But there are new challenges we face in the post-Cold War terrain. There are still pioneer days ahead. At one point in the movie "Awakenings," a fellow who's been asleep for decades finally wakes up and has the whole world in front of him. When his doctor asks him what he wants to do that day, his face breaks into a huge grin and he shouts: "Everything!" That's the spirit we need to call up right now -- that purely American belief in a future that knows no limits.

But the fact is: we're entering a different economic world than the one we grew up in. William Jennings Bryan captured the bold spirit which will lead us to success when he said: "Destiny is not a matter of chance -- it's a matter of choice. It is not a thing to be waited for -- it is a thing to be achieved."

I've seen how Californians are achieving your destiny. You're not waiting for chance -- you're making the choice. That's what we must do all over this land. For 200 years, our prosperity has sprung from our ability to innovate, to create, to change as the world changes. That's the heart of entrepreneurial capitalism -- a heart I hear beating right here in Orange County.

This place is almost like an R&D lab for the whole country, because you're figuring out how to shape your own identity in an

evolving economy. All around us here are successful examples of the technological transition from the Cold War to the era of global economic competition. As the defense department "down-sizes," you face the challenge of adapting from the military to the competitive civilian market. It's tough for private sector companies and employees -- but this administration is firmly behind you, with a steady hand on this nation's helm. Together we will keep our economy the most productive in this world.

I've seen examples here of some remarkably creative thinking. During the Cold War, the military essentially funded the development of new manufacturing techniques. Now, you're demonstrating astounding innovation in turning these systems developed for national defense to take aim at the commercial market worldwide.

The proof is right here. Hughes Aircraft is applying the military's Global Positioning Satellite System to a new procedure controlling shipping traffic along our coastal waters. McDonnell Douglas' SDIO-funded Delta Clipper Program will dramatically reduce costs of reaching into orbit -- this will ensure that we lead the world's commercial aerospace industry. Rockwell is developing ways of using SDI's high-tech offshoots to give us smart cars and smart freeways, breaking gridlock on our highways -- that's certainly good news for Southern California.

The more closely we look at these companies, the more we understand why they're thriving -- why they're hiring when so many others are firing. It's because they're able to adapt. They're at the cutting edge of the post-Cold War era, leading the

drive to transform this world into a productive peace.

And defense conversion has put you back in the business of job creation: a skill you mastered in the 80s, with all the high-tech startups that made this area famous. Now you're redefining it for the 90s. But for Orange County, job creation doesn't mean job-training -- your workers are already the most qualified in our labor force. What they need is opportunity. If we give a budding entrepreneur a chance, he'll bring training, experience and old-fashioned American hunger to his own business -- and create jobs for dozens, maybe even hundreds, of fellow workers.

As a nation, we must support these risk-takers -- for their vision of today will be our future of tomorrow. Venture capital has dried up, so we must take action to get it flowing again. We must create new jobs by stimulating private sector investment and we'll do this by pushing Congress to slash the capital gains tax -- by getting rid of passive loss rules for venture capital -- by making the Research and Experimentation tax credit permanent.

Already, we've introduced our National Technology Initiative, to bring government officials together with private businesses to let them know what government can offer in technology. This moves new discoveries out of federal laboratories, into the marketplace to create new jobs -- that's what this is all about.

Of course, this transformation is not going to be easy. The world economy of the 21st century will be a new age of American competition in a fiercely challenging global marketplace. And we simply have to make some changes if we expect to compete. We

have to realize the intensified need for sophisticated, well-educated workers. The worldwide high-tech explosion will leave us behind unless we literally reinvent American education -- to turn out the best-prepared workers in this world. To do this, let's borrow a page from business -- let's bring competition into our schools through ideas like school choice. That's how we'll make our schools -- and our future -- the best in the world.

We have a huge challenge ahead. But we can more than meet it if we remember what FDR said a half-century ago: "The only limit to our realization of tomorrow will be our doubts of today."

I'll use every resource to pave our way into the future. For example, I'm announcing an important regulatory change that will help many companies with defense-related businesses make the transition to the post-Cold War era. One unnecessary obstacle has been the "recoupment" fee -- or tax, if you will -- that DoD charges on military and commercial products sold to customers other than the U.S. government. These fees hurt American workers by making it more difficult for them to compete for business here and abroad. Given the historic changes we've seen during the last year, this burden is no longer justified. So today I direct my Secretary of Defense to take what actions he can to eliminate these fees.

In addition, I will continue to fight to create more American jobs by encouraging trade and opening markets abroad. You know how vital that is since America is the world's leading exporting nation, and California leads America, accounting for

one of every eight U.S. export dollars. Just last year -- a 13% increase over 1990 -- this state exported over \$50 billion in goods, creating jobs up and down this golden coast.

I will keep pushing for NAFTA, to lower trade barriers even further and establish one of the biggest and richest markets in the world, with the potential of creating hundreds of thousands of jobs. The opportunities for export success in this new global economy are virtually unlimited -- and tremendously exciting.

Long-term, Washington must have the courage to do the hard work of government -- work which requires a little less self-interest and a lot more discipline than most elected officials currently show. I'm talking about whipping government spending into control. I'm talking about being brave enough to launch a genuine, strong effort to reduce runaway spending and to enforce disciplinary measures. I'm talking about real government reform.

We must begin by forcing Congressmen to come down from their ivory tower, down off Capitol Hill to listen to the American people, nearly 80% of whom support the balanced budget amendment. Voters are saying to Congress: "You're borrowing from the future to pay for indulgences of the present and we won't stand for it any more." For years, I've called for a balanced budget amendment because to ensure long-term economic growth we must get federal spending under control. High deficits raise interest rates -- high interest rates kill jobs -- a ransomed future kills hope.

