GEAR TECHNOLOGY

The Journal of Gear Manufacturing

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November/December 1997

GEAR CRACK PROPAGATION
GEAR SHAVING BASICS

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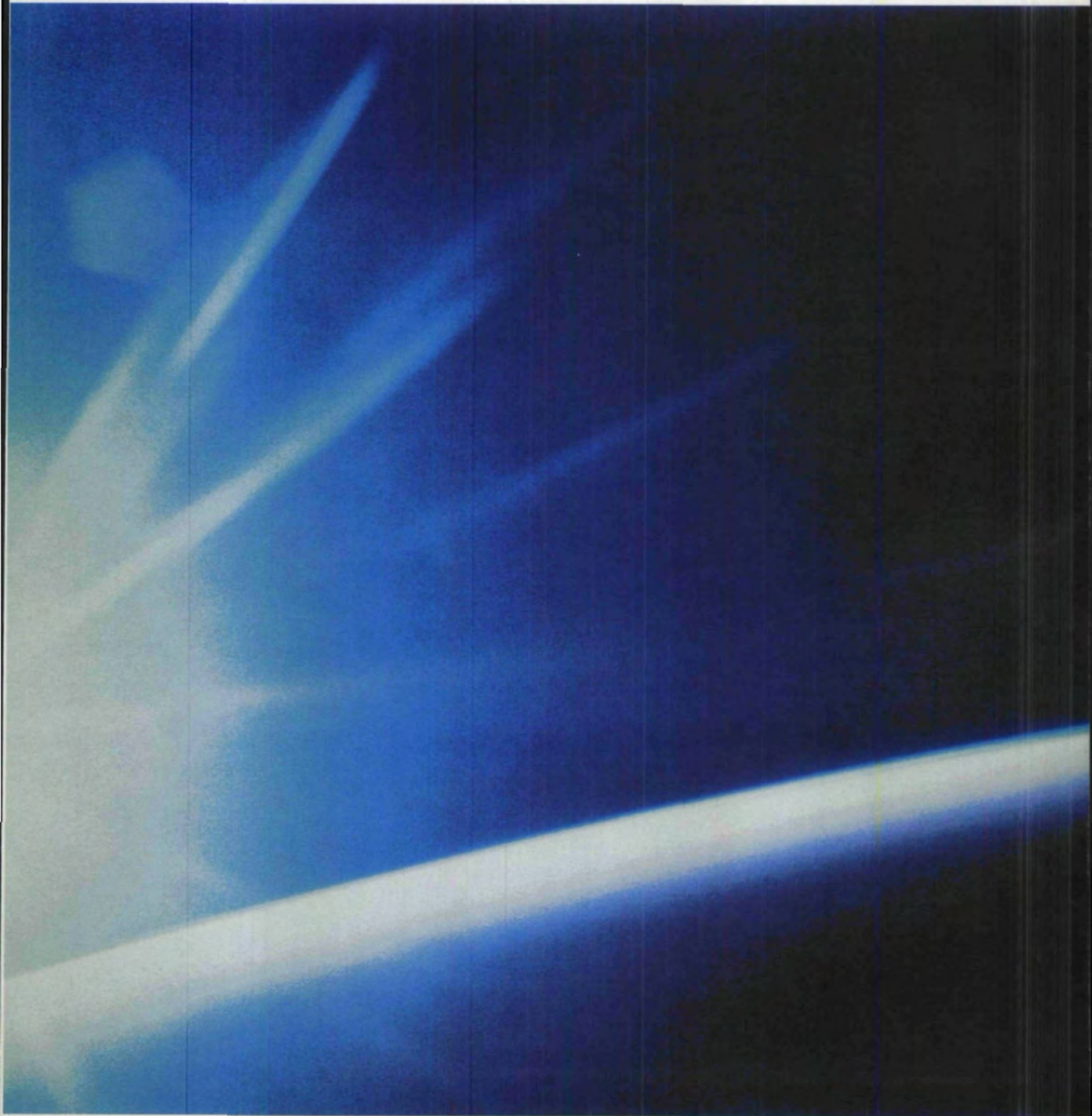

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CIRCLE 100

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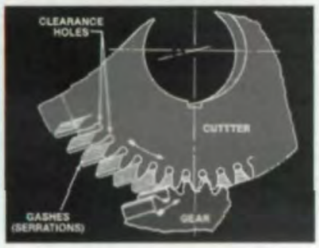

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CIRCLE 114

Good-Bye, Dad

Harold Goldstein, 1917–1997

I sat down to write this editorial about my father, Harold Goldstein, as he approached his 80th birthday in October. I had meant it to be a celebration of his nearly 65 years in the machine tool business. Unfortunately, on August 26, as I was working on it, my father passed away after a long battle with emphysema. This editorial has now become a memorial as well as a celebration.

In many ways, my father's story was that of his generation. He entered his teenage years at the beginning of the Depression and spent his young manhood in a world shattered by war. He had to leave high school in his second year to earn money to help support his family and never knew the easy security that comes from having (or at least believing one has) a guaranteed lock on one's fair share of the good things in life.

But these early experiences strengthened him. Along the way, he made sure his own children had some of the important things he'd missed in the formative stages of his life; not so much material things, although he took care of that as well, but a strong sense of the importance of family, togetherness, love and caring.

He was self-taught. He turned himself into a very well-read, articulate individual, and his knowledge of accounting, business law, sales and marketing came on the job. In 1950, he struck out on his own from the business he ran with his father and founded Cadillac Machinery.

Dad also earned the trust and respect of his colleagues. Along with his father, he was one of the founding members of the Machinery Dealers National Association (MDNA) and became its national president in 1967-8. Later, in 1971 he was awarded the organization's Randolph K. Vinson Award for outstanding contributions to the industry. But he was particularly proud that he, with no formal education, was selected to represent the machine tool industry and the MDNA to give testimony before the House Ways and Means Commission with respect to the Investment Tax Credit.

He placed a tremendous importance on education as a tool to help us move through our lives, and he always stressed that importance to his children.

And it wasn't just "book learning" he impressed on my brothers and sister and me. In spite of all his early disadvantages and the hardships he faced during his formative years, there were certain admirable personal truths he lived out and taught his children, lessons which have helped to give my life some focus and direction. . .

. . .Your Word Is Your Bond. . . Be Scrupulously Honest. . . Don't Be Just A Taker In Life; Give Back As Well. . . It's Easy to Write a Check to a Charity; It's Harder, But More Useful, to Give Your Time, Experience and Talent. . . Fight For What You Believe and Stand Up For What You Think Is Right, Even If It's Not Popular. . . You Can't Be Successful If You Work Only 40 Hours a Week. . . Your Company Doesn't Pay Your Salary; Your Customers Do. Without Them, You Don't Have A Job or A Business. . .

To help his children to have a wider vision of any given situation, my dad would constantly tell us, "You don't know what you don't know."

Throughout my life, I have found this last statement to be particularly insightful. It's taught me to look beneath the surface of situations; to assume that, most of the time, there's more going on than first meets the eye; that things are generally deeper and more complex than they first appear. It's helped me to avoid making superficial judgments, not to be too cocky too early in the game and to do my homework.

Harold and his wife, Susan.

Working with and for my dad, I learned about industriousness, leadership, tenacity, ambition, self-confidence and perseverance. Dad could be a tough boss, but he was a fair one, and I was fortunate to have mostly his praise and admiration as I went through my own career.

He provided a tower of strength for our companies, Cadillac Machinery and Randall Publishing. Even after he was no longer strong enough to come into the office, he had a seemingly inexhaustible supply of interest and enthusiasm for the business. I spoke to him nearly every day, and he always had the same questions: What did we buy today? What did we sell? What new projects were we working on?

And he had the same kind of interest and concern for the larger industry and for both our immediate and extended families. He was a patriarch in the truest and best sense of the word.

The end of his life, like the beginning, was not easy, but even when he was quite ill, he continued to teach us by example. He put his affairs in order quietly and efficiently so his family would be spared the burden of tying up the loose ends. He called those close to him together to say his good-byes, an act of closure that's been deeply meaningful to me these past few weeks. He met his end with a courage, grace and dignity that made me even prouder to be his son. His job was done, he was rightfully proud of what he accomplished, and he went in peace.

Once this summer, reflecting on the number of his family and friends throughout the world who called or came to visit with him, he said, "I guess I did something right."

Dad, you did so many, many things right. We're going to miss you.

