



# **GEAR TECHNOLOGY**

*The Journal of Gear Manufacturing*

## **1995 BUYERS GUIDE GEAR EXPO PRE-SHOW ISSUE**

*September/October 1995*

**POWDER METAL TECHNOLOGY —  
BEGINNER'S GUIDE TO P/M  
P/M vs. STEEL GEAR SURFACE DURABILITY**

**PLUS • Really Big Gears  
• Interview with Peter Kozma of Liebherr/Sigma Pool**

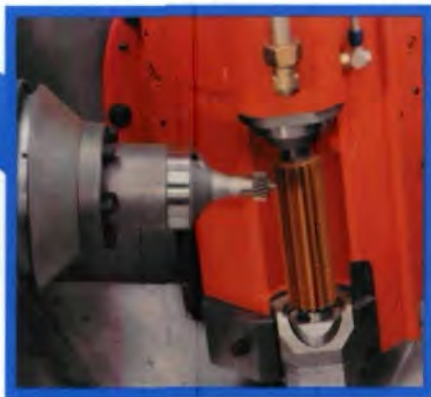
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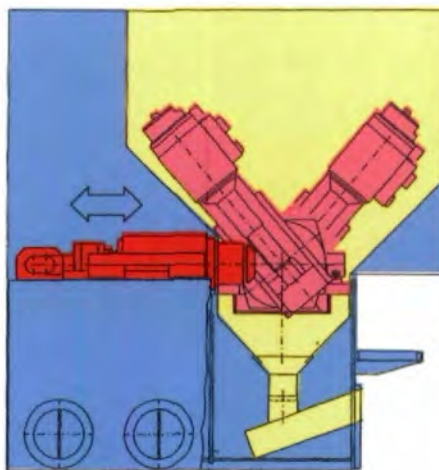
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# GEAR TECHNOLOGY

SEPTEMBER/OCTOBER 1995

*The Journal of Gear Manufacturing*

## 1995 BUYERS GUIDE — OUR BEST EVER

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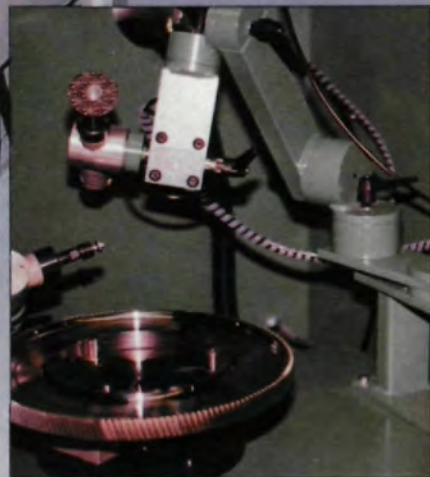
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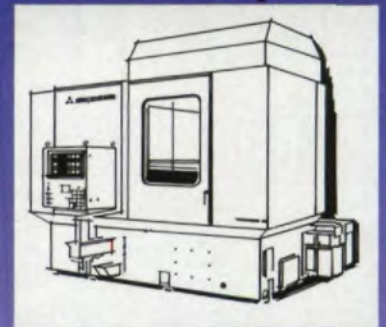
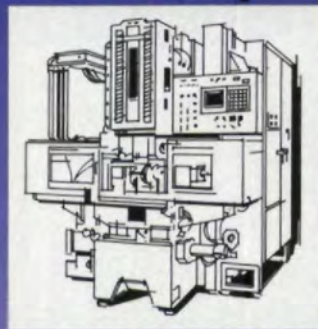
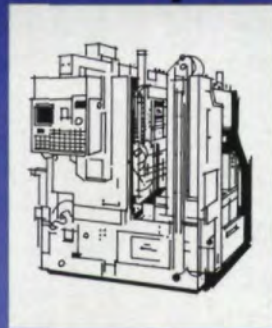
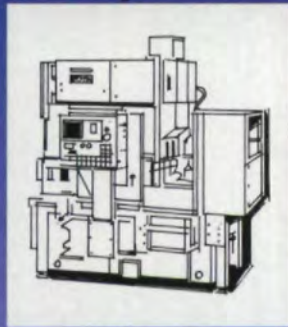
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**K**nowing the right thing to do isn't hard. Most often, it's very obvious. Actually *doing* it is something else again. For example, we all know that we probably eat too much refined sugar and fat, but when the double chocolate cheesecake comes by, it's easy to convince ourselves that one piece won't hurt.

By the same token, it doesn't take an MBA or a doctorate in economics to figure out that investing in the best new equipment we can afford on a consistent basis to keep our factories as up-to-date as possible is a wise business decision. Better to upgrade incrementally than one day to wake up and discover the whole factory is ten, twenty or more years out of date, and almost all the equipment needs replacing right away.

So why is it so hard to do that?

A couple of recent conversations have set me wondering about this question. Some employees of a high-production division of a very large company were effusive during a recent visit about how well their business is doing—sales, production volume and profits are all setting records; business has never been better. But they are not allowed to buy any new equipment now, even though a lot of the machinery needs upgrading, and investment in past years has been lagging. There might be a recession on the horizon, the corporate decision-makers explain. Better to keep the cash.

But if the company's not going to buy new equipment when business is good, when is it going to buy it? During a recession?

A tidy sum of readily available cash on the books may be a bit like that slice of chocolate cheesecake. It gives you a good feeling to have it right now, but is it really that good for you? Wouldn't prudent investment in capital equipment be better over the long haul?

Another, more ironic recent conversation was a variation on this theme. In this case, a manufacturer told me how he lost market share in recent years to competitors selling cheaper technology that wasn't as good as his. It really hurt until customers started coming back after realizing that the "cheaper" machines really weren't, when downtime, repair and quality problems were factored into the equation. It had taken some of his customers a while to relearn the truism that cheaper isn't necessarily better.

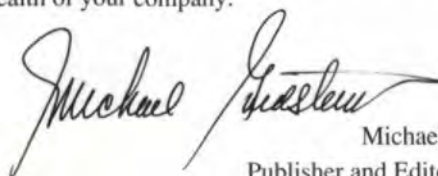
And yet this same manufacturer, who had suffered from the "cheaper is better" philosophy of others, didn't make the connection to his own buying practices. He was still giving bottom-line price the deciding vote in purchasing decisions. Short-term benefit looked better to him than long-term investment.

This short-term strategy can burn you in the long run. In current conditions, only the companies that have invested in new equipment and training and have adapted to the changing environments in both their home and international markets will survive.

Furthermore, the effects of this kind of investment are geometric. These companies have more profits and cash flow now to continue their investment, which only gives them a greater advantage over the companies that lag behind. And the farther behind the laggard companies that hoard their cash fall, the harder it will be for them to keep up.

I'm not suggesting that price is not important or that now is the best time for every company to invest heavily in new equipment. It is possible to overinvest or to invest unwisely or in the wrong equipment. But I think the greater danger now lies in underinvestment in capital improvements that increase productivity and lower costs.

That's a judgment call businesspeople have to make for themselves. But in making that call, beware of the temptation to go for the chocolate cheesecake every time. Short-term savings always look attractive at first glance. They may not be the best thing for the overall, long-term health of your company.

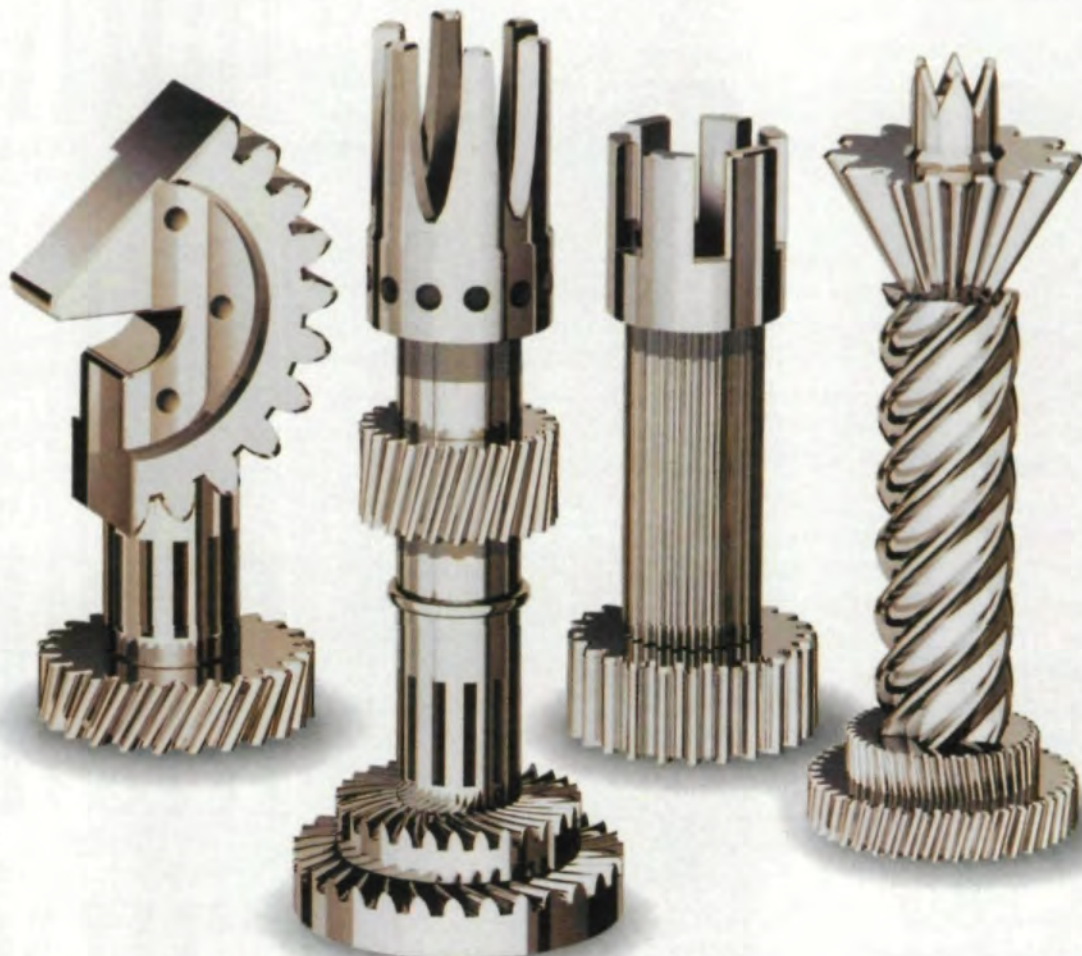


Michael Goldstein  
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# LIEBHERR

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# Peter Kozma of Liebherr-America, Inc.

*Peter Kozma, executive vice president of Liebherr-America, Inc., talks with us about Liebherr and its partners in the Sigma Pool.*

**GT:** Since three out of the four members of the Sigma Pool manufacture at least some similar products, how do they keep from cannibalizing one another's sales?

**PK:** Because Sigma Pool-member technologies are actually complementary rather than competitive. Each specializes in a different aspect of gear manufacturing, which we define according to gear type and process.

Liebherr offers hobbing and grinding machines, Lorenz covers the shaping process and Klingelberg and Oerlikon manufacture different types of spiral bevel gear manufacturing and testing equipment. Because all of the partners' machine tools are designed for gear manufacturing, the Sigma Pool's expertise is concentrated in a single field. We can give our customers objective recommendations based on workpiece, process, required geometry and quality.

Far from hurting individual company sales, Sigma Pool synergy supports even greater participation in the gear manufacturing field.

**GT:** We have been told that gear grinding is becoming more and more popular in the U.S. Companies that in the past would never have used ground gears—for example, Harley-Davidson—are now adopting them for the sake of noise reduction and quality improvement. Do you see gear grinding becoming a "growth" part of the industry?



*Peter Kozma, executive vice president.*

**PK:** There is definitely a growing demand for higher quality gearing. We are noticing growth in three major areas—automotive, commercial or industrial applications and production technology. In vehicles, people have become aware that excessive noise and quality are related; higher quality gears lead to reduced noise emission and increased passenger comfort. In the commercial-industrial area, there is a recognized demand for ground gears to increase performance and economy. Advances in production technology have required grinding from solid and near-net forging for economical gear development and production.

**GT:** Why has grinding gears been more popular in Europe than in the U.S.? Why has this technology been slower to arrive here?

**PK:** Because of Europe's astronomical fuel costs and its strict environmental laws, fuel efficiency has long been a more urgent concern in Europe than in

the United States. Therefore, rather than controlling noise through the usual method of insulating the transmission, which adds weight and increases fuel consumption, European manufacturers have sought methods such as grinding to eliminate gear inaccuracies that are the source of operating noise.

**GT:** As gear grinding becomes more popular, do you see a push on the part of grinding machine customers to demand "open architecture," so that grinding wheels from one company can be used on the machines from another?

**PK:** Aside from cost issues, manufacturers are always trying to avoid bottlenecks and maintain flexibility. Specifically for CBN grinding wheels, we have already anticipated a demand for interchangeability among different types of machines and have responded to customers' needs.

**GT:** Liebherr has been very successful with its launch of a dry hobbing machine. What are the possibilities for a similar advance in dry grinding? Is this technically feasible?

**PK:** Every new technology introduced over the past few decades appeared at one time to be technically impossible, so I would not doubt the feasibility of dry grinding. Currently, we are aware of attempts to develop dry grinding methods using dressable grinding tools. The challenge of dry grinding *hardened* materials is much more difficult because the process itself can cause significant changes in material properties.

**GT:** According to your literature, one

of Liebherr's most successful products in the recent past has been its gantry robot. Why and how did Liebherr get into materials handling?

**PK:** In the 1970s, many of our customers began to ask us to automate part flow between our gear-cutting machines. As the demand grew to include linking our machine tools with the preceding and subsequent operations, Liebherr extended its periphery of

machine-integrated buffers and loading units to include more comprehensive and intelligent systems. From our earliest blue steel conveyors to today's range of gantry robots, rail cars, palletizers and storage systems, we have concentrated on giving customers the degree of flexibility they really need.

From the beginning, Liebherr has been a system integrator working with other manufacturers' machine tools.

Through experience, we have developed an uncommon expertise in electrical interface and physical layout, both of which must be optimized in a reliable and efficient automation system.

**GT:** Has the declining value of the dollar made it more difficult for European-owned companies to compete in the U.S.? Has it hurt your business? Would this be a good time for U.S. gear manufacturing companies, which suffered badly in the 80s, to try to rebound on the global market?

**PK:** Certainly the declining dollar has made competition more difficult for European companies, but Liebherr and Klingelberg both have been global competitors for many years and continually take steps to minimize the effect of currency fluctuation. The recent recession in the United States helped our long-term prospects by making us find

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*There is a growing demand for ground gears in three areas — automotive, commercial and industrial applications and production technology.*

ways to reduce customers' total investments without limiting functionality or quality. These tools—smarter manufacturing and money management—are standing us in good stead, and we continue to compete successfully despite the dollar's weakness.

With the advent of global sourcing, it is increasingly important for companies to have a global view of competition. The present currency situation makes it easier for U.S. firms to establish operations and sell their products overseas.

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**GT:** There's a lot of talk in the industry about the development of the technology to grind gears from the solid. Is the Sigma Pool working on technology in this area?

**PK:** Yes, we are exploring this technology and working to stretch its current economic and technical limitations. Our Sigma Pool partner Oerlikon has been experimenting with different wheel compositions and coolant formulas. We have seen very positive results, and we are optimistic that this technology will prove effective.

**GT:** Both Klingelnberg and Oerlikon have gear measuring and testing product lines. Are there any new developments in this area? What are customers demanding now in terms of measuring and testing equipment?

**PK:** Oerlikon manufactures test machines that specialize in structure-borne noise analysis and single flank testing of complete spiral bevel and hypoid gear sets. The prevailing demand is for the testing of gear sets under simulated operational conditions.

Alternately, Klingelnberg manufactures analytical CNC inspection machines for precision measuring of all parallel axis and bevel gear tooth geometries as well as associated cutting tools. Our customers are requesting networking for statistical process control, complete inspection of all workpiece dimensions with a compensation option for eccentric workpiece clamping, customized software packages and faster inspection cycles. We are also seeing more interest in closed-loop systems that network between the inspection machine and the bevel gear generating and grinding machines for the calculation of corrective machine settings.

**GT:** One of the selling points of Sigma Pool is the synergy it can bring to solving gear manufacturing problems. In one of the news releases issued at IMTS, a project was mentioned where Liebherr and Oerlikon worked together to develop an automated system for lapping spiral bevel gears. Can you tell us more about this project?

**PK:** This system uses a CNC Liebherr gantry loader to automate a number of CNC Oerlikon lapping machines. Our challenge was to find an economical solution for automatically loading spiral bevel gear lapping machines—using automation for the first time to load pinion and gear sets of different sizes and ratios directly into a machine fixture. The Sigma Pool system achieved its goal of providing a system that reduces

cycle time, increases production and, ultimately, makes a positive contribution to our customers' profitability. ☉

**For more information about Liebherr/Sigma Pool, please circle Reader Service No. A-100.**

**Tell Us What You Think...** If you found this article of interest and/or useful, please circle Reader Service Number A-101.

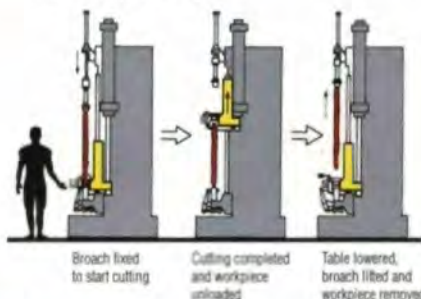
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### SEPTEMBER 11-15

AGMA Training School for Gear Manufacturing. Daley College, Chicago, IL. Contact AGMA at 703-684-0211 or fax 703-684-0242 for more information.

### SEPTEMBER 12-14

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### SEPTEMBER 12-14

Ohio State University, "Gear Noise Seminar." Covers measurement, sources, transmission error, rattle, reduction techniques and more. Contact Susie Young, 614-292-5860.

### SEPTEMBER 12-14

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### SEPTEMBER 25-26

Verein Deutscher Ingenieure (VDI). Symposium on Vibration in Drives. Mainfrankensäle, Veitshöchheim, Germany. For registration information call (49) 211-62 14-431 or fax (49) 211-62 14-164.

### OCTOBER 16-18

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Charleston, SC. Presentations on gear manufacturing and research subjects. For more information, contact AGMA at 703-684-0211 or fax 703-684-0242.

### OCTOBER 23-27

American Society for Metals Seminar, Principles of Heat Treating. ASM Headquarters, Materials Park, OH. Course for those who are new to heat treating or want an update on heat treating technology. Call 800-336-5152, x613 for details.

### NOVEMBER 12-15

AGMA Gear Expo '95. Indiana Convention Center, Indianapolis, IN. The one trade show devoted exclusively to the gear and gear-related products and services industry. For more information, contact AGMA at 703-684-0211 or fax 703-684-0242.

### NOVEMBER 16-17

IMEchE 2nd International Conference on Gearbox Noise, Vibration and Diagnostics. IMechE Headquarters, London, England. The conference will focus on both the control of gearbox dynamic behavior and the utilization of diagnostic information by enhanced analysis, measurement and case history data. For more information, contact IMechE Conference Services, Dept. C492, One Birdcage Walk, London, SW1H 9JJ. Phone: (44) 171-973-1249/1317; Fax: (44) 171-222-9881.

### CALLS FOR PAPERS

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*To announce an important technical meeting, exposition or seminar, please send notification to Gear Technology Tech Calendar, P. O. Box 1426, Elk Grove Village, IL 60009. Notices should arrive in our offices six weeks prior to the date of the issue in which you wish them to appear. Items are used on a space-available basis.*



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*Gear Expo '95*

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**What:**

*Gear Expo '95*

**Where:**

*Indiana Convention Center,  
Indianapolis, IN*

**When:**

*November 12-15, 1995*

**Why:**

*To See Cool Gear Stuff*

**How:**

*For more information, call  
AGMA at (703) 684-0211*

*Gear Expo '95*, scheduled for November 12-15 at the Indiana Convention center in Indianapolis, IN, will attract more exhibitors from a wider array of industries than any previous show, according to the show's sponsor, the American Gear Manufacturers Association.

With more than 100 exhibitors booked and 95% of available floor space sold by mid-July, show officials are optimistic. AGMA expects exhibitor space to break all previous records with around 34,000-35,000 square feet by the time the show opens. By comparison, Gear Expo '93 in Detroit had 30,700 square feet of exhibitor space.

Of more significance to AGMA is the fact that a greater diversity of products and services will be on display. "We're trying to attract exhibits to make the industry more aware of changing technology," says Gear Expo show chairman Marty Woodhouse of Starcut Sales, Inc. Visitors at the show will see heat treaters, steel providers, abrasives manufacturers, lubricant companies, job shops and other product and service providers.

For example, companies will demonstrate the latest in plastics, powder metal and other alternative gear materials, says AGMA executive director Joe Franklin. "We've made a very conscious and significant effort to go beyond machine tool manufacturers to include other products and services that a manufacturer or user of a gear or gearbox would need."

Burgess-Norton Mfg. Co. of Muskegon, MI, a manufacturer of powder metal gears, will be exhibiting at Gear Expo for the first time this year. "We feel it's an opportunity for people who traditionally buy cut gears to get an idea of what our gears are capable of," says Tom L. Stockwell, Jr., sales manager for Burgess Norton's P/M parts and assemblies division. Stockwell points to significant advances in the last several years that have made powder metal gears cost-advantageous for many industries.

Another company trying Gear Expo for the first time is Welduction Corp., a manufacturer of heat treating equipment from Farmington Hills, MI. Welduction, which traditionally has gone only to heat treating industry shows, wants to focus on gear manufacturers, says sales engineer Marty Frania. "We've had many gear customers before, but we don't know them all," Frania says. "We're trying to broaden our customer base." The Welduction booth will have sample heat treated parts, machines and a video on the basics of induction heat treating.

AGMA officials hope that the variety of products and services on display will help attract more buying customers to the show. The association is expecting approximately 4,000 people to attend, compared with about 3,000 who came to Detroit in 1993, Franklin says. In addition, show sponsors expect the central location of the show to draw increased numbers of visitors from the U.S. manufacturing belt.

Gear Expo traditionally has been scheduled in conjunction with AGMA's Fall Technical Meeting so that the trade show could benefit from the meeting's usual strong attendance. As another sign of the show's expansion, the two events will be held separately. This year the Fall Technical Meeting is being held at a different time, in a different city (October 16-18 in Charleston, S.C.). "Gear Expo no longer needs a strong sister to support it, and we really don't want to take away from the technical program," says Franklin. AGMA officials feel that each event is now strong enough to stand on its own. In addition, people who go to those events will be able to focus on either buying at Gear Expo or the latest research and development at the Fall Technical Meeting, Franklin says.

With all the work that's gone into making Gear Expo '95 a better show, AGMA officials expect this year's event to be the premier event in the world for the gear industry. Says show chairman Marty Woodhouse, "Times are good. The economy is good. We're expecting a really good show." ◉



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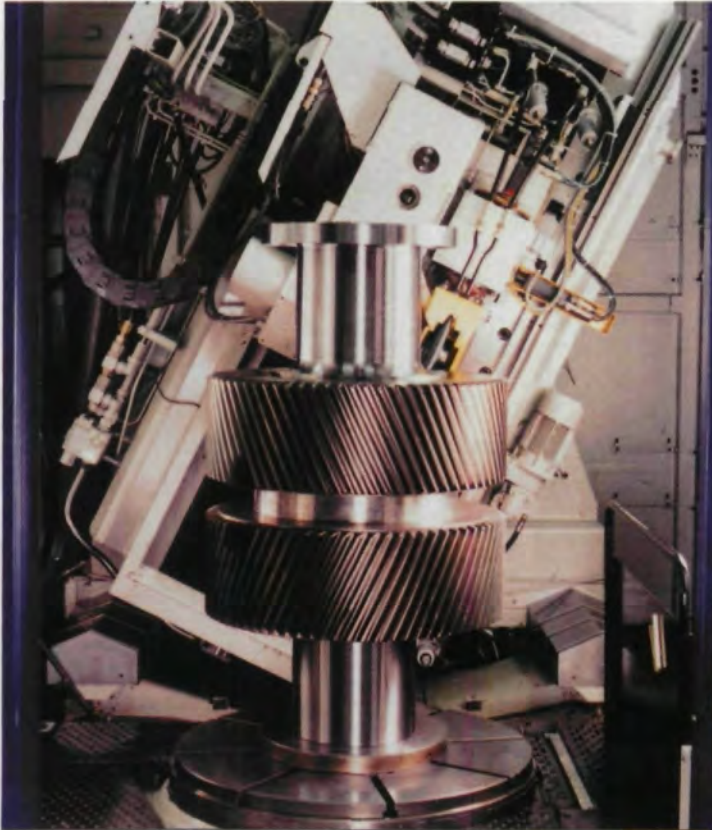
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CIRCLE A-10 on READER SERVICE CARD

# Gleason Acquires Assets of Hurth

Rochester, NY—Gleason Corporation has acquired the assets of **Hurth Maschinen and Werkzeuge GmbH**, the designer and builder of cylindrical (parallel-axis) gear-making machinery and tooling based in Munich, Germany. The addition of Hurth gear shaving machines and tooling and gear honing machines will further broaden Gleason's expanding product line for manufacturers of cylindrical gears.

According to James S. Gleason, chairman and president, "Gleason sales of parallel-axis gear equipment have tripled over the past three years because of the success of our 125 GH hobbing machine and our TAG 400 threaded-wheel gear grinding machine. The addition of the Hurth machines should play an important role in our sustained growth in this market." Hurth's Modul operation (Chemnitz, Germany), builders of gear hobbing and bevel gear-making machines, was not included in the acquisition.

Gleason has acquired Hurth patents, trademarks, equipment and inventories and will also assume existing obligations for installation and warranty of machines previously sold, as well as completion of customer orders in backlog.

According to David Burns, vice president, machine products, "Gleason will continue operations in Munich and will retain approximately two-thirds of the 400+ employees currently at that location. In addition to the CNC shaving machines, we are very excited about producing Hurth tooling for the shaving process. Both the Hurth machines and the shaving cutters will benefit greatly from Gleason's worldwide sales and distribution network. We're also confident that the reduced overhead structure and combined technology of the two companies will enhance the competitiveness of the shaving and honing machines."

Hurth currently has about 30% of worldwide market share for shaving

machines and about 25% of the shaving tooling market. Included in the Gleason acquisition is the complete line of shaving machines and peripheral support equipment, including a shaving cutter grinder. Gleason plans to discontinue some of Hurth's older product lines.

The acquisition of Hurth was made for approximately \$10.5 million in

cash. The assets include a backlog of over \$30 million.

Gleason plans to exhibit the Hurth machines at the AGMA Gear Expo in Indianapolis in November, 1995.

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CIRCLE A-23 on READER REPLY CARD

# Comparison of Surface Durability & Dynamic Performance of Powder Metal & Steel Gears

A. Yoshida, Y. Ohue & Isamu Karasuno

Table I

	Pinion	Gear
Module mm	5	
Standard Pressure Angle	20°	
Number of Teeth	15	16
Addendum Modification Coefficient	+0.571	+0.560
Tip Circle Diameter mm	90.71	94.60
Center Distance mm	82.55	
Face Width mm	18	6
Contact Ratio	1.246	
Accuracy*	Class 1	Class 1
Tooth Surface Finishing	Grinding	
*JIS B 1702		

Table II

Gear Specimen		ISPM
Powder Type		0.7% Mn 1.0% Cr 0.2% Mo Balance Fe
Particle diameter $\mu\text{m}$		75-106
Mixing		0.5% Graphite 0.8% Zinc Stearate
Compacting Pressure $\text{kN/cm}^2$		64
Green Density $\text{g/cm}^3$		6.9
Sintering		1403 K x 0.5 hr N <sub>2</sub> Gas
Machining		Hobbing
Induction-Hardening	Frequency kHz Heating Time s	30 7.7
Tempering		453 K x 2 hr
Finishing		Grinding

## Introduction

Surface-hardened, sintered powder metal gears are increasingly used in power transmissions to reduce the cost of gear production. One important problem is how to design with surface durability, given the porous nature of sintered gears. Many articles have been written about the mechanical characteristics, such as tensile and bending strength, of sintered materials, and it is well-known that the pores existing on and below their surfaces affect their characteristics (Refs. 1-3). Power transmission gears are frequently employed under conditions of high speed and high load, and tooth surfaces are in contact with each other under a sliding-rolling contact condition. Therefore it is necessary to consider not only their mechanical, but also their tribological characteristics when designing sintered gears for surface durability.