We will let nothing threaten our hope. We'll bequeath to our next generation the proudest legacies that make up the

essence of our great national spirit -- the inheritance that made us strong -- the American legacies of jobs, family and peace.

And we will act with determination. As a nation, we will chart the course that will guide America into the world of the new century -- a world in which defeatism produces defeat, but where confidence and self-reliance produce greatness.

We will find that greatness. We will shape from inside ourselves a country ready to seize the opportunities the new world economy offers. I believe in that -- I believe in us -- I believe in America. God bless you all.

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THE WHITE HOUSE
WASHINGTON

June 18, 1992

MEMORANDUM TO CHRISTINA MARTIN

FROM: GARY GERSHOWITZ

SUBJECT: INDUSTRIAL LEAGUE SPEECH

It is strongly recommended that the line -- "by getting rid of passive loss rules for venture capital" -- be removed entirely from the speech.

Reason: This administration HAS NOT even proposed "getting rid of passive loss rules for venture capital", because it would be EXTREMELY COSTLY

The CORRECT WORDING should be: "by providing passive loss relief for real estate developers."

HOWEVER, EVEN THIS WORDING, "BY PROVIDING PASSIVE LOSS RELIEF FOR REAL ESTATE DEVELOPERS" IS VERY INAPPROPRIATE FOR THE AUDIENCE THE PRESIDENT IS ADDRESSING, BECAUSE IT IS RELEVANT ONLY TO REAL ESTATE DEVELOPERS OR PEOPLE IN COMMERCIAL CONSTRUCTION - NOT TO BUSINESSMEN WITH DoD CONTRACTS WHO ARE MAKING THE --TRANSITION TO THE PRIVATE SECTOR.

to: _____

room: _____ date: _____

Department
of the Treasury

Office of
Public Affairs

- ① We have not proposed "getting rid" of passive loss rules for venture capital - and the concept would be extremely expensive.
- ② "providing passive loss relief for real estate developers" doesn't seem relevant to the theme of the speech or the topic.
- ③

Rich Myers

room 2325

phone (202) 566-2041

(Hinchliffe/Gershowitz)
June 15, 1992 4 p.m.
DOD Draft Two

**PRESIDENTIAL REMARKS: INDUSTRIAL LEAGUE OF ORANGE COUNTY
FRIDAY, JUNE 19, 1992 1 P.M.
IRVINE HYATT, IRVINE, CALIFORNIA**

(ACKNOWLEDGMENTS) And I'm proud to be standing here with three men who are solid, strong leaders not only for Orange County, but for this country. Bob Dornan -- a real champion of American values, who's been at my side in every election -- an aggressive spokesman for the things we believe in. ²²⁵⁻⁵⁶¹¹ Chris Cox -- an innovative, creative Congressman who embodies the vibrant, entrepreneurial spirit of this area -- he's pushing great new ideas like Turbo Enterprise Zones, and is a real champion of budget reform. And Dana Rohrbacher -- glad to see you could take some time off from surfing -- he's deeply involved in what I want to talk to you about today -- our nation's transition into the post-Cold War era, and what this means to a competitive economy.

Three days ago, I sat in the Oval Office with Russia's freely elected President, Boris Yeltsin, and we spoke of the dreams we share for our people. It was an extraordinary moment. Just think how in the last few years we've witnessed great gains for democracy -- events we scarcely dreamed would take place in our lifetimes. We're closer than ever to the people of every nation, rejoicing as one at the new breeze of freedom which swept the globe, scattering the last dust of grim totalitarianism.

But there are new challenges we face in the unexplored post-Cold War terrain. There are still pioneer days ahead. You know, at one point in the movie called "Awakenings," a fellow who's

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been asleep for decades finally wakes up and has the whole world in front of him. When his doctor asks him what he wants to do that day, his face breaks into a huge grin and he shouts:

"Everything!" That's the spirit we need to call up right now -- that purely American belief in a future that knows no limits.

We're entering an entirely different economic world than the one we grew up in -- and that unbeatable spirit is what's going to lead us to success. William Jennings Bryan captured that bold spirit when he said: "Destiny is not a matter of chance -- it's a matter of choice. It is not a thing to be waited for -- it is a thing to be achieved."

→ New Dictionary Book of Quotes -- PAGE 283, Feb 1899

I've seen how Californians are achieving your destiny. You're not waiting for chance -- you're making the choice. That's what we must do all over this land. For 200 years, our prosperity has sprung from our ability to innovate, to create, to change as the world changes. That's the heart of entrepreneurial capitalism -- a heart I hear beating right here in Orange County.

This place is almost like an R&D lab for the whole country, because you're figuring out how to shape your own identity in an evolving economy. This area is packed with successful examples of the technological transition from the Cold War to the era of global economic competition -- you're using systems developed for national defense to take aim at commercial markets worldwide.

As the defense department "downsizes" in the new post-Cold War era, you face the daunting challenge of adapting from the military to the competitive civilian market. It'll be tough for

} Beth
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Spoke to Nick DYKEMA, Cong Rephracker
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a lot of private sector companies, and their employees.

But I've seen examples of some remarkably creative thinking. During the Cold War, the military essentially funded the development of new manufacturing techniques. Now, led by Orange County, companies are demonstrating astounding innovation in turning these techniques to new uses in the civilian market.