Michael

Michael Goldstein
Publisher & Editor-in-Chief

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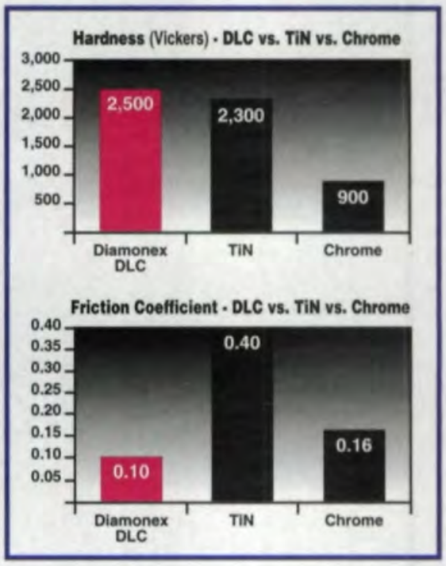

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Rock Valley Apprenticeship Program To Graduate First Class

The first group of seven students will complete their training in the Rock Valley College Manufacturing Youth Apprenticeship Program next spring. Upon graduation, they will have earned their Associate of Arts degrees from Rock Valley College or their journeyman's card from the Rockford Tooling and Machine Association.

The Rock Valley Apprenticeship Program is part of the nationwide Tech Prep program. It is modeled on the German apprenticeship program, which combines academic study with on-the-job training.

Students begin their training in their junior year of high school. The program is a combination of classroom and on-the-job training, including an extensive summer school program between the junior and senior high school years. After completing high school, students go on to a four-year apprenticeship program.

The apprenticeship training facility is located at the Pfauter-Maag Cutting Tools facility in Loves Park, IL, and Pfauter-Maag was one of the original sponsoring companies of the program.

Twenty-eight manufacturing companies in the Rock Valley/Rockford area are involved. Since 1993, some 140 students have participated in the program, which boasts a 70% retention rate.

M & M Precision Systems Acquires New Product Line

M & M Precision Systems Corp., manufacturer of gear inspection systems, has acquired the product lines of Apeiron, Inc. of Bloomington, MN. M & M will manufacture these laser dimensional measurement systems and market them worldwide under the M & M name. These non-contact laser measurement systems can accurately and rapidly identify dimensions on surfaces that cannot be measured by traditional contact methods.

Bison Gear Opens New Facility

Bison Gear and Engineering has officially opened its new world headquarters and gear motor manufacturing plant in St. Charles, IL. The 115,000 sq. ft. facility on 9.7 acres brings all the Bison operations under one roof.

The new building, designed and built to Bison's specifications, houses administration, finance, sales and marketing, research and development, warehousing and manufacturing. Special amenities include a gear technology center, a fitness center for employees and training facilities for professional and personal advancement. It has high technology equipment for hobbing, machining, gear inspection and assembly and testing.

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Capitalizing on Your Human Capital

Skill levels, productivity and labor availability all affect your bottom line.

Dr. Michael D. Bradley

A fundamental characteristic of the gear industry is that it is capital intensive. In the last decade, the gear manufacturing industry has been undergoing an intense drive toward improving and modernizing its capital equipment base. The Department of Commerce reports that annual sales of gear cutting equipment have increased nearly 60% since 1990. While this effort has paid off in increased competitiveness for the American gear industry, it is important to remember that there is another capital crucial to manufacturing success—"human capital."

Human capital is the set of skills, knowledge and abilities that makes an individual productive. The higher an individual's skill level, the more productive he will be and the more he will earn. This is exactly parallel to a new machine generating a higher rate of return than an older, less productive machine. Human capital is generally acquired through education and training. An engineer, for example, dramatically increases his or her human capital by going to college.

A gear manufacturer's human capital stock is measured by adding together the individual human capital of all its workers. Just as the total productive capacity of the physical capital stock is measured by adding up the physical capacities of the individual pieces of equipment, so too is the human capital stock measured.

Unfortunately, this sometimes doesn't get done. For one reason, acquisition of human capital doesn't typically require the outlay of a single huge pile of cash; a gear company makes payments gradually to workers through time. These gradual payments take away a natural point of focus in analyzing the human capital stock.

Another reason the human capital stock is less closely monitored may be that the state of human capital is more difficult to assess than that of machinery. Finding standards that measure and describe the status of human capital in an industry is often hard.

Fortunately, this latter problem is being remedied in the gear industry. The American Gear Manufacturers Association annually produces a comprehensive study of the state of human capital in the gear industry, called "Wage and Benefit Survey." This survey provides insight into the three important aspects of human capital stock which gear manufacturers should be monitoring. These are the expense of hiring the labor, the training and skill level of the labor force and the availability of skilled labor, both in the present and future.

The expense of hiring labor shows up in the quarterly bottom line, and it is this aspect of human capital that gets the most attention. According to the AGMA study, the average hourly wage paid to a direct worker in the gear industry is \$12.65. Adding average hourly benefits of \$7.20 per hour gives an average total hourly compensation of \$19.85, or an average cost of \$40,000 per year or \$1.2 million during the worker's potential employment. Moreover, this represents the *average* direct employee's wages, including both low and high skilled employees. When just skilled workers, like tool makers or CNC machinists are considered, the lifetime compensation cost can climb to more than \$1.5 million. Viewed in this way, it is clear that gear manufacturers make a substantial investment in their workers.

ACCORDING TO AGMA THE AVERAGE HOURLY WAGE IN THE INDUSTRY IS \$12.65 PLUS \$7.20 IN BENEFITS, MAKING FOR A TOTAL PACKAGE OF \$19.85 AN HOUR.

The average gear manufacturer is small—less than half have more than 100 direct workers—but even with just 100 employees, the annual cost of compensation can exceed \$4 million. Moreover, this sum does not include additional indirect labor costs like training, administration and other non-direct human resource activities. It also does not include selling costs, engineering costs or management costs. In addition, compensation is even higher at unionized gear manufacturers, with between one quarter and one third of gear firms being unionized. Compensation is about 30% higher at unionized firms, so the compensation cost at a unionized, 100-worker gear company can exceed $5 million a year.

Given the size of these costs, it is important for gear manufacturers to control their growth. One area in which they have been successful is in health care costs. The AGMA study shows that, after years of rapid growth, the annual average health care cost per employee has grown little in recent years. In fact, annual employee health care cost has grown by only 3% over the last *two* years, a rate that is less than that of inflation. Gear firms have achieved this success by aggressively pursuing cost-saving strategies, such as by switching to managed care, switching carriers, increasing employee contributions to premiums and increasing deductibles.

Worker's compensation is another example. After several years of sharp increase in premiums, about half of gear firms have undertaken safety plans that reduce accidents. This has two benefits: It reduces worker's compensation premiums, and it reduces the lost productive output from injured workers. The point is, when a human capital issue comes to the attention of gear manufacturers, they can take successful steps to address it.

The worker's compensation issue also helps to reveal the dual nature of the human capital issue for gear manufacturers. While the level of compensation is obviously important, it is only half of the human capital story. High wages by themselves are not necessarily a burden for a firm. In fact, some firms that pay the highest wages are the most profitable.

The other half of the human capital story is the productivity of the labor. The higher the human capital content of the labor force, the greater its skills and abilities, and the more productive it will be. A useful summary of the important relationship between a firm's compensation cost and the productivity of its labor is given by a measure called "unit labor costs." Like the internal rate of return to physical capital, this is a measure that helps a gear firm figure out how well it is managing its labor force.

The unit labor cost measure recognizes the two parts of labor costs. It accounts for both the rate of compensation to workers and the amount of labor required to produce output. In this sense, it is the mirror image of productivity. When productivity rises, output-per-labor-hour rises. When productivity rises, the labor hours required to produce a single unit of output falls. This mirror image of productivity is called the labor content of output, and it falls as productivity rises.

Unit labor cost is derived by multiplying this measure of labor content by the rate of average hourly compensation, and is, therefore, a dollar measure of the labor cost of producing a unit of output. When unit labor costs are falling, productivity is rising faster than wages, indicating that the gear manufacturer is doing a good job managing its human capital. Falling

unit labor costs also help profitability because declining unit labor costs mean that profits will rise without an increase in prices. This is crucial during a period of intense competition.

While unit labor costs measure how quickly labor productivity is rising relative to compensation, it tells us nothing about efforts to improve labor productivity. Even in an economy with modest inflation, wages tend to rise every year, and without an increase in productivity, higher wages mean higher unit labor costs and lower profitability. Therefore gear manufacturers must try to continuously improve the productivity of their work force.