The authors have investigated the surface durability, the failure modes and the changing of contact surfaces during the fatigue process of induction-hardened, sintered powder metal spur gears and rollers (Refs. 4-7). These investigations have shown that the surface durability of induction-hardened, sintered rollers was affected by the sintered density and the powder size, and that the failure mode was spalling (Refs. 4, 7). The failure mode of the induction-hardened, sintered gears was pitting spread over the tooth surface with spalling (Ref. 5).

In this article, induction-hardened, sintered powder metal spur gears were compared with induction-hardened, melted steel spur gears for surface durability and dynamic performance using a power circulating gear testing machine. The changes in the dynamic performance and the tooth surface of both gears were measured and

observed during the fatigue processes. The differences in the surface durability and the dynamic performance between the sintered gears and the melted steel gears are discussed.

### Test Gears

Induction-hardened, sintered powder metal gears (ISPM) and induction-hardened melted steel gears (ISCM) were employed as the test gears. The specifications of spur gears used in this experiment are given in Table I. These test gears had a module of 5 mm and a standard pressure angle of  $20^\circ$ . Case-hardened pinions (CSCM) made of chromium molybdenum alloy steel (JIS SCM415: 0.15% C) were mated with both test gears.

The manufacturing conditions of the sintered powder metal gears are given in Table II. The powder was a pre-alloyed steel. It was mixed with graphite and zinc stearate and compacted into disks having a green density of  $6.9 \text{ g/cm}^3$ . The disks were sintered, hobbed and then induction-hardened. The material of the induction-hardened, melted gears was 1.0% Cr-0.25% Mo alloy steel (JIS SCM440: 0.40% C). After hobbing, the steel gears were induction-hardened under the same conditions as the sintered gears. The tooth surfaces of both test gears were finished by grinding. The surface roughnesses along the tooth traces of gears ISPM, ISCM and CSCM were 1.6, 1.5 and  $1.8 \mu\text{m } R_{\text{max}}$ , respectively. Young's modulus and Poisson's ratio of the sintered gears were 152 GPa and 0.25. Those of the steel gears were 206 GPa and 0.3.

The hardness distributions below the tooth surfaces of the test gears and pinions are shown in Fig. 1. The hardness was measured at the working pitch point of each gear using a micro-Vickers hardness tester. The hardnesses of the tooth surfaces of test gears ISPM and ISCM were  $H_v 620$  and  $H_v 700$ , and the total hardened depths of these test gears were 2.8 and 3.6 mm, respectively. The hardness of test gear ISPM was lower than that of ISCM in spite of the same induction-hardening conditions, since ISPM had many pores below the tooth surface. The hardness of the tooth surface of mating case-hardened pinion CSCM was  $H_v 800$ , and the effective hardened depth was 0.8 mm.

### Experimental Procedure

Fig. 2 shows a sketch of the gear testing machine and the measuring system for tooth root strain, the vibration acceleration and the sound pressure from the gearbox. The test apparatus used in this experiment was a power circulating type gear testing machine with a center distance of 82.55 mm. This machine was operated by driving a power transmission gear set through a Kopp variable speed drive with an electric motor.

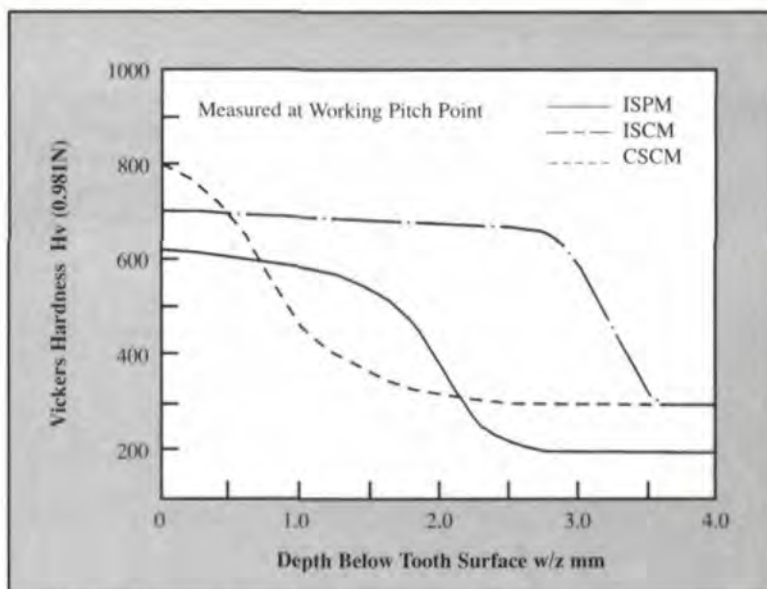


Fig. 1 — Hardness distributions of test gears and pinions.

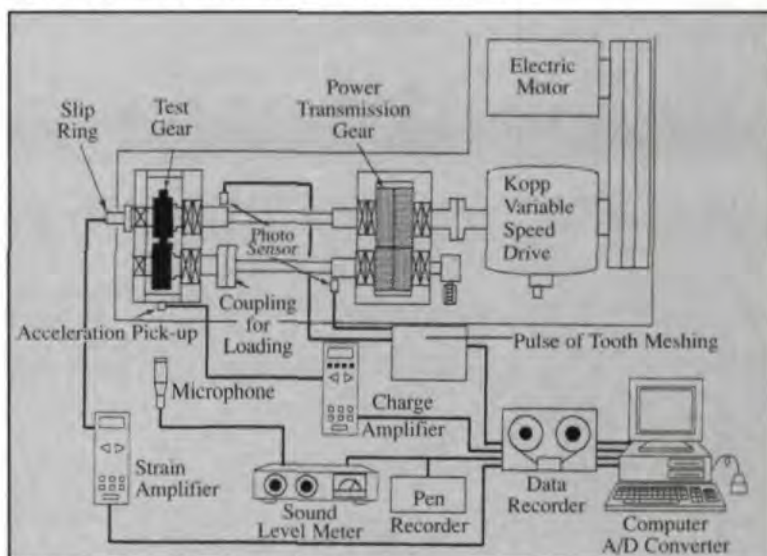


Fig. 2 — Sketch of gear testing machine and measuring system.

The fatigue tests were conducted at a rotation speed  $n_2$  of 1800 rpm for test gears. The lubricant employed here was a gear oil with EP additives that had a kinematic viscosity of  $190.9 \times 10^{-6} \text{ m}^2/\text{s}$  at 313 K and a viscosity index of 98. The oil was supplied to the engaging side of a test gear pair at a rate of 750 ml/min. The supplied oil temperature was  $313 \pm 5 \text{ K}$ . The maximum Hertzian stress  $p_{\text{max}}$  at the working pitch point was taken as a scale for loading in this experiment.

The dynamic tooth root strain was measured using a dynamic strain amplifier and a wire strain gage bonded on a compression side of the tooth fillet. The vibration acceleration of the gearbox was detected by a piezo-electric pickup through an amplifier. The sound pressure was detected by a condenser microphone fixed at a distance of 300 mm from the gearbox. To evaluate the dynamic tooth root stress, the static tooth root strain was measured at a rotation speed of 6.6 rpm for the test gear. The tooth profile measurement

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is general manager of the Material Evaluation Division of Sumitomo Metal Industries Co., Ltd., Osaka City, Japan.

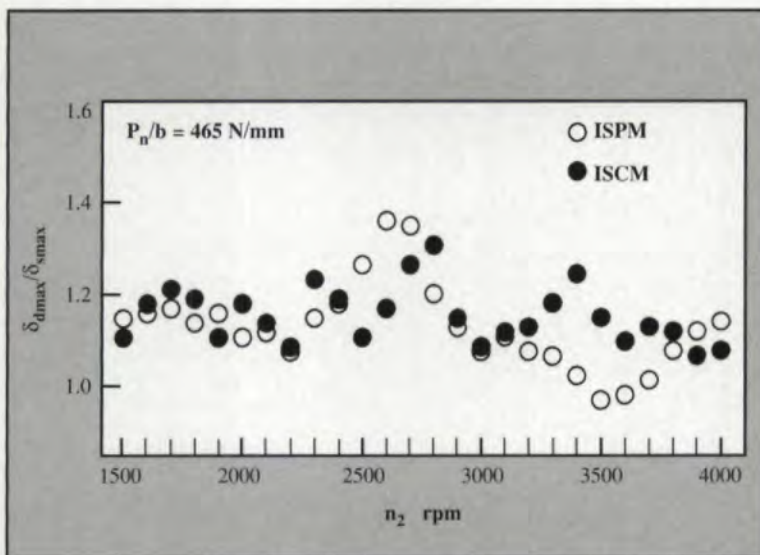


Fig. 3 — Ratio  $\delta_{dmax}/\delta_{smax}$  of dynamic maximum tooth root stress to static maximum tooth root stress.

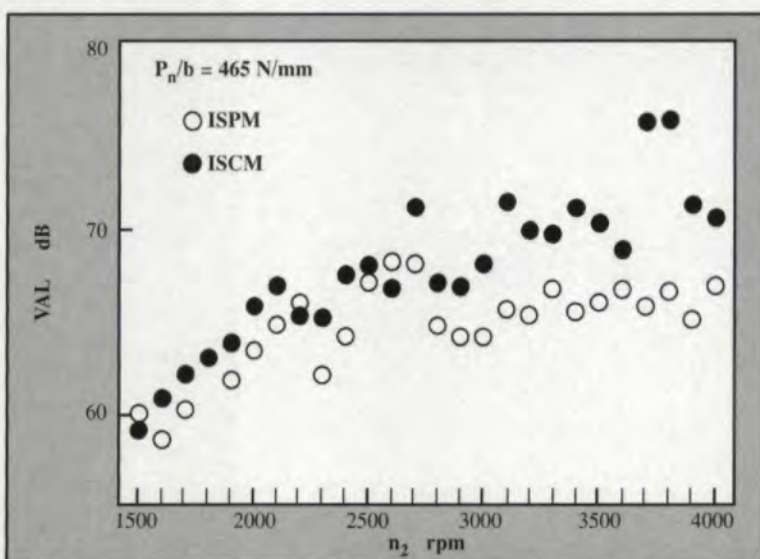


Fig. 4 — Vibration acceleration level VAL of gearbox.

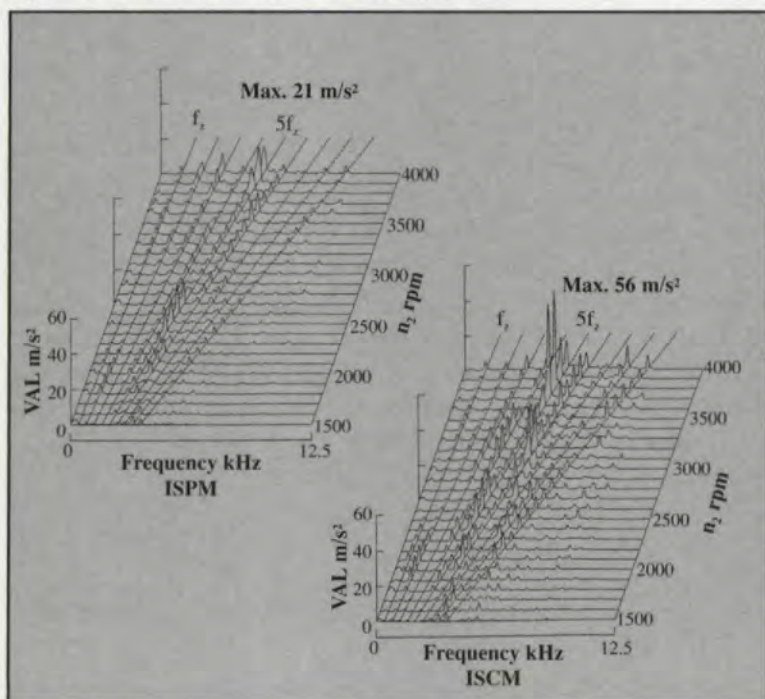


Fig. 5 — Spectra of vibration acceleration of gearbox.

and the replica observation of the tooth surface were also performed. These measurements of the dynamic performance and the observations of the test gear pair were conducted at regular intervals during the fatigue process. A vibration-sensitive shutoff transducer was fixed on the testing machine, stopping the machine automatically when a vibration increase caused by the tooth failure was detected.

### Experimental Results and Discussions

**Dynamic tooth root stress & vibration acceleration of a gearbox at rotational speeds of 1500–4000 rpm.** To compare the dynamic performance of the sintered gear with the steel gear under a normal load per unit face width  $Pn/b$  of 465 N/mm, the dynamic tooth root stress and the vibration acceleration of both test gears were measured at rotational speeds  $n_2$  of 1500–4000 rpm.

Fig. 3 shows the ratio  $\delta_{dmax}/\delta_{smax}$  of the dynamic maximum tooth root stress  $\delta_{dmax}$  to the static maximum tooth root stress  $\delta_{smax}$ . The changes of the ratio  $\delta_{dmax}/\delta_{smax}$  of both gears ISPM and ISCM were almost the same up to a rotational speed  $n_2$  of 2400 rpm. The ratio  $\delta_{dmax}/\delta_{smax}$  of ISPM was lower than that of test gear ISCM at a rotational speed  $n_2$  of more than 300 rpm. In the range of rotational speeds  $n_2$  of 1500–4000 rpm, the ratio  $\delta_{dmax}/\delta_{smax}$  for ISPM became the peak value at a rotational speed  $n_2$  of 2600 rpm, while the ratio for ISCM became the peak values at rotational speeds of 2800 and 3400 rpm.

Fig. 4 shows the vibration acceleration level VAL of the gearbox. The changes of the value of VAL for both ISPM and ISCM were almost the same up to a rotational speed  $n_2$  of 2600 rpm. The values of VAL for ISPM were lower than those for ISCM at a rotational speed  $n_2$  of more than 2700 rpm. Especially at rotational speeds  $n_2$  of 3700 and 3800 rpm, the values of VAL for ISCM were about 10 dB higher than those for ISPM.

Fig. 5 shows the spectra of the vibration acceleration of the gearbox. For both test gears, the main components of the vibration acceleration of the gearbox were the tooth meshing frequency  $f_z$  and its harmonics. The components of a tooth meshing frequency of  $5f_z$  at rotational speeds  $n_2$  of 3700 rpm ( $5f_z = 4.93$  kHz) and 3800 rpm ( $5f_z = 5.07$  kHz) were considerably higher than the others. The vibration of the gear pairs caused by tooth meshing at these rotational speeds was resonated with the natural frequency of the gearbox, since the gearbox of the testing machine used in this experiment had a natural frequency of about 5 kHz. The values of spectra at  $5f_z$  of test gear ISPM were lower than those of test gear ISCM at a rotational speed  $n_2$  of more than 2700 rpm.

Since the vibration of the gear pair caused by tooth meshing travels to the gearbox through the shafts and bearings supporting the gear, the damping characteristics of gears can be evaluated by the dynamic tooth stress and the vibration of the gearbox. These results show that the damping characteristics of the sintered gear ISPM are slightly better than those of the steel gear ISCM at the rotational speeds  $n_2$  of 1500–4000 rpm in this experiment.

**Surface durability and failure mode.** Fig. 6 shows the relationship between the maximum Hertzian stress  $p_{max}$  at the working pitch point and the number  $N_2$  of cycles to failure. The percentage of the pitted area is defined as a ratio of total pitted areas to total areas of working tooth surfaces on both gear and pinion. In the case of ISPM, the failure mode was pitting with spalling (Ref. 5), and the fatigue life for pitting was taken as a number of cycles of the test gear when a percentage of pitted area reached 5%. The pitted areas also included spalled areas.

In the case of test gear ISCM, the failure mode was tooth breakage caused by pitting near the working pitch point, and the fatigue life was taken as the number of cycles made by the test gear when tooth breakage due to pitting automatically stopped the testing machine. In this case, the tooth breakage caused by pitting occurred before the percentage of pitted area reached 5%. The test gear ISCM, fatigue-tested under a Hertzian stress  $p_{max}$  of 1600 MPa, did not fail up to a number  $N_2$  of  $10^8$  cycles. The surface durability at a number  $N_2$  of  $10^8$  cycles in ISPM was 870 MPa, and that in ISCM was 1600 MPa.

Fig. 7 shows photographs of whole failed tooth surfaces and magnified photographs on the dedendum tooth surfaces of both test gears at a final fatigue stage. Those photographs were taken by a scanning electron microscope. On the failed tooth of test gear ISPM, which had some large pits, one can observe many small pits. On the dedendum tooth surface, pits having diameters of 10 to 100  $\mu\text{m}$  were observed, while on the failed tooth of ISCM, large pits were observed near the working pitch point. The tooth breakage caused by pitting in test gear ISCM occurred from the bottom of the large pits near the working pitch point. On the dedendum tooth surface, the surface was smooth and a few small pits were observed.

The percentage of the pitted area in ISPM increased progressively, because the number of small pits increased gradually (Ref. 5). Spalling failure was also observed on the tooth surface near the working pitch point during the fatigue process (Ref. 5). On the other hand, the percentage of the

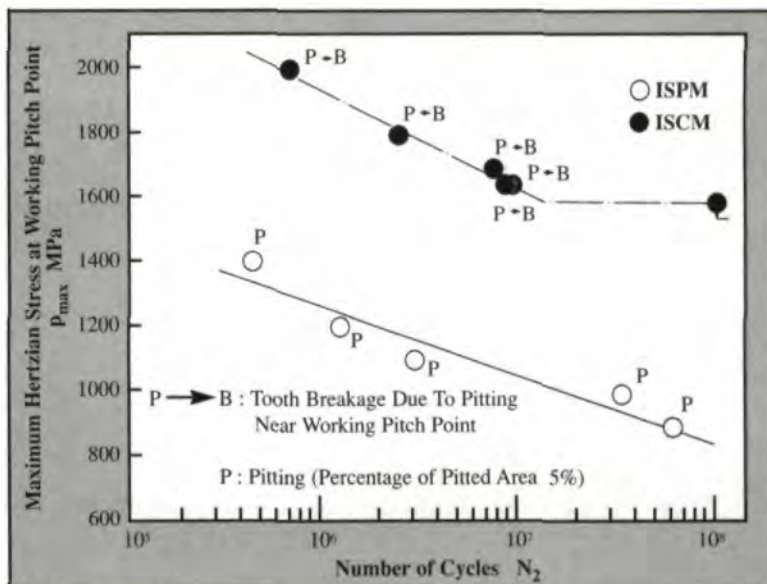


Fig. 6 —  $p_{max}$  -  $N_2$  curves.

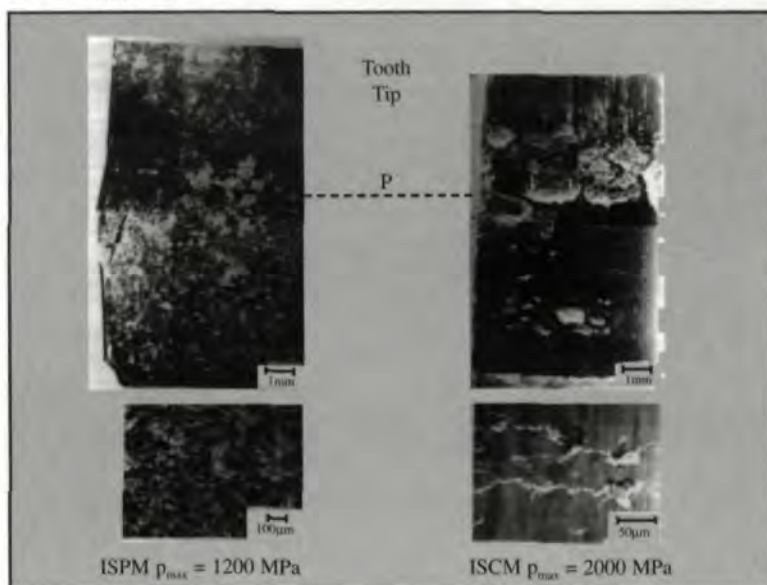


Fig. 7 — Failed tooth surfaces observed by SEM.

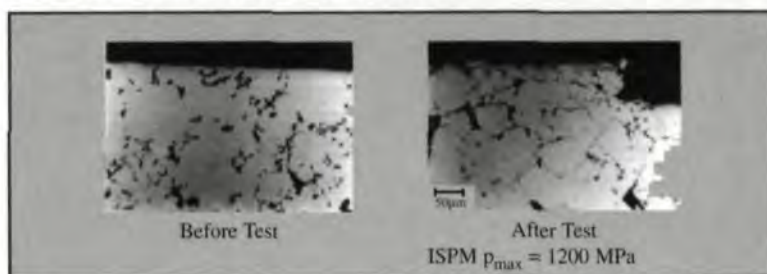


Fig. 8 — Transverse sections of test gear ISPM near tooth surface before and after test.

pitted area in ISCM increased sharply, because large pits appeared rapidly at the final fatigue stage. Spalling failure was not observed in these fatigue tests. Under a Hertzian stress  $p_{max}$  of 1600 MPa, pits were not observed on the tooth surfaces of ISCM up to a number  $N_2$  of  $10^8$  cycles.

Fig. 8 shows transverse sections near the tooth surface of test gear ISPM before and after the fatigue test. The pores existing below the tooth surface are visible. The mean size of pores in the transverse section is about 15  $\mu\text{m}$  in diameter. In

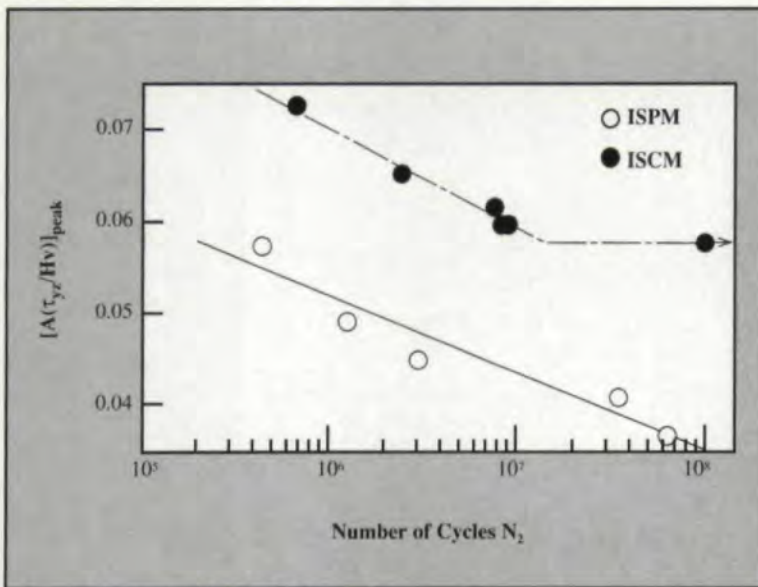


Fig. 9 — Relationships between  $[A(\tau_{yz}/Hv)]_{peak}$  and  $N_2$ .

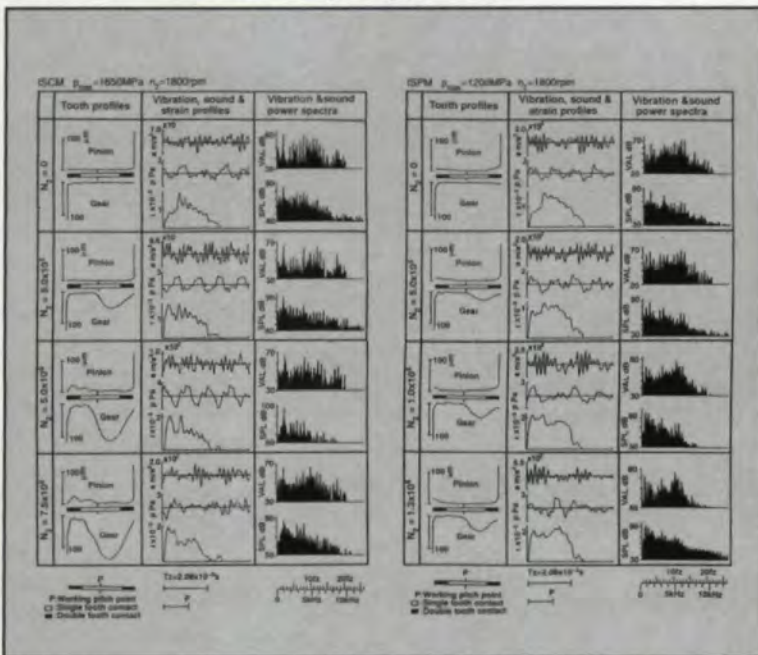


Fig. 10 — Changes in tooth profiles and dynamic performance during fatigue process.

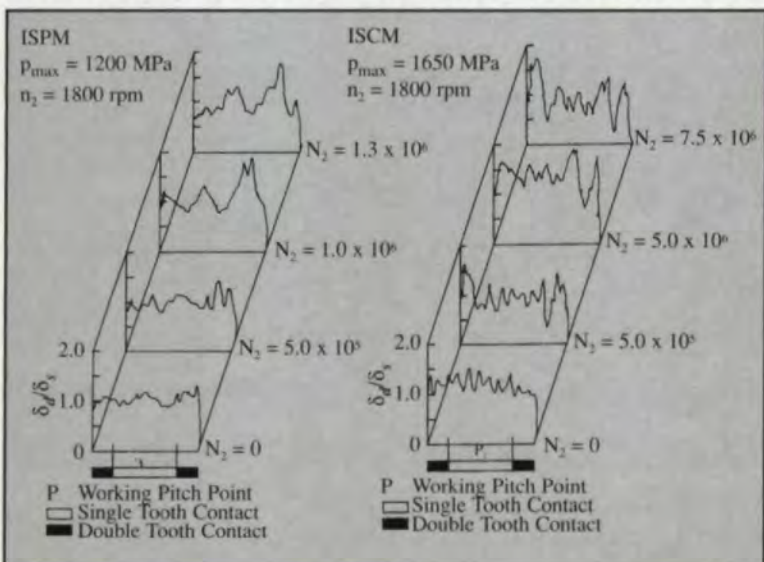


Fig. 11 — Changes in ratio  $\delta_d/\delta_s$  of dynamic tooth root stress to static tooth root stress during fatigue process.

the post-test photograph, the pores are linked to each other by cracks. Therefore, it can be assumed that these cracks caused small pits, and the formation mechanism of pits in sintered gears is different from that in steel gears.

In order to clarify design methods to reduce spalling failure rates in surface-hardened steel rollers and gears, the authors have studied their surface durability using an amplitude of the ratio of orthogonal shear stress to Vickers hardness below the surface (Refs. 8–9). The calculation methods of the spalling fatigue life and the allowable load for spalling were proposed using the amplitude of the ratio of shear stress to hardness (Ref. 8). In this article, the same method was also applied to a sintered gear. Fig. 9 shows the relationship between the peak amplitude  $[A(\tau_{yz}/Hv)]_{peak}$  of the ratio of orthogonal shear stress  $\tau_{yz}$  to Vickers hardness  $Hv$  and the number  $N_2$  of cycles. The stresses below the tooth surface at the working pitch point were calculated by an analytical method after Smith and Liu (Ref. 10). It was also assumed here that the material strength of each test gear is directly proportional to each Vickers hardness. In this fatigue test, the spalling failure for test gear ISCM was not observed. But the relationship  $[A(\tau_{yz}/Hv)]_{peak} - N_2$  in test gear ISCM was located lower than that in ISPM because of the porous quality of the sintered gear. This fact indicates that the relationship between the material strength and the hardness in the sintered gear is different from that in the steel gear.