Beverly of Ind League confirmed

The proof is all around us. Hughes Aircraft is applying the military's Global Positioning Satellite System to a new procedure controlling shipping traffic along our coastal waters. McDonnell Douglas is using the SDI-funded SSTO program to dramatically reduce costs of reaching into orbit -- this will ensure that we lead the world's commercial aerospace industry. Rockwell is developing ways of using SDI's high-tech offshoots to give us smart cars and smart freeways, breaking gridlock on our highways -- that's certainly good news for Southern California. \\\

Tim Nyger suggested new wording for M.D. - just the part of the sentence

Tim Nyger in Cong Rephracker's office confirmed these facts

And I just came from visiting Aura Systems. I got to see up close how this small company is thriving: why they're hiring when so many others are firing. It's because they're able to adapt. They're at the cutting edge of the post-Cold War era, leading the drive to transform this world into a productive peace.

Marc Feldman Aura Systems confirmed

But while we look ahead to these exciting new horizons there is one critical element we must never forget. Just because the Cold War is over doesn't mean that our need for the strongest defense is over, too. That need may change, but it will never disappear. Look at the threat posed by terrorists -- by renegade regimes -- by global uncertainties. Well, because companies like

these in Orange County continue to develop and use technology begun for defense, our next generation of the military will find that the technology has continued to evolve. We need not fear for our defense -- for our children -- for our future.

In the meantime, look how one company is successfully making the post-Cold War transition to replace disappearing defense contracts. Aura Systems started as a military R&D company, doing virtually 100% DoD work. Now, they've won civilian contracts that make up 80% of their work. They have seen the future -- they're using their military-developed technology to beat weapons into ploughshares. For instance, their imagination has led them to use SDI-funded work on electromagnetics to develop vibrationless jackhammers -- and precision instruments used in cataract surgery. And they're applying their military electro-optics technology to improve commercial telecommunications.

These Orange County companies lead us because they're not stuck in the old ways of thinking. They're not afraid to take risks. Look what happens to companies who want to be the biggest fish in the pond -- but who are afraid to be the first to dive in. Companies willing to maneuver and adapt to changing marketplace realities survive. Dinosaurs are fated to die. \\
 CONFIDENTIAL
 by Marc
 Feldman
 AURA
 SYSTEMS
 TELEVISIONS SPONSORS
 FILM NEWS
 PROJECTORS

Of course, this transformation is not going to be easy. The new world economy of the 21st century will be a new age of American competition in a fiercely challenging global marketplace. And we simply have to make some changes if we expect to compete. We have to realize the intensified need for sophisticated, well-

educated workers. The worldwide high-tech explosion will leave us behind unless we literally reinvent American education -- to turn out the best-prepared workers in this world. To do this, let's borrow a page from business -- let's bring competition into our schools through ideas like school choice. That's how we'll make our schools -- and our future -- the best in the world.

We have a huge challenge ahead of us. But we can more than match it if we remember what FDR said a half-century ago: "The only limit to our realization of tomorrow will be our doubts of today." *Bartlett's: pg 917, col 2*

I am absolutely committed to using every resource I can to pave our way into the future. Right now, I'll fight for measures to add jobs -- actions like encouraging investments through the capital gains tax cut; increasing jobs by reducing regulations; and encouraging trade and opening markets abroad. You know first-hand how important that is. California leads this nation in exports -- accounting for one out of every seven U.S. export dollars. Just last year -- in an 8% increase over 1990 -- this state exported over \$63 billion in goods. And, in all, your ports handled two-way trade values at nearly \$175 billion -- creating jobs up and down this golden coast.

*California
World Trade
Comm.
FAG
Sheet*

Long-term, Washington must have the courage to do the hard work of government -- work which requires a little less self-interest and a lot more discipline than most elected officials currently show. I'm talking about whipping government spending into control. I'm talking about being brave enough to launch a

genuine, strong effort to reduce runaway spending and to enforce disciplinary measures. I'm talking about real government reform.

We must begin by forcing Congressmen to come down from their ivory tower, down off Capitol Hill to listen to the American people -- 77% of whom support the balanced budget amendment. Voters are saying to Congress: "We know you're borrowing from the future to pay for indulgences of the present and we won't stand for this any more." For years now, I've called for a balanced budget amendment because to ensure long-term economic growth we must get federal spending under control. High deficits raise interest rates -- high interest rates kill jobs -- a ransomed future kills hope.

80% is the number we used for the BBA radio address 6/5/92

When I was visiting Aura Systems this morning, I was struck by its motto: "The Link Between Problem and Solution." Well, we all have the chance to be that link for our country. We have the chance to guide America into the world of the new century -- a world in which defeatism produces defeat, but where confidence and self-reliance produce greatness.

confirmed by Marc Feldman, AURA SYSTEMS

We will find that greatness. We will shape from inside ourselves a country ready to seize the opportunities the new world economy offers. I believe in that -- I believe in us -- I believe in America. God bless you all.

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(Hinchliffe/Gershowitz)
June 15, 1992 11 a.m.
DOD Draft Two

**PRESIDENTIAL REMARKS: INDUSTRIAL LEAGUE OF ORANGE COUNTY
FRIDAY, JUNE 19, 1992 1 P.M.
IRVINE HYATT, IRVINE, CALIFORNIA**

(ACKNOWLEDGMENTS) Three days ago, I sat in the Oval Office with Russia's freely elected President, Boris Yeltsin, and we spoke of the dreams we share for our people. I was awed by the significance and the emotion of that moment. My friends, we are poised at an extraordinary point in history. In the last few years we've witnessed events we scarcely dreamed would take place in our lifetimes. We're closer than ever to the peoples of this world, rejoicing as one at the new breeze of freedom which swept the globe, scattering the last dust of grim totalitarianism.