The primary way gear manufacturers accomplish this for direct workers is through training. While there are some bright spots, this is an area in which the American gear industry is not particularly strong. For example, less than a quarter of gear manufacturers have apprenticeship programs. These programs are the fundamental way in which relatively new workers can rapidly increase their productivity through organized programs of skill transfer. This lack of apprenticeship programs stands in marked contrast to gear industries in other countries that tend to have well-established and successful apprenticeship programs.

It is true that several gear manufacturers have started partnerships with local community colleges. These programs include donations of old equipment, the establishment of scholarships for studying gear manufacturing and the creation of coordinate work/study programs. Unfortunately, these programs are still the exception rather than the rule.

Gear manufacturers have begun to offer incentives for workers to get skills and become more productive. For example, the AGMA study reveals over the last three years a dramatic increase in the number of gear firms that "pay for knowledge." In 1994, less than 10% of the gear firms offered this incentive plan, but by 1996 more than 25% were offering it. Pay-for-knowledge programs provide financial compensation for the acquisition of additional skills. For example, some gear firms pay a premium to workers who can operate multiple machines. To be effective, this premium must be substantial, and it is averaging about 85 cents per hour among the gear manufacturers that use them.

Another incentive for workers to increase their productivity is through profit-sharing plans. In these plans, a worker's total compensation is linked to the performance of the firm. Usually, the firm's contribution to the worker's pension program depends upon firm performance, but 17% of

TIGHT LABOR MARKETS IMPLY RISING WAGES THAT WILL DRIVE UP LABOR COSTS.

gear manufacturers have profit-sharing programs in which workers' current pay depends upon current profits.

Of course, no incentive plan will work unless the gear manufacturer has the employees to work. The third important aspect of human capital in the gear industry is the availability of skilled workers. Given the rapid economic expansion in the gear industry in the last five years and the paucity of training programs, it is not surprising that many gear firms are having difficulty finding and hiring skilled workers. Some gear firms have reported that a shortage of skilled labor is currently limiting their capacity to produce. In other words, these firms have the machinery available to expand production, but simply cannot find the additional skilled workers to run the equipment.

The AGMA study tracks labor scarcity, and this problem has clearly become more severe in recent years. As recently as 1994, over a quarter of gear firms reported that grinder machinists were readily available, but by 1996, this percentage has fallen to just over 11% Similarly 93% of gear companies reported that in 1996, toolmakers were scarce and difficult to hire.

This problem is unlikely to improve as time passes. The industry work force is relatively old, and as older skilled workers retire, finding the new workers to replace them will be difficult. Forty-three percent of gear manufacturing workers are more than 45 years old, and 82% are more than 30 years old. In an industry where a current shortage of skilled labor already exists, this age profile foreshadows a continuing problem over the next two decades. Tight labor markets imply rising wages that will drive up unit labor costs. Unless productivity rises continuously, the labor shortage could provide an ongoing drag on the industry's profitability.

The American gear industry has made impressive strides in the last ten years to recapitalize itself and become world-class. However, not forgetting the "other" capital, human capital, is important. Labor costs remain a substantial part of gear firms' total costs, and the pressure to improve labor productivity continues. When we combine these factors with the current, and probable future shortages of skilled labor, the human capital dimension of gear manufacturing presents a persistent challenge for the future. ○

Michael D. Bradley

is Professor of Economics at the George Washington University in Washington, D.C. He has been a consultant to the gear industry for twelve years, and in 1996 he won AGMA's Executive Committee Award for "his efforts to enhance the art of management in the gear industry."

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Cyclo System Also New Technology

As always, I enjoyed reading your magazine. It was interesting and enjoyable to read your article about Mr. E. K. Buckingham, who I highly regard as an exceptional authority in the field of gearing in the U.S. His views sometimes do not conform with mainstream practices, opinions and standards as represented by AGMA. I strongly believe it is important to have individuals like him to avoid viewing things too one-sidedly.

I was somewhat disappointed that, according to your article, Mr. Buckingham says "only two new technologies come directly from the gear industry in the last 50 years," namely the Spiroid system and Novikov-Wildhaber gearing.

These two developments are certainly significant. However, I feel that the CYCLO gear system is a much more important new technology. Next to the numerous unique technical and practical advantages of this gear system, no other could achieve a real, economic success in the last 50 years. The CYCLO system, however, became the backbone of close to a billion-dollar gearbox/gear motor industry and is the only significant competitive system to classical involute spur/helical gears.

It is also odd that AGMA is not interested in devoting attention to this system. It seems to me sometimes that the classical gear manufacturers hope: "If we ignore the CYCLO system, it will go away." However, the CYCLO system is being continuously updated, refined and is gaining market share worldwide.

Gerhard Antony, PhD.
Vice President,
Sumitomo Machinery Corp. of America

The Kish Hunting Mesh Method

The Kish method for determination of hunting mesh, (Vol. 14, No.4) looks remarkably like Euclid's algorithm for finding the greatest common divisor of two numbers. Euclid invented his algorithm some 2,300 or so year ago, and here it is in your latest issue, still being useful.

Jules Kish is an estimable engineer, and I am more than glad to call it, as you do, the Kish method, but I think that Euclid deserves at least a nod and, from me, a wink when I do so.

Ron Mosier
Applied Mathematician
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Gear Crack Propagation Investigations

David G. Lewicki and Roberto Ballarini

Introduction

A common design goal for gears in helicopter or turboprop power transmissions is reduced weight. To help meet this goal, some gear designs use thin rims. Rims that are too thin, however, may lead to bending fatigue problems and cracks. The most common methods of gear design and analysis are based on standards published by the American Gear Manufacturers Association. Included in the standards are rating formulas for gear tooth bending to prevent crack initiation (Ref. 1). These standards can include the effect of rim thickness on tooth bending fatigue (Ref. 2). The standards, however, do not indicate the crack propagation path or the remaining life once a crack has started. Fracture mechanics has developed into a useful discipline for predicting strength and life of cracked structures.

Ahmad and Loo (Ref. 3) applied fracture mechanics to gear teeth to illustrate the procedure and estimate crack propagation direction. Honda and Conway (Ref. 4) also applied fracture mechanics to simulate tooth crack propagation, compute threshold loads and calculate tooth life. Flasker and Jezernik (Ref. 5) applied fracture mechanics to gear teeth to estimate stress intensity factors and gear life. Researchers at Tohoku University in Japan performed a series of analyses and experiments to determine the effect of residual stress on crack initiation and propagation (Refs. 6, 7). Also, Daniewicz et al. (Ref. 8) developed a comprehensive, self-contained analysis package to refine the spur gear bending fatigue theory using fracture mechanics. Lastly, Flasker and Pehan (Ref. 9) described their method for calculating crack propagation in gear teeth using fracture mechanics. Much of the work of the above references considered only an initial crack, and propagation paths were not considered. Many of the references that did consider crack propagation assumed the propagation occurred in a straight path. In addition, experimental validation of the cited analyses was sparse. Finally, no work using fracture mechanics was performed for thin-rim gears.

The objective of this study was to determine the effect of gear rim thickness on crack propagation life. From an extensive study (Ref. 10), linear elastic fracture mechanics was used to analyze gear tooth bending fatigue in standard and thin-rimmed gears. Finite element computer programs were used to determine stress distributions, estimate stress intensity factors and model crack propagation. Various fatigue crack growth models were used to estimate crack propagation life. Experimental tests were performed to validate predicted crack propagation results.

Fatigue Crack Growth

Many machine elements, such as gear teeth, are cyclically loaded in application. The overall fatigue life of such components may be represented by three distinct phases: 1) crack initiation, 2) crack propagation and 3) final failure. Once crack initiation has occurred, fracture mechanics may be used to estimate crack propagation fatigue growth rate and time to final failure.

The most universally used method to calculate crack propagation crack growth was postulated by Paris and Erdogan (Ref. 11). Purely Mode I loaded specimens subjected to cyclic load were considered. Unstable crack growth such that the stress intensity factor grew with increasing crack size was also considered. Paris postulated that the rate of crack growth with respect to number of stress cycles was a logarithmic relationship with the stress intensity factor range as

$$\frac{da}{dN} = C(\Delta K)^n \qquad (1)$$

where da is the change in crack length for dN number of stress cycles, ΔK is the range of the Mode I stress intensity factor at a given time and C and n are material constants. The material constants C and n must be determined by some experimental means.