**Changes in dynamic performance during fatigue process.** Fig. 10 shows an example of the changes in the tooth profiles of gear and pinion, vibration acceleration  $a$ , sound pressure  $p$ , compressive tooth root strain  $\epsilon$ , and vibration and sound spectra during a fatigue process at a rotational speed  $n_2$  of 1800 rpm. Since the Hertzian stress  $p_{max}$  for test gear ISPM was different from that for test gear ISCM in Fig. 10, ISPM was qualitatively compared with ISCM on dynamic performance. Concerning the tooth profile change, wear of both ISPM and ISCM occurred on the dedendum tooth surface at an initial fatigue stage and developed in the direction of the working pitch point as the number of cycles increased. The tooth profile of the mating pinions of both test gears did not change remarkably during the fatigue stage. The profiles of vibration acceleration and sound pressure change periodically at tooth meshing period  $Tz$  at the initial fatigue stage. As the number of cycles increased, the profiles of both of them changed gradually through the fatigue process. But the profile did not change periodically at the final fatigue stage.



In the results of the spectra analysis, the main components of the spectra of both VAL and SPL were the tooth meshing frequency  $f_z$  and its harmonics at the initial fatigue stage. But the values of the components, except for the tooth meshing frequency and its harmonics, became gradually higher as the number of cycles increased. Comparing the profile change of the tooth root strain near the final fatigue stage with that at the initial fatigue stage, we can see that the load in the test gear was not smoothly transmitted at the recess contact zone. These dynamic performances during the fatigue tests were qualitatively similar in both test gears.

To evaluate the dynamic tooth root stress quantitatively, the dynamic tooth root stress was evaluated by comparing the changes of the ratio  $\delta_d/\delta_s$  of dynamic tooth root stress  $\delta_d$  to static tooth root stress  $\delta_s$  at each contact position during the fatigue process. Fig. 11 shows the changes of the ratio  $\delta_d/\delta_s$  during the fatigue process. At the initial fatigue stage, the value of the ratios  $\delta_d/\delta_s$  for each test gear was near 1.0 through tooth meshing. The profile of the ratio for ISPM changed more smoothly through the tooth meshing compared with that for ISCM. This fact indicates that the damping characteristic of ISPM was superior to that of ISCM. As a number of cycles increased, the profile of the ratio for both test gears changed gradually. Especially at the final fatigue stage for both gears, the profile of the ratio at the recess contact zone changed rapidly because of the wear of the tooth surface. In the case of test gear ISCM, the profile of the ratio  $\delta_d/\delta_s$  also fluctuated widely at the beginning of the tooth meshing from the early fatigue stage.

### Conclusions

To discover how to apply surface-hardened, sintered, powder metal gear technology to power transmission gears, an induction-hardened, sintered powder metal spur gear was compared with an induction-hardened, melted steel spur gear for surface durability and dynamic performance. The fatigue tests were conducted using a power circulating gear testing machine having a center distance of 82.5 mm. The results are summarized as follows:

1. Under the same normal load per unit face width, the sintered gears were slightly superior to the steel gears on the dynamic tooth stress and the vibration acceleration of the gearbox at rotational speeds of 1500–4000 rpm.

2. The surface durability of the sintered gear was lower than that of the steel gear. The failure mode of the sintered gear was pitting with spalling, while that of the steel gear was tooth breakage due to pitting near working pitch point.

The pitted area of the sintered gear increased gradually during the fatigue process. On the other hand, that of the steel gears increased rapidly at the final fatigue stage. The pitting of the sintered gear was mainly caused by the porous nature of the material. The pores existing on and below the tooth surface of the sintered gear played an important role in pit formation.

3. In both cases, the wear of the tooth profile occurred at the dedendum tooth surface because of tip interference between gear and pinion, and was developed in the direction of the working pitch point during the fatigue process. The changes in the dynamic performance of both test gears were almost the same qualitatively during the fatigue process. ◉

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# A Huge Success

*Sivyer Steel casts 62' bull gear in seventeen weeks  
from purchase order to shipping.*

Nancy Bartels

**S**ivyer Steel Corporation, Bettendorf, IA, an ISO-9002-certified casting specialist, is familiar with tackling tough jobs. The company has built an international reputation as a supplier of high-integrity castings, especially those which require engineering and/or full machining. It's not unusual for Sivyer's customers, especially those in the mining, recycling, power generation, valve and nuclear fields, to ask the foundry to produce a one-of-a-kind casting—often something revolutionary—but AmClyde Engineered Products' request was a special challenge, even for Sivyer.

AmClyde, a designer and manufacturer of large specialty equipment for lifting, pulling, moving and mooring the heaviest loads in the offshore oil and gas market, asked Sivyer to create a gear to turn large platforms or similar structures. Though the basic specs—a high-strength alloy steel per ASTM-A-148, Grade 115/95, with minimum 115,000 psi ultimate tensile strength, minimum 95,000 psi yield strength, minimum 14% elongation and minimum 30% reduction of area—were well within the ordinary, the size was not. The cast tooth bull gear required a diameter of 62 feet.



Fig. 1 — A close up view of the gear shows how the toothed sections were assembled during the roundup. Sections had to fit together with a very tight tolerance of  $\pm 5$  mm on the 62' diameter.

## Project Constraints

Other project constraints, though common to gearing, became crucial, because of the massive size of the gear. The 2" profile teeth had to be cast into each segment with zero draft angle allowed. The casting tolerances were extremely tight, and during roundup, all twenty segments had to be leveled and bolted together. When shipped, the gear had to meet Level 1 requirements—the casting industry's highest quality standard.

As Sivyer's design engineers looked at the project, they broke it down into several phases:

- Redesign for efficient manufacture at Sivyer's large, no-bake facility.
- MAGMAsoft® simulation modeling of mold filling and solidification.
- Building of new pattern equipment.
- First article approval.
- Production pouring.
- Heat treatment.
- Machining.
- Full radiography.
- Roundup.
- Shipment on time.

As Sivyer's engineers originally looked at the project, the biggest concerns were with the solidification modeling, heat treatment, machining and roundup. There were special customer requests on the last three, and the first was crucial to the success of the entire project.

However, once the purchase order was signed, there was an overriding concern: The process, which would normally take twenty-eight to thirty weeks, had a mere seventeen-week schedule. Scheduling, managerial and teamwork skills would really be put to the test.

Despite the fact that the foundry schedule in the floor molding area was extremely tight, Sivyer's engineers were sure the job could be completed on time if everything worked smoothly. But success hinged in the early days on their ability to

use computer modeling to design the patterns and related process parameters.

The final design called for casting in twenty segments, each 6" high x 6" wide, with a 2" cast tooth profile, cast onto the outside diameter. Sivyer's previous cast tooth gear projects had involved an identical number of teeth per segment. But because of the design of the 114.86" circular arc (based on the inside radius), this project would be different. In the final design, the 62-foot gear had a total of 558 teeth, 0.75 DP, 20° PA stub tooth form. It would be manufactured in eighteen segments containing 28 teeth per segment and two segments with 27 teeth per segment. Each segment would weigh 1600 lbs. and be 117 inches long. The designers were aware that any final adjustments would have to be handled at roundup stage.

#### Modeling

Producing the gear in the traditional manner would have involved weeks of trial and error, even with Sivyer's skilled and experienced staff—weeks they didn't have. In order to determine more efficiently where to best place the chills and related process components for successful pouring, company engineers turned to their computers and a software program known as MAGMAsoft.

MAGMAsoft is an extremely accurate mold-filling and solidification modeling software. With it, the design engineer is able to simulate a prototype of the actual mold and casting prior to its creation. By manipulating the location of the process particulars on screen, the software can accurately predict where faults, failures and shrinkage will appear in the actual casting process. Because of the program's 3-D capabilities, this computerized trial run shows trouble spots and allows for redesign of the mold to eliminate them, effectively ensuring the integrity of the actual casting.

While that work was being processed, other departments prepared for the pouring and the crucial steps that would follow. When the castings were ready for heat treatment, they would require normalization, as well as quench and temper processes. Arrangements also had to be made for special fixturing during loading to prevent warpage.

#### Machining

The specs called for top and bottom faces ground to dimension, milled ends machined to proper radial angle and milled pilot holes drilled for the splice joints. During machining, nine holes were drilled through the height of the gear for bolt-down. No machining was necessary on the teeth, thanks to exceptional dimensional accuracy and surface quality.



Fig. 2 — A view of the floor as the gear was being assembled gives some idea of the magnitude of the gear. A special site had to be found for the assembly process, and every piece fit together and leveled properly.

#### Roundup

The last step was roundup. The specs called for the radius to have an extremely tight tolerance of  $\pm 10$  mm. Sivyer engineers arranged a site for the roundup and the necessary equipment. With specifications as tight as they were, each segment of the 62' diameter gear had to be individually leveled, then bolted together to ensure overall uniformity of roundness. Highly accurate measurements were made using laser technology to verify that the critically important assembly dimensions were held to  $\pm 5$  mm.

At roundup, the customer asked for only one alteration. Because of the final shipping weight—over 34,200 pounds—he requested that lifting holes be drilled into each segment to make transportation easier. This done, the project shipped on time.

#### Project Management Skills

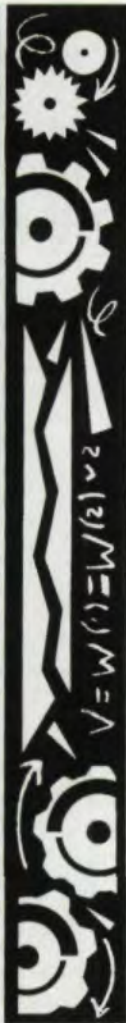
##### Crucial to Success

A special combination of skills was required to make a success of the AmClyde project. Sivyer's technical know-how, project management expertise and its experience in handling short turnaround times and turnkey projects were essential. So was the company's recognition that sometimes, in order to keep a project on schedule, parts of it may have to be jobbed out—even if they are tasks the organization is normally capable of handling. In the AmClyde project, a local machine shop handled the machining under Sivyer's supervision. According to Patrick J. Comparin, Sivyer's vice-president, it was this combination of background, skills and teamwork that made the AmClyde gear project doable and account for Sivyer's success in the castings market. ☉

**For more information about Sivyer Steel, please circle Reader Service No. A-105.**

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**Nancy Bartels**  
is Gear Technology's  
Senior Editor.



# The Beginner's Guide to Powder Metal Gears

*What you should know about this gear cutting alternative.*

George Shturtz

Increasingly gear designers and product engineers are capitalizing on the economic advantages of powder metallurgy (P/M) for new and existing gear applications. Powder metal gears are found in automobiles, outdoor power equipment transmissions and office machinery applications as well as power hand tools, appliances and medical components.

Helical, bevel (both straight and spiral), rack, face, internal and external spur gears, including compound gears, can be manufactured to final shape with no machining operations. Consequently, material scrap losses are eliminated. Internal configurations (splines, keys, keyways) are formed simultaneously with the gear profile, eliminating subsequent machining operations. P/M gear shapes produced by two or more compacted powder preforms that are sinter-bonded or sinter-brazed together result in complex, single-piece geometries that cannot be produced economically by other manufacturing methods. This efficient utilization of materials and energy increases the competitiveness of the P/M process.

Powder metallurgy offers a unique combination of benefits for gear manufacturing that presents a cost-effective alternative to traditional metal forming techniques. A wide variety of base metals are currently available in powder form; brass, bronze, iron and numerous steel grades, including stainless. Customized mixing and blending of elemental powders provides a variety of possibilities for the development of alloy compositions formulated for specific mechanical properties.

Conventional powder metallurgy involves the forming of blended metal powders, usually at room temperature, at pressures typically between 20–50 tsi (tons per square inch) of projected surface area. Generally, P/M molds or tooling come in several pieces. The mold for a single-level gear consists of a die, an upper punch and a lower punch. If the particular part to be formed requires a bore or other ID configuration, a core rod(s) is also part of the tooling. Multi-level compound gears or other complex parts may have two or more upper and/or lower punches.

To form the gear, the die is filled with powder at a ratio of approximately two times the parts thickness: e.g., a spur gear that has a thickness of .750" will be compacted from a column of powder 1.500" thick. During the compaction cycle of the most commonly used type of press, the upper punch enters the die while the lower punch, which in the fill position seals off the bottom of the die, remains stationary. As the upper punch travels downward, the compressive forces cause the die assembly to move downward in relationship to the lower punch, resulting in the same effect as if the lower punch were moving upward during the compaction stroke. The rate of movement and pressure of the upper punch and the motion of the die are relatively equal to ensure uniform density within the compacted preform.

After completion of the compaction cycle, the upper punch retracts from the die, and the lower

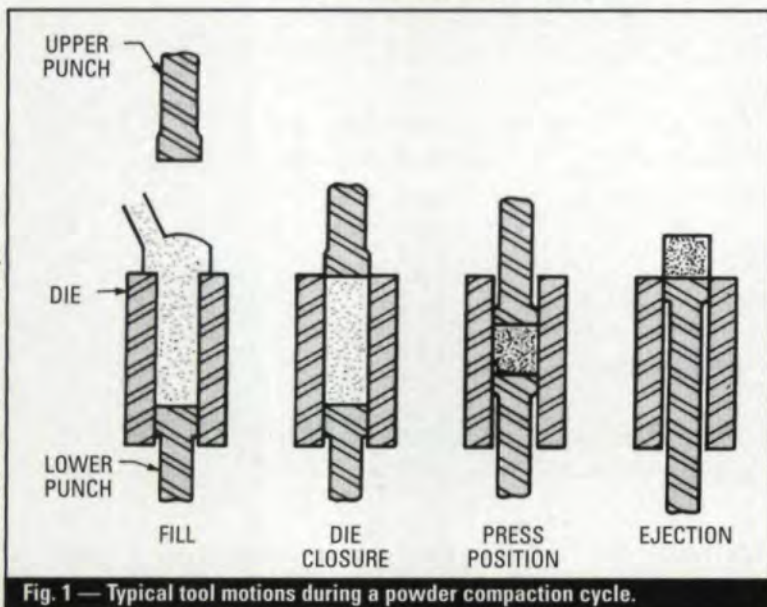


Fig. 1 — Typical tool motions during a powder compaction cycle.

punch initiates an upward motion, ejecting the preform from the die. (See Fig. 1.) The compacted preform is the exact shape of the final part. Depending on the final part shape, secondary operations may be required.

The shape of the compacted preform is determined by the shape of the tooling and the axial motion of the compaction press. Two main factors influence part design; the flow behavior and characteristics of the metal powders and the movement of the tools within the pressing cycle. Metal powders do not flow hydraulically, and the allowance for friction between the powder particles themselves and with the moving tool members must be factored in the final P/M part design. The pressing action from both top and bottom largely governs the shape, length and dimensional details of the preform.

The compacted preform then must be thermally processed or sintered. Sintering is the metallurgical bonding of the powder particles at a temperature below the melting point of the base material. Sintering at temperatures of approximately 2050°F produces tensile properties from 18,000–90,000 psi, depending on material composition. The addition of heat treatment can increase the ultimate tensile properties of a single, compacted/sintered component to 130,000 psi and higher. Depending on the required mechanical and physical properties and dimensional specifications, the gear may be complete at the end of the compact-sinter cycle or after heat treatment if required.

#### Designing P/M Gears

Six major factors need to be taken into consideration when designing a new or existing gear for the P/M process.

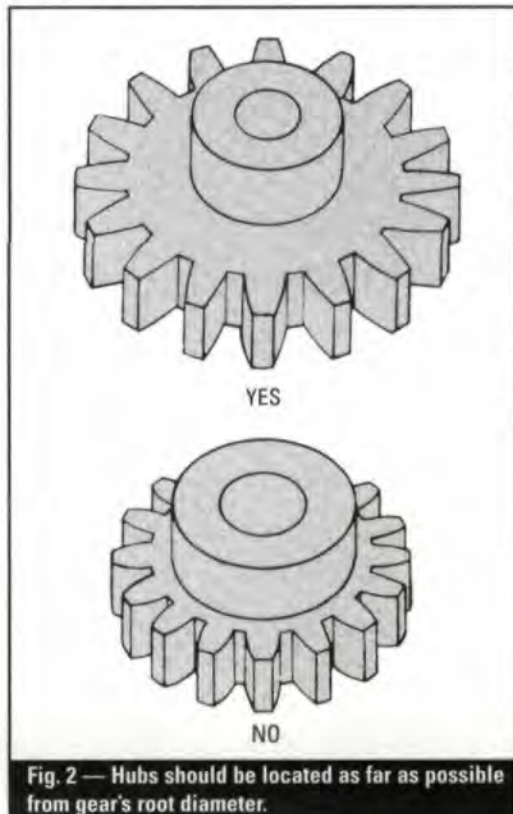
**1. The configuration of the gear should allow for ejection from the die.** While P/M is considered a net-shape technology, some features must be eliminated from the final part design or added through secondary machining operations because they would inhibit ejection of the preform from the die. For example, undercuts, reverse angles, details at right angles to the direction of pressing (for example, holes or grooves), threads, diamond knurls and re-entrant angles, all might interfere with smooth ejection.

**2. The configuration of the gear should allow for movement of the metal powders throughout the tool members during the compaction cycle.** As mentioned previously, metal powders do not flow hydraulically. Therefore extremely thin-walled sections, very narrow grooves and deep counterbores should be avoided because metal powders will not fill these parts of a die cavity.

**3. The configuration of the gear should allow for "practical" tooling.** Tooling life can be improved and production efficiencies enhanced by avoiding narrow deep grooves, very sharp edges, complete spherical profiles and knife-thin tool thicknesses. Often design simplification of these features will allow for a more robust or "practical" set of compaction tools without adding machining operations. Another consideration for gear design is to maintain sufficient clearance between the ID and the root diameter, which can range from .035" on small pinions to .300" for more demanding applications.

**4. The configuration of the gear should limit the changes in section thickness.** P/M processes work very well with compound gear geometries. Because the gear profiles are formed during compaction within the tooling, complex compound gears such as gear-pinion and spur-face combinations are well within the capability of the process. Uniform density and high strength is best achieved by limiting the number of section thickness changes (levels) that are designed into the preform. The number of levels a part may have is determined by the specific type of compaction press and/or the design of the compaction tooling.

**5. The configuration of the gear should minimize right angle intersections.** Radii should be incorporated at right angle intersections of section thickness changes. These radii improve the integrity of the preform. Gear engagement should be designed to occur above the radius. Often



Metal Powder Industries Federation. Used with permission.

#### George Shturtz

is the general sales manager for Carbon City Products, St. Marys, PA, suppliers of powder metal components.

### How To Specify P/M Parts

The importance of discussing the part application with your P/M parts manufacturer cannot be overstated. When requesting a quotation, accurate part information must be provided. Refer to the Metal Powder Industries Federation Standard 35 for P/M materials, properties and specifications. In describing a part, stress function and critical requirements for satisfactory service. For optimum results and efficiencies, give the P/M parts manufacturer the widest possible latitude in specifying material, design, physical characteristics, dimensional tolerances, etc. Typical information needed includes the following:

- Information about quantities, including initial needs and a future demand forecast. This enables the most economical approach to costs, manufacturing integration and delivery.
- Detailed drawings of the part and any assembly drawings. Actual samples or prototypes would be helpful. Transmit any information such as knowledge of materials that have worked well in the application.
- Information as to whether the part design can be modified without affecting function. If so, where?
- Part history and usage. Will the P/M part replace one currently in production, or is this a new application? Is the application military, aerospace, medical, etc.?
- Actual service conditions: heat, moisture, impact, corrosiveness, etc.
- Necessary physical, mechanical, corrosion resistance or special properties (tensile, elongation, hardness, flatness, conductivity, impact energy, fatigue strength, etc.)
- The finish required (plating, oxide coating, surface finish).
- Any machining or secondary operations the P/M supplier will be required to perform.
- For gears, specific data are required: a) number of teeth, b) diametral pitch, c) pressure angle, d) measurement over wires, e) tooth thickness, f) backlash, g) helix angle, h) AGMA quality class.

Tools for each P/M part are custom designed and developed specifically for that part. The expense of the tooling may justify the more economical approach of initially testing prototypes machined from P/M slugs.

The quality level and inspection techniques required contribute to the cost of a P/M part. Programs such as SPC and ISO 9000, for example, should be thoroughly discussed and specified by the purchaser and manufacturer prior to submission of a quotation.

### More P/M Gear Design Hints

- Carbide dies provide long life and accuracy.
  - Residual part porosity tends to dampen sound.
  - P/M gears can be made with blind corners, thus eliminating the need for undercut relief.
  - P/M gears can be combined with other parts such as cams, ratchets, other gears and various components.
  - Helical gears are possible; copper infiltration is sometimes used to improve teeth densities.
  - Since tooth configuration is not a problem, true involute gear forms are easier to make than by other methods.
- When designing P/M gears:
- Note that hole locations relative to the gear shape itself are affected by the running tolerances of the various tool members. This makes it more difficult to hold the close TIRs (Total Indicator Readings) obtainable with arbor-cut gears, and hubs or pinions that increase the number of concentric tool members increase the TIR tolerance needed. TIRs can be reduced by grinding gear IDs true to the gear pitch diameter.
  - As the AGMA class of gear increases, so does the cost of the gear because of the secondary operations required to meet the tighter tolerances.
  - To avoid having too-thin members, gear hubs or pinions should be located as far as possible from gear root diameters. (See Fig. 2.)

raised surface features can be added to the compacted preform to assist in this engagement.

**6. The configuration of the gear should incorporate edge detail (i.e., chamfers on top and bottom of gear teeth and on ODs and IDs).** This edge detail or chamfer has two main purposes. First, it increases the density in the teeth. Higher tooth density results in improved mechanical properties, particularly strength. It also reduces adverse effects of burrs. The chamfer detail will in most cases keep the burr within the overall thickness (width) of the gear. These burrs are a result of fit clearance of the tooling and, if necessary, can be removed by a vibratory finishing (tumbling) operation or a machining operation.

Typically gears produced in powder metallurgy are in the AGMA range of 6 to 8, with higher AGMA classifications possible, depending on size of the compacted gear and with additional secondary operations.

### Conclusion

The net-shape forming capability of the P/M process produces certain forms and geometries (hubs, bosses, counterbores and cam shapes) which are not practical through other manufacturing technologies. Powder metallurgy produces high strength gears of consistent quality at high production volumes while offering very significant economies. P/M deserves serious consideration when designing new gear components, when analyzing current gears for improvement in functional properties or evaluating cost reduction conversion alternatives.

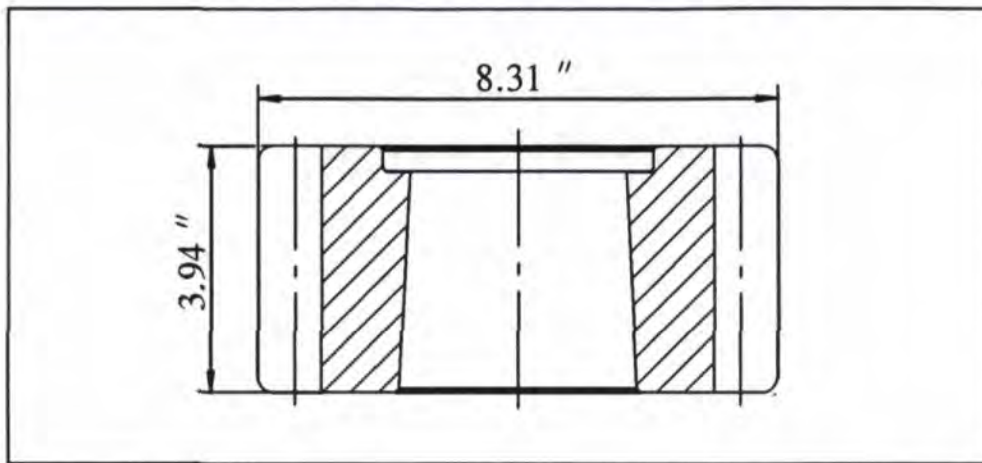
Gear applications that blend the functional requirements of the end use with the fundamentals of powder metallurgy will allow gear designers and engineers to realize the maximum advantages the P/M can offer for long term reliability in demanding applications. While powder metallurgy is best suited and most widely known for high volume production quantities, there are numerous applications where small quantities (as low as a few thousand pieces) can still offer cost benefits over traditional manufacturing methods. ⚙

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# Ground in 13.5 Minutes



## GEAR DATA:

Outside Diameter	:	8.31 "
Face width	:	3.94 "
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Helix Angle	:	0 °
Grinding Stock per flank	:	0.007 "
Profile Modification	:	0.002 "
Lead Modifikation	:	0.004 "
Hardness	:	62 HRc
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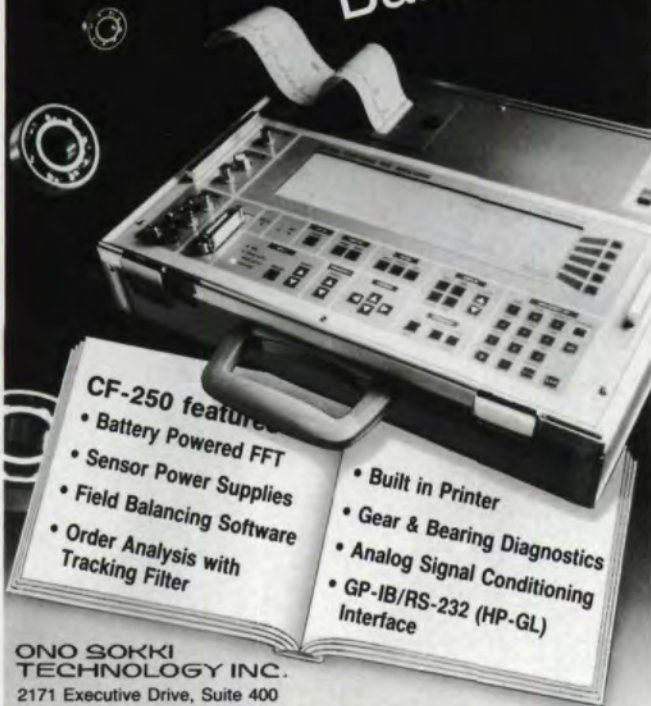
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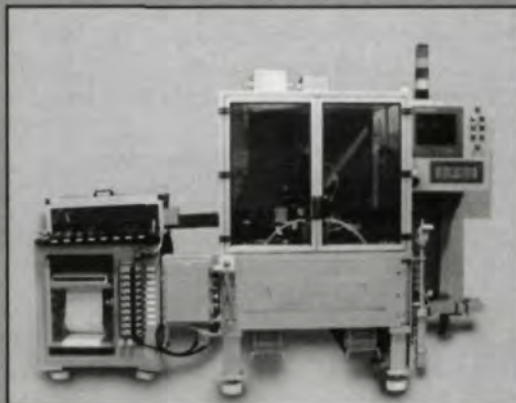
We offer complete design, manufacturing, sales and service to the gear inspection industry.

#### Products:

- manual gear rolling inspection devices
- gear analyzers
- computerized gear rollers
- semi-automatic gear inspection machines
- high speed fully automatic:
  - gear inspection with automated part handling
  - gear burnishing equipment

#### Services:

- installation/training/service
- service contracts
- design services
- engineered quality management



**ITW Heartland**

We will be at AGMA Gear Expo '95. Stop and see us at Booth 514.  
Alexandria, MN • PH: 612-762-5223 • FAX: 612-762-5260

CIRCLE A-28 on READER REPLY CARD

**QUICK  
QUALITY!**

**SPLINE GAGES**

"Quick" because our delivery time from specifications to finished product is usually about six weeks. "Quality" because each is carefully produced to spec, with a traceable certificate if required.  
We supply to ANSI requirements, to British and DIN Standards, and to those for French, Italian and Japanese splines. We also supply master gears. Call or fax for more information.