But there are new challenges we face in the unexplored post-Cold War terrain. There are still pioneer days ahead. You know, at one point in the movie called "Awakenings," a fellow who's been asleep for decades finally wakes up and has the whole world in front of him. When his doctor asks him what he wants to do that day, his face breaks into a huge grin and he shouts: "Everything!" That's the spirit we need to call up right now -- that purely American belief in unlimited possibilities.

We're entering an entirely different economic world than the one we grew up in -- and that unbeatable spirit is what's going to lead us to success. We will triumph over economic uncertainty because when Americans are hit by a blow they don't give up -- they get up more determined than ever before. William Jennings Bryan captured that bold spirit when he said: "Destiny is not a

matter of chance -- it's a matter of choice. It is not a thing to be waited for -- it is a thing to be achieved." I'm impressed by how the people of California are achieving your destiny. You're not waiting for chance: you're making the choice. That's what we must do all over this land. For 200 years, our prosperity has sprung from our ability to innovate, to create, to change as the world changes. That's the heart of entrepreneurial capitalism: a heart I hear beating right here in Orange County.

This place is almost like an R&D lab for the whole country - - because you're figuring out how to shape your own identity in an evolving economy. This area is packed with successful examples of the technological transition from the Cold War to the era of global economic competition -- you're using systems developed for national defense to take aim at commercial markets worldwide.

As the defense department cuts back on contracts in the new post-Cold War era, you face the daunting challenge of adapting from the military to the competitive civilian market. It'll be tough for a lot of private sector companies, and their employees.

But I've seen examples of some remarkably creative thinking. For the past decades, our finest minds have been working on the task of preserving the peace. Now that they're turning to the commercial world, amazing gates of opportunity are opening. During the Cold War, the military essentially funded the development of new manufacturing techniques. Now, led by Orange County, companies are demonstrating wonderful innovation in turning these techniques to new uses in the civilian market.

Look right around us. Hughes Aircraft is applying the military's Global Positioning Satellite System to a new procedure controlling vessel traffic along our coastal waters. McDonnell Douglas is using the SDI-funded SSTO program to dramatically reduce costs of getting planes into orbit -- this will ensure that we lead the world's commercial aerospace industry. Rockwell is developing ways of using SDI technology offshoots to give us smart cars and smart freeways, breaking gridlock on our highways -- and that's good news for Souther California.

And I just came from visiting Aura Systems. I got to see up close how this small company is thriving: why they're hiring when so many others are firing. It's because they're able to adapt. They're at the cutting edge of the post-Cold War era, leading the drive to transform this world into a productive peace.

Aura started as a military R&D company, doing virtually 100% DOD work. Now, to replace discontinued defense contracts, they're recruited civilian contracts that make up 80% of their work. They have seen the future -- they're using their military-developed technology to beat weapons into ploughshares. For instance, their imagination has led them to turn SDI-funded work on electromagnetics for vibrationless jackhammers and cataract surgery. And they're applying their military electro-optics technology to improve commercial telecommunications.

But while we look ahead to these exciting new horizons there is one critical element we must never forget. Just because the Cold War is over doesn't mean that our need for the strongest

Tim
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office
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defense is over, too. That need may change, but it will never disappear. Look at the threat posed by terrorists -- by third world dictators -- by global uncertainties. Well, because companies like these in Orange County continue to develop and use technology begun for defense, our next generation of the military will find that the technology has continued to evolve. We need not fear for our defense -- for our children -- for our future.

These Orange County companies lead us because they're not stuck in the old ways of thinking. They're not afraid to take risks. Look what happens to companies who want to be the biggest fish in the pond -- but who are afraid to be the first to dive in. Companies willing to maneuver and adapt to changing marketplace realities survive. Dinosaurs are fated to die.

Of course, this development is not going to be easy. The economic world of the 21st century will be a new age of American competition in a fiercely challenging global marketplace. And we simply have to make some changes if we expect to compete. We have to realize the intensified need for sophisticated, well-educated workers. The worldwide high-tech explosion will leave us behind unless we literally reinvent American education -- to turn out the best-prepared workers in this world. We have a huge challenge ahead of us. But we can more than match it if we remember what FDR said a half-century ago: "The only limit to our realization of tomorrow will be our doubts of today."

I am absolutely committed to using every resource I can to pave our way into the future. Right now, I'll fight for measures

*Deere speaks
1/92*

to add jobs -- actions like encouraging investments through the capital gains tax cut; increasing jobs by reducing regulations; and encouraging trade and opening markets abroad. [CALIFORNIA FOREIGN TRADE STATS TO COME].

Long-term, Washington must have the courage to do the hard work of government -- work which requires a little less self-interest and a lot more discipline than most elected officials currently show. I'm talking about whipping government spending into control. I'm talking about being brave enough to launch a genuine, strong effort to reduce runaway spending and to enforce disciplinary measures. I'm talking about real government reform.

We must begin by forcing Congressmen to come down from their Capitol Hill ivory tower and listen to the American people -- 77% of whom support the balanced budget amendment. Voters are saying to Congress: "We know you're borrowing from the future to pay for indulgences of the present and we won't stand for this any more." I've consistently called for a balanced budget amendment because to ensure long-term economic growth -- we must get federal spending under control. High deficits raise interest rates -- high interest rates kill jobs -- a ransomed future kills hope.

When I was visiting Aura Systems this morning, I was struck by its motto: "The Link Between Problem and Solution." Well, we all have the chance to be that link for our country. We have the chance to guide America into the world of the new century -- a world in which defeatism produces defeat, but where confidence and self-reliance produce greatness.

} more

We will find that greatness. We will shape from inside ourselves a country ready to seize the opportunities the new world economy offers. I believe in that -- I believe in us -- I believe in America. God bless you all.