Further research of fatigue crack growth has shown three important factors not considered in the Paris model. First was the effect of load ratio R on crack growth (R = minimum cyclic load/maximum cyclic load). Second was the instability of crack growth observed when the stress intensity factor range approached the material's fracture toughness index, K_{IC}. Third was the presence of a stress intensity threshold factor ΔK_{th}. The stress intensity threshold factor is the highest stress intensity factor in which no crack growth would occur. The Collipriest crack growth model (Ref.12) accounts for these effects where

$$\frac{da}{dN} = C(K_{IC}\Delta Kth)^{n/2} \bullet$$

$$exp\left\{ln\left(\frac{K_{IC}}{\Delta K_{th}}\right)^{n/2} \bullet \tanh^{-1}\left[\frac{\ln\left(\frac{\Delta K^2}{(1-R)K_{IC}\Delta K_{th}}\right)}{\ln\left(\frac{(1-R)K_{IC}}{\Delta K_{th}}\right)}\right]\right\} \qquad (2)$$

In addressing applications to gears, Inoue et al. (Ref. 7) describe fatigue crack growth of gear bending fatigue tests. Here, crack growth equations were derived as a function of crack depth through a gear tooth. The expression derived for crack growth rate da/dN, as a function of stress intensity range ΔK was

$$\frac{da}{dN} = \begin{cases} \dfrac{\lambda}{(1-\alpha^{\eta})}(\Delta K^{\eta} - \Delta K_{th}{}^{\eta}) \text{ for } \Delta K_{th} \le \Delta K \le \Delta K_C \\ \dfrac{\lambda}{(1-\alpha^{\eta})} \dfrac{\Delta K^{\eta} K_{IC}{}^{\eta}}{(K_{IC}{}^{\eta} - \Delta K^{\eta})} \text{ for } \Delta K_C < \Delta K < \Delta K_{IC} \end{cases} \qquad (3)$$

where the parameters K_{IC}, α, ΔK_C, ΔK_{th}, η and λ were all estimated as a function of tooth hardness (Ref. 7).

Crack Propagation Simulation

The analysis of the current study used the FRANC (FRacture ANalysis Code) computer program described by Wawrzynek (Ref. 13). FRANC is a general purpose finite element code for the static analysis of cracked structures. FRANC is designed for two-dimensional problems and is capable of analyzing plane strain, plane stress or axi-symmetric problems.

Among the variety of capabilities, a unique feature of FRANC is the ability to model a crack in a structure. FRANC uses a method called "delete and fill" to accomplish this. To illustrate, the user would first define an initial crack by identifying the node of the crack mouth and coordinates of the crack tip. FRANC will then delete the elements in the vicinity of the crack tip. FRANC will next insert a rosette of quarter-point, six-node triangular elements around the crack tip to model the inverse square-root stress singularity (Refs. 14, 15). Finally, FRANC will fill the remaining area between the rosette and original mesh with conventional six-node triangular elements. The user can then run the finite element equation solver to determine nodal displacements, forces, stresses and strains.

A further unique feature of FRANC is the automatic crack propagation capability. After an initial crack is inserted in a mesh, FRANC models a propagated crack as a number of straight line segments. For each segment, FRANC models the crack tip using a rosette of quarter-point elements. FRANC then solves the finite element equations, calculates the stress intensity factors and calculates the crack propagation angle. After the crack propagation angle is determined, FRANC then places the new crack tip at the calculated angle and at a user-defined crack increment length. The model is then remeshed using the "delete and fill" method described above. The procedure is repeated a specific number of times as specified by the user. In the current study, the stress intensity factors were determined from the calculated nodal displacements using the displacement correlation method (Ref. 16). The method of Erdogan and Sih (Ref. 17) was used in the current study to determine the crack propagation angle.

Once the stress intensity factors are determined for each segment, the predicted number of crack propagation cycles can be estimated using the fatigue crack growth models. Regardless of the model used, the crack growth rates *da/dN*, were of the form

$$\frac{da}{dN} = g(\Delta K) \qquad (4)$$

where $g(\Delta K)$ is given by Eq. 1 for the Paris relationship, Eq. 2 for the Collipriest relationship or Eq. 3 for Inoue's method. The predicted number of crack propagation cycles for the i_{th} crack segment, N_i, was estimated by

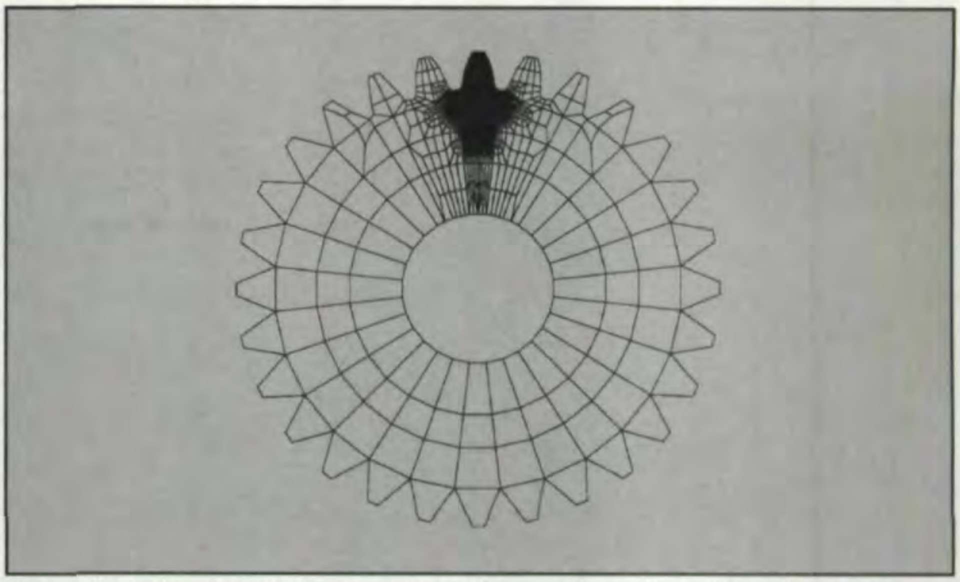

Fig. 1 — Finite element model of gears used in crack propagation studies, solid model, m_B = 3.3.

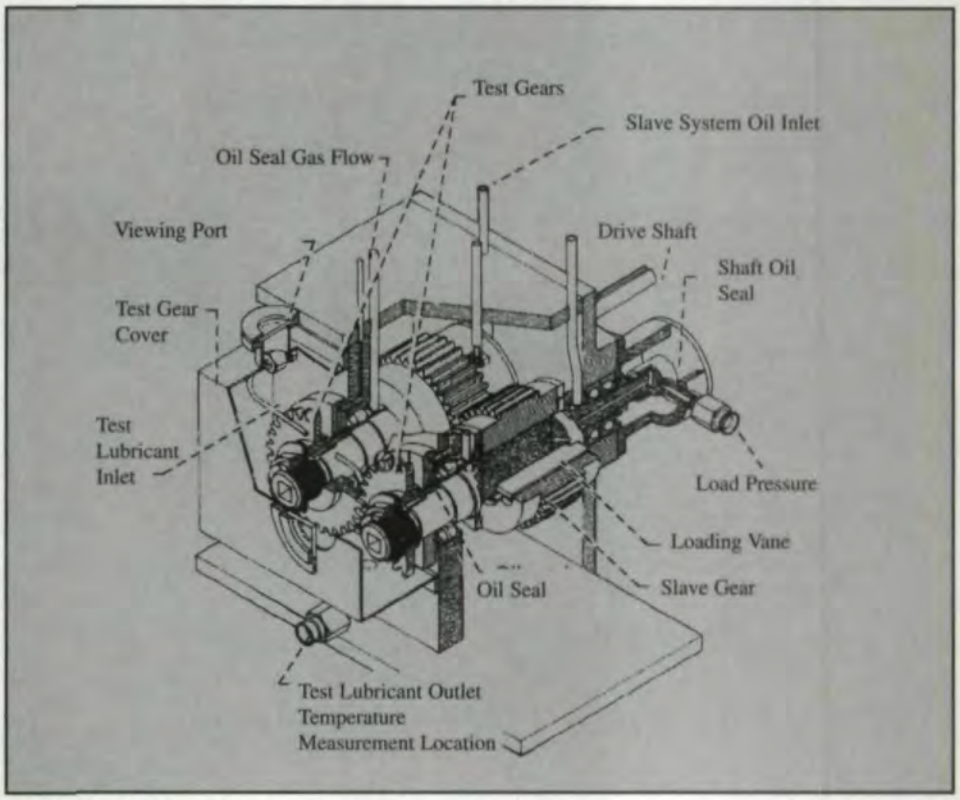

Fig. 2 — NASA Lewis Spur Gear Fatigue Rig.