**PARKER**  
PARKER INDUSTRIES INC.  
1650 Sycamore Ave.,  
Bohemia, NY 11716  
Phone: 516-567-1000  
Fax: 516-567-1355

CIRCLE A-25 on READER REPLY CARD

**PROCESS GEAR**

**CNC GEAR AND  
HOB INSPECTION SERVICE**



Process Industries, a leader in the manufacture of Custom Gears, is now offering a gear and hob inspection service.

Using our state-of-the-art **M & M® Gear Analyzer** allows geometrical analysis of gear characteristics as well as diagnosis and troubleshooting of gear problems.

- |                                  |                                 |
|----------------------------------|---------------------------------|
| <b>Gear Inspection Includes:</b> | <b>Hob Inspection Includes:</b> |
| Profile (Involute) Form          | Flute Lead                      |
| Tooth Alignment (Lead)           | Thread Lead                     |
| Tooth Spacing Variation          | Pressure Angle                  |
| Pitch Line Run-out               | Sharpening                      |
| Evaluation                       |                                 |
| Outside Diameter Run-out         |                                 |

Let us help you prove the quality of your gears or hobs. 2 day inspection standard. Rush inspection provides 24 hour turn around. We also Sharpen Hobs!

3860 N. River Road • Schiller Park, IL 60176

For More Information Call  
**1-800-860-1631**  
The Companies of  
**Process Industries**

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**ADVERTISER INDEX**

For more information about a product or service advertised in this issue of *Gear Technology*, circle the appropriate number on the Reader Response Card and put the card in the mail.

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# PRODUCTS & SERVICES INDEX

Welcome to the newly expanded and revised 1995 *Gear Technology Buyers Guide*. This year we bring you more listings and more categories to help you find the gear products and services you need.

Use this Products and Services directory to locate the names of companies according to the products and services they provide. The complete address, phone number and fax number for each company can be found in the Company Index section. *Gear Technology* advertisers are shown in

boldface type. To find the pages on which their ads appear, see the *Advertisers Index* on page 32.

While *Gear Technology* has made every effort to ensure that company names and addresses are correct, we cannot be held responsible for errors of fact or omission. If your company was not listed in this directory and would like to be included in 1996, call 708-437-6604 or fax 708-437-6618, and we will add you to our mailing list.

## GEAR MANUFACTURERS

### Gears—Gearboxes, Speed Reducers & Enclosed Drives

Calicut Engineering Works, Ltd.  
Gear Group International  
Kaman Aerospace Corp. Merger Corp.  
Nuttall Gear Corp.  
Philadelphia Gear Corp.  
Westerman Inc.

### Gears—Helical

A. W. Sadler Machine ABA-PGT Inc.  
The Adams Company  
Aerocom Industries Inc.  
Akron Gear & Engineering  
Alliance Gear Inc.  
**Amarillo Gear Co.**  
American Machine Works  
**American Pfauter, L.P.**  
American Speed Reducer  
Ancon Gear & Instrument Corp.  
Anderson-Cook Inc.  
Arrow Gear Co.  
Ashot Ashkelon Industries  
ATA Gears Inc.  
Best Engineering Co.  
Bluewater Industrial Service  
Boeing Precision Gear  
Boston Gear—Div. of IMO  
**Bourn & Koch Machine Tool Co.**  
Boxx Gear Manufacturing  
Buckeye Gear Co.  
Bucyrus-Erie Co.  
Calicut Engineering Works Ltd.  
Capstan Atlantic  
**Caterpillar Industrial Products Inc.**  
Chardam Gear Co.  
Charles A. Templeton Machinery Inc.  
Charles Bond Co.  
Chicago Gear-D. O. James  
Chicago Gear Works  
Ciateq  
Cincinnati Gear  
Clarke Gear Co., Inc.  
Cloyes Gear & Products  
Columbia Gear Corp.  
Dabko Industries Inc.  
Dana Corp.—Heavy Axle Div.

Dayton Gear & Tool  
Dearborn Gear & Tool Designatronics  
Dynamic Tool Grinding Service  
Eaton Corp.  
Engratec de Mexico  
Equitable Engineering  
Fairfield Manufacturing  
Fairlane Gear Inc.  
**Fellows Corp.**  
Flender Corp.  
**Forest City Gear Co.**  
Franke Gear Works Inc.  
Fuller Company  
Gearcoa  
Gear Group International  
*Gear Systems Inc.*  
Gears & Drive Systems  
Gears for Industry Inc.  
Geartronics Industries  
General Electric—Marine Products Div.  
Generated Gear & Machine  
**The Gleason Works**  
GW Plastics Inc.  
Harder Precision Components  
Hamischfeger  
Highway Machine Co.  
Invincible Gear Co.  
Invo Spline Inc.  
Island Machinery  
KA-Wood Gear & Machine  
Keller Machine Co.  
Krupp Engineering Inc.  
L&H Welding & Machine Co.  
Lamont Gear  
Linamar  
**M&M Precision Systems**  
M.J.H. Gear & Tool Co.  
Mattoon Precision Manufacturing Inc.  
Merger Corp.  
**Merit Gear Corp.**  
Mid-State Machine Co.  
**Midwest Gear**  
Mobile Pulley & Machine Works  
Modified Gear & Spline  
Molon Gear & Shaft  
Moore Gear & Manufacturing Co.  
Moore Machine & Gear  
Murray Brothers Manufacturing  
**National Broach & Machine Co.**  
New Venture Gear Inc.  
**Niagara Gear Corp.**  
Nuttall Gear Corp.  
O'Neill Gear  
Omni Gear & Machine  
Patterson Gear & Machine  
Pennsylvania Pressed

Metals Inc.  
Philadelphia Gear Corp.  
PIC Design  
Power Eng. & Mfg. Ltd.  
Precision Gear Co.  
Precision Gears Inc.  
Presrite Corp.  
Process Industries  
Progressive Engineering  
Qualicast Corp.  
RD Industries  
Reef Gear Manufacturing  
Riley Gear Corp.  
Riverside Spline & Gear  
Robotronix Drive Systems  
Rockwell International—On-Highway Div.  
Russell, Holbrook & Henderson  
Schafer Gear Works Inc.  
SDMG, Inc.  
**Simon International Distribution**  
Southern Gear & Machine  
Sumitomo Machinery  
Tifco Inc.  
TPI Powder Metallurgy  
Trojon Gear Inc.  
U.S.E.M.  
Vic Machine Tools  
Von Ruden Manufacturing  
Wedin International Inc.  
Westerman Inc.  
Wohler Corp.  
Worcester Gear Works  
Xtek Inc.  
Yieh Chen Co. Ltd.

### Gears—Herringbone

A. W. Sadler Machine  
Akron Gear & Engineering  
**American Pfauter, L.P.**  
Anderson International  
Bluewater Industrial Service  
Boston Gear—Div. of IMO  
Bucyrus-Erie Co.  
Calicut Engineering Works Ltd.  
Charles Bond Co.  
Chicago Gear-D. O. James  
Ciateq  
Cincinnati Gear  
Engratec de Mexico  
**Fellows Corp.**  
Fuller Company  
Highway Machine Co.  
L&H Welding & Machine Co.  
Lamont Gear  
**Midwest Gear**

Moore Gear & Manufacturing Co.  
Process Industries  
Qualicast Corp.  
Robotronix Drive Systems  
Westerman Inc.  
Xtek Inc.

### Gears—Hypoid

**Amarillo Gear Co.**  
Arrow Gear Co.  
Ashot Ashkelon Industries  
**ATA Gears Inc.**  
Cincinnati Gear  
*Dana Corp.—Heavy Axle Div.*  
Fairfield Manufacturing  
Gears for Industry Inc.  
The Gleason Works  
Moore Gear & Manufacturing Co.  
Philadelphia Gear  
Precision Gear Co.  
Qualicast Corp.  
Robotronix Drive Systems  
Sumitomo Machinery  
Von Ruden Manufacturing

### Gears—Internal

Calicut Engineering Works, Ltd.  
Engratec de Mexico  
Equitable Engineering  
**Forest City Gear Co.**  
Invincible Gear Co.  
Xtek Inc.

### Gears—Master Gears

Accu-Prompt Inc.  
Ace World Company  
**American Pfauter, L.P.**  
Arrow Gear Co.  
Best Engineering Co.  
Boeing Precision Gear  
Cincinnati Gear  
Equitable Engineering  
**Fellows Corp.**  
Gear Motions  
Generated Gear & Machine  
**The Gleason Works**  
Harder Precision Components  
**ITW Heartland**  
ITW Spiroid  
Invo Spline Inc.  
Island Machinery  
**M&M Precision Systems**  
Modified Gear & Spline  
Moore Products Co.—

Gage Div.  
**National Broach & Machine Co.**  
**Parker Industries Inc.**  
Precision Gage Co.  
Riverside Spline & Gear  
Robotronix Drive Systems  
Russell, Holbrook & Henderson  
Southern Gear & Machine  
Spline Gauges Ltd.  
**SU America, Inc.**  
Tifco Inc.  
Yieh Chen Co. Ltd.

### Gears—Non-Circular

ABA-PGT Inc.  
Akron Gear & Engineering  
American Machine Works  
Cunningham Industries  
**Fellows Corp.**  
Highway Machine Co.  
Krupp Engineering Inc.  
**Merit Gear Corp.**  
Wedin International Inc.  
Winzeler Gear

### Gears—Plastic

A & E Gears BV  
A. W. Sadler Machine  
ABA-PGT Inc.  
Accu-Prompt Inc.  
Akron Gear & Engineering  
Alliance Gear Inc.  
American Machine Works  
Arrow Gear Co.  
Bengal Industries Inc.  
Boston Gear—Div. of IMO  
Boxx Gear Manufacturing  
Buckeye Gear Co.  
Calicut Engineering Works Ltd.  
Charles Bond Co.  
Chicago Gear Works  
Clarke Gear Co., Inc.  
Dabko Industries Inc.  
Designatronics  
**Forest City Gear Co.**  
Gear Systems Inc.  
Gearcoa  
Geartronics Industries  
Generated Gear & Machine  
GW Plastics Inc.  
Invincible Gear Co.  
Keller Machine Co.  
Lamont Gear  
M.J.H. Gear & Tool Co.  
Moore Gear &

Manufacturing Co.  
Moore Machine & Gear  
O'Neill Gear  
Omni Gear & Machine  
PIC Design  
Precision Gear Co.  
**Process Industries**  
RD Industries  
Reef Gear Manufacturing  
**Simon International Distribution**  
Southern Gear & Machine  
Trogetec Inc.  
Trojon Gear Inc.  
Wedin International Inc.  
Winzeler Gear  
Worcester Gear Works

### Gears—Powder Metal

Alpha Sintered Metals,  
Asco Sintering Co.  
Boston Gear—Div. of IMO  
Capstan Atlantic  
Carbon City Products  
**Caterpillar Industrial Products Inc.**  
Chicago Gear Works  
Cloyes Gear & Products  
Dabko Industries Inc.  
Deco-Technologies  
Keystone Carbon Company  
Krupp Engineering Inc.  
**M&M Precision Systems**  
**Merit Gear Corp.**  
Pennsylvania Pressed Metals Inc.  
Reef Gear Manufacturing  
St. Marys Carbon Co.  
TPI Powder Metallurgy  
TPS Inc.  
Viking Air Tools  
Yieh Chen Co. Ltd.  
Zenith Sintered Products, Inc.

### Gears—Rack & Pinion

A. W. Sadler Machine  
ABA-PGT Inc.  
Accu-Prompt Inc.  
Akron Gear & Engineering  
Anderson International  
Asco Sintering Co.  
Boston Gear—Div. of IMO  
Calicut Engineering Works Ltd.  
Capstan Atlantic  
Charles Bond Co.  
Cincinnati Gear  
Cornell Forge Co.

Dayton Gear & Tool  
Deco-Technologies  
Designatronics  
Engratec de Mexico  
Fairlane Gear Inc.  
**Fellows Corp.**  
Franke Gear Works Inc.  
Gear Group  
International  
Gear Motions  
Gearcoa  
Gears for Industry Inc.  
Generated Gear & Machine  
GW Plastics Inc.  
Harder Precision Components  
Harnischfeger  
Highway Machine Co.  
Island Machinery  
Krupp Engineering Inc.  
Lamont Gear  
Linamar  
Mid-State Machine Co.  
Moore Gear & Manufacturing Co.  
Moore Machine & Gear  
National Broach & Machine Co.  
O'Neill Gear  
Patterson Gear & Machine  
PIC Design  
Qualicast Corp.  
Riverside Spline & Gear  
Robotronix Drive Systems  
**Simon International Distribution**  
Southern Gear & Machine  
Standard Steel Specialty  
TPI Powder Metallurgy  
Trojon Gear Inc.  
Vic Machine Tools  
Viking Air Tools  
Wedin International Inc.  
Winzeler Gear  
Worcester Gear Works  
Xtek Inc.  
Yieh Chen Co. Ltd.

**Gears—Spiral Bevel**

A. W. Sadler Machine  
ABA-PGT Inc.  
Akron Gear & Engineering  
**Amarillo Gear Co.**  
Arrow Gear Co.  
Asco Sintering Co.  
**ATA Gears Inc.**  
Bluewater Industrial Service  
Boston Gear—Div. of IMO  
Boeing Precision Gear  
**Bourn & Koch Machine Tool Co.**  
Case Corp.  
**Caterpillar Industrial Products Inc.**  
Chicago Gear-D. O. James  
Ciateq  
Dana Corp.—Heavy Axle Div.  
Designatronics  
Engratec de Mexico  
Fairfield Manufacturing  
Flender Corp.  
Gear Group  
International  
**The Gleason Works**

Merger Corp.  
Moore Gear & Manufacturing Co.  
New Venture Gear Inc.  
Pennsylvania Pressed Metals Inc.  
Philadelphia Gear Corp.  
Power Eng. & Mfg. Ltd.  
Precision Gear Co.  
Presrite Corp.  
Robotronix Drive Systems  
Rockwell  
International—On-Highway Div.  
**Simon International Distribution**  
Southern Gear & Machine  
Sumitomo Machinery  
Von Ruden  
Manufacturing  
Winzeler Gear

**Gears—Spur**

A. W. Sadler Machine  
ABA-PGT Inc.  
Accu-Prompt Inc.  
The Adams Company  
Aerocom Industries Inc.  
Akron Gear & Engineering  
Albro Gear & Instrument  
Alliance Gear Inc.  
American Machine Works  
**American Pfauter, L.P.**  
Ancon Gear & Instrument Corp.  
Anderson-Cook Inc.  
Arrow Gear Co.  
Asco Sintering Co.  
Ashot Ashkelon Industries  
**ATA Gears Inc.**  
Best Engineering Co.  
Bluewater Industrial Service  
Boeing Precision Gear  
Boston Gear—Div. of IMO  
**Bourn & Koch Machine Tool Co.**  
Boxx Gear Manufacturing  
Buckeye Gear Co.  
Bucyrus-Erie Co.  
Calicut Engineering Works Ltd.  
Capstan Atlantic  
**Caterpillar Industrial Products Inc.**  
Chardam Gear Co.  
Charles A. Templeton Machine Inc.  
Charles Bond Co.  
Chicago Gear-D. O. James  
Chicago Gear Works  
Ciateq  
Cincinnati Gear  
Clarke Gear Co., Inc.  
Cloyes Gear & Products  
Columbia Gear Corp.  
Cornell Forge Co.  
Cunningham Industries  
Dabko Industries Inc.  
Dana Corp.—Heavy Axle Div.  
Davis Tool & Engineering  
Dayton Gear & Tool

Dearborn Gear & Tool  
Designatronics  
Dynamic Tool Grinding Service  
Eaton Corp.  
Engratec de Mexico  
Equitable Engineering  
Fairfield Manufacturing  
Fairlane Gear Inc.  
**Fellows Corp.**  
Flender Corp.  
**Forest City Gear Co.**  
Franke Gear Works Inc.  
Fuller Company  
Gearcoa  
Gear Group  
International  
Gear Motions  
Gear Systems Inc.  
Gears & Drive Systems Inc.  
Gears for Industry Inc.  
Geartronics Industries  
General Electric—Marine Products Div.  
Generated Gear & Machine  
GW Plastics Inc.  
Hand Screw Machine  
Harder Precision Components  
Harley-Davidson  
Harnischfeger  
Highway Machine Co.  
Howard's Machine Shop  
Invincible Gear Co.  
Invo Spline Inc.  
Island Machinery  
KA-Wood Gear & Machine  
Keller Machine Co.  
Krupp Engineering Inc.  
L&H Welding & Machine Co.  
Lamont Gear  
**M&M Precision Systems**  
M.J.H. Gear & Tool Co.  
**Merit Gear Corp.**  
Micron Instrument Corp.  
Mid-State Machine Co.  
**Midwest Gear**  
Mobile Pulley & Machine Works  
Modified Gear & Spline  
Molton Gear & Shaft  
Moore Gear & Manufacturing Co.  
Moore Machine & Gear  
Murray Brothers  
Manufacturing  
**National Broach & Machine Co.**  
New Venture Gear Inc.  
**Niagara Gear Corp.**  
O'Neill Gear  
Omni Gear & Machine  
Patterson Gear & Machine  
Pennsylvania Pressed Metals Inc.  
Philadelphia Gear Corp.  
PIC Design  
Power Eng. & Mfg. Ltd.  
Precision Gear Co.  
Precision Gears Inc.  
Presrite Corp.  
**Process Industries**  
Progressive Engineering  
Qualicast Corp.  
RD Industries  
Reef Gear  
Manufacturing  
Riley Gear Corp.  
Riverside Spline & Gear

Robotronix Drive Systems  
Rockwell  
International—On-Highway Div.  
Russell, Holbrook & Henderson  
Schafer Gear Works Inc.  
SDMG, Inc.  
Sepac Electric Clutch & Brake  
**Simon International Distribution**  
Southern Gear & Machine  
Tifco Inc.  
TPI Powder Metallurgy  
Trogetec Inc.  
Trojon Gear Inc.  
U.S.E.M.  
Vic Machine Tools  
Von Ruden  
Manufacturing  
Waldeman Design & Machine  
Wedin International Inc.  
Winzeler Gear  
Wohler Corp.  
Worcester Gear Works  
Xtek Inc.  
Yieh Chen Co. Ltd.  
Zenith Sintered Products, Inc.

**Gears—Straight Bevel**

A. W. Sadler Machine  
ABA-PGT Inc.  
Accu-Prompt Inc.  
The Adams Company  
Akron Gear & Engineering  
Alliance Gear Inc.  
American Machine Works  
Arrow Gear Co.  
Asco Sintering Co.  
Ashot Ashkelon Industries  
Best Engineering Co.  
Bluewater Industrial Service  
Boston Gear—Div. of IMO  
Calicut Engineering Works, Ltd.  
Capstan Atlantic  
Case Corp.  
**Caterpillar Industrial Products Inc.**  
Charles A. Templeton Machine Inc.  
Charles Bond Co.  
Chicago Gear-D. O. James  
Chicago Gear Works  
Clarke Gear Co., Inc.  
Cornell Forge Co.  
Dayton Gear & Tool  
Designatronics  
Engratec de Mexico  
Fairfield Manufacturing  
**Fellows Corp.**  
Franke Gear Works Inc.  
Gear Motions  
Gearcoa  
Gears & Drive Systems  
Gears for Industry Inc.  
Geartronics Industries  
Generated Gear & Machine  
**The Gleason Works**  
GW Plastics Inc.  
Krupp Engineering Inc.

Lamont Gear  
M.J.H. Gear & Tool Co.  
Merger Corp.  
Moore Gear & Manufacturing Co.  
Moore Machine & Gear  
New Venture Gear Inc.  
Pennsylvania Pressed Metals Inc.  
Philadelphia Gear Corp.  
PIC Design  
Precision Gear Co.  
Presrite Corp.  
**Process Industries**  
Progressive Engineering  
Robotronix Drive Systems  
Rockwell  
International—On-Highway Div.  
**Simon International Distribution**  
Southern Gear & Machine  
TPI Powder Metallurgy  
Von Ruden  
Manufacturing  
Waldeman Design & Machine  
Wedin International Inc.  
Winzeler Gear  
Worcester Gear Works  
Xtek Inc.  
Yieh Chen Co. Ltd.  
Zenith Sintered Products, Inc.

**Gears—Worm**

A. W. Sadler Machine  
ABA-PGT Inc.  
Accu-Prompt Inc.  
Accurate Specialties Inc.  
The Adams Company  
Akron Gear & Engineering  
Alliance Gear Inc.  
American Machine Works  
Allison Gear Inc.  
American Machine Works  
Anderson-Cook Inc.  
Best Engineering Co.  
Bluewater Industrial Service  
Boston Gear—Div. of IMO  
**Bourn & Koch Machine Tool Co.**  
Buckeye Gear Co.  
Calicut Engineering Works Ltd.  
Charles A. Templeton Machine Inc.  
Charles Bond Co.  
Chicago Gear-D. O. James  
Chicago Gear Works  
Ciateq  
Cincinnati Gear  
Clarke Gear Co., Inc.  
Dabko Industries Inc.  
Dayton Gear & Tool  
Delroyd Worm Gear—Div. of IMO  
Designatronics  
Engratec de Mexico  
Equitable Engineering  
Fairlane Gear Inc.  
**Fellows Corp.**  
Flender Corp.  
**Forest City Gear Co.**  
Franke Gear Works Inc.  
Gear Group  
International  
Gear Motions

Gear Systems Inc.  
Gearcoa  
Gears for Industry Inc.  
Geartronics Industries  
General Electric—Marine Products Div.  
Generated Gear & Machine  
GW Plastics Inc.  
Harder Precision Components  
Harley-Davidson  
Invincible Gear Co.  
KA-Wood Gear & Machine  
Lamont Gear  
M.J.H. Gear & Tool Co.  
Merger Corp.  
Mid-State Machine Co.  
**Midwest Gear**  
Molton Gear & Shaft  
Moore Gear & Manufacturing Co.  
Moore Machine & Gear  
O'Neill Gear  
Omni Gear & Machine  
Patterson Gear & Machine  
Philadelphia Gear Corp.  
PIC Design  
Precision Gear Co.  
Precision Gears Inc.  
**Process Industries**  
Progressive Engineering  
Riley Gear Corp.  
Riverside Spline & Gear  
Robotronix Drive Systems  
Russell, Holbrook & Henderson  
Schafer Gear Works Inc.  
SDMG, Inc.  
**Simon International Distribution**  
Southern Gear & Machine  
Spline Gauges Ltd.  
Sumitomo Machinery  
Tifco Inc.  
Trojon Gear Inc.  
U.S.E.M.  
Vic Machine Tools  
Wedin International Inc.  
Winzeler Gear  
Worcester Gear Works  
Yieh Chen Co. Ltd.

**Spline Gages**

Invo Spline Inc.  
**M&M Precision Systems**  
**Parker Industries Inc.**  
Precision Gage Co.  
Spline Gauges Ltd.  
Tifco Inc.

**Splines**

A. W. Sadler Machine  
ABA-PGT Inc.  
Accu-Prompt Inc.  
The Adams Company  
Akron Gear & Engineering  
American Machine Works  
**American Pfauter, L.P.**  
Ancon Gear & Instrument Corp.  
Anderson-Cook Inc.  
Arrow Gear Co.  
Ashot Ashkelon

Industries  
 Best Engineering Co.  
 Bluewater Industrial Service  
 Boeing Precision Gear  
 Boston Gear—Div. of IMO  
**Bourn & Koch Machine Tool Co.**  
 Boxx Gear  
 Manufacturing  
 Buckeye Gear Co.  
 Bucyrus-Erie Co.  
 Calicut Engineering Works Ltd.  
 Capstan Atlantic  
 Chardam Gear Co.  
 Charles A. Templeton Machine Inc.  
 Chicago Gear-D. O. James  
 Chicago Gear Works  
 Cincinnati Gear  
 Clarke Gear Co., Inc.  
 Columbia Gear Corp.  
 Dabko Industries Inc.  
 Dayton Gear & Tool  
 Dearborn Gear & Tool  
 Deco-Technologies  
 Designtronics  
 Eaton Corp.  
**Elmass North America**  
 Engratec de Mexico  
 Equitable Engineering  
 Fairfield Manufacturing  
 Fairlane Gear Inc.  
**Fellows Corp.**  
**Forest City Gear Co.**  
 Franke Gear Works Inc.  
 Gear Motions  
 Gear Systems Inc.  
 Gearcoa  
 Gears for Industry Inc.  
 Geartronics Industries  
 Generated Gear & Machine  
 Hand Screw Machine  
 Harder Precision Components  
 Harley-Davidson  
 Hamischfeger  
 Highway Machine Co.  
 Howard's Machine Shop  
 Invo Spline Inc.  
 Island Machinery  
 KA-Wood Gear & Machine  
 L&H Welding & Machine Co.  
 Lamont Gear  
 Linamar  
 Lovejoy Inc.  
**M&M Precision Systems**  
 M.J.H. Gear & Tool Co.  
 Mattoon Precision Manufacturing Inc.  
**Merit Gear Corp.**  
 Micromatic Textron  
 Mid-State Machine Co.  
**Midwest Gear**  
 Modified Gear & Spline  
 Moore Gear & Manufacturing Co.  
 Moore Machine & Gear  
 Murray Brothers Manufacturing  
**National Broach & Machine Co.**  
 New Venture Gear Inc.  
**Niagara Gear Corp.**  
 O'Neill Gear  
 Omni Gear & Machine  
 Patterson Gear & Machine

Pennsylvania Pressed Metals Inc.  
 Philadelphia Gear Corp.  
 Power Eng. & Mfg. Ltd.  
 Precision Gear Co.  
 Precision Gears Inc.  
**Process Industries**  
 Progressive Engineering  
 Reef Gear  
 Manufacturing  
 Rhinestahl Corp.  
 Riley Gear Corp.  
 Riverside Spline & Gear  
 Robotronix Drive Systems  
 Rockwell  
 International—On-Highway Div.  
 Russell, Holbrook & Henderson  
 Schafer Gear Works Inc.  
 SDMG, Inc.  
 Sepac Electric Clutch & Brake  
**Simon International Distribution**  
 Southern Gear & Machine  
 Spline Gauges Ltd.  
 Tifco Inc.  
 TPI Powder Metallurgy  
 Trojon Gear Inc.  
 U. S. Axle Inc.  
 Viking Air Tools  
 Von Ruden Manufacturing  
 Wedin International Inc.  
**Worcester Gear Works**  
 Xtek Inc.  
 Yieh Chen Co. Ltd.  
 Zenith Sintered Products, Inc.

**Sprockets**

Buckeye Gear Co.  
 Dabko Industries  
 Ka-Wood Gear & Machine  
 Keller Machine Co.  
 Precision Gear Co.  
 SDMG, Inc.  
 Wohler Corp.