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THE WHITE HOUSE
WASHINGTON

June 17, 1992

MEMORANDUM FOR THE PRESIDENT

THROUGH:

DAVID DEMAREST *DD*

FROM:

BETH HINCHLIFFE *BH*

SUBJECT:

THE INDUSTRIAL LEAGUE OF ORANGE COUNTY

On Friday, June 19, at the Hyatt Hotel in Irvine, California, you will address approximately 1,000 members and guests of the Industrial League of Orange County. Most audience members will be businessmen who have been directly affected by DoD downsizing and other negative economic changes. Congressmen Cox, Dornan and Rohrbacher plan to attend. (Dana Rohrbacher particularly likes the surfing reference in the introduction.)

Your remarks (14 minutes/teleprompter) address how Orange County companies can lead the way in making the transition from government contracts to the competitive private sector. The remarks emphasize your commitment to successful DoD conversion, job creation, the encouragement of private investment, trade and economic recovery.

(Hinchliffe/Gershowitz)
June 17, 1992 2 p.m.
DOD Draft Four

**PRESIDENTIAL REMARKS: INDUSTRIAL LEAGUE OF ORANGE COUNTY
FRIDAY, JUNE 19, 1992 1 P.M.
IRVINE HYATT, IRVINE, CALIFORNIA**

[ACKNOWLEDGEMENTS] I'm proud to be standing here with three men who are solid, strong leaders not only for Orange County, but for this country. **Bob Dornan**: a real champion of American values, who's been at my side in every election, an aggressive spokesman for the things we believe in. **Chris Cox**: an innovative, creative Congressman who embodies the vibrant, entrepreneurial spirit of this area -- he's pushing great new ideas like Turbo Enterprise Zones, and is dedicated to budget reform. And **Dana Rohrbacher**, fresh off his surfboard: he's deeply involved in what I want to talk to you about today -- our nation's transition into the post-Cold War era, and what this means to a competitive economy.

Three days ago I met at the White House with Russia's freely elected President, Boris Yeltsin. We rejoiced at the new breeze of freedom which has swept the globe, scattering the last dust of grim totalitarianism. And we spoke of the dreams we share for our people. [ADD ANECDOTE/DETAIL FROM PRIVATE TIME WITH YELTSIN]

It was an extraordinary moment in history. We stood next to each other in the Rose Garden and together announced the end to a generation's nuclear nightmare. Our agreement will lead to the greatest arms reductions of the nuclear age -- reductions far deeper than we could have hoped for even six months ago. Think of what that means -- not for presidents, not for heads of state, not for historians -- but for parents and for their children. It

means a future free from fear -- a miracle for mankind.

As I travel across this country after this historic summit, I see what our nuclear agreement means in the daily life of every American. With the threat of the Cold War behind us, we now have the freedom to focus on the concerns that trouble us at home. And with the new partnership of peace we've forged with Russia, we have the chance to expand trade -- to create jobs and opportunities that will benefit both our nations.

But while we look ahead to these exciting new horizons there is one critical element we must never forget. Just because the Cold War is over doesn't mean that our need for the strongest defense is over, too. That need may change, but it will never disappear. Look at the threat posed by terrorists -- by renegade regimes -- by global uncertainties. We will continue to invest in military R&D. And we will depend upon companies like many in Orange County, who will continue to develop and use technology that was begun for defense, but will now be used for commercial products as well. As a result, our next generation of the military will find that they have the technology they need. We need not fear for our defense; for our children; for our future.

But there are new challenges we face in the post-Cold War terrain. There are still pioneer days ahead. At one point in the movie "Awakenings," a fellow who's been asleep for decades finally wakes up and has the whole world in front of him. When his doctor asks him what he wants to do that day, his face breaks into a huge grin and he shouts: "Everything!" That's the spirit

we need to call up right now -- that purely American belief in a future that knows no limits.

But the fact is: we're entering a different economic world than the one we grew up in. William Jennings Bryan captured the bold spirit which will lead us to success when he said: "Destiny is not a matter of chance -- it's a matter of choice. It is not a thing to be waited for -- it is a thing to be achieved."

I've seen how Californians are achieving your destiny. You're not waiting for chance -- you're making the choice. That's what we must do all over this land. For 200 years, our prosperity has sprung from our ability to innovate, to create, to change as the world changes. That's the heart of entrepreneurial capitalism -- a heart I hear beating right here in Orange County.

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astounding innovation in turning these systems developed for national defense to take aim at the commercial market worldwide.

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The more closely we look at these companies, the more we understand why they're thriving -- why they're hiring when so many others are firing. It's because they're able to adapt. They're at the cutting edge of the post-Cold War era, leading the drive to transform this world into a productive peace.

And defense conversion has put you back in the business of job creation: a skill you mastered in the 80s, with all the high-tech startups that made this area famous. Now you're redefining it for the 90s. But for Orange County, job creation doesn't mean job-training -- your workers are already the most qualified in our labor force. What they need is opportunity. If we give a budding entrepreneur a chance, he'll bring training, experience and old-fashioned American hunger to his own business -- and create jobs for dozens, maybe even hundreds, of fellow workers.

As a nation, we must support these risk-takers -- for their

vision of today will be our future of tomorrow. Venture capital has dried up, so we must take action to get it flowing again. We must create new jobs by stimulating private sector investment and we'll do this by pushing Congress to slash the capital gains tax -- by getting rid of passive loss rules for venture capital -- by making the Research and Experimentation tax credit permanent.

Already, we've introduced our National Technology Initiative, to bring government officials together with private businesses to let them know what government can offer in technology. This moves new discoveries out of federal laboratories, into the marketplace to create new jobs -- that's what this is all about.