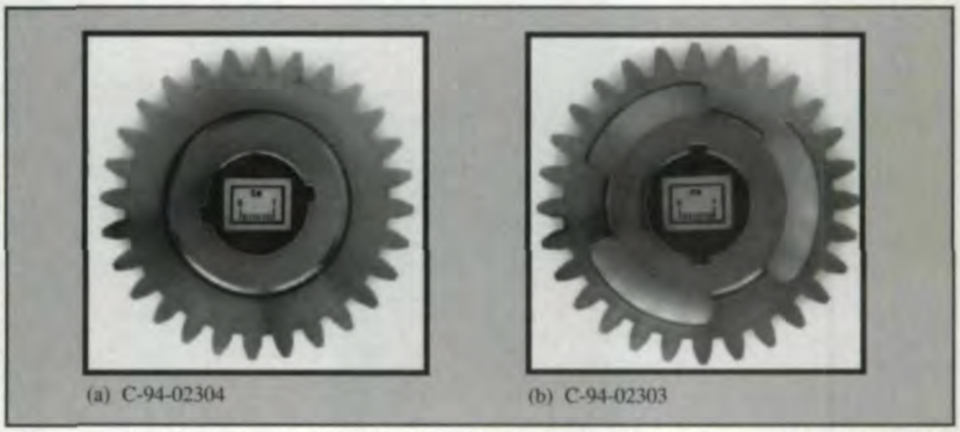

Fig. 3 — Test gears used to determine effect of rim thickness on crack propagation. (a) m_B = 3.3. (b) m_B = 0.3.

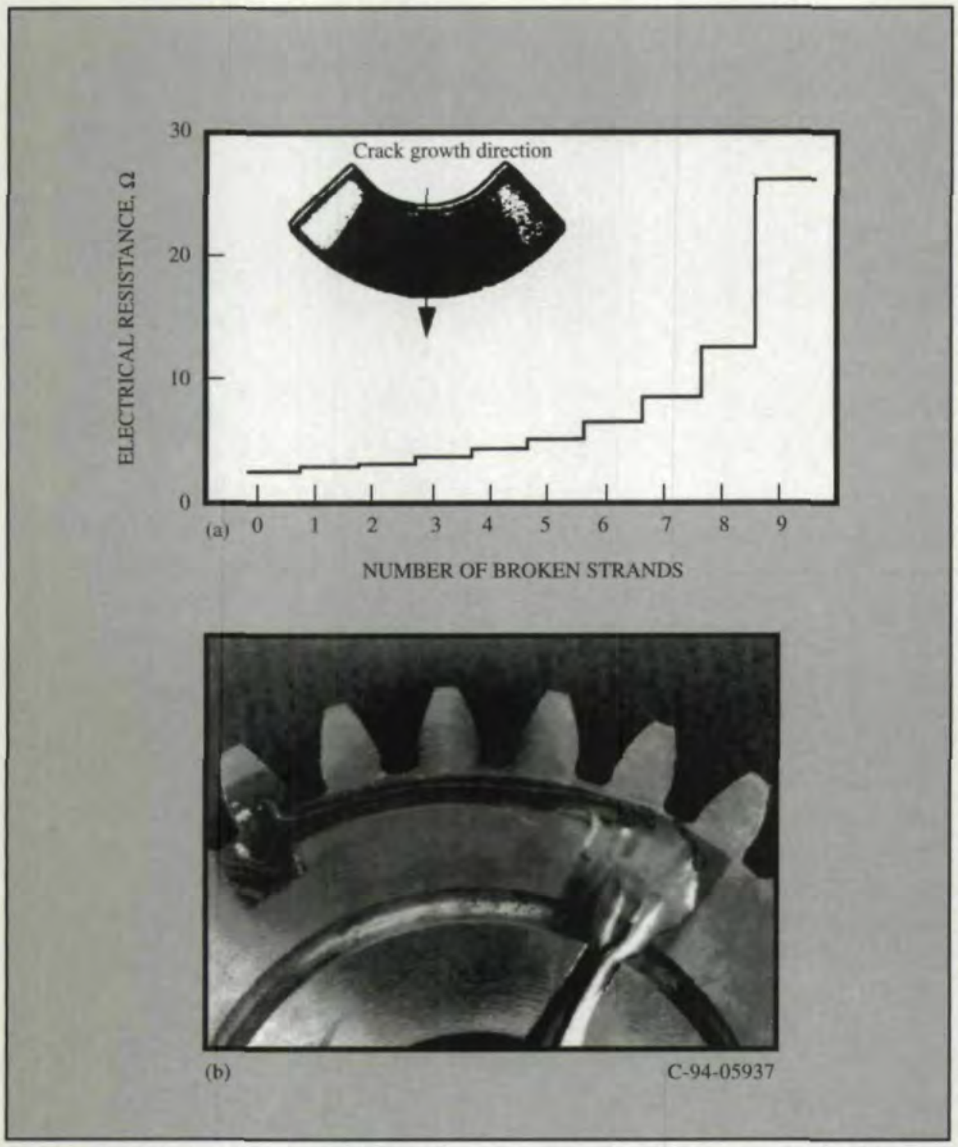

Fig. 4 — Specialized crack propagation gages for gear tooth crack growth measurements. (a) Increase in gage electrical resistance as the number of broken strands increases. (b) Installation of crack propagation gage on test gear.

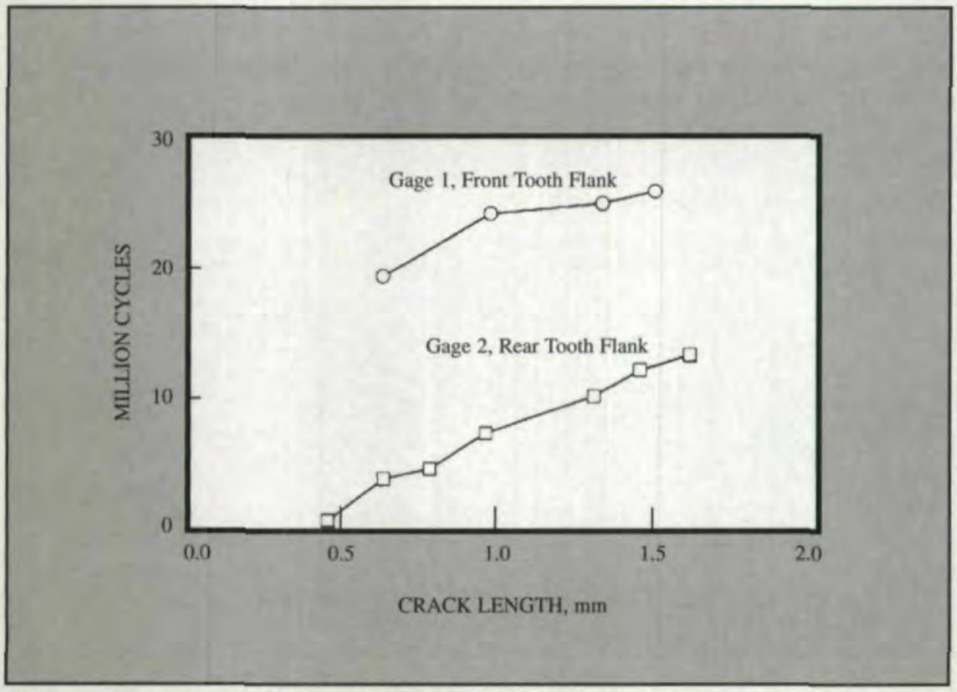

Fig. 5 — Crack propagation fatigue growth for Test 1, $m_B = 0.3$.

$$N_i = \frac{a_i - a_{i-1}}{g(\Delta K_i)} + N_{i-1} \qquad (5)$$

where a_i was the crack length of the i_{th} segment, a_{i-1} was the crack length of the $(i-1)_{th}$ segment, N_{i-1} was the number of cycles of the $(i-1)_{th}$ segment and $g(\Delta K_i)$ was the average crack growth rate of the i_{th} and $(i-1)_{th}$ segments. Note that a_1 was the initial crack length, and $N_1 = 0$ and i varied from 2 to the total number of segments.

Gear Finite Element Modeling

Basic gear tooth geometry data was input to a tooth coordinate generation computer program. The tooth coordinate generator program used the method of Hefeng et al. (Ref. 18) to determine the tooth coordinates. The output was tooth coordinate and rim coordinate data which defined a single tooth sector of a gear. This output was used by a commercially available pre- and post-processing finite element analysis software package (Ref. 19). This package created the finite element mesh of the complete gear. FRANC then used this mesh and performed crack propagation simulations.