**Gear Manufacturers—Other**

ABA-PGT Inc.—Cycloidal Gears  
 Accu-Prompt Inc.—Tapered Spur Gears  
 Buckeye Gear Co.—Internal & External Broaching  
 Clarke Gear Co.—Face Gears  
 Equitable Engineering—Curvic Couplings, Double Helical Gears  
**Forest City Gear Co.—Ratchets, Serrations, Face Gears**  
 Franke Gear Works—Double  
 Enveloping Worm & Gear Sets, Power/Feedback Racks  
 Gearcoa—Evoloids  
 Invincible Gear Co.—Face Gears, Taper Gears  
 Invo Spline Inc.—Fixture Gages

Ka-Wood Gear & Machine—Pulleys, Broaching  
 Lovejoy Inc.—Gear Couplings  
 Michigan Automatic  
 Turning—Spline Rolling  
 Micron Instrument Corp.—Precision Gearheads  
 Modified Gear & Spline—Index Plates  
 Molon Gear & Shaft—Gear & Pinion Assemblies  
 Moore Products Co.—Gear Gages  
**National Broach & Machine Co.—Prototypes**  
 Precision Gear Co.—Ratchets, Timing Belts  
 Progressive Tool Co.—Wire EDM  
 Experimental Gears  
**Simon International Distribution—Shafts**  
 Spline Gauges Ltd.—Worm Masters  
 Teledyne Portland Forge—Carbon/Alloy Steel Forging, Near-net Forgings  
 Tifco Inc.—Gear Gages  
 Trogetec Inc.—Cycloidal Gears, Harmonic Gearing  
 Xtek Inc.—Couplings, Gear Assemblies  
 Yieh Chen Co.—Gear Pumps

**GEAR MANUFACTURING MACHINES**

**Broaching Machines**

Detroit Broach Co.  
**Elmass North America**  
 General Broach & Engineering Co.  
 Jack Dustman & Assoc.  
 Mitts & Merrill L.P.  
**National Broach & Machine Co.**  
 The Ohio Broach & Machine Co.  
 Ty Miles Inc.  
 W.C. Divers & Associates

**Chamfering Machines**

American Sykes Co.  
 American Wera Inc.  
**Basic Machine Tools**  
**The Gleason Works GMI**  
**Redin Corp.**  
 SU America, Inc.  
 V&R Associates  
 W.C. Divers & Associates

**Deburring Machines**

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 Best Engineering Co.  
**Bourn & Koch Machine Tool**  
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**ITW Heartland**  
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**JRM International Inc.**  
**M&M Precision Systems**  
 Miller Industrial Services Inc.  
**Redin Corp.**  
 Schenck Turner  
**SU America, Inc.**  
 V&R Associates  
 W.C. Divers & Associates

**EDM Machines**

AGIE USA Ltd.  
 Bluegrass Precision Machinery  
 Charmilles Technologies  
 Current EDM, Inc.  
 Easco-Sparcatron  
 EDM Solutions Co.  
 Engemaq U.S.A.  
 Hansvedt Industries, Inc.  
 Hermes Machine Tool Co., Inc.  
 Hitachi EDM Products  
 KGK International Corp./Sodick EDM  
 LeBlond Makino Machine Tool Co.  
 Mecatool USA Ltd.  
 Mitsubishi EDM/MC Machinery  
 Okamoto Corp.  
 EDM Div.  
 Raycon Corp.  
 Vic Machine Tools  
 Victek Machinery, Inc.  
 Xermac, Inc.

**Generating Machines**

**American Pfauter, L.P.**  
 American Wera Inc.  
**Basic Machine Tools Bourn & Koch Machine Tool**  
**The Gleason Works**  
 Koepfer America, L.P.  
**Liebherr/Sigma Pool**  
**National Broach & Machine Co.**  
 V&R Associates  
 Vic Machine Tools

**Grinding Machines**

**American Pfauter, L.P.**  
**Basic Machine Tools**  
 Bluegrass Precision Machinery  
**Bourn & Koch Machine Tool**  
 The Daniluk Corp.  
**The Gleason Works**  
**GMI**  
**Höfler Maschinenbau GmbH**  
 Hoglund Technology Corporation  
**JRM International Inc.**  
**Liebherr/Sigma Pool**  
 Miller Industrial Services Inc.  
**Mitsubishi Machine Tool**  
**National Broach &**

**Machine Co.**

Normac Inc.  
**Reishauer Corporation**  
**SU America, Inc.**  
 Sunnen Products Co.  
 USACH Technologies  
 V&R Associates  
 W.C. Divers & Associates  
**WMW Machinery Company**

**Heat Treating Equipment**

Abar Ipsen Industries  
**Ajax Magnethermic**  
 Bluegrass Precision Machinery  
 Can-Eng Furnaces Ltd.  
 Contour Hardening Inc.  
 Custom Electric Mfg.  
 Detroit Flame Hardening  
 Euclid Heat Treating Co.  
**The Gleason Works**  
**Inductoheat Inc.**  
 K.H. Huppert Co.  
 McEnglevan Industrial Furnace  
 Metaplas Ionon  
 Pacific Industrial Furnace Co.  
**Pillar Industries**  
 Quench Press Specialists  
 Surface Combustion Inc.  
 Therm Alliance Co.  
 TOCCO Inc.  
 Walnil Company

**Hobbing Machines**

Ace World Company  
**American Pfauter, L.P.**  
**Basic Machine Tools Bourn & Koch Machine Tool**  
 Fayscott Co./Lees-Bradner  
**Fellows Corp.**  
**The Gleason Works**  
 Koepfer America, L.P.  
**Liebherr/Sigma Pool**  
**Mitsubishi Machine Tool**  
**National Broach & Machine Co.**  
 V&R Associates  
 Vic Machine Tools  
 W.C. Divers & Associates  
**WMW Machinery Company**

**Honing Machines**

**American Pfauter, L.P.**  
**Basic Machine Tools**  
 Bates Technologies Inc.  
 Bluegrass Precision Machinery  
 Engis Corp.  
**The Gleason Works**  
 Miller Industrial Services Inc.  
**National Broach & Machine Co.**  
**Reishauer Corporation**  
 Sunnen Products Co.  
 V&R Associates  
 W.C. Divers & Associates

**Inspection Machines**

**American Pfauter, L.P.**  
**American Sykes Co.**  
**Basic Machine Tools**  
 Best Engineering Co.  
 Bluegrass Precision Machinery  
**Bourn & Koch Machine Tool**  
 Brown & Sharpe Mfg.  
**Fellows Corp.**  
 FGT Gage & Systems,  
**The Gleason Works**  
**ITW Heartland**  
**JRM International Inc.**  
 Kokusai Inc.  
**Liebherr/Sigma Pool**  
**M&M Precision Systems**  
 Moore Products Co.—Gage Div.  
**National Broach & Machine Co.**  
 National Metrology  
 NewAge Industries Inc.  
**Ono Sokki Technology**  
**Profile Engineering**  
**Reishauer Corporation**  
 Spline Gauges Ltd.  
**SU America, Inc.**  
 USACH Technologies  
 V&R Associates  
 W.C. Divers & Associates

**Keyseating Machines**

**Basic Machine Tools**  
 Elmass North America  
 Mitts & Merrill L.P.

**Lapping Machines**

**Basic Machine Tools**  
**The Gleason Works**  
 Lapmaster International  
 Miller Industrial Services Inc.

**Measuring Machines**

**American Pfauter, L.P.**  
**American Sykes Co.**  
**Basic Machine Tools**  
 Bluegrass Precision Machinery  
**Bourn & Koch Machine Tool**  
 Brown & Sharpe Mfg.  
**Fellows Corp.**  
 FGT Gage & Systems,  
**Liebherr/Sigma Pool**  
**M&M Precision Systems**  
**National Broach & Machine Co.**  
**Ono Sokki Technology**  
**Profile Engineering**  
 Spline Gauges Ltd.  
**SU America, Inc.**  
 USACH Technologies  
 W.C. Divers & Associates

**Shaping Machines**

**American Pfauter, L.P.**  
 American Wera Inc.  
**Basic Machine Tools**  
**Bourn & Koch**

**Machine Tool**  
 Elmass North America  
**Fellows Corp.**  
**Liebherr/Sigma Pool**  
 Micromatic Textron  
**Mitsubishi Machine Tool**  
**National Broach & Machine Co.**  
 V&R Associates  
 W.C. Divers & Associates

**Shaving Machines**

**American Pfauter, L.P.**  
**Basic Machine Tools**  
 Elmass North America  
**GMI**  
**Mitsubishi Machine Tool**  
**National Broach & Machine Co.**  
 V&R Associates  
 W.C. Divers & Associates

**Spline Rolling Machines**

**GMI**  
 Micromatic Textron  
**National Broach & Machine Co.**  
 W.C. Divers & Associates

**Testing Machines**

**American Sykes Co.**  
**Basic Machine Tools**  
 Euro-Tech Corporation  
**The Gleason Works**  
 Jack Dustman & Assoc.  
 Krautkramer Branson  
**M&M Precision Systems**  
 National Metrology  
 NewAge Industries Inc.  
**Ono Sokki Technology**  
**Parker Industries Inc.**  
 Precision Gage Co.  
**Profile Engineering**  
 Spline Gauges Ltd.  
**SU America, Inc.**  
 W.C. Divers & Associates

**Turning Machines**

American Wera Inc.  
 The Daniluk Corp.  
**Fellows Corp.**  
 Miller Industrial Services Inc.  
**Mitsubishi Machine Tool**  
 V&R Associates  
 Vic Machine Tools

**Worm Milling Machines**

**American Pfauter, L.P.**  
**Basic Machine Tools**  
**Bourn & Koch Machine Tool**  
 Koepfer America, L.P.

**Gear Manufacturing Machines—Other**

Comtorgage Corporation—Hand-Held Dimensional Gages  
 Daniluk Corp.—Machining Centers  
 Euro-Tech Corp.—Spline Gaging Machines  
 Finishing Equipment Inc.—Cleaning Machines  
 Harper Surface Finishing Systems—Finishing Machines  
 Hoglund Technology Corporation—Gear Wheel Dressers  
**JRM International—Rack Milling, Rack Grinding, Part Marking, Broach Milling Machines**  
 Koepfer America, L.P.—Hob Sharpening Machines  
 Manufacturing Technology Inc.—Inertia/Friction Welders  
 National Metrology—Optical Comparators  
 Normac Inc.—CNC Grinding Wheel Dressers  
**Redin Corporation—Design/Build Special Machines**  
 Sala/BLM Corp.—Saws & Sawing Systems  
 Schenck Turner—Pointing Machines  
 Sunnen Products Co.—Surfacers, Boring Machines  
 Walnil Co.—Parts Washers

**GEAR MATERIALS**

**Gear Materials—Plastics**

ABA-PGT, Inc.  
 American Machine Works  
 Best Engineering Co.  
 Equitable Engineering  
**GW Plastics Inc.**  
 Harder Precision Components  
 Hoechst Celanese Corp.  
 Howard's Machine Shop  
 Moore Gear & Mfg.  
 Trogetec Inc.  
 Worcester Gear Works

**Gear Materials—Powder Metal**

Alpha Sintered Metals  
 Asco Sintering Co.  
 Capstan Atlantic  
 Carbon City Products  
 Interlake Hoeganaes  
 Keystone Carbon Company  
 St. Marys Carbon Co.  
 TPI Powder Metallurgy  
 TPS Inc.

Zenith Sintered Products, Inc.

**Gear Materials—Steel**

Ace World Company  
 American Machine Works  
 Cincinnati Gear Co.  
 Crucible Service Centers  
 Disston Precision Inc.  
 Equitable Engineering  
 Harder Precision Components  
 Howard's Machine Shop  
 Latrobe Steel Co.—Div. of Timken  
 Moore Gear & Mfg.  
 RD Industries  
 Trogetec Inc.  
 Worcester Gear Works

**Gear Materials—Other**

**Dura-Bar—Continuous Cast Iron Barstock**  
 Trogetec Inc.—Nonferrous Metals  
 Wells Manufacturing—Iron

**GEAR SERVICES**

**Cryogenics**

Boeing Precision Gear  
 Detroit Flame Hardening  
 FPM Heat Treating  
 Gearcoa  
**Merit Gear Corp.**  
 Robotronix Drive Systems

**Fault Analysis**

Akron Gear & Engineering  
 Ashot Ashkelon Industries  
**Aston Metallurgical Services**  
 Brown & Sharpe Manufacturing Co.  
 Ciateq  
 Drive-Systems Technology  
 Fairfield Manufacturing  
 Gear Research Institute  
 Geartech  
 Harnischfeger  
 Penn State University/NCADT  
 Reilly Engineering Inc.  
 Robotronix Drive Systems  
 Technimet Corp.  
 Xtek Inc.

**Gear Blanks**

A.W. Sadler Machine  
 Accu-Prompt Inc.  
 Accurate Specialties Inc.  
 The Adams Company  
 Akron Gear & Engineering  
 American Machine Works  
 Ancon Gear & Instrument Corp.  
 Arrow Gear Co.

Boeing Precision Gear  
**Bourn & Koch**  
 Machine Tool  
 Boxx Gear  
 Manufacturing  
 Bucyrus-Erie Co.  
 Capstan Atlantic  
 Charles Bond Co.  
 Chicago Gear Works  
 Cincinnati Gear  
 Clarke Gear Co., Inc.  
**Clifford-Jacobs**  
 Forging  
 Columbia Gear Corp.  
 Cornell Forge Co.  
 Disston Precision Inc.  
 DMS Inc.  
 Engratec de Mexico  
 Fairfield Manufacturing  
 Fairlane Gear Inc.  
**Fellows Corp.**  
 Fuller Company  
 Gear Motions  
 Gearcoa  
 Gears & Drive Systems  
 Geartronics Industries  
 Generated Gear &  
 Machine  
**The Gleason Works**  
 Harder Precision  
 Components  
 Highway Machine Co.  
 Howard's Machine Shop  
 Keller Machine Co.  
 Linamar  
 Mattoon Precision  
 Manufacturing Inc.  
**Merit Gear Corp.**  
 Mid-State Machine Co.  
 Moore Gear &  
 Manufacturing Co.  
 Moore Machine & Gear  
 PIC Design  
 Presrite Corp.  
**Process Industries**  
 Qualicast Corp.  
 RD Industries  
 Reef Gear  
 Manufacturing  
 Robotronix Drive  
 Systems  
 Schafer Gear Works Inc.  
 Schmid Tool &  
 Engineering  
 Southern Gear &  
 Machine  
 Tifco Inc.  
 Trogetec Inc.  
 Trojan Gear Inc.  
 Van Beelaere Machine  
 Works  
 Viking Air Tools  
 Wedin International Inc.  
 Wells Manufacturing  
 Westerman Inc.  
 Wohlert Corp.  
 Worcester Gear Works

**Gear Design**

A. W. Sadler Machine  
 ABA-PGT Inc.  
 Accu-Prompt Inc.  
 The Adams Company  
 Akron Gear &  
 Engineering  
 Arrow Gear Co.  
 Ashot Ashkelon  
 Industries  
**ATA Gears Inc.**  
 Axicon Technologies  
 C-Dot Engineering  
 Capstan Atlantic  
**Caterpillar Industrial**

**Products Inc.**  
 Charles Bond Co.  
 Chicago Gear-D. O.  
 James  
 Chicago Gear Works  
 Ciateq  
 Cincinnati Gear  
 Columbia Gear Corp.  
 Contour Hardening Inc.  
 Deco-Technologies  
 DMS Inc.  
 Drive Systems  
 Technology  
 Dynamic Tool Grinding  
 Service  
 Engratec de Mexico  
 Equitable Engineering  
 Fairfield Manufacturing  
 Fairlane Gear Inc.  
**Fellows Corp.**  
 Gear Research Institute  
 Gear Systems Inc.  
 Gearesearch Assoc.  
 Gears & Drive Systems  
 General Electric—  
 Marine Products Div.  
 Generated Gear &  
 Machine  
**The Gleason Works**  
 GW Plastics Inc.  
 Highway Machine Co.  
 Hy-Mech Systems Inc.  
 Invo Spline Inc.  
 ITW Spiroid  
 Labeco  
 McGinty Gear

**Merit Gear Corp.**  
 Mississippi State  
 University  
 Mobile Pulley &  
 Machine Works  
 Moore Machine & Gear  
 Power Eng. & Mfg. Ltd.  
 Process Industries  
 Qualicast Corp.  
 RD Industries  
 Reef Gear  
 Manufacturing  
 Reilly Engineering Inc.  
 Robotronix Drive  
 Systems  
 SDMG, Inc.  
 Southern Gear &  
 Machine  
 Southern Sales &  
 Engineering  
 Sussex Gear Company  
 Technimet Corp.  
 Trogetec Inc.  
 Universal Technical  
 Systems  
**Van Gerpen-Reece**  
**Engineering**  
 Von Ruden  
 Manufacturing  
 Wedin International Inc.  
 Winzeler Gear  
 Wohlert Corp.  
 Xtek Inc.

**Merit Gear Corp.**  
 Mississippi State  
 University  
 Mobile Pulley &  
 Machine Works  
 Moore Machine & Gear  
 Power Eng. & Mfg. Ltd.  
 Process Industries  
 Qualicast Corp.  
 RD Industries  
 Reef Gear  
 Manufacturing  
 Reilly Engineering Inc.  
 Robotronix Drive  
 Systems  
 SDMG, Inc.  
 Southern Gear &  
 Machine  
 Southern Sales &  
 Engineering  
 Sussex Gear Company  
 Technimet Corp.  
 Trogetec Inc.  
 Universal Technical  
 Systems  
**Van Gerpen-Reece**  
**Engineering**  
 Von Ruden  
 Manufacturing  
 Wedin International Inc.  
 Winzeler Gear  
 Wohlert Corp.  
 Xtek Inc.

**Gear Engineering**

A. W. Sadler Machine  
 ABA-PGT Inc.  
 Accu-Prompt Inc.  
 The Adams Company  
 Akron Gear &  
 Engineering  
 Ashot Ashkelon  
 Industries  
**ATA Gears Inc.**  
 Axicon Technologies  
**Bourn & Koch**  
 Machine Tool

Brown & Sharpe  
 Manufacturing Co.  
 C-Dot Engineering  
 Calicut Engineering  
 Works Ltd.  
 Capstan Atlantic  
**Caterpillar Industrial**  
**Products Inc.**  
 Charles Bond Co.  
 Chicago Gear-D. O.  
 James  
 Chicago Gear Works  
 Cincinnati Gear  
 Columbia Gear Corp.  
 Consulting & Design  
 Service  
 Contour Hardening Inc.  
 Dabko Industries Inc.  
 DMS Inc.  
 Drive Systems  
 Technology  
 Dynamic Tool Grinding  
 Service

Equitable Engineering  
 Fairfield Manufacturing  
 Fairlane Gear Inc.  
**Fellows Corp.**  
 Gear Research Institute  
 Gear Systems Inc.  
 Gearesearch Assoc.  
 Gears & Drive Systems  
 Geartech  
 General Electric—  
 Marine Products Div.  
 Generated Gear &  
 Machine  
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 Components  
 Harnischfeger  
 Highway Machine Co.  
 Hy-Mech Systems Inc.  
 Invo Spline Inc.  
 Labeco  
 McGinty Gear  
**Merit Gear Corp.**  
 Mississippi State  
 University  
 Mobile Pulley &  
 Machine Works  
 Moore Machine & Gear  
 Power Eng. & Mfg. Ltd.  
 Process Industries  
 Qualicast Corp.  
 RD Industries  
 Reef Gear  
 Manufacturing  
 Reilly Engineering Inc.  
 Robotronix Drive  
 Systems  
 SDMG, Inc.  
 Southern Gear &  
 Machine  
 Southern Sales &  
 Engineering  
 Sussex Gear Company  
 Technimet Corp.  
 Trogetec Inc.  
 Universal Technical  
 Systems  
**Van Gerpen-Reece**  
**Engineering**  
 Von Ruden  
 Manufacturing  
 Wedin International Inc.  
 Winzeler Gear  
 Wohlert Corp.  
 Xtek Inc.

Equitable Engineering  
 Fairfield Manufacturing  
 Fairlane Gear Inc.  
**Fellows Corp.**  
 Gear Research Institute  
 Gear Systems Inc.  
 Gearesearch Assoc.  
 Gears & Drive Systems  
 Geartech  
 General Electric—  
 Marine Products Div.  
 Generated Gear &  
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**The Gleason Works**  
 GW Plastics Inc.  
 Harder Precision  
 Components  
 Harnischfeger  
 Highway Machine Co.  
 Hy-Mech Systems Inc.  
 Invo Spline Inc.  
 Labeco  
 McGinty Gear  
 Mobile Pulley &  
 Machine Works  
 Moore Machine & Gear  
 Morrison Knudsen  
 Power Eng. & Mfg. Ltd.  
 Precision Engineering  
 Services  
**Process Industries**  
**Profile Engineering**  
 Qualicast Corp.  
 Reef Gear  
 Manufacturing  
 Reilly Engineering Inc.  
 Riley Gear Corp.  
 Robotronix Drive  
 Systems  
 Southern Gear &  
 Machine  
 Southern Sales &  
 Engineering  
 Spline Gauges Ltd.  
 Sussex Gear Company  
 Technimet Corp.  
 Trogetec Inc.  
 Universal Technical  
 Systems  
 Von Ruden  
 Manufacturing  
 Wedin International Inc.  
 Winzeler Gear  
 Wohlert Corp.  
 Xtek Inc.

**Gear Grinding**

Accu-Prompt Inc.  
 Aerocom Industries Inc.  
 Akron Gear &

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 Manufacturing  
 Equipment

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- Cutting Tools
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 Ultra-Case • One Shot Hardening  
 Lift-Rotates • Power Supplies  
 Automation • Complete Factory Cells  
 Heat Treating Development

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 CORPORATION

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- ✓ or call Dave Burt, Training Manager, at 716-256-8761 for more information.

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**American Pfauter, L.P.**  
 Arrow Gear Co.  
 Ashot Ashkelon Industries  
 Boeing Precision Gear  
**Bourn & Koch Machine Tool Co.**  
**Caterpillar Industrial Products Inc.**  
 Charles Bond Co.  
 Cincinnati Gear  
 Columbia Gear Corp.  
 Dynamic Tool Grinding Service  
 Equitable Engineering  
 Fairfield Manufacturing  
 Fairlane Gear Inc.  
**Fellows Corp.**  
 Gear Motions  
 Gearcoa  
 Gears & Drive Systems  
 Generated Gear & Machine  
**The Gleason Works**  
 Invincible Gear Co.  
 Invo Spline Inc.  
**Merit Gear Corp.**  
**Midwest Gear**  
 Modified Gear & Spline  
 Moore Gear & Manufacturing Co.  
 Moore Machine & Gear  
**Niagara Gear Corp.**  
 Patterson Gear & Machine  
 Power Eng. & Mfg. Ltd.  
 Precision Gear Co.  
**Pro-Gear Co. Inc.**  
**Process Industries**  
 Qualicast Corp.  
 RD Industries  
 Reef Gear  
 Manufacturing  
 Riley Gear Corp.  
 Riverside Spline & Gear  
 Robotronix Drive Systems  
 SDMG, Inc.  
**Simon International Distribution**  
 Southern Gear & Machine  
 Tifco Inc.  
 USACH Technologies  
 Viking Air Tools  
 Wedin International Inc.  
 Xtek Inc.

**Gear Inspection**

A. W. Sadler Machine  
 ABA-PGT Inc.  
 Ace World Company  
 Accu-Prompt Inc.  
 Akron Gear & Engineering  
 Alpha Precision Inc.  
**American Pfauter, L.P.**  
 American Stress Technologies  
**American Sykes Co.**  
 Arrow Gear Co.  
 Ashot Ashkelon Industries  
**Aston Metallurgical Services**  
 Boeing Precision Gear  
**Bourn & Koch Machine Tool Co.**  
 Brown & Sharpe  
 Manufacturing Co.  
 Charles Bond Co.  
 Chicago Gear Works

Cincinnati Gear  
 Columbia Gear Corp.  
 Contour Hardening Inc.  
 Equitable Engineering  
 Fairfield Manufacturing  
 Fairlane Gear Inc.  
**Fellows Corp.**  
**Forest City Gear Co.**  
 Fuller Company  
 Gear Motions  
 Gearcoa  
 Gears & Drive Systems  
 Generated Gear & Machine  
**The Gleason Works**  
 Harder Precision Components  
 Highway Machine Co.  
 Invo Spline Inc.  
 Island Machinery  
 Jack Dustman & Assoc.  
**M&M Precision Systems**  
**Merit Gear Corp.**  
 Moore Gear & Manufacturing Co.  
 Moore Machine & Gear  
**National Broach & Machine Co.**  
 National Metrology  
**Niagara Gear Corp.**  
 Patterson Gear & Machine  
 Penn State  
 University/NCADT  
**Pfauter-Maag Cutting Tools**  
 Precision Gage Co.  
 Precision Gear Co.  
 Precision Gears Inc.  
**Process Industries**  
**Profile Engineering**  
 Qualicast Corp.  
 RD Industries  
 Reef Gear  
 Manufacturing  
 Riley Gear Corp.  
 Riverside Spline & Gear  
**Roto-Technology, Inc.**  
 SDMG, Inc.  
 Southern Gear & Machine  
 Spline Gauges Ltd.  
 Tifco Inc.  
 Trogetec Inc.  
 UBM Corporation  
 United Tool Supply  
 Viking Air Tools  
 Von Ruden  
 Manufacturing  
 Wedin International Inc.

**Heat Treating**

The Adams Company  
**Ajax Magnethermic American Metal Treating**  
**American Pfauter, L.P.**  
 Applied Process Inc.  
 Arrow Gear Co.  
 Ashot Ashkelon Industries  
 Boeing Precision Gear  
 Bucyrus-Erie Co.  
**Caterpillar Industrial Products Inc.**  
 Charles Bond Co.  
 Cincinnati Gear  
**Clifford-Jacobs Forging**  
 Contour Hardening Inc.  
 Detroit Flame Hardening  
 Disston Precision Inc.

Dynamic Metal Treating  
 Euclid Heat Treating Co.  
 Fairfield Manufacturing  
**Fellows Corp.**  
 FPM Heat Treating  
 Gearcoa  
 Gears & Drive Systems Inc.  
 Generated Gear & Machine  
**The Gleason Works**  
 Hamischfeger  
 Howard's Machine Shop  
**Inductoheat Inc.**  
 Linamar  
 Lindberg Heat Treating  
**Merit Gear Corp.**  
 Metlab Co.  
 Mobile Pulley & Machine Works  
 Molon Gear & Shaft  
 Moore Gear & Manufacturing Co.  
 Moore Machine & Gear  
**National Broach & Machine Co.**  
 Penn State  
 University/NCADT  
**Pillar Industries**  
 Progressive Engineering  
 Qualicast Corp.  
 RD Industries  
 Robotronix Drive Systems  
**Simon International Distribution**  
 TOCCO Inc.  
 Wedin International Inc.  
 Wells Manufacturing  
 Wohlert Corp.  
 Xtek Inc.

**Shot Peening**

The Adams Company  
 Arrow Gear Co.  
 Ashot Ashkelon Industries  
 Boeing Precision Gear  
 Cincinnati Gear  
 Columbia Gear Corp.  
 Fairfield  
 Manufacturing Co.  
**Fellows Corp.**  
 Generated Gear & Machine  
 Mobile Pulley & Machine Works  
 Qualicast Corp.  
 RD Industries  
 Wohlert Corp.