Of course, this transformation is not going to be easy. The world economy of the 21st century will be a new age of American competition in a fiercely challenging global marketplace. And we simply have to make some changes if we expect to compete. We have to realize the intensified need for sophisticated, well-educated workers. The worldwide high-tech explosion will leave us behind unless we literally reinvent American education -- to turn out the best-prepared workers in this world. To do this, let's borrow a page from business -- let's bring competition into our schools through ideas like school choice. That's how we'll make our schools -- and our future -- the best in the world.

We have a huge challenge ahead. But we can more than meet it if we remember what FDR said a half-century ago: "The only limit to our realization of tomorrow will be our doubts of today."

I'll use every resource to pave our way into the future. For

example, I'm announcing an important regulatory change that will help many companies with defense-related businesses make the transition to the post-Cold War era. One unnecessary obstacle has been the "recoupment" fee, or tax, that DoD charges on military and commercial products sold to customers other than the U.S. government. These fees hurt American workers by making it more difficult for them to compete for business here and abroad. Given the historic changes we've seen during the last year, this burden is no longer justified. So today I direct my Secretary of Defense to take what actions he can to eliminate these fees.

In addition, I will continue to fight to create more American jobs by encouraging trade and opening markets abroad. You know how vital that is since America is the world's leading exporting nation, and California leads America, accounting for one of every eight U.S. export dollars. Just last year -- a 13% increase over 1990 -- this state exported over \$50 billion in goods, creating jobs up and down this golden coast.

I will keep pushing for NAFTA, to lower trade barriers even further and establish one of the biggest and richest markets in the world, with the potential of creating hundreds of thousands of jobs. The opportunities for export success in this new global economy are virtually unlimited -- and tremendously exciting.

Long-term, Washington must have the courage to do the hard work of government -- work which requires a little less self-interest and a lot more discipline than most elected officials currently show. I'm talking about whipping government spending

into control. I'm talking about being brave enough to launch a genuine, strong effort to reduce runaway spending and to enforce disciplinary measures. I'm talking about real government reform.

We must begin by forcing Congressmen to come down from their ivory tower, down off Capitol Hill to listen to the American people, nearly 80% of whom support the balanced budget amendment. Voters are saying to Congress: "You're borrowing from the future to pay for indulgences of the present and we won't stand for it any more." For years, I've called for a balanced budget amendment because to ensure long-term economic growth we must get federal spending under control. High deficits raise interest rates -- high interest rates kill jobs -- a ransomed future kills hope.

We will let nothing threaten our hope. We'll bequeath to our next generation the proudest legacies that make up the essence of our great national spirit -- the inheritance that made us strong -- the American legacies of jobs, family and peace.

And we will act with determination. As a nation, we will chart the course that will guide America into the world of the new century -- a world in which defeatism produces defeat, but where confidence and self-reliance produce greatness.

We will find that greatness. We will shape from inside ourselves a country ready to seize the opportunities the new world economy offers. I believe in that -- I believe in us -- I believe in America. God bless you all.

#

THE WHITE HOUSE
WASHINGTON

June 17, 1992

MEMORANDUM FOR THE PRESIDENT

THROUGH:

DAVID DEMAREST *DD*

FROM:

BETH HINCHLIFFE *BH*

SUBJECT:

THE INDUSTRIAL LEAGUE OF ORANGE COUNTY

On Friday, June 19, at the Hyatt Hotel in Irvine, California, you will address approximately 1,000 members and guests of the Industrial League of Orange County. Most audience members will be businessmen who have been directly affected by DoD downsizing and other negative economic changes. Congressmen Cox, Dornan and Rohrbacher plan to attend. (Dana Rohrbacher particularly likes the surfing reference in the introduction.)

Your remarks (14 minutes/teleprompter) address how Orange County companies can lead the way in making the transition from government contracts to the competitive private sector. The remarks emphasize your commitment to successful DoD conversion, job creation, the encouragement of private investment, trade and economic recovery.

(Hinchliffe/Gershowitz)
June 17, 1992 2 p.m.
DOD Draft Four

**PRESIDENTIAL REMARKS: INDUSTRIAL LEAGUE OF ORANGE COUNTY
FRIDAY, JUNE 19, 1992 1 P.M.
IRVINE HYATT, IRVINE, CALIFORNIA**

[ACKNOWLEDGEMENTS] I'm proud to be standing here with three men who are solid, strong leaders not only for Orange County, but for this country. **Bob Dornan**: a real champion of American values, who's been at my side in every election, an aggressive spokesman for the things we believe in. **Chris Cox**: an innovative, creative Congressman who embodies the vibrant, entrepreneurial spirit of this area -- he's pushing great new ideas like Turbo Enterprise Zones, and is dedicated to budget reform. And **Dana Rohrbacher**, fresh off his surfboard: he's deeply involved in what I want to talk to you about today -- our nation's transition into the post-Cold War era, and what this means to a competitive economy.

Three days ago I met at the White House with Russia's freely elected President, Boris Yeltsin. We rejoiced at the new breeze of freedom which has swept the globe, scattering the last dust of grim totalitarianism. And we spoke of the dreams we share for our people. [ADD ANECDOTE/DETAIL FROM PRIVATE TIME WITH YELTSIN]

It was an extraordinary moment in history. We stood next to each other in the Rose Garden and together announced the end to a generation's nuclear nightmare. Our agreement will lead to the greatest arms reductions of the nuclear age -- reductions far deeper than we could have hoped for even six months ago. Think of what that means -- not for presidents, not for heads of state, not for historians -- but for parents and for their children. It

means a future free from fear -- a miracle for mankind.