Fig. 1 shows a sample finite element mesh of an uncracked gear. The tooth geometry used modeled that of the test gears of the NASA Lewis Spur Gear Fatigue Rig (described in the following section). The analysis used 8-node, place stress, quadrilateral finite elements. The mesh was refined in the region of the loaded tooth for improved accuracy. The model of Fig. 1 had 2,353 elements and 7,295 nodes. Material properties used were that of AISI 9310 steel. The tooth load was placed at the highest point of single tooth contact. For boundary conditions, four hub nodes were fixed. In addition, gears with various rim thicknesses were modeled. The parameter describing the rim thickness was the backup ratio m_B, where

$$m_B = \frac{b}{h} \qquad (6)$$

where b was the rim thickness, and h was the tooth whole depth. Gears with various backup ratios were modeled by incorporating slots in the model. All cases used the same finite element mesh for the loaded tooth.

Test Facility

Crack propagation experiments were performed in the NASA Lewis Spur Gear Fatigue Rig (Fig. 2). The test stand operated on a torque regenerative principle in which torque was circulated in a loop of test gears and slave gears. Oil pressure was supplied to load vanes in one slave gear which displaced the gear with respect to its shaft. This produced a torque on the test gears, slave gears and connecting shafts proportional to the amount of applied oil pressure. A 19 KW (25 hp), variable-speed motor provided speed to the drive shaft using a belt and pulley. The lubricant used for the gears, bearings and loading systems was a synthetic paraffinic oil. The test gear lubricant was filtered through a 5-micron fiberglass filter.

Test Gears

The test gears were 28-tooth, 8-pitch, 20° pressure angle external spur gears with a face width of 6.35 mm (0.25"). The teeth had involute profiles with linear tip relief starting at the highest point of single tooth contact and ending at the tooth tip at an amount of 0.013 mm (0.0005"). All test gears used in the experiments were fabricated and machined from a single batch of material. The test gear material was vacuum-melted , consumable-electrode AISI 9310 steel. The gears were case carburized and ground. The teeth were hardened to a case hardness of R_c 61 and a core hardness of R_c 38. The effective case depth (depth at a hardness of R_c 50) was 0.81 mm (0.032"). Two different test gear designs were considered. The first was a thick-rimmed gear with a backup ratio of m_B = 3.3 (Fig. 3a). The second was a thin-rimmed gear which incorporated slots (Fig. 3b). The backup ratio of the thin-rimmed gear was $m_B = 0.3$.

It was believed that tooth bending fatigue cracks would be difficult to initiate based on the load capacity of the test rig. Due to this, notches were fabricated in the fillet region (loaded side) on one tooth of each of the test gears to promote crack initiation. The notches were fabricated using electrical discharge machining (EDM) with a 0.10 mm (0.004") diameter wire electrode. The nominal notch dimensions were 0.20 mm (0.008") in length and 0.13 mm (0.1005") in width along the full face width of the tooth. The notches were located at the same location for both test gears. This location was at a radius of 40.49 mm (1.594") on the fillet, which was the position of the greatest tensile stress for the solid gear (m_B = 3.30). The notches produced a stress concentration factor of approximately three as determined using a finite element analysis.

Instrumentation

The standard test rig instrumentation monitored test gear speed, oil load pressure, test gear and slave gear oil pressure and oil temperatures. Also, overall test stand vibration was monitored using an accelerometer mounted on the top housing. In addition to the standard facility vibration sensor, an advanced vibration processing diagnostic system was installed in the test stand to help assist in crack detection. Crack propagation gages were used in the experiments to determine fatigue crack growth. Special gages were fabricated for installation in the tooth fillet region of the test gears. The gages had ten circular strands with an inner radius of 1.52 mm (0,.060") and an outer radius of 3.05 mm (0.120") (Fig. 4). The strands were designed to break as the crack propagated through them, which in turn increased the electrical resistance of the gage (Fig. 4a). Fig. 4b shows the installation of a gage in the fillet region of a notched tooth. A gage was installed on each side of the tooth flank for each gear instrumented with crack gages. The electrical resistance of the crack gages was monitored along with the load cycle count to estimate cycles as a function of crack length. The information from the rotating crack gages was transferred through brush-type slip rings. Also, an infrared tach sensor was used to measure number of load cycles.

Measured Gear Fatigue Crack Growth

The thin-rimmed gear was used in Test 1. The test was run at 89 Nm (786 in/lb) torque and 10,000 rpm speed for 6.5 hrs., at which time rim fracture occurred. Fig. 5 plots the number of load cycles as a function of the measured crack length. The crack gage results indicated the crack growth was non-uniform throughout the tooth face width. A crack started on the rear flank of the tooth at the tip of the notch and reached an initial size of 0.46 mm (0.018") at 1,060,000 cycles. The crack continued to propagate through the rear flank, but did not reach the front flank until approximately 2,680,000 cycles. At 2,910,000 cycles, the crack reached a size of 0.64 mm (0.025") on the front flank, but completed propagation through the rear gage by this time. Even though the crack initiation time was not uniform throughout the tooth face width, the crack propagation rate was uniform. This was indicated by the similarity in slopes of the curves in Fig. 5 for Gages 1 and 2.

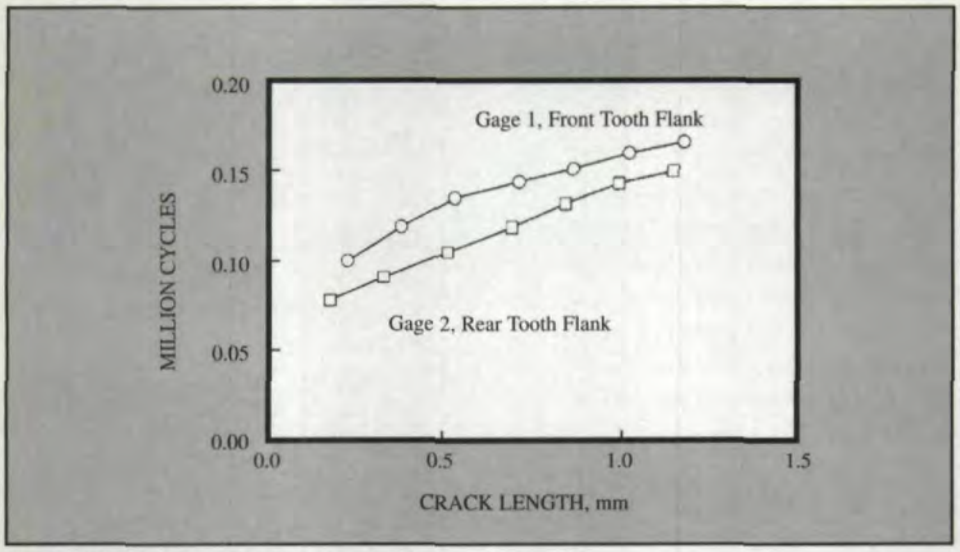

Fig. 6 — Crack propagation fatigue growth for Test 2, $m_B = 3.3$.