**Tool Coating**

**American Pfauter, L.P.**  
 Balzers Tool Coating  
 Best Engineering Co.  
**DiamondBLACK Technologies Inc.**  
 Dynamic Metal Treating Inc.  
**Fellows Corp.**  
 Fette Tool Systems  
 General Magnaplate Corp.  
 Jack Dustman & Assoc.  
 Moore Gear & Manufacturing Co.  
 Multi-Arc Inc.  
 P.F. Markey Inc.  
**Pfauter-Maag Cutting Tools**  
**Star Cutter Co.**

Wohlert Corp.  
**Gear Services—Other**  
 Accurate Specialties Inc.—Bronze Gear Blanks  
**AGMA—Standards Development**  
 Ascent Drafting Service—Drafting Service  
**Aston Metallurgical Services—Metallurgical, Mechanical & Chemical Testing**  
**ATA Gears Inc.—Custom Gearbox Design**  
 Capital Associates International—Machinery Leasing & Financing  
 Detroit Flame Hardening—Vibratory Stress Relief  
 Fairlane Gear Inc.—Noise Evaluation  
 Fuji Univance Corp.—Gear Transmissions  
 Geartech—Gear Seminars  
 Hy-Mech Systems Inc.—Technical Seminars on Gearing  
 International Financial Services—Machinery & Equipment Financing  
 Kluber Lubrication—Lubrication Analysis  
 Koeper America, L.P.—Hob Sharpening  
**Koro Sharpening Service—Hob Sharpening**  
 Metlab Co.—Annealing & Stress Relieving  
 Mikrofinish—Wear Enhancement  
 Modified Gear & Spline—Crown Gear Grinding  
 NASA Lewis Research Center—Consultation, Performance Testing  
 Ohio Broach & Machine Tool—Broaching Services  
 Precise Inspection—Instrument Repair  
 Precision Gear Co.—Gear Shaving, Broaching  
 Repair Parts Inc.—Hob Sharpening  
 Sales Consultants—Marketing Consulting, Executive Recruiting  
 Spline Gauges Ltd.—Master Gear Regrinding, NAMAS/NIST Calibration  
**Star Cutter—Hob Sharpening**  
 Stearns Financial—Consultants, Machinery Financing  
 Technimet Corp.—Metallurgical

Testing & Consulting  
 U.S. Tech Corporation—CNC Integration, Consulting and Software

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**American Pfauter, L.P.**  
**American Sykes Co.**  
 Axicon Technologies  
**Bourn & Koch Machine Tool Co.**  
 C-Dot Engineering  
 Ciateq  
 Drive Systems Technology  
 Euro-Tech Corporation  
 Gearesearch Assoc.  
 Gearsoft Design  
**The Gleason Works**  
 Hoglund Technology Corporation  
**M&M Precision Systems**  
 Mtrscope Corp.  
 NASA Lewis Research Center  
 PC Enterprises  
 Power Eng. & Mfg. Ltd.  
**Profile Engineering**  
 R.H. Software  
**Roto-Technology, Inc.**  
 Scott Machine Tool Co.  
 Software Engineering Service  
 Trogetec Inc.  
 U.S. Tech Corporation  
 Universal Technical Systems  
 User Solutions Inc.  
**Van Gerpen-Reece Eng. WMW Machinery Company**

**Software—Gear Design**

ABA-PGT Inc.  
 Accu-Prompt Inc.  
**American Gear Mfgs. Assn.**  
 Axicon Technologies  
 Bluegrass Precision Machinery  
 Ciateq  
 Contour Hardening Inc.  
 Drive Systems Technology  
**Ernst Winter & Son**  
 Fairfield Manufacturing  
 Gearesearch Assoc.  
 Gearsoft Design  
 Geartech  
**The Gleason Works**  
 NASA Lewis Research Center  
 PC Enterprises  
 Power Eng. & Mfg. Ltd.  
**Roto-Technology, Inc.**  
 Software Engineering Service  
 Trogetec Inc.  
 Universal Technical Systems  
**Van Gerpen-Reece Eng.**

**Software—Gear Inspection**

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**Bourn & Koch Machine Tool Co.**  
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 Contour Hardening Inc.  
 Euro-Tech Corporation  
 FGT Gage & Systems  
**The Gleason Works**  
**Lièbherr/Sigma Pool M&M Precision Systems**  
 Mtrscope Corp.  
 PC Enterprises  
 Penn State  
 University/NCADT  
**Pfauter-Maag Cutting Tools**  
 Precision Gage Co.  
**Profile Engineering**  
 R.H. Software  
**Roto-Technology Inc.**  
 Scott Machine Tool Co.  
 Software Engineering Service  
 Trogetec Inc.  
 Universal Technical Systems

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 Power Eng. & Mfg. Ltd.  
 R.H. Software  
 Scott Machine Tool Co.  
 Trogetec Inc.  
 U.S. Tech Corporation  
 User Solutions Inc.  
**WMW Machinery Company**

**Other Software**

Engis Corp.—Gear Grinding Software

**GEAR TOOLING & ACCESSORIES**

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 Bates Technologies Inc.  
 Best Engineering Co.  
 Bluegrass Precision Machinery  
**Bourn & Koch Machine Tool Co.**  
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 Engis Corp.  
**Ernst Winter & Son Inc.**  
**GMI**  
 Hoglund Technology Corporation  
 Lapmaster International  
 Meister Grinding Tech.  
 P. F. Markey Inc.  
**Redin Corp.**  
 Rex-Cut Products Inc.  
 Sidley Diamond Tool  
**Star Cutter Co.**  
 Sunnen Products Co.



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W. E. Litwin Assoc.

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General Broach & Engineering Co.  
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**National Broach & Machine Co.**  
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Ty Miles Inc.  
W.C. Divers & Associates

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Reid Tool Service Inc.

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EDM Solutions Co.  
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Hansvedt Industries, Inc.  
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KGG International Corp./Sodick EDM  
Koolant Coolers Inc.  
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Xermac, Inc.

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**Bourn & Koch**  
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**Höfler Maschinenbau GmbH**  
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**Star Cutter Co.**  
**SU America, Inc.**  
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**Liebherr/Sigma Pool**  
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**National Broach & Machine Co.**  
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Fiske Brothers Refining  
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**Oberlin Filter Co.**  
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Sunnen Products Co.

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Machine Tool Co.  
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**Liebherr/Sigma Pool**  
Mitsubishi Machine Tool  
**National Broach & Machine Co.**  
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GMI  
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JRM International Inc.  
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Kromhard Twist Drill  
Parker Industries Inc.  
Pfauter-Maag Cutting Tools  
Reid Tool Service Inc.  
Russell, Holbrook & Henderson  
Star Cutter Co.

**Gear Tooling & Accessories—Other**

A/W Systems Co.—Spiral Gear Cutters  
ABA-PGT Inc.—Thermal Plastic Injection Molds  
Abrasive Technology Inc.—Honing Tools, Diamond Tools  
American Wera Inc.—Tooling for Wera Profilers  
American Sykes Co.—Gear Hones, Rack Cutters, Adjustable Floating Reamers  
Barit International Corp.—Form-Relieved Milling Cutters  
Best Engineering Co.—Rack Cutters  
Buckeye Gear Co.—Change Gears  
Clipper Diamond Tool Co.—Diamond Dressing Rolls & Tools  
Etna Products Inc.—Quenching Oils, Rust Preventatives  
GW Plastics Inc.—Prototype & Production Molds  
Höfler Maschinenbau GmbH—Double-

**Tapered Grinding Wheels**  
Hoglund Technology Corporation—Plated CBN Grinding Wheels  
**ITW Heartland—Burnishing Dies**  
Koolant Coolers Inc.—Industrial Liquid Coolers/Chillers  
**M&M Precision Systems—Powder Metal Dies for Gears**  
Micromatic Textron—Spline & Thread Rolling Tools  
P.F. Markey Inc.—Hones  
**Pfauter-Maag Cutting Tools—Form Milling Cutters**  
Richter Precision Inc.—Titanium Nitride Coatings, Coating Equipment  
Spline Gauges Ltd.—Powder Metal/Cold Forging Tools  
**SU America, Inc.—Rotors**  
Sunnen Products Co.—Precision Bore Gages

**GEAR WORKHOLDING & FIXTURING**

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M&M Precision

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**Parker Industries Inc. Profile Engineering**  
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**Schunk Intec Inc.**  
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Toolink Engineering  
Triangle Machine Tool  
U.S. Tech Corporation  
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Bates Technologies Inc.  
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Bluco Corp.  
Bluegrass Precision Machinery  
**Bourn & Koch Machine Tool Co.**  
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**M&M Precision Systems**  
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**Schunk Intec Inc.**  
Toolink Engineering  
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American Sykes Co.  
Bates Technologies Inc.  
Bluco Corp.  
Bluegrass Precision

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Drewco Corp.  
**Elmass North America Fellows Corp.**  
General Broach & Engineering Co.  
Harder Precision Components  
**JRM International Inc.**  
Moore Products Co.—Gage Div.  
P.F. Markey Inc.  
Paul W. Marino Gages, Reid Tool Services Inc.  
**Schunk Intec Inc.**  
Sunnen Products Co.  
**Sytec Corp.**  
Triangle Machine Tool  
U.S. Tech Corporation  
USACH Technologies  
Viking Air Tools  
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Bluegrass Precision Machinery  
Drewco Corp.  
**Elmass North America Fellows Corp.**  
General Broach & Engineering Co.  
Harder Precision Components  
Jack Dustman & Assoc.  
**JRM International Inc.**  
Mobile Pulley & Machine  
P.F. Markey Inc.  
**Profile Engineering**  
Reid Tool Services Inc.  
**Schunk Intec Inc.**  
**Star Cutter Co.**  
Toolink Engineering  
Triangle Machine Tool  
U.S. Tech Corporation  
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**Gear Workholding & Fixturing—Other**

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Bluco Corp.—Expanding Mandrels  
Drewco Corp.—Hobbing/Shaving Fixtures  
**Fellows Corp.—Automation for Gear Production Systems**  
Interstate Tool Corp.—Herringbone Gear Cutter Sharpening Fixtures  
Invo Spline Inc.—Rolling Fixtures  
**JRM International Inc.—Centering Vises, Hydraulic Locknuts, Quick-change Shaper Adapters**  
Kaman Aerospace

Corp.—Test Rig for Gearboxes  
Paul W. Marino Gages, Inc.—Machine Probe Stylus  
**Schunk Intec Inc.—Centric Clamping Systems**  
**Sytec Corp.—Pitch Line Workholding**  
Tifco Inc.—Spline Arbors  
Ty Miles Inc.—Broach Tooling

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Ace World Company—Jed Heavy Industry (Korea)  
American Pfauter, L.P.—Zeiss-Höfler, Hurth, Kapp  
American Sykes Co.—James Technologies  
American Wera Inc.—Wera Werk Herman Werner GmbH  
Bluegrass Precision Machinery—Mitsubishi  
**Bourn & Koch Machine Tool—Hamai gear inspection machines**  
Brown & Sharpe Mfg. Co.—Leitz CMMs  
Eltech Inc.—SU America, M&M Precision Systems, Niles Grinders  
Euro-Tech Corporation—Frenco  
Gear Group International—Katsa, Parkano, Tasowheel  
**The Gleason Works—Fässler**  
Jack Dustman & Assoc.—American Broach, Cogsdill Tool Products, Speedgrip Chuck, Rohm of America, All Lube International  
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Mid-State Machine Co.—Victor Machinery  
Miller Industrial Services Inc.—Tornos, Ahlburg, Posalux, Mollart, Agathon, UVA, Kadia, Sulmecanica  
National Metrology—Metronics, Heidenhain  
Precision Gage Co.—Vari-Roll gear testers  
R.L. Wagner & Assoc.—Reef Gear, Ascoforge  
Reid Tool Service Inc.—Fellows  
Scott Machine Tool Co.—Carl Zeiss, Rank Taylor Hobson  
**Simon International**

**Distribution—Herzog GmbH**  
Southern Sales & Engineering—Horsburgh & Scott  
**Star Cutter Co.—Stieber**  
Toolink Engineering—MTM König  
U.S. Tech Corporation—Richardon GmbH  
V&R Associates—Hurth, Gould & Eberhardt, Laschet & Partner  
W. C. Divers & Associates—National Broach  
W. E. Litwin Assoc.—Special Tools, etc.  
**WMW Machinery Co.—Niles Werkzeugmaschinen**

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Penn State University/NCADT  
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**Bourn & Koch Machine Tool**  
Drive Systems Technology  
**Fellows Corp.**  
**The Gleason Works**  
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Koeper America, L.P.  
**National Broach & Machine Co.**  
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Universal Technical Systems  
Van Gerpen-Reece Eng.

**Research Institutions**

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Gearesearch Assoc.  
M.J. Gallagher & Assoc.  
NASA Lewis Research Center  
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American Society of Mechanical Engineers  
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# COMPANY INDEX

Welcome to the newly expanded and revised 1995 *Gear Technology* Buyers Guide. This year we bring you more listings and more categories to help you find the gear products and services you need.

Use this Company Index to locate the complete address, phone number and fax number for each company listed in the Products and Services directory. *Gear Technology* advertisers are shown in boldface type. To find the pages on

which their ads appear, see the Advertisers Index on page 32.

While *Gear Technology* has made every effort to ensure that company names and addresses are correct, we cannot be held responsible for errors of fact or omission. If your company was not listed in this directory and would like to be included in 1996, call 708-437-6604 or fax 708-437-6618, and we will add you to our mailing list.

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RD1, Box 43D Montmorenci Rd.  
Ridgway, PA 15853  
814-773-3191  
Fax: 814-776-1009

**Amarillo Gear Co.**  
**2401 Sundown Lane**  
**Amarillo, TX 79105**  
**806-622-1273**  
**Fax: 806-622-3258**

**American Gear**  
**Manufacturers Assn.**  
**1500 King St., Suite 201**  
**Alexandria, VA 22314-2730**  
**703-684-0211**  
**Fax: 703-684-0242**

American Machine Works  
1210 Jackson St.  
Omaha, NE 68102  
402-342-4881  
Fax: 402-342-8061

**American Metal Treating**  
**1043 E. 62nd St.**  
**Cleveland, OH 44103**  
**216-431-4492**  
**Fax: 216-431-1508**

**American Pfauter, L.P.**  
**1351 Windsor Rd.**  
**Loves Park, IL 61111**  
**815-282-3000**

Fax: 815-282-3075

American Society of Manufacturing Engineers  
345 E. 47th Street  
New York, NY 10017  
212-705-7338

American Speed Reducer  
3375 Richmond St.  
Philadelphia, PA 19134  
215-426-9115  
Fax: 215-426-9101

American Stress Technologies  
61 McMurray Rd.  
Pittsburgh, PA 15241  
412-854-0789  
Fax: 412-854-1290

**American Sykes Co.**  
**1302 Research Park Dr.**  
**Beavercreek, OH 45432**  
**513-427-0507**  
**Fax: 513-427-9653**

American Wera Inc.  
4630 Freedom Dr.  
Ann Arbor, MI 48108  
313-973-7800  
Fax: 313-973-3053

Ancon Gear & Instrument Corp.  
149 Verdi St.  
Farmingdale, NY 11735  
516-694-5255  
Fax: 516-694-5056

Anderson-Cook Inc.  
44785 Macomb Ind. Dr.  
Clinton Twp., MI 48036  
810-954-0700  
Fax: 810-954-0706

Anderson International Corp.  
6200 Harvard Ave.  
Cleveland, OH 44105-4896  
216-641-1112  
Fax: 216-641-0709

Apex Broach & Machine Co.  
6401 E. Seven Mile Rd.  
Detroit, MI 48234  
313-891-8600  
Fax: 313-891-5083

Applied Process Inc.  
12238 Newburgh Rd.  
Livonia, MI 48150-1046  
313-464-2030  
Fax: 313-464-6314

Arrow Gear Co.  
2301 Curtiss St.  
Downers Grove, IL 60515  
708-969-7640  
Fax: 708-969-0253

Ascent Drafting Service  
7050 Rodney Dr. #4  
Los Angeles, CA 90027  
213-913-2711

Asco Sintering Co.  
2750 S. Garfield Ave.  
Commerce, CA 90040  
614-882-7460  
Fax: 614-882-7396

Ashot Ashkelon Indust.  
P.O. Box 21  
78100 Ashkelon  
Israel  
972-7-729186  
Fax: 972-7-728167

ASM International  
Materials Park, OH 44073  
216-338-5151  
Fax: 216-338-4634

**Aston Metallurgical Services**  
**4201 N. Ravenswood Ave.**  
**Chicago, IL 60613**  
**312-528-9830**  
**Fax: 312-929-0773**

**ATA Gears Inc.**  
**1340 Depot St.**  
**Cleveland, OH 44116**  
**216-331-2231**  
**Fax: 216-356-0289**

Axicon Technologies  
1521-A Shattuck Ave.  
Suite 203  
Berkeley, CA 94709  
510-843-8300  
Fax: 510-268-1165

## B

Balzars Tool Coating Inc.  
661 Erie Ave.  
N. Tonawanda, NY 14120  
800-435-5010  
Fax: 716-695-1995

**Barit International Corp.**  
**3384 Commercial Ave.**  
**Northbrook, IL 60062**  
**708-272-8128**  
**Fax: 708-272-8210**

**Basic Machine Tools**  
**2619 Exposition Blvd.**  
**Los Angeles, CA 90018**  
**213-933-7191**  
**Fax: 213-933-7487**

Bates Technologies Inc.  
9059 Technology Dr.  
Fishers, IN 46038  
800-331-6778  
Fax: 317-841-9443

Bengal Industries Inc.  
11346 53rd St. North  
Clearwater, FL 34620  
813-572-4249  
Fax: 813-573-2428

Best Engineering Co.  
2385 S. 162nd St.  
New Berlin, WI 53151

## COMPANY INDEX

414-784-2200  
 Fax: 414-784-2541  
 Bluco Corp.  
 135 E. St. Charles Rd.  
 Carol Stream, IL 60188  
 800-535-0135  
 Fax: 708-690-4683

Blue Water Industrial Service  
 2880 Bardamar  
 Fort Gratiot, MI 48059  
 810-385-1820  
 Fax: 810-385-1820

Bluegrass Precision Machinery  
 442 Three Springs Rd.  
 Bowling Green, KY 42104  
 502-842-7201  
 Fax: 502-842-7242

Boeing Precision Gear  
 5136 S. New England  
 Chicago, IL 60638  
 312-847-4211

Boston Gear—Div. of IMO  
 14 Hayward St.  
 Quincy, MA 02171  
 617-328-3300  
 Fax: 617-479-6238

**Bourn & Koch Machine Tool**  
**2500 Kishwaukee St.**  
**Rockford, IL 61104**  
**815-965-4013**  
**Fax: 815-965-0019**

Boxx Gear Mfg.  
 1314 Central Pkwy SW  
 Decatur, AL 35601  
 205-355-4611  
 Fax: 205-355-4661

Brown & Sharpe Mfg. Co.  
 200 Frenchtown Rd.  
 North Kingstown, RI 02852  
 401-886-2369  
 Fax: 401-886-2970

Buckeye Gear Co.  
 5130 Richmond Rd.  
 Bedford Heights, OH 44146  
 216-292-6424  
 Fax: 216-292-6454

Bucyrus-Erie Co.  
 1100 Milwaukee Ave.  
 S. Milwaukee, WI 53172  
 414-768-4361  
 Fax: 414-768-4750

### C

C-Dot Engineering  
 14900 Robinwood  
 Plymouth, MI 48170-2660  
 810-726-5286  
 Fax: 810-726-5239

Calicut Engineering Works Ltd.  
 26A, Camac St.  
 Calcutta, W.B. 700016  
 INDIA  
 (91) 33-2475693  
 Fax: (91) 33-2476072

Can-Eng Furnaces Ltd.  
 P.O. Box 235  
 Niagara Falls, NY 14302  
 905-356-1327  
 Fax: 905-356-1817

Capital Associates International  
 4598 Valleyview Dr., Suite 200

West Bloomfield, MI 48323  
 810-855-0855  
 Fax: 810-855-0972

Capstan Atlantic  
 10 Cushing Drive  
 Wrentham, MA 02093  
 508-384-3100  
 Fax: 508-384-3196

Carbon City Products  
 150 Ford Rd.  
 St. Marys, PA 15857  
 814-834-2886  
 Fax: 814-834-9091

Case Corp.  
 700 State St.  
 Racine, WI 53404  
 414-636-0266  
 Fax: 414-636-7132

**Caterpillar Industrial Products Inc.**  
**100 N. E. Adams St.**  
**Peoria, IL 61629-4355**  
**309-675-4059**  
**Fax: 309-675-6457**

Chardam Gear Co.  
 40810 Brentwood  
 Sterling Heights, MI 48310  
 810-795-8900  
 Fax: 810-795-8908

Charles A. Templeton  
 Machine Inc.  
 2727 N. Golder  
 Odessa, TX 79764  
 915-332-2932  
 Fax: 915-332-0412

Charles Bond Co.  
 1035 Louis Dr.  
 Warminster, PA 18974  
 800-922-0125  
 Fax: 215-957-7900

Charmilles Technologies Corp.  
 560 Bond St.  
 Lincolnshire, IL 60069  
 708-913-5300  
 Fax: 708-913-5340

Chicago Gear-D. O. James  
 2823 W. Fulton St.  
 Chicago, IL 60612  
 312-638-0508  
 Fax: 312-638-7161

Chicago Gear Works  
 1805 S. 55th Ave.  
 Cicero, IL 60650  
 708-863-2700  
 Fax: 708-863-2749

Ciateq  
 Retablo 150  
 Queretaro 76150  
 QRO, Mexico  
 (52) 42163808  
 Fax: (52) 42169963

Cincinnati Gear  
 5657 Wooster Pike  
 Cincinnati, OH 45227  
 513-271-7700  
 Fax: 513-271-0049

Cincinnati Milacron  
 4701 Marburg Ave.  
 Cincinnati, OH 45209  
 513-841-8121  
 Fax: 513-841-7178

Clarke Gear Co., Inc.  
 8058 Lankershim Blvd.  
 N. Hollywood, CA 91605  
 818-768-0690  
 Fax: 818-767-5577

**Clifford-Jacobs Forging Co.**  
**2410 N. Fifth Street**  
**Champaign, IL 61824**  
**217-352-5172**  
**Fax: 217-352-4629**

Clipper Diamond Tool Co.  
 47-16 Austell Pl.  
 Long Island City, NY 11101  
 718-392-3671  
 Fax: 718-392-4124

Cloyes Gear & Products Inc.  
 4520 Beidler Rd.  
 Willoughby, OH 44094  
 216-942-8200  
 Fax: 216-942-1422

Columbia Gear Corp.  
 530 County Road 50  
 Avon, MN 56310  
 612-356-7301  
 Fax: 612-356-2131

Comtorgage Corporation  
 58 NS Industrial Dr.  
 Slatersville, RI 02876  
 401-765-0900  
 Fax: 401-765-2846

Consulting & Design Service  
 17033 E. Aloe  
 Fountain Hills, AZ 85268  
 602-837-8283  
 Fax: 602-837-8211

Contour Hardening Inc.  
 7898 Zionsville Rd.  
 Indianapolis, IN 46268  
 317-876-1530  
 Fax: 317-879-2484

Cornell Forge Co.  
 6666 W. 66th St.  
 Chicago, IL 60638  
 312-767-4242  
 Fax: 312-767-9443

Crucible Service Centers  
 5639 W. Genesee St.  
 Camillus, NY 13031-0991  
 315-487-0800  
 Fax: 315-487-4028

Cunningham Industries  
 102 Lincoln Ave.  
 Stamford, CT 06902  
 203-324-2942  
 Fax: 203-324-6039

Current EDM, Inc.  
 2577 Leghorn St.  
 Mountain View, CA 94043  
 415-966-9676  
 Fax: 415-966-1881

Custom Electric Mfg.  
 48973 West Rd.  
 Wixom, MI 48393  
 810-305-7700  
 Fax: 810-305-7705

### D

D. A. Stuart Co.  
 7575 Plaza Court  
 Willowbrook, IL 60521

708-655-4595  
 Fax: 708-655-1088

Dabko Industries Inc.  
 61 E. Main St.  
 Forestville, CT 06010  
 800-437-3398  
 Fax: 203-583-6902

Dana Corp.  
 2424 W. State  
 Fort Wayne, IN 46801  
 219-481-3437  
 Fax: 219-481-3115

The Daniluk Corp.  
 8200 S.W. 29th St.  
 Oklahoma City, OK 73179  
 405-745-6644  
 Fax: 405-745-6646

Davis Tool & Engineering  
 19250 Plymouth Rd.  
 Detroit, MI 48228  
 313-835-6000  
 Fax: 313-837-7220

Dayton Gear & Tool  
 500 Fame Rd.  
 Dayton, OH 45449  
 513-866-4327  
 Fax: 513-866-0408

Dearborn Gear & Tool Co.  
 4300 Cabot  
 Detroit, MI 48210  
 313-581-3111  
 Fax: 313-581-3115

Deco-Technologies  
 1360 E. Big Beaver  
 Troy, MI 48083  
 810-524-9800  
 Fax: 810-524-9804

Delroyd Worm Gear—Div. of IMO  
 121 First Ave.  
 Trenton, NJ 08650  
 800-432-0121  
 Fax: 609-890-6800

Designatronics  
 2101 Jericho Turnpike  
 New Hyde Park, NY 11042-5416  
 516-328-3300  
 Fax: 516-326-8827

Detroit Broach Co.  
 431 S. Buncombe Rd.  
 Greer, SC 29651  
 803-879-7641  
 Fax: 803-879-8811

Detroit Flame Hardening  
 17644 Mt. Elliott  
 Detroit, MI 48212  
 313-891-2936  
 Fax: 313-891-3150

**Diamond BLACK Technologies Inc.**  
**100 Somerset Dr.**  
**Conover, NC 28613**  
**704-327-7442**  
**Fax: 704-322-4636**

Dianamic Abrasive Products Inc.  
 2566 Industrial Row  
 Troy, MI 48084  
 810-280-1185  
 Fax: 810-280-2733

Disston Precision Inc.  
 6795 State Rd.

Philadelphia, PA 19135  
215-338-1200  
Fax: 215-338-7060

DMS Inc.  
554 W. Wood  
Palatine, IL 60067  
708-359-7882  
Fax: 708-359-8481

Drewco Corp.  
3745 Nicholson Rd.  
Franksville, WI 53126  
414-886-5050  
Fax: 414-886-5872

Drive Systems Technology  
24 Marlborough Ln.  
Glen Mills, PA 19342-1519  
610-358-0785  
Fax: 610-358-2776

**Dura-Bar**  
2100 W. Lake Shore Dr.  
Woodstock, IL 60193  
815-338-7800  
Fax: 815-338-1549

Dynamic Metal Treating Inc.  
7857 Ronda Dr.  
Canton Twp., MI 48187  
313-459-8022  
Fax: 313-459-7863

Dynamic Tool Grinding Service  
872 Ridge Ave.  
Lombard, IL 60148  
708-620-5044  
Fax: 708-620-0177

**E**

Easco-Sparcatron  
10799 Plaza Dr.  
Whitmore Lake, MI 48189  
800-523-4449  
Fax: 313-449-4447

Eaton Corp.  
Highway 29 S.  
Kings Mountain, NC 28086  
704-937-7411  
Fax: 704-937-4354

EDM Solutions Co.  
2010 East Touhy Ave.  
Elk Grove Village, IL 60007  
708-981-3361  
Fax: 708-981-0158

**Elmass North America Inc.**  
N114 W19320 Clinton Dr.  
Germantown, WI 53022  
414-255-5644  
Fax: 414-255-6509

Engemaq U.S.A.  
Montville Business Center  
20 Chapin Rd., Unit 1002A  
Pine Brook, NJ 07058  
201-808-2665  
Fax: 201-808-5258

Engis Corp.  
105 W. Hintz Rd.  
Wheeling, IL 60090  
708-808-9400  
Fax: 708-808-9430

Engratec de Mexico  
Poniente 128, #425  
Nueva Vallejo, D.F. 07750  
Mexico  
(52) 567-73-43

Fax: (52) 567-32-06

Equitable Engineering  
1840 Austin  
Troy, MI 48099  
810-689-9700  
Fax: 810-689-0281

**Ernst Winter & Son Inc.**  
100 Wilhelm Winter St.  
Travelers Rest, SC 29690  
803-834-4145  
Fax: 803-834-3730

Etna Products Inc.  
16824 Park Circle Dr.  
Chagrin Falls, OH 44022  
216-543-9845  
Fax: 216-543-1789

Euclid Heat Treating Co.  
1408 E. 222nd St.  
Cleveland, OH 44117  
216-481-8444  
Fax: 216-481-3473

Euro-Tech Corporation  
14665 W. Lisbon Rd.  
Brookfield, WI 53005  
414-781-6777  
Fax: 414-781-2822

**F**

Fairfield Mfg. Co.  
U. S. 52 South  
Lafayette, IN 47903-7940  
317-474-3474  
Fax: 317-477-7342

Fairlane Gear Inc.  
8182 Canton Center Rd.  
Canton, MI 48187  
313-459-2440  
Fax: 313-459-2941

Fayscott Co.  
225 Spring St.  
Dexter, ME 04930  
207-924-7331  
Fax: 207-924-5510

**Fellows Corp.**  
Precision Dr.  
Springfield, VT 05156  
802-886-8333  
Fax: 802-886-2700

Fette Tool Systems  
3725-I No. 126 St.  
Brookfield, WI 53005  
414-783-7606  
Fax: 414-783-5043

FGT Gage & Systems, Inc.  
2624 S. 162nd St.  
New Berlin, WI 53151  
414-827-0558  
Fax: 414-781-2284

Finishing Equipment Inc.  
3640 Kennebec Dr.  
St. Paul, MN 55122  
612-452-1860  
Fax: 612-452-9851

Fiske Brothers Refining Co.  
1500 Oakdale Ave.  
Toledo, OH 43605  
800-347-5343  
Fax: 419-693-3806

Flender Corp.  
1589 Aztec Ln.