As I travel across this country after this historic summit, I see what our nuclear agreement means in the daily life of every American. With the threat of the Cold War behind us, we now have the freedom to focus on the concerns that trouble us at home. And with the new partnership of peace we've forged with Russia, we have the chance to expand trade -- to create jobs and opportunities that will benefit both our nations.

But while we look ahead to these exciting new horizons there is one critical element we must never forget. Just because the Cold War is over doesn't mean that our need for the strongest defense is over, too. That need may change, but it will never disappear. Look at the threat posed by terrorists -- by renegade regimes -- by global uncertainties. We will continue to invest in military R&D. And we will depend upon companies like many in Orange County, who will continue to develop and use technology that was begun for defense, but will now be used for commercial products as well. As a result, our next generation of the military will find that they have the technology they need. We need not fear for our defense; for our children; for our future.

But there are new challenges we face in the post-Cold War terrain. There are still pioneer days ahead. At one point in the movie "Awakenings," a fellow who's been asleep for decades finally wakes up and has the whole world in front of him. When his doctor asks him what he wants to do that day, his face breaks into a huge grin and he shouts: "Everything!" That's the spirit

we need to call up right now -- that purely American belief in a future that knows no limits.

But the fact is: we're entering a different economic world than the one we grew up in. William Jennings Bryan captured the bold spirit which will lead us to success when he said: "Destiny is not a matter of chance -- it's a matter of choice. It is not a thing to be waited for -- it is a thing to be achieved."

I've seen how Californians are achieving your destiny. You're not waiting for chance -- you're making the choice. That's what we must do all over this land. For 200 years, our prosperity has sprung from our ability to innovate, to create, to change as the world changes. That's the heart of entrepreneurial capitalism -- a heart I hear beating right here in Orange County.

This place is almost like an R&D lab for the whole country, because you're figuring out how to shape your own identity in an evolving economy. All around us here are successful examples of the technological transition from the Cold War to the era of global economic competition. As the defense department "down-sizes," you face the challenge of adapting from the military to the competitive civilian market. It's tough for private sector companies and employees -- but this administration is firmly behind you, with a steady hand on this nation's helm. Together we will keep our economy the most productive in this world.

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THE WHITE HOUSE
WASHINGTON

June 17, 1992

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THROUGH: DAVID DEMAREST *DD*
FROM: BETH HINCHLIFFE *BH*
SUBJECT: THE INDUSTRIAL LEAGUE OF ORANGE COUNTY

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WHITE HOUSE STAFFING MEMORANDUM

DATE: 6/15/92 ACTION/CONCURRENCE/COMMENT DUE BY: TUES. 6/16 3:00pm

PRESIDENTIAL REMARKS: INDUSTIRAL LEAGUE OF ORANGE COUNTY
 SUBJECT: IRVINE, CA - FRI. 6/19/92 - 1:00 p.m.

	ACTION	FYI		ACTION	FYI
VICE PRESIDENT	<input type="checkbox"/>	<input checked="" type="checkbox"/>	HORNER	<input type="checkbox"/>	<input type="checkbox"/>
SKINNER	<input type="checkbox"/>	<input checked="" type="checkbox"/>	MCBRIDE <i>likes it alot!</i>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
SCOWCROFT	<input checked="" type="checkbox"/>	<input type="checkbox"/>	MOORE	<input checked="" type="checkbox"/>	<input type="checkbox"/>
DARMAN	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PETERSMEYER <i>M/C</i>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
BRADY	<input type="checkbox"/>	<input checked="" type="checkbox"/>	PORTER	<input checked="" type="checkbox"/>	<input type="checkbox"/>
BROMLEY	<input type="checkbox"/>	<input type="checkbox"/>	ROLLINS	<input type="checkbox"/>	<input type="checkbox"/>
CALIO <i>M/C</i>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	SMITH	<input checked="" type="checkbox"/>	<input type="checkbox"/>
DEMAREST	<input checked="" type="checkbox"/>	<input type="checkbox"/>	YEUTTER	<input type="checkbox"/>	<input checked="" type="checkbox"/>
FITZWATER	<input type="checkbox"/>	<input checked="" type="checkbox"/>	FINDLAY	<input type="checkbox"/>	<input checked="" type="checkbox"/>
GRAY	<input checked="" type="checkbox"/>	<input type="checkbox"/>	KAUFMAN	<input type="checkbox"/>	<input checked="" type="checkbox"/>
HOLIDAY	<input checked="" type="checkbox"/>	<input type="checkbox"/>	MCGROARTY	<input type="checkbox"/>	<input checked="" type="checkbox"/>
BOSKIN	<input checked="" type="checkbox"/>	<input type="checkbox"/>			

REMARKS:

Please forward your comments directly to Dan McGroarty, RM. 122, x2930, no later than 3:00 p.m., TUESDAY, JUNE 16, with a copy to this office. Thank you.

RESPONSE:

PHILLIP D. BRADY
 Assistant to the President
 and Staff Secretary
 Ext. 2702

(Hinchliffe/Gershowitz)
June 15, 1992 4 p.m.
DOD Draft Two

02 JUN 15 P5:09
**PRESIDENTIAL REMARKS: INDUSTRIAL LEAGUE OF ORANGE COUNTY
FRIDAY, JUNE 19, 1992 1 P.M.
IRVINE HYATT, IRVINE, CALIFORNIA**

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Three days ago, I sat in the Oval Office with Russia's freely elected President, Boris Yeltsin, and we spoke of the dreams we share for our people. It was an extraordinary moment. Just think how in the last few years we've witnessed great gains for democracy -- events we scarcely dreamed would take place in our lifetimes. We're closer than ever to the people of every nation, rejoicing as one at the new breeze of freedom which swept the globe, scattering the last dust of grim totalitarianism.