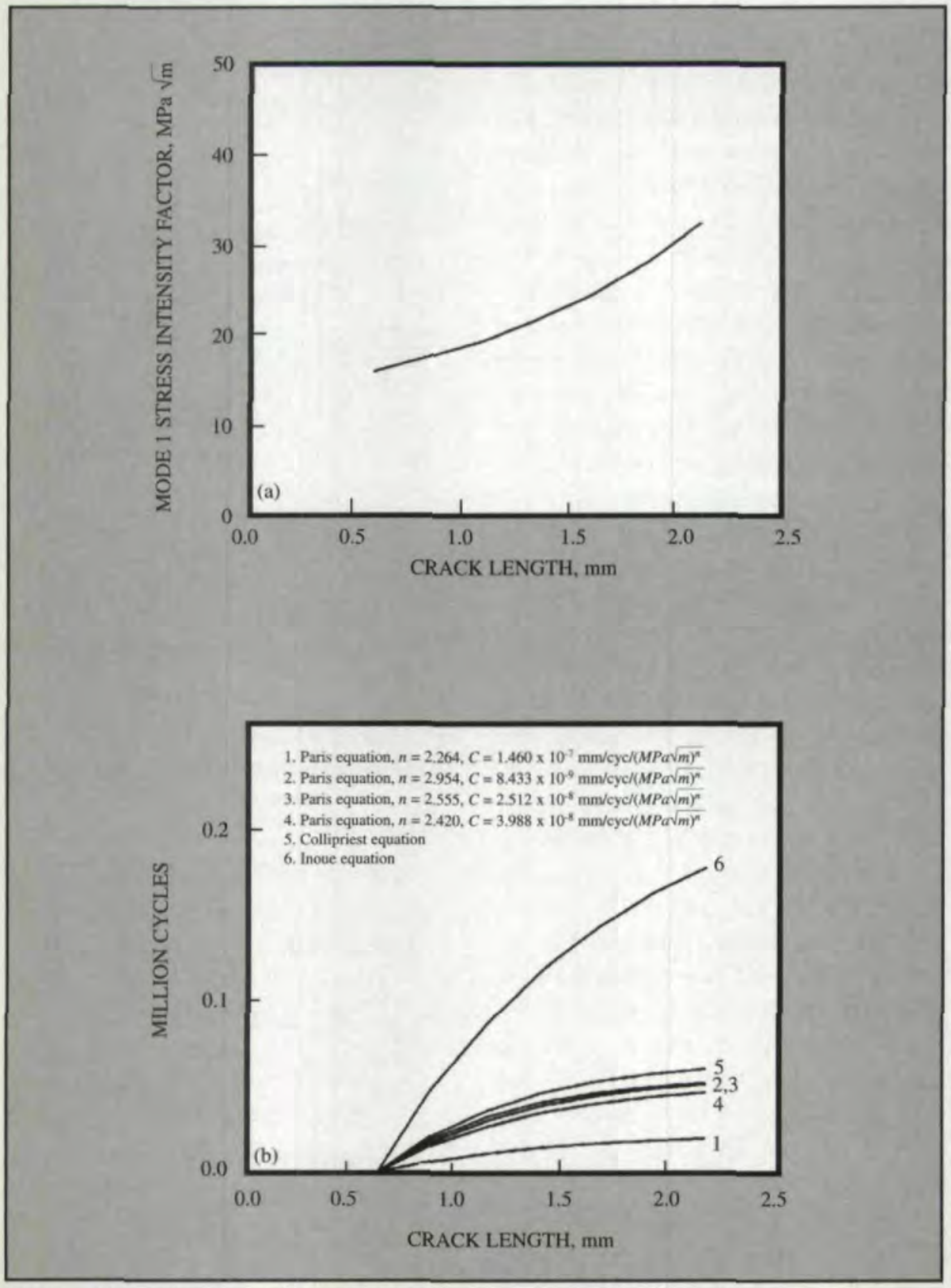

Fig. 7 — Comparison of predicted crack propagation cycles using Paris, Collipriest and Inoue equations. Model for $m_B = 0.3$. (a) Mode 1 stress intensity factor. (b) Life comparison.

The thick-rimmed gear was used in Test 2. This gear was run at 136 Nm (1200 in/lb) torque and 10,000 rpm speed for 15 minutes, at which time tooth fracture occurred. Fig. 6 gives the processed crack propagation results for Test 2. Note that the crack initiation and crack propagation was fairly uniform throughout the tooth face width for this test.

Comparison of Predicted and Measured Crack Growth

The FRANC computer program was used to simulate crack propagation and calculate Mode I stress intensity factors as a function of crack length. The predicted stress intensity factors were then used with three different fatigue crack growth models (Paris, Collipriest and Inoue) to estimate crack propagation.

A comparison of predicted crack propagation cycles using the Paris, Collipriest and Inoue methods is shown in Fig. 7. For this, the thin-rimmed model ($m_B = 0.3$) was used to simulate the test gear of Fig. 3b. An initial crack of 0.64 mm (0.025") was placed in the tooth fillet at the location of the maximum tensile stress. Crack propagation was then simulated, and the Mode I stress intensity factor as a function of crack length is given in Fig. 7a. From this, six different fatigue growth cases were considered. The first four cases used the Paris equation and material constants of AISI 9310 specimens from experiments of Au and Ke (Ref. 20). The fifth case used the Collipriest equation and AISI 9310 material constants from Forman and Hu (Ref. 21). The load ratio used was $R = 2.6$, as determined from the finite element analysis. The sixth case used Inoue's method and the material constants of the SCM 415 material (SCM 415 is a high-strength Japanese steel with properties similar to AISI 9310). The predicted number of cycles per crack length varied significantly among the cases studied (Fig. 7b). Note that the cycles were defined as the number of crack propagation cycles after an initial crack of 0.64 mm (0.025").

Predicted crack growth for the $m_B = 0.3$ and 3.3 gears was compared to the measured crack growth from the experiments. Again, the six different prediction schemes mentioned above were used. The predicted number of crack propagation cycles using the sixth schemes were, for the most part, extremely low compared to the measured number of cycles from the experiments. To account for this, the concept of fatigue crack closure was investigated. Elber (Ref. 22) performed crack experiments on aluminum alloys and deduced that residual compressive stresses existed near the crack tip region because of plastic deformation. These residual stresses reduced the effective stress intensity factor range (and thus, increased crack propagation life) and provided a better fit to experimental data than other empirical expressions. Elber proposed an effective stress intensity range ratio U such that

$$\Delta K_{eff} = U(\Delta K) \qquad (7)$$

where ΔK_{eff} was the effective stress intensity factor range. Elber then used the effective stress intensity factor range in the Paris fatigue crack growth model. In addition, Elber defined U through experimental studies as a linear function of the load ratio R.

The concept of fatigue crack closure was applied to the current gear crack experiments and predictions. A study was conducted to estimate the effective stress intensity factor range ratio for the experiments. The predicted number of crack propagation cycles using the same six schemes were plotted versus crack length at a variety of arbitrarily chosen U ratios. For the Paris equation and material constants n = 2.954 and $C = 8.433 \times 10^{-9}$ mm/cyc/(MPa$\sqrt{m}$)^n, good correlation between predicted crack cycles and the experiments occurred when: 1) $U = 0.4$ for $R = 2.6$, and 2) $U = 0.8$ for $R = 0.1$. Assuming a linear relation between U and R produced

$$= 0.82 + 0.16(R) \qquad (8)$$

Fig. 8 shows a sample comparison of predicted and measured crack growth when the fatigue crack closure concept was used. The cycles were defined as the number of crack propagation cycles after an initial crack of 0.64 mm (0.025"). It should be noted that good correlation was also achieved when the Collipriest equation was used with certain U values. This produced a relationship similar to Eq. 8, but with different coefficients (Ref. 10).

Fig. 9 displays the effect of rim thickness on predicted Mode I stress intensity factors and predicted crack propagation cycles. The stress intensity factors were determined from FRANC using the appropriate finite element models. The Paris equation was used along with the effective stress intensity range ratios of Eq. 8. The initial cracks of the various models were placed at the location of the maximum tensile stress in the tooth fillet. The stress intensity factors were lowest for the $m_B = 0.5$ case. This gave the highest predicted number of cycles for the cases studied. The cycles were all defined as the number of crack propagation cycles after an initial crack of 0.28 mm (0.011"). The stress intensity factors were highest for the $m_B = 0.3$ case. However, the predicted life for this was somewhere between the case of

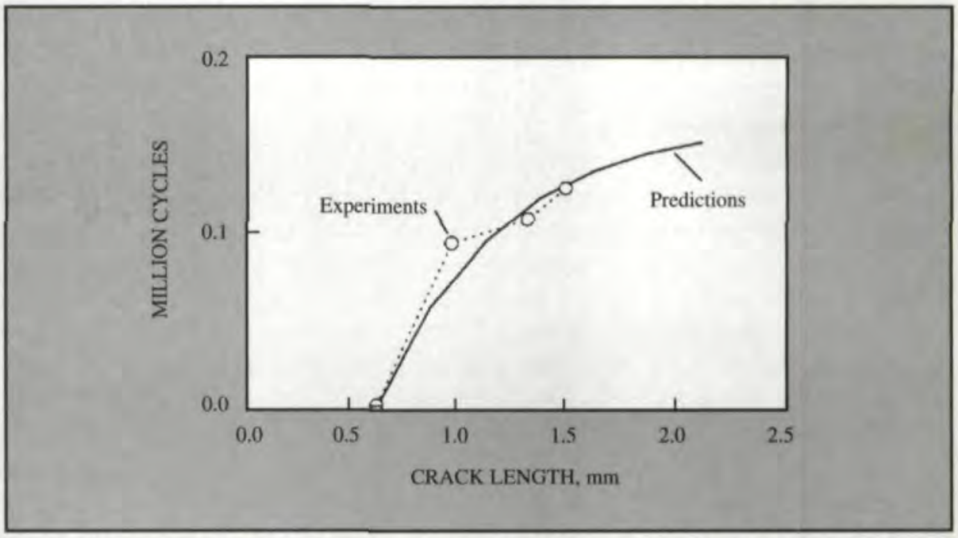

Fig. 8 — Comparison of predicted crack propagation cycles to experiments. Paris fatigue crack growth model, n = 2.954, $C = 8.433 \times 10^{-9}$ mm/cyc/($MPa\sqrt{m}$)^n, R = -2.6, U = 0.4, used for predictions. Test 1, Gage 1, front flank, for experiments.