Mount Pleasant, SC 29464  
803-856-0108  
Fax: 803-856-0104

**Forest City Gear Co.**  
11715 Main St.  
Roscoe, IL 61073  
815-623-2168  
Fax: 815-623-6620

FPM Heat Treating  
1501 S. Lively Blvd.  
Elk Grove Village, IL 60007  
708-228-2525  
Fax: 708-228-5912

Franke Gear Works Inc.  
4401 Ravenswood Ave.  
Chicago, IL 60640  
312-561-0950  
Fax: 312-561-9078

Fuji Univance Corp.  
38505 Country Club Dr.  
Suite 204  
Farmington Hills, MI 48331  
810-489-5641  
Fax: 810-489-5642

Fuller Company  
South 10th & Mill St.  
Allentown, PA 18103  
610-770-7400  
Fax: 610-770-7429

**G**

Gearcoa  
14300 Lorain Ave.  
Cleveland, OH 44111  
216-671-5400  
Fax: 216-671-5825

Gear Group International  
1825 I St., N.W.  
Washington, DC 20006  
202-429-2734  
Fax: 703-522-7153

Gear Motions  
1750 Milton Ave.  
Syracuse, NY 13209  
315-488-0100  
Fax: 315-488-0196

Gear Research Institute  
1801 Maple Ave.  
Evanston, IL 60201  
708-491-5900  
Fax: 708-491-5986

Gear Systems Inc.  
23400 Apollo Ct.  
Lake Villa, IL 60046  
708-356-1606  
Fax: 708-356-1631

Gearesearch Assoc.  
750 Indian Wells Rd.  
Banning, CA 92220-5308  
909-845-5822  
Fax: 909-845-5822

Gears & Drive Systems Inc.  
1364 Welsh Rd.  
Spring House, PA 19477-0109  
215-540-0820  
Fax: 215-540-0360

Gears for Industry Inc.  
1925 S. Moorland Rd.  
New Berlin, WI 53151  
414-797-9960  
Fax: 414-797-9245

Gearsoft Design  
8/26 Huxtable Ave.  
Lane Cove 2066  
Australia  
(61) 2-4111282  
Fax: (61) 2-4111282

Geartech  
1017 Pomona Ave.  
Albany, CA 94706  
510-524-8943  
Fax: 510-524-7060

Geartronics Industries  
100 Chelmsford Rd.  
North Billerica, MA 01862  
617-933-1400  
Fax: 508-667-3130

General Broach & Engineering Co.  
13231 Twenty-Three Mile Rd.  
Shelby Twp., MI 48315-2713  
810-598-7594  
Fax: 810-949-8007

General Electric—  
Marine Products Div.  
1100 Western Ave.  
Lynn, MA 01910  
617-594-7298  
Fax: 617-594-2464

General Magnaplate Corp.  
1331 Route 1  
Linden, NJ 07036  
908-862-6200  
Fax: 908-862-0497

Generated Gear & Machine  
25418 Ryan Rd.  
Warren, MI 48091  
810-756-6470  
Fax: 810-756-8517

**The Gleason Works**  
1000 University Ave.  
Rochester, NY 14692  
716-473-1000  
Fax: 716-461-4348

**GMI**  
6709 Ivandale Rd.  
Independence, OH 44131-0038  
216-642-0230  
Fax: 216-642-0231

GW Plastics  
113 Pleasant St.  
Bethel, VT 05032  
802-234-9941  
Fax: 802-234-9940

**H**

Hand Screw Machine  
17703 Pennsylvania Ave.  
Maple Hts., OH 44137  
216-475-0220

Hane Industrial Training  
120 S. 7th St.  
Terre Haute, IN 47807  
812-232-0753  
Fax: 812-232-3978

Hansvedt Industries, Inc.  
803 Kettering Park  
Urbana, IL 61801  
217-384-5900  
Fax: 217-384-0091

Harder Precision Components  
1123 Seminole St.  
Clearwater, FL 34615

813-442-4212  
Fax: 813-447-4463

Harley-Davidson  
3700 W. Juneau Ave.  
Milwaukee, WI 53201  
414-535-3747

Harnischfeger  
4400 W. National  
Milwaukee, WI 53201  
414-671-7684  
Fax: 414-671-7309

Harper Surface  
Finishing Systems  
70 Gracey Ave.  
Meriden, CT 06450  
203-630-0550  
Fax: 203-630-0346

Hermes Machine  
Tool Co., Inc.  
5 Gardner Rd.  
Fairfield, NJ 07004  
201-227-9150  
Fax: 201-227-9364

Highway Machine Co.  
RR#1 Box 208A  
Princeton, IN 47670  
812-385-3639  
Fax: 812-385-5232

Hitachi EDM Products  
1555 Barclay Blvd.  
Buffalo Grove, IL 60089  
708-808-0098  
Fax: 708-808-0233

Hoechst Celanese Corp.  
90 Morris Ave.  
Summit, NJ 07901  
908-598-4000  
Fax: 908-598-4330

**Höfler Maschinenbau GmbH**  
Industriestr. 19  
Ettlingen 76258  
Germany  
(49) 7243-599-0  
Fax: (49) 7243-599-165

Hoglund Technology Corp.  
1050 Route 22 West  
Lebanon, NJ 08833  
908-236-7794  
Fax: 908-236-6826

Houghton International Inc.  
Madison and Van Buren Avenues  
Valley Forge, PA 19482  
610-666-4000  
Fax: 610-666-1376

Howard's Machine Shop  
2230 S. Main St.  
Carthage, MO 64836  
417-358-7143  
Fax: 417-358-3130

Hy-Mech Systems Inc.  
3641 E. Long Lake Rd.  
Traverse City, MI 49684  
616-946-7781

**Inductoheat Inc.**  
32251 N. Avis Dr.  
Madison Hts., MI 48071  
810-585-9393  
Fax: 810-589-1062

Interlake Hoeganaes  
River Rd. & Taylors Ln.  
Riverton, NJ 08077  
609-829-2220

International Financial Services  
Nine Village Circle, Suite 450  
Westlake, TX 76034  
817-488-3230  
Fax: 817-488-3345

Interstate Tool Corp.  
4538 W. 130th  
Cleveland, OH 44135  
216-671-1077  
Fax: 216-671-5431

Invincible Gear Co.  
11970 Mayfield  
Livonia, MI 48150  
313-421-4620  
Fax: 313-421-6132

Invo Spline Inc.  
2357 E. Nine Mile Rd.  
Warren, MI 48090  
810-757-8840  
Fax: 810-757-8849

Island Machinery  
26 Wells East  
Hilton Head, SC 29926  
803-681-9697

**ITW Heartland**  
1205 36th Ave. West  
Alexandria, MN 56308  
612-762-5223  
Fax: 612-762-5260

ITW Spiroid  
3700 W. Lake Ave.  
Glenview, IL 60025  
708-657-5074  
Fax: 708-657-5098

**J**

Jack Dustman & Assoc.  
3600 Washington Blvd.  
Indianapolis, IN 46205  
317-925-3537  
Fax: 317-925-3383

JobBOSS Software, Inc.  
7701 York Ave.  
Minneapolis, MN 55435  
612-831-7182  
Fax: 612-831-3055

**JRM International Inc.**  
1214 Shappert Dr.  
Rockford, IL 61115  
815-282-9330  
Fax: 815-282-9150

**K**

KA-Wood Gear & Machine  
32500 Industrial Dr.  
Madison Heights, MI 48071  
810-585-8870  
Fax: 810-585-3011

Kaman Aerospace Corp.  
Blue Hills Ave.  
Bloomfield, CT 06002  
203-243-7929  
Fax: 203-243-7276

Keller Machine Co.  
315 N. Leavitt St.  
Chicago, IL 60612

312-421-5285  
Fax: 312-421-4102

Keystone Carbon Company  
1935 State St.  
St. Marys, PA 15857  
814-781-1591  
Fax: 814-781-7648

KGK International/Sodick EDM  
901 Deerfield Parkway  
Buffalo Grove, IL 60089  
708-465-4432  
Fax: 708-465-0181

KH Huppert Co.  
16850 S. State St.  
South Holland, IL 60473  
708-339-2020  
Fax: 708-339-2225

Kluber Lubrication North America  
54 Wentworth Ave.  
Londonderry, NH 03053  
603-434-7704  
Fax: 603-434-8046

Koepfer America, L.P.  
1965 Salem Rd.  
S. Elgin, IL 60177  
708-931-4121  
Fax: 708-931-4192

Kokusai Inc.  
6009 W. 71st St.  
Indianapolis, IN 46278  
317-293-6038  
Fax: 317-293-6514

Koolant Coolers Inc.  
2625 Emerald Dr.  
Kalamazoo, MI 49001  
800-968-5665  
Fax: 616-349-8951

**Koro Sharpening Services**  
9530 85th Avenue N.  
Maple Grove, MN 55369  
612-425-5247

Krautkramer Branson  
50 Industrial Park Rd.  
Lewistown, PA 17044  
717-242-0327  
Fax: 717-242-2606

Kromhard Twist Drill Co.  
1097 Sweitzer Ave.  
Akron, OH 44301-1382  
216-535-7129  
Fax: 216-535-3729

Krupp Engineering Inc.  
8121 Gregory Road  
Dexter, MI 48130  
313-426-2604  
Fax: 313-426-2450

**L**

L & H Welding & Machine Co.  
913 L & J Court  
Gillette, WY 82716  
(307) 682-7238  
Fax: (307) 686-1646

Labeco  
156 E. Harrison St.  
Mooreville, IN 46158  
317-831-2990  
Fax: 317-831-2978

Lamont Gear  
1850 Gravers Rd.

Norristown, PA 19401  
610-277-7350  
Fax: 610-277-3787

Lapmaster International  
6400 Oakton St.  
Morton Grove, IL 60053  
708-967-2975  
Fax: 708-967-2975

Latrobe Steel Co.—Div. of Timken  
P.O. Box 31  
Latrobe, PA 15650-0031  
412-537-7711  
Fax: 412-532-6521

LeBlond Makino Machine Tool Co.  
7680 Innovation Way  
Mason, OH 45040  
513-573-7330  
Fax: 513-573-7360

LeCount, Inc.  
12 Dewitt Dr.  
White River Junction, VT 05001  
802-296-2200  
Fax: 802-296-6843

**Liebherr/Sigma Pool**  
1465 Woodland Dr.  
Saline, MI 48076  
313-429-7225  
Fax: 313-429-2294

Linamar  
30555 Southfield Rd., Suite 250  
Southfield, MI 48076  
810-642-0800  
Fax: 810-642-7815

Lindberg Heat Treating  
1975 N. Ruby St.  
Melrose Park, IL 60160  
708-344-4080  
Fax: 708-344-4010

Lovejoy Inc.  
2655 Wisconsin Ave.  
Downers Grove, IL 60515  
708-852-0500  
Fax: 708-852-2120

**M**

**M&M Precision Systems**  
300 Progress Rd.  
West Carrollton, OH 45449  
513-859-8273  
Fax: 513-859-4452

M.J. Gallagher & Assoc.  
P.O. Box 281  
Spring Grove, IL 60081  
815-675-2648  
Fax: 815-675-2648

M.J.H. Gear & Tool Co.  
442 W. 49th St.  
New York, NY 10019  
212-246-3800  
Fax: 212-265-4053

Manufacturing Technology Inc.  
1702 W. Washington  
South Bend, IN 46628  
219-233-9490  
Fax: 219-233-9489

Mattoon Precision Mfg. Inc.  
1221 Old State Rd.  
Mattoon, IL 61938  
217-235-6000  
Fax: 217-235-6010

## COMPANY INDEX

McEnglevan Industrial Furnace  
700 Griggs St.  
Danville, IL 61834  
217-446-0941  
Fax: 217-446-0943

McGinty Gear  
11050 McKeese Rd.  
Suttons Bay, MI 49682  
616-271-4153

Mecatool USA Ltd.  
165 Hansen Ct., #111E  
Wood Dale, IL 60191  
708-595-9696  
Fax: 708-595-9101

Meister Grinding Tech.  
1200 Millbury St. Unit 7F  
Worcester, MA 01607  
508-753-0808  
Fax: 508-753-4404

Merger Corp.  
978 Southampton Rd.  
Westfield, MA 01085-1364  
413-568-6181  
Fax: 413-568-6839

Merit Gear Corp.  
810 Hudson St.  
Antigo, WI 54409  
800-756-3748  
Fax: 715-623-2990

Metal Powder Industries Federation  
105 College Road East  
Princeton, NJ 08540  
609-452-7700  
Fax: 609-987-8523

Metaplas Ionon  
14301-C South Lakes Dr.  
Charlotte, NC 28273  
704-587-4554  
Fax: 704-587-4560

Metlab Co.  
1000 E. Mermaid Ln.  
Wyndmoor, PA 19038  
215-233-2600  
Fax: 215-233-5653

Metrscope Corp.  
355 Woodruff Rd., Suite 405  
Greenville, SC 29607  
Fax: 803-234-4852

Michigan Automatic Turning  
1375 Rickett Rd.  
Brighton, MI 48116  
810-227-3520  
Fax: 810-227-1014

Micromatic Textron  
345 E. 48th St.  
Holland, MI 49423  
616-392-1461  
Fax: 616-392-1710

Micron Instrument Corp.  
50 Alexander Ct.  
Ronkonkoma, NY 11779  
516-467-8000  
Fax: 516-467-9814

Mid-State Machine Co.  
2960 Corriher Grainge Rd.  
Mount Ulla, NC 28125  
704-636-7029  
Fax: 704-637-3484

Midwest Gear  
2182 E. Aurora Rd.  
Twinsburg, OH 44087

216-425-4419  
Fax: 216-425-8600

Mikrofinish  
1275 Bloomfield Ave.  
Fairfield, NJ 07004  
201-227-8777  
Fax: 201-227-7953

Miller Industrial Services Inc.  
9415 W. Forest Home Ave.  
Hales Corners, WI 53130  
414-425-7766  
Fax: 414-425-7090

Mississippi State Univ.  
Mechanical Engineering Dept.  
210 Carpenter Bldg.  
Mississippi State, MS 39762  
601-325-7313  
Fax: 601-325-7223

Mitsubishi EDM/MC Machinery  
1500 Michael Dr., Suite C  
Wood Dale, IL 60191  
708-860-4210  
Fax: 708-860-2572

Mitsubishi Machine Tool  
907 W. Irving Park Rd.  
Itasca, IL 60143  
708-860-4222  
Fax: 708-860-4233

Mitts & Merrill L.P.  
615 Chippewa Dr.  
Harvard, IL 60033  
815-943-3303  
Fax: 815-943-3366

Mobile Pulley & Machine  
Works Inc.  
905 S. Ann St.  
Mobile, AL 36633  
334-432-7631  
Fax: 334-432-8364

Modified Gear & Spline  
18300 Mt. Elliott  
Detroit, MI 48234  
313-893-3511  
Fax: 313-893-6110

Molon Gear & Shaft  
335 E. Illinois St.  
Palatine, IL 60067  
708-259-3750  
Fax: 708-705-8349

Moore Gear & Mfg. Co.  
Two Hawthorne Dr.  
Hermann, MO 65041  
314-486-5415  
Fax: 314-486-3487

Moore Machine & Gear  
10920 N. St. Joseph Ave.  
Evansville, IN 47720  
812-963-3074

Moore Products Co.  
—Gage Division  
One Sumneytown Pike  
Spring House, PA 19477-0900  
215-646-7400  
Fax: 215-653-0347

Morrison Knudsen  
1500 W. 3rd St.  
Cleveland, OH 44113  
216-523-5600

Multi-Arc Inc.  
200 Roundhill Dr.  
Rockaway, NJ 07866

201-625-3400  
Fax: 201-625-2244

Murray Brothers Mfg.  
7711 W. 99th St.  
Hickory Hills, IL 60457  
708-430-8111  
Fax: 708-430-8222

### N

NASA Lewis Research Center  
21000 Brookpark Rd.  
Cleveland, OH 44135  
216-433-3915  
Fax: 216-433-3954

National Broach & Machine Co.  
17500 Twenty-Three Mile Rd.  
Macomb, MI 48044  
810-263-0100  
Fax: 810-263-4571

National Metrology  
11 Stagecoach Ln.  
Sunapee, NH 03782  
603-763-5881  
Fax: 603-763-3058

NCADT  
Pennsylvania State University  
P.O. Box 30  
State College, PA 16804-0030  
814-865-8207  
Fax: 814-863-1183

New Venture Gear Inc.  
1650 Research Dr., Suite 325  
Troy, MI 48083  
810-680-4900  
Fax: 810-680-6566

NewAge Industries Inc.  
2300 Maryland Rd.  
Willow Grove, PA 19090  
215-657-6040  
Fax: 215-657-1697

Niagara Gear Corp.  
941 Military Rd.  
Buffalo, NY 14217  
716-874-3131  
Fax: 716-874-9003

Normac Inc.  
Airport Road Industrial Park  
Arden, NC 28704  
704-684-1002  
Fax: 704-684-1384

Northeast Wisconsin  
Technical College  
1601 University Dr.  
Marinette, WI 54143  
715-735-9361  
Fax: 715-735-0171

Nuttall Gear Corp.  
2221 Niagara Falls Blvd.  
Niagara Falls, NY 14302  
716-731-5180  
Fax: 716-731-9329

Nye Lubricants Inc.  
12 Howland Rd.  
New Bedford, MA 02742  
508-996-6721  
Fax: 508-997-5285

### O

O'Neill Gear  
9207 Ivanhoe St.

Schiller Park, IL 60176  
708-678-0676  
Fax: 708-678-0784

Oberlin Filter Co.  
404 Pilot Ct.  
Waukesha, WI 53188  
414-547-4900  
Fax: 414-547-0683

The Ohio Broach & Machine Co.  
35264 Topps Ind. Pkwy.  
Willoughby, OH 44094  
216-946-1040  
Fax: 216-946-0725

Okamoto Corp. EDM Div.  
1500 Busch Parkway  
Buffalo Grove, IL 60089  
708-520-7700  
Fax: 708-520-7980

Omni Gear & Machine  
90 Bissel St.  
Joliet, IL 60432  
815-723-4327  
Fax: 815-723-9207

Ono Sokki Technology Inc.  
2171 Executive Dr. #400  
Addison, IL 60101  
800-922-7174  
Fax: 708-627-0004

### P

P. F. Markey Inc.  
2880 Universal Dr.  
Saginaw, MI 48603  
800-792-3811  
Fax: 517-793-9511

Pacific Industrial Furnace  
26000 Capitol Ave.  
Redford, MI 48239-2499  
313-937-4130  
Fax: 313-937-1677

Parker Industries Inc.  
1650 Sycamore Ave.  
Bohemia, NY 11716  
516-567-1000

Patterson Gear & Machine  
5876 Sandy Hollow Rd.  
Rockford, IL 61126  
815-874-4327  
Fax: 815-874-7448

Paul W. Marino Gages, Inc.  
20215 Van Dyke Ave.  
Detroit, MI 48234  
313-366-8100  
Fax: 313-366-8113

PC Enterprises  
115 Yonder Lane  
Sedona, AZ 86336  
800-437-2368  
Fax: 520-282-6104

Pennsylvania Pressed Metals  
RR#2, Box 47  
Emporium, PA 15834  
814-486-3314  
Fax: 814-486-9273

Pfauter-Maag  
Cutting Tools  
1351 Windsor Rd.  
Loves Park, IL 61132  
815-877-8900  
Fax: 815-877-0264

## COMPANY INDEX

Philadelphia Gear Corp.  
181 S. Gulph Rd.  
King of Prussia, PA 19406  
610-265-3000  
Fax: 610-337-5637

PIC Design  
86 Benson Rd.  
Middlebury, CT 06762  
203-758-8272  
Fax: 203-758-8271

**Pillar Industries**  
**N92 W15800 Megal Dr.**  
**Menomonee Falls, WI 53051**  
**800-558-7733**  
**Fax: 414-255-0359**

Power Eng. & Mfg. Ltd.  
2635 WCF&N Dr.  
Waterloo, IA 50704  
319-232-2311  
Fax: 319-232-6100

Precise Inspection  
28126 Jefferson Ave.  
St. Clair Shores, MI 48081-1316  
810-775-3334  
Fax: 810-775-3334

Precision Engineering Services  
388 Palmer Ln.  
Pleasantville, NY 10570  
914-769-3196  
Fax: 914-769-3196

Precision Gage Co.  
6939 W. 59th St.  
Chicago, IL 60638  
312-586-2121  
Fax: 312-586-2159

Precision Gear Co.  
1901 Midway Dr.  
Twinsburg, OH 44087  
216-487-0888  
Fax: 216-487-0618

Precision Gears Inc.  
N13 W24705 Bluemound Rd.  
Pewaukee, WI 53072  
414-542-4261  
Fax: 414-542-1592

Presrite Corp.  
3665 E. 78th St.  
Cleveland, OH 44105  
216-441-5990  
Fax: 216-441-2644

**Pro-Gear Co. Inc.**  
**23 Dick Rd.**  
**Depew, NY 14043**  
**716-684-3811**  
**Fax: 716-684-7717**

Process Industries  
3860 N. River Rd.  
Schiller Park, IL 60176  
708-671-1631  
Fax: 708-671-6840

Profile Engineering  
100 River St.  
Springfield, VT 05156  
802-885-9176  
Fax: 802-885-3745

Progressive Engineering Co.  
2010 E. Main St.  
Richmond, VA 23223  
804-648-7221  
Fax: 804-780-2230

Progressive Tool Co.

1624 Blackhawk St.  
Waterloo, IA 50704  
319-234-6619  
Fax: 319-234-7828

Purdue University  
—Indianapolis  
Dept. of Manufacturing  
799 W. Michigan St.  
Indianapolis, IN 46202  
317-274-7377  
Fax: 317-274-4567

### Q

Qualicast Corp.  
P.O. Box 122  
Broomall, PA 19008  
610-356-7464  
Fax: 610-353-7829

Quench Press Specialists Inc.  
4159 Church St.  
Roebuck, SC 29376  
803-576-3502  
Fax: 803-576-3513

### R

R.H. Software  
Four Reddick Rd.  
Asheville, NC 28815  
704-298-1008  
Fax: 704-298-6030

R.L. Wagner & Assoc.  
695 Cavalcade Circle  
Naperville, IL 60540  
708-961-9200  
Fax: 708-961-9917

Raycon Corp.  
2850 S. Industrial Highway  
Ann Arbor, MI 48104  
313-677-2614  
Fax: 313-677-2778

RD Industries  
2901 State St.  
Omaha, NE 68112  
402-455-9070  
Fax: 402-455-8242

Rebco Industrial Products  
450 Ardmore Terrace  
Addison, IL 60101  
708-272-0737  
Fax: 708-272-8723

**Redin Corp.**  
**1817 18th Ave.**  
**Rockford, IL 61104**  
**815-398-1010**  
**Fax: 815-398-1055**

Reef Gear Mfg. Inc.  
50903 E. Russell Schmidt Blvd.  
Chesterfield, MI 48051-2458  
810-949-2520  
Fax: 810-949-3481

Reid Tool Service Inc.  
1900 Commonwealth Ave.  
Charlotte, NC 28205  
704-333-3769  
Fax: 704-372-6703

Reilly Engineering Inc.  
531 Sutliff Rd.  
Lisbon, IA 52253  
319-455-2206  
Fax: 319-455-2206

**Reishauer Corporation**  
**1525 Holmes Rd.**  
**Elgin, IL 60123**  
**708-888-3828**  
**Fax: 708-888-0343**

Rex-Cut Products Inc.  
960 Airport Rd.  
Fall River, MA 02720  
508-678-1985  
Fax: 800-638-8501

Rhinestahl Corp.  
6510 Corporate Dr.  
Cincinnati, OH 45242  
513-489-1317  
Fax: 513-489-3899

Richter Precision Inc.  
1021 Commercial Ave.  
East Petersburg, PA 17520  
717-560-9990  
Fax: 717-560-8741

Riley Gear Corp.  
One Precision Dr.  
St. Augustine, FL 32092  
904-829-5652  
Fax: 904-829-5839

Riverside Spline & Gear  
1390 S. Parker  
Marine, MI 48039  
810-765-8302  
Fax: 810-765-9595

Robotronix Drive Systems  
8327 Foothill Rd.  
Cottage Grove, MN 55016  
612-459-0985  
Fax: 612-459-1537

Rockwell International—  
On-Highway Div.  
One Rockwell Dr.  
Morristown, TN 37814  
615-585-3206  
Fax: 615-585-3218

**Roto-Technology Inc.**  
**351 Fame Rd.**  
**Dayton, OH 45449**  
**513-859-8503**  
**Fax: 513-865-0656**

Russell, Holbrook & Henderson  
Two North St.  
Waldwick, NJ 07463  
201-670-4220  
Fax: 201-670-4266

### S

St. Marys Carbon Co.  
State Street  
St. Marys, PA 15857  
814-781-7333  
Fax: 814-781-6957

Sala/BLM Corp.  
1255 Tonne Rd.  
Elk Grove Village, IL 60007  
708-437-8522  
Fax: 708-228-7067

Sales Consultants  
Two Hudson Place  
Hoboken, NJ 07030  
201-659-5205  
Fax: 201-659-5009

Schafer Gear Works Inc.  
814 S. Main St.  
South Bend, IN 46544

219-234-4116  
Fax: 219-234-4115

Schenck Turner  
100 Kay Industrial  
Orion, MI 48359  
810-377-2100  
Fax: 810-377-2744

Schmid Tool & Engineering  
9101 W. Belden Ave.  
Franklin Park, IL 60131  
708-455-9221  
Fax: 708-455-0432

**Schunk Intec Inc.**  
**2925 Huntleigh Dr.**  
**Raleigh, NC 27604**  
**919-954-1752**  
**Fax: 919-954-1869**

Scott Machine Tool Co.  
2780 Bert Adams Rd.  
Atlanta, GA 30339  
404-432-7300  
Fax: 404-432-7500

Sepac Electric Clutch & Brake  
453 E. Clinton St.  
Elmira, NY 14901-2552  
607-732-2030  
Fax: 607-732-0273

Sidley Diamond Tool Co.  
32320 Ford Rd.  
Garden City, MI 48135  
313-261-7970  
Fax: 313-261-2028

**Simon International**  
**Distribution**  
**P.O. Box 1**  
**Elizabethtown, KY 42702**  
**502-737-3983**  
**Fax: 502-769-1875**

Software Engineering Service  
2801 Ridge Ave.  
Rockford, IL 61103  
815-963-1760  
Fax: 815-963-1760

Southern Gear & Machine  
3685 N.W. 106th St.  
Miami, FL 33127  
305-691-6300  
Fax: 305-696-3576

Southern Sales & Engineering  
One Ravinia Dr., Suite 1105  
Atlanta, GA 30346  
800-831-8377  
Fax: 404-393-0018

SDMG  
1704 Westwood Dr.  
Sterling, IL 61081  
815-625-4846  
Fax: 815-625-8960

Society of Manufacturing Engineers  
One SME Drive  
Dearborn, MI 48121  
800-733-4763  
Fax: 313-271-2861

Spline Gauges Ltd.  
Picadilly, Kingsbury  
Tamworth, Staffs B78 2ER  
England  
(44) 1827-872771  
Fax: (44) 1827-874128