But there are new challenges we face in the unexplored post-Cold War terrain. There are still pioneer days ahead. You know, at one point in the movie called "Awakenings," a fellow who's

been asleep for decades finally wakes up and has the whole world in front of him. When his doctor asks him what he wants to do that day, his face breaks into a huge grin and he shouts:

"Everything!" That's the spirit we need to call up right now -- that purely American belief in a future that knows no limits.

We're entering an entirely different economic world than the one we grew up in -- and that unbeatable spirit is what's going to lead us to success. William Jennings Bryan captured that bold spirit when he said: "Destiny is not a matter of chance -- it's a matter of choice. It is not a thing to be waited for -- it is a thing to be achieved."

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As the defense department "downsizes" in the new post-Cold War era, you face the daunting challenge of adapting from the military to the competitive civilian market. It'll be tough for

a lot of private sector companies, and their employees.

But I've seen examples of some remarkably creative thinking. During the Cold War, the military essentially funded the development of new manufacturing techniques. Now, led by Orange County, companies are demonstrating astounding innovation in turning these techniques to new uses in the civilian market.

The proof is all around us. Hughes Aircraft is applying the military's Global Positioning Satellite System to a new procedure controlling shipping traffic along our coastal waters. McDonnell Douglas is using the SDI-funded SSTO program to dramatically reduce costs of reaching into orbit -- this will ensure that we lead the world's commercial aerospace industry. Rockwell is developing ways of using SDI's high-tech offshoots to give us smart cars and smart freeways, breaking gridlock on our highways -- that's certainly good news for Southern California. \\

And I just came from visiting Aura Systems. I got to see up close how this small company is thriving: why they're hiring when so many others are firing. It's because they're able to adapt. They're at the cutting edge of the post-Cold War era, leading the drive to transform this world into a productive peace.

But while we look ahead to these exciting new horizons there is one critical element we must never forget. Just because the Cold War is over doesn't mean that our need for the strongest defense is over, too. That need may change, but it will never disappear. Look at the threat posed by terrorists -- by renegade regimes -- by global uncertainties. Well, because companies like

these in Orange County continue to develop and use technology begun for defense, our next generation of the military will find that the technology has continued to evolve. We need not fear for our defense -- for our children -- for our future.

In the meantime, look how one company is successfully making the post-Cold War transition to replace disappearing defense contracts. Aura Systems started as a military R&D company, doing virtually 100% DoD work. Now, they've won civilian contracts that make up 80% of their work. They have seen the future -- they're using their military-developed technology to beat weapons into ploughshares. For instance, their imagination has led them to use SDI-funded work on electromagnetics to develop vibrationless jackhammers -- and precision instruments used in cataract surgery. And they're applying their military electro-optics technology to improve commercial telecommunications.

These Orange County companies lead us because they're not stuck in the old ways of thinking. They're not afraid to take risks. Look what happens to companies who want to be the biggest fish in the pond -- but who are afraid to be the first to dive in. Companies willing to maneuver and adapt to changing marketplace realities survive. Dinosaurs are fated to die. \\

Of course, this transformation is not going to be easy. The new world economy of the 21st century will be a new age of American competition in a fiercely challenging global marketplace. And we simply have to make some changes if we expect to compete. We have to realize the intensified need for sophisticated, well-

educated workers. The worldwide high-tech explosion will leave us behind unless we literally reinvent American education -- to turn out the best-prepared workers in this world. To do this, let's borrow a page from business -- let's bring competition into our schools through ideas like school choice. That's how we'll make our schools -- and our future -- the best in the world.

We have a huge challenge ahead of us. But we can more than match it if we remember what FDR said a half-century ago: "The only limit to our realization of tomorrow will be our doubts of today."

I am absolutely committed to using every resource I can to pave our way into the future. Right now, I'll fight for measures to add jobs -- actions like encouraging investments through the capital gains tax cut; increasing jobs by reducing regulations; and encouraging trade and opening markets abroad. You know first-hand how important that is. California leads this nation in exports -- accounting for one out of every seven U.S. export dollars. Just last year -- in an 8% increase over 1990 -- this state exported over \$63 billion in goods. And, in all, your ports handled two-way trade values at nearly \$175 billion -- creating jobs up and down this golden coast.

Long-term, Washington must have the courage to do the hard work of government -- work which requires a little less self-interest and a lot more discipline than most elected officials currently show. I'm talking about whipping government spending into control. I'm talking about being brave enough to launch a

genuine, strong effort to reduce runaway spending and to enforce disciplinary measures. I'm talking about real government reform.

We must begin by forcing Congressmen to come down from their ivory tower, down off Capitol Hill to listen to the American people -- 77% of whom support the balanced budget amendment. Voters are saying to Congress: "We know you're borrowing from the future to pay for indulgences of the present and we won't stand for this any more." For years now, I've called for a balanced budget amendment because to ensure long-term economic growth we must get federal spending under control. High deficits raise interest rates -- high interest rates kill jobs -- a ransomed future kills hope.

When I was visiting Aura Systems this morning, I was struck by its motto: "The Link Between Problem and Solution." Well, we all have the chance to be that link for our country. We have the chance to guide America into the world of the new century -- a world in which defeatism produces defeat, but where confidence and self-reliance produce greatness.

We will find that greatness. We will shape from inside ourselves a country ready to seize the opportunities the new world economy offers. I believe in that -- I believe in us -- I believe in America. God bless you all.

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