Standard Steel Specialty  
260 Parkway East



## COMPANY INDEX

Duncan, SC 29334  
803-486-9500  
Fax: 803-486-9005

**Star Cutter Co.**  
P.O. Box 376  
Farmington, MI 48332-0376  
810-474-8200  
Fax: 810-474-9518

Stearns Financial  
131 5th St.  
Albany, MN 56307  
612-845-2149  
Fax: 612-845-4982

**SU America Inc.**  
8775 Capital Ave.  
Oak Park, MI 48237  
810-548-7177  
Fax: 810-548-4443

Sumitomo Machinery Corp.  
P.O. Box 6628  
Chesapeake, VA 23323-0628  
804-485-3355  
Fax: 804-487-3193

Sunnen Products Co.  
7910 Manchester Ave.  
St. Louis, MO 63143  
314-781-2100  
Fax: 314-781-2268

Surface Combustion Inc.  
1700 Indian Wood Circle  
Maumee, OH 43537  
419-891-7150  
Fax: 419-891-7151

Sussex Gear Company Inc.  
28 Snover Rd.  
Lafayette, NJ 07848  
201-579-2060  
Fax: 201-579-5501

**Sytec Corp.—  
Benemac Div.**  
25 Middlesex Turnpike  
Essex, CT 06426  
203-767-1322  
Fax: 203-767-1345

### T

Technimet Corp.  
2345 S. 170th St.  
New Berlin, WI 53151  
414-782-6344  
Fax: 414-782-3653

Teledyne Portland Forge  
400 Corporate Dr.  
Lebanon, KY 40033  
502-692-3554  
Fax: 502-692-1751

Therm Alliance Co.  
701 South Post Ave.  
Detroit, MI 48209  
313-843-1545  
Fax: 313-841-1335

Tifco Inc.  
29905 Anthony Dr.  
Wixom, MI 48393  
810-624-7900  
Fax: 810-624-1260

TOCCO Inc.  
HO 1506 Industrial Blvd.  
Boaz, AL 35957  
205-593-7770  
Fax: 205-593-4735

Toolink Engineering  
2870 Wilderness Place  
Boulder, CO 80301  
303-938-8570  
Fax: 303-938-8572

TPI Powder Metallurgy  
12030 Beaver Rd.  
St. Charles, MI 48655  
517-865-9921  
Fax: 517-865-9924

TPS Inc.  
24 Tuttle Rd.  
Watchung, NJ 07060  
908-756-4026  
Fax: 908-753-1086

Triangle Machine Tool Co.  
5670 W. 73rd St.  
Indianapolis, IN 46278  
317-297-6475  
Fax: 317-297-6484

Trogetec Inc.  
605 E. Washington Ave.  
Riverton, WY 82501  
307-856-0579  
Fax: 307-856-0579

Trojan Gear Inc.  
418 San Jose St.  
Dayton, OH 45401  
513-254-1737  
Fax: 513-254-3029

Ty Miles Inc.  
9855 Derby Ln.  
Westchester, IL 60154  
708-344-5480  
Fax: 708-344-0437

### U

U.S. Axle Inc.  
275 Shoemaker Rd.  
Pottstown, PA 19464  
610-323-3800  
Fax: 610-970-2010

U.S.E.M.  
8050 W. Florissant  
St. Louis, MO 63136  
314-553-2000  
Fax: 314-553-2498

U.S. Tech Corporation  
333 S. Cross St.  
Wheaton, IL 60187-5405  
708-668-7886  
Fax: 708-668-5076

UBM Corporation  
415 Hope Ave.  
Roselle, NJ 07203  
908-241-8652  
Fax: 908-241-7288

United Tool Supply  
851 Ohio Pike  
Cincinnati, OH 45245  
513-752-6000  
Fax: 513-752-5599

Universal Technical Systems  
1220 Rock St.  
Rockford, IL 61101  
815-963-2220  
Fax: 815-963-8884

USACH Technologies  
1515 Commerce Dr.  
Elgin, IL 60123-9304  
708-888-0148

Fax: 708-888-0144

User Solutions Inc.  
11009 Tillson Dr.  
South Lyon, MI 48178-9318  
800-321-USER  
Fax: 810-486-6376

### V

V&R Associates  
P.O. Box 538  
Wilmington, NC 28480  
910-392-5559  
Fax: 910-392-5559

Van Becelaere Machine Works  
504 N. Grand  
Pittsburg, KS 66762  
316-231-6916  
Fax: 316-231-6936

**Van Gerpen-Reece Engineering**  
1502 Grand Blvd.  
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## What's Happening Now— The News, The Names, The Numbers

*Movin' on up . . .* M & M Precision Systems Corp., West Carrollton, OH, has announced the appointment of **William S. Miller** as national sales manager, CNC metrology systems. Miller will direct all field sales activities for metrology systems in the U.S. and Canada. . . **Charles Brannen** is the new president of AGMA. Brannen, vice president of **Overton Gear & Tool Corp.**, Addison, IL, was elected at the group's annual meeting in Tucson, AZ. . . **Daniel T. Koenig** was named the 114th president of the **American Society of Mechanical Engineers** at the Society's meeting in Kansas City, KA. Koenig is senior vice president, manufacturing technology, at **AAVID Thermal Technologies, Inc.**, Laconia, NH. . . **Dr. Debabrata Paul** joins **Monitoring Technology Corporation's** Advanced Technology Group as a signal processing engineer. The Fairfax, VA, company develops new methods of applying vibration analysis to the monitoring of rotating machinery. . . **Jack Carlson** joins **Reishauer Corp.**, Elgin, IL, as the company's new service manager.

*Corporate Notes . . .* **Brown & Sharpe** of North Kingstown, RI, and **Dassault Systemes**, Paris, France, have announced a joint project to develop a new graphical off-line CMM programming module to provide an automated path between CAD/CAM operations and computer-aided inspection. . . **Deckel Maho Gildemeister**, now known as **DMG America Inc.**, has opened its new North American headquarters in Schaumburg, IL. The new headquarters will house all sales, application engineering, parts and service resources for the company's North American operations. . . **General Broach Company**, Morenci, MI, has been awarded Ford Motor's Q1 award. It is only the second broaching company to receive the Ford quality award. . . **Schafer Gear Works, Inc.**, South

Bend, IN, has expanded its plant in the "Studebaker Corridor" near the city's downtown. The 48,500 sq. ft. facility represents the company's commitment to the redevelopment of this major South Bend industrial area. . . **Burgess-Norton**, full-service gear manufacturer in Geneva, IL, is implementing a new "factory within a factory" organizational concept with the goal of improving response to customer needs for flexible scheduling, smaller quantity requirements, lower costs, short lead-times and J.I.T. deliveries. . . **DiamondBLACK®**, Conover, NC, has been awarded a contract with one of the "Big Three" automakers to apply the company's patented coating to transmission gears for 1996 models. . .

*Society News. . .* The proceedings of the First International Conference on Induction Hardened Gears and Critical Components, held last May in Indianapolis, IN, are available from the **Gear Research Institute** (708-491-5900). They include the 23 papers presented at the conference.

*The Numbers Game. . .* The **Association for Manufacturing Technology (AMT)** has released figures on machine tool orders through April, 1995. Total year-to-date orders were \$1,669.20 million, 17.57% ahead of 1994 figures for the same period. Metal cutting machine tool orders were \$1,073.55 million, up 16.77% from the first quarter of 1994, and year-to-date metal forming orders totaled \$595.65 million, 19.05% ahead of comparable 1994 figures. The April, 1995, machine tool order backlog was \$2,414.35 million, compared with \$1,676.45 million in April, 1994. ⦿

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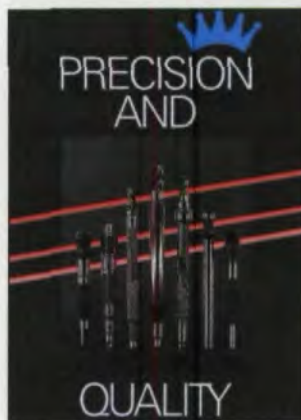
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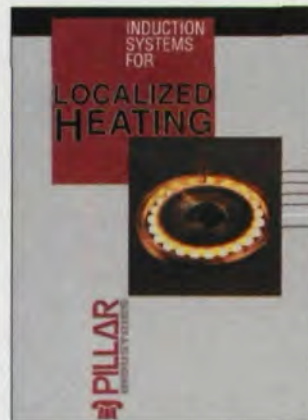
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# Gear Inspection For The Long Haul

*Beating the controller obsolescence demon.*

**Douglas Beerck & Mark Cowan**

*Question:*

We just received permission to purchase our first CNC gear inspection system. With capital approvals so hard to come by, especially for inspection equipment, I want to be sure to purchase a system I can count on for years to come. My past experience with purchasing CNC equipment has shown me that serviceability of the computer and the CNC controller portion of the system can be a problem in just a few years because of the obsolescence factor. What information do I need to look for when selecting a supplier to reduce the risk of obsolescence, as well as to reduce the long-term servicing costs in the computer and controls portion of the system?

*Answer:*

As we have all painfully discovered, obsolescence of our CNC controls, computer hardware and software, machine tools, inspection equipment, etc., can be expensive. We have come to expect a long life out of the mechanical portion of our CNC inspection machines. After all, inspec-

tion machines don't see the tooling forces applied to machine tools, and they typically operate in a cleaner, more temperature-controlled environment than other equipment. But the electronic and computer hardware and software are victims of a rapidly changing technology, with a much shorter serviceability. Keeping ahead of product developments in these areas is a constant battle.

When purchasing CNC gear inspection systems with the goal of maximizing product life and serviceability, a number of "optimum design factors" should be taken into account. These include cost, reliability, performance, flexibility, upgradability and serviceability. Another factor of increasing importance is the networking capability of the system. Let's take a look at each of these factors, keeping in mind their long-term design considerations, costs and points to remember when researching suppliers.

**Cost**

When we talk about cost in this article, we are not looking at the initial system cost or a cost breakdown of the computer controller itself. We are

referring to the long-term cost associated with the design of the software and computer controller itself. The overall system price may or may not be attractive at the time of purchase, but the real question is, can the product, which you expect to be using for years to come, be economically serviced in the future? What design criteria were used on the computer controller? Some initial questions that can be asked easily without being an electronics or software genius include:

1. Did the system supplier design the controller specifically for the application, or is this unit a generic off-the-shelf package?
2. Does the system supplier make the controller, or is it purchased complete? From whom?
3. Will the system supplier agree to service the controller as well as the machine? If not, who will?

Off-the-shelf, generic CNC controls may appear to be more cost-effective at the time of sale, but they may or may not lend themselves to future upgrading or component-only replacement.

A CNC system supplier should be intimately familiar



**This column will answer your questions about gear machinery controls and electrical systems. Send your questions to Mission: Controls, P. O. Box 1426, Elk Grove, IL 60009, or fax them to 708-437-6618.**

**Douglas Beerck**

*is marketing manager for M & M Precision Systems Corporation, designers and manufacturers of high-accuracy CNC gear inspection, generative inspection and motion systems.*

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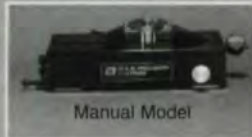
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## MISSION: CONTROLS

with the design of the controller and its operating software if he is, in fact, going to service this equipment for you. He or she should be able to tell you things about the design of the controller that reduce the cost of service for you in the years to come.

### PC or Not PC?

Today's machine controllers are more and more moving into the PC environment for a number of reasons, including cost. If the system supplier's control hardware is not PC-based, find out why not.

What specific advantages can a CNC PC-based system offer? Perhaps the biggest is that the design utilizes the industry standard architecture (ISA) bus to ensure multiple vendor selection of components and international service support. With multiple vendor selection of the system's computer and control components, the cost of service typically is reduced. Your system supplier is not held hostage by one component supplier, a situation that raises his cost of doing business with you.

A PC-based system will also function with a standard operating system, such as DOS. Maintenance of control and software can be addressed more easily with the use of such a standard operating system. File maintenance, updates, etc., can more easily and more cost-effectively take advantage of standard modem technology in the PC environment.

As mentioned earlier, CNC gear inspection systems usually have machine hardware that outlives the computer and control hardware and software from a functional standpoint. Newer computer hardware usually means

faster processing speed. The computer industry has gone from 286 processors to Pentiums in about 10 years. By using a PC-based platform, standardization of much of the computer/controller hardware lends itself to multiple sources for upgrading, retrofitting, etc., for the years to come.

### Reliability and Performance

Questions regarding reliability and performance follow the same logic as those relating to the system as a whole. All suppliers of CNC gear inspection equipment typically quote impressive uptime percentages, accuracy and inspection times. How does the supplier back up these statements? Can the supplier give you the names of other customers who are using the type of controller hardware and software he is offering you? How many systems using this configuration are in the field operating today?

### Flexibility

Will this system be able to address not only your present needs, but also your future ones? Can software options be added later? How much will it cost to do so? Can the software be modified by the supplier if your needs change over time? How much software customization is done by this company? Can the vendor provide you with the names of customers for whom software was modified? Does the supplier offer a computer/controller package that allows you to purchase replacement components (i.e. monitor, keyboard, CPU, etc.) direct from the component manufacturer if you choose? Are these standard components truly "standard," available from several sources?



### Upgradability

Chances that the system you purchase today will meet all your requirements five years from now are usually slim if your company is adding products, changing designs, improving processes, taking on new customers, etc. Does your supplier offer the ability to upgrade your system's software and computer hardware over time?



Fig. 1 — M & M Precision's 4-axis, Model 3025 PC gear process control system.

### Networking Capability

Once again, analyze your future requirements. Will you have a need for multiple systems? Will you have the need to do off-line part parameter entry or tolerance modification as your needs change? What about downloading data to a central computer where information can be evaluated, stored, etc., by another source? What costs are associated just with the networking requirements? If networking is or may be a requirement for you, this is another reason to look at a PC-based system. Today's PCs offer plenty of power and lower networking costs than most other alternatives. Most end users that utilize a centralized data analysis site for their SPC, process control,

etc., work with a PC-based system. Look at the supplier's ability to assist you in networking as well as his or her ability to interface to your existing network if you are already using one.

**Closed Loop Process Control.** With the advancement of gear inspection software and CNC technology, some manufacturers offer the ability to link the inspec-

tion system directly to the machine tool, sending machine tool setting change data based on the inspection results. Even if your current machine tools do not offer the ability to interpret this data, what about your future machine tool purchases? If you are considering this degree of process control, the selection of a CNC inspection system should include research into the supplier's capability in this area and the willingness to work with you and the machine tool manufacturer.

### Serviceability

Last, but certainly not least, is the serviceability factor of the equipment you are purchasing. There are basically two schools of thought

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### MISSION: CONTROLS

among end users. Some users of computer-controlled equipment prefer servicing the equipment themselves as much as possible after the warranty period expires in an effort to keep costs at a minimum. If this is your view, consider a number of points. Can the computer itself be serviced locally by either factory or independent sources

Many end users look for the system supplier to be their sole support arm. If this is your view, make sure the company you deal with has an adequate service staff. Does the company handle all service calls directly or does it contract out to independent service companies? If your system is made overseas, where are the people who will service it based?

#### Longevity

The future and stability of your proposed vendor's business is a consideration as well. How long has the company been in business? What is its position in the industry? Is it profitable? Getting service on equipment manufactured by a company no longer in business or no longer servicing your market can be extremely difficult.

#### Conclusion

As with all capital equipment, selecting the appropriate CNC inspection system and vendor requires research. Obsolescence and serviceability considerations also require you to look into the future a bit more than some other purchases might. Look at the long-term view and your future requirements. Looking at the big picture today can mean big savings tomorrow when it comes to meeting your CNC gear inspection system needs well into the future. ⚙

**For more information about M&M Precision Systems Corporation, please circle Reader Service No. A-110.**

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## PRODUCT NEWS

Welcome to our Product News page. Here we feature new products of interest to the gear and gear products markets. To get more information on these items, please circle the Reader Service Number shown.



### Single-Column Gear Inspection

Zeiss Höfler has introduced a new line of gear inspection systems that feature a revolutionary single-column design with improved accessibility compared to competitive two-column systems. The ZP400 and ZP630 systems offer a 400 or 630 mm diameter x 850 mm high measuring envelope to accommodate a wide range of internal/external gears, shaper cutters, shaver cutters, hobs, worms and bevel gears. Both feature the tailstock and measuring slides in a single column, eliminating the thermal differences and potential accuracy problems of two-column systems.

Circle Reader Service No. A-50



### Dual Agitation Stacked Mixer Drives

Nord Gear Corp. offers dual agitation, stacked mixer drives for heavy duty service in industrial and food processing uses where mixing applications must withstand torque and heavy bending stress. Available in sizes from 1/4 to 200 hp and output torques up to 221,200 in-lbs.

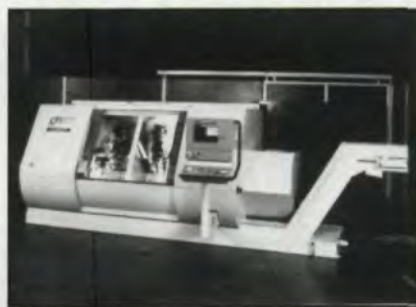
Circle Reader Service No. A-51



### Wizard DROs

Anilam Electronics, Inc., has introduced its new Wizard Series line of DROs that think, calculate, compensate, remember and recall so the operator doesn't have to. Features include "smart" power supplies to help regulate power fluctuations, interlinking keyboard modules for fast upgrading, VFD displays for easy readability, interactive display windows with help messages and a visual feedrate display to take the guesswork out of milling.

Circle Reader Service No. A-52



### CTX Twin Coaxial CNC Lathe

Gildemeister has added a new coaxial turning machine with double-sided machining capability to its CTX series of CNC 2-axis turning machines. The CTX Twin features two identical, integrated 25 hp (18kW) spindle motors and two 12-station turrets to enable machining of both sides of a component in a single cycle or parallel machining of two similar components using the two spindles separately. The machine features the new Gildemeister/Grundig "Turn Plus" CNC Control with "window" technology, interactive graphic component description and fully automatic program development.

Circle Reader Service No. A-53



### Promat CNC 200 Form Type Grinder

Höfler has developed a small form type gear grinding machine dedicated to gear manufacturers who have large and small lot sizes of spur gears to grind. The economically priced machine's operating range covers spur gears up to 8" (200 mm) OD and face widths of 6" (150 mm). The machine's high grinding performance and versatility lead to low per-gear machining costs.

Please Circle Reader Service No. A-54



Bison Series 650

### New Gear Motors

Bison Gear & Engineering introduces three new lines of gear motors. The parallel shaft Series 650 offers compact size and extremely high torque ratings. It delivers torques up to 720 in-lbs. with a gearbox measuring only 5" x 6-1/4" x 5-3/4". Speeds range from 1 to 160 rpm. A choice of motors, either permanent split capacitor AC or permanent magnet DC, with ratings of 1/20 hp, 1/6 hp and 1/2 hp is available.

The Series 950 are parallel shaft gear motors and C-face reducers with power ratings up to 3 hp. The new high-quality heavy duty line is designed for applications calling for long life and critical loads. Torques from 242-2830 in-lbs. Available in single-phase, capacitor start and 3-phase AC motors and permanent magnet DC motors.

## MANUFACTURING ENGINEER

Eaton Corporation - Truck Components Operations North America, Galesburg, MI, currently has an opening for a Manufacturing Engineer.

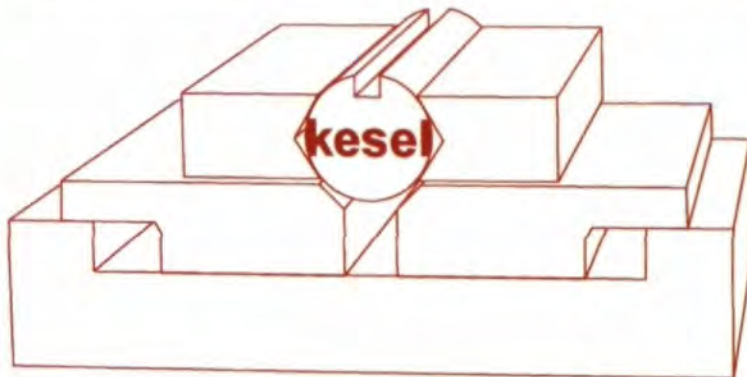
The essential functions of this position include the design and procurement of gear cutting tools and gages; gear chart interpretation and problem solving; training skills to assist plant locations in operator training and maintenance of gear and heat treat databases.

Candidates must be able to perform all essential job functions and possess the following qualifications: a B.S. degree in Mechanical Engineering or Manufacturing Engineering (Mathematics required); gear engineering prior work experience essential and manufacturing experience in gear manufacture, gear tooling design, gear lead, involute, spacing and runout chart interpretation. Position also requires gear manufacturing operation equipment knowledge and PC skills in spreadsheet, wordprocessor, MS-DOS, and Windows.

Eaton Corporation provides a competitive salary and a comprehensive benefits package. Respond with resume and cover letter by September 29, 1995 to: Eaton Corporation-Truck Components Operations North America, P.O. Box 4013, Kalamazoo, MI 49003-4013, Human Resources Dept./Joe Elser, Reference:Gears. We are an Equal Opportunity Employer M/F/D/V.

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## PRODUCT NEWS

The Series 800 are heavy-duty right angle gear motors available with integral AC or DC motors and as C-face reducers. They are rated from 1/4 hp-1 hp with torques from 179-501 in-lbs. and speeds from 23-257 rpm. Available gear ratios run 7:1 to 80:1. They are available with permanent split capacitor or 3-phase AC motors and permanent magnet DC motors.

Please Circle Reader Service No. A-55

### Spiral Bevel Gearboxes

The new "Z" Series spiral bevel gearboxes, available from **Andantex USA, Inc.**, comes in 27 sizes and 6 types with 30 different mounting configurations. The units offer 11 different ratios from 0.5:1 to 6:1, counterclockwise and clockwise rotation of input and output shafts, 5000 lb-ft. torque capacity and speeds to 3500 rpm. Efficiency of the units is from 96-99%. They are rated for either 10,000 or 15,000 hours of life and are grease-, oil-splash- or force-feed-lubricated, according to the application.

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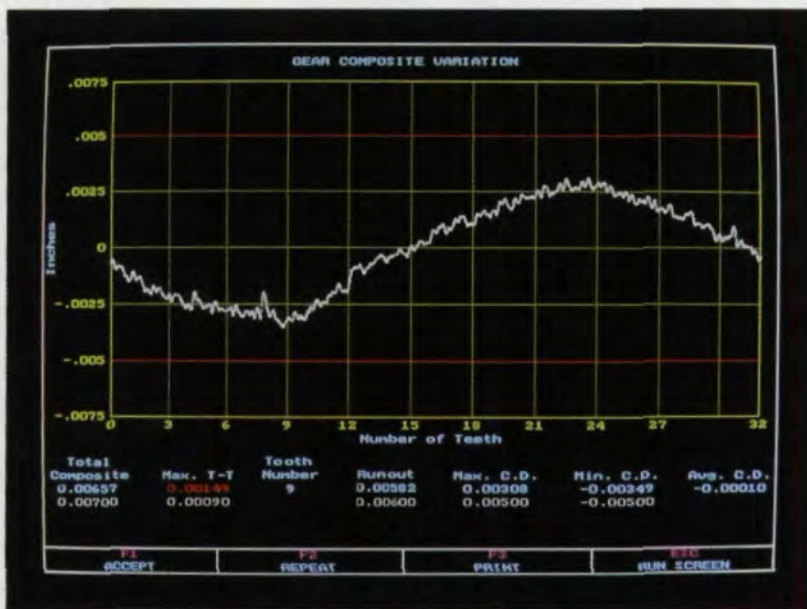
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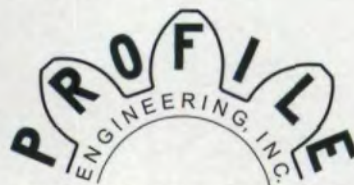
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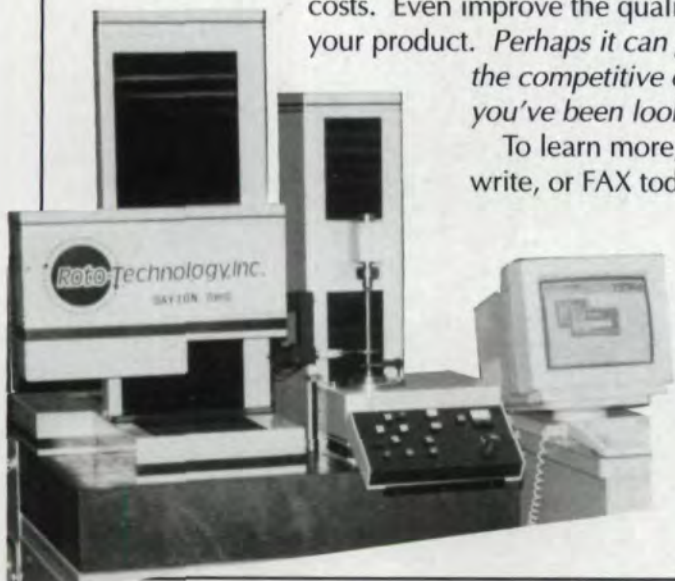
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# The Case of This Issue's Column

Gear Technology's bimonthly aberration — gear trivia, humor, weirdness and oddments for the edification and amusement of our readers. Contributions are welcome.

## 221B Baker Street

We've always said that gears show up in all the best places, even, it turns out, among the papers of that most famous of detectives, Sherlock Holmes. "The Adventure of the Engineer's Thumb" is, according to Dr. Watson, a case "so strange in its inception and so dramatic in its details," that it merits a mention even in our exalted pages.

Young Victor Hatherly, the hydraulic engineer, is having a hard time getting his business off the ground, so he's tempted by the mysterious Colonel Lysander Stark, who's offering him 50 guineas (about \$262.50 in 1890s money) for an hour's work diagnosing the problem with his hydraulic stamping machine, which has "got out of gear." The only kicker is that Hatherly is sworn to absolute secrecy: he must tell no one where he's going, and he has to be there at midnight.

We won't say more except that there's a beautiful lady with a foreign accent, a creepy old house, unusual applications for a hydraulic press and other matters of interest to the "world's first consulting detective." The engineering theory may be a bit dodgy (Watson was an M.D., after all), but as a mystery story, it has its moments.

## Meanwhile, in Traverse City, MI...

If detective stories strike you as too frivolous, and you just can't get enough metal cutting at work, we have the solution—*The Home Shop Machinist*. According to its tagline, this bimonthly magazine published in Traverse City, MI, is "dedicated to precision metalworking." Its audience is those millions (well, maybe thousands) of people driven by lathe lust to hang out in their basements and garages working on handy home metalworking projects. The issue we saw covered

"Serious Milling With the Lathe," "Reviving a Lunch Break Shaper" and "Chatterless Countersinks," among other things. It also has great ads for tooling, equipment, videos and books. We intend to include *The Machinist's Bedside Reader*, Vols. 1, 2, & 3, in our letter to Santa. For more information, call 800-447-7367.

## ... enter a gentleman wearing the ribbon of a foreign order ...

Feeling megalomaniacal? Having delusions of grandeur? Fed up with your life as you know it? Addendum can help. For \$13.00 you can buy a book called *How to Start Your Own Country* by Erwin Strauss. According to the publicity blurb, the book contains information on acquiring land, picking a flag, establishing diplomatic relations, printing stamps and money, collecting taxes (of course) and other information vital to wannabee potentates. Available from *Real Goods*® in Ukiah, CA. 1-800-762-7325.

## The Interactive Section

Surely we at Addendum can't be the only people stumbling across gears and their applications, odd and otherwise. If you have an Addendum weirdness, fact, joke or piece of trivia you'd like to share, send it to us at *Gear Technology*. The keepers will throw it into our cage along with our dinners. Your reward—same as ours: the notice, if not the respect and admiration, of your peers and all the Gummi Bears you can eat (but the Addendum editor gets all the pale yellow ones). 🍬

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"Our real problem is these damn charts."

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