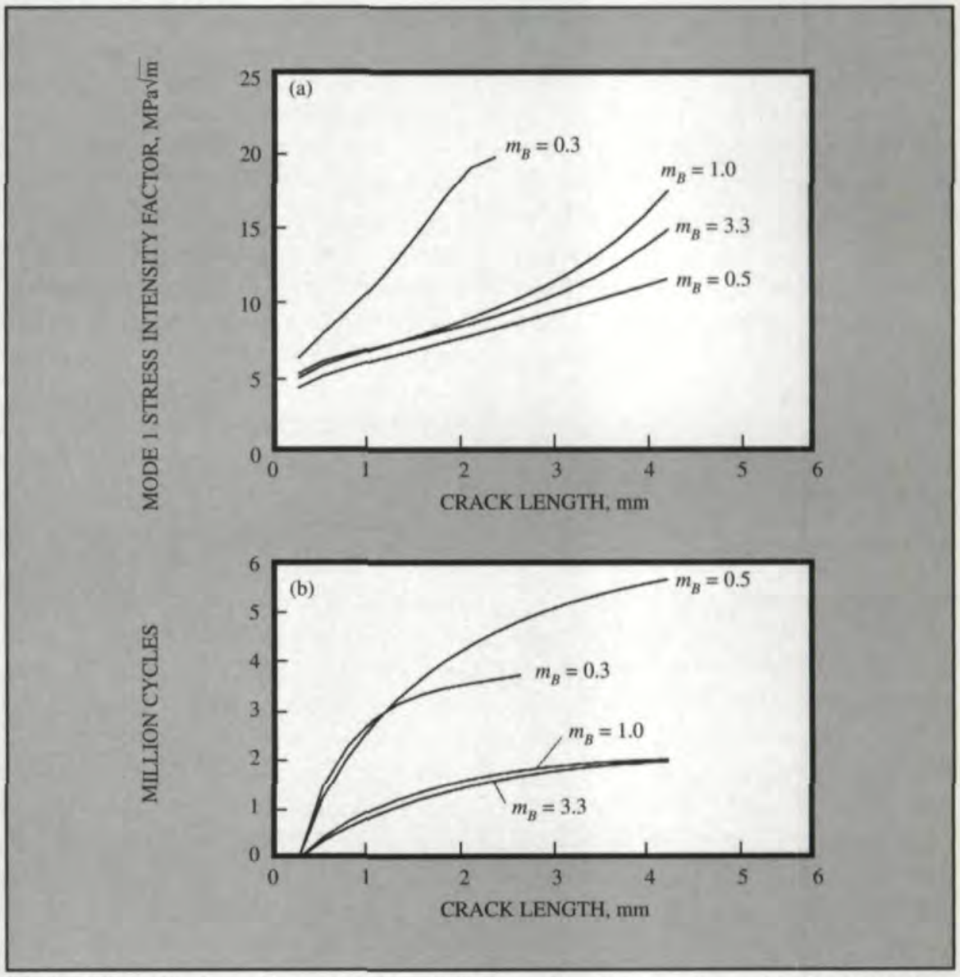

Fig. 9 — Effect of backup ratio on stress intensity factors and crack propagation cycles. (a) Mode 1 stress intensity factors. (b) Crack propagation cycles, Paris fatigue crack growth model, n = 2.954, $C = 8.433 \times 10^{-9}$ mm/cyc/($MPa\sqrt{m}$)^n, $U = 0.82 + 0.16\ R$.

$m_B = 0.5$ and 1.0 due to the fatigue crack closure effect. The cases of $m_B = 3.3$ and 1.0 gave nearly the same predicted life.

Conclusions

Based on these analytical and experimental studies, the following conclusions were made: 1) Good correlation between predicted and measured gear crack growth was achieved when the predictions used the Paris crack growth equation and the concept of fatigue crack closure. 2) For thin rims, a decrease in rim thickness caused an increase in both the stress intensity factor and the compressive cyclic stress in the gear tooth fillet region. The increase in stress intensity factor promoted crack growth, while the increase in cyclic compressive stress tended to retard crack growth and increase the number of propagation cycles to failure. ✪

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Gear Shaving Basics – Part I

John P. Dugas

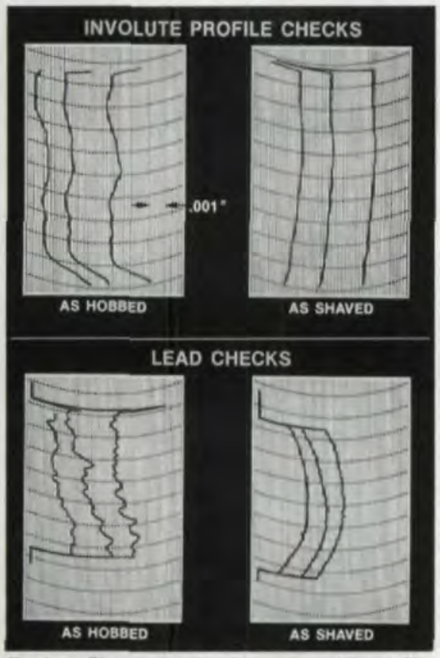

Fig. 1 — Charts showing improvement in profile and lead, 5.7 NPD, 20°, NPA, 3.85" P.D., crowned shaved with stock removal of 0.011" over pins.

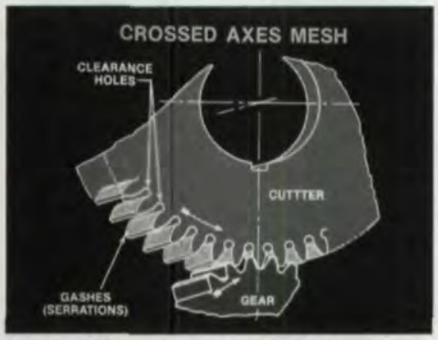

Fig. 2 — Work gear in crossed-axes mesh with rotary shaving cutter mounted above.

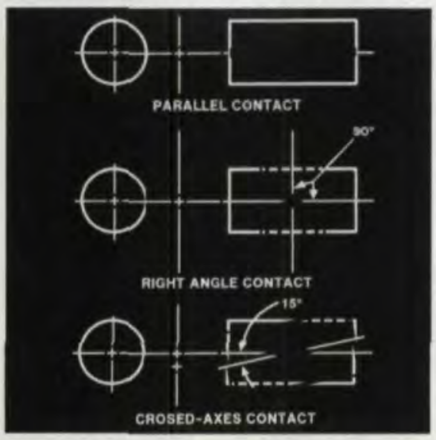

Fig. 3 — Contact between cylinders change as crossed axes are varied.

Gear shaving is a free cutting gear finishing operation which removes small amounts of metal from the working surfaces of gear teeth. Its purpose is to correct errors in index, helix angle, tooth profile and eccentricity (Fig. 1). The process also improves tooth surface finish and eliminates by means of crowned tooth forms the danger of tooth end load concentrations in service. Shaving provides for profile modifications that reduce gear noise, increase a gear's load carrying capacity, its factor of safety and its service life. Gear finishing (shaving) is not to be confused with gear cutting (roughing). They are essentially different. Any machine designed primarily for one cannot be expected to do both with equal effectiveness or with equal economy.

Gear shaving is the logical remedy for the inaccuracies inherent in gear cutting. It is equally effective as a control for those troublesome distortions caused by heat treatment.

The form of the shaving cutter can be reground to make profile allowance for different heat treat movements caused by varying heats of steel. The shaving machine can also be reset to make allowance for lead change in heat treatment.

Rotary gear shaving is a production process that utilizes a high speed, hardened and ground, ultra-precision steel shaving cutter. The cutter is made in the form of a helical gear. It has gashes in the flanks of the teeth which act as the cutting edges.

The cutter is meshed with the work gear in a crossed-axes relationship (Fig. 2) and rotated in both directions during the work cycle while the center distance is reduced in small increments. Simultaneously the work is traversed back and forth across the width of the cutter. The traverse path can either be parallel or diagonal to the work gear axis, depending on the type of work gear, the production rate and finish requirements. The gear shaving process can be performed at high production rates. It removes material in the form of fine hair-like chips.

Machines are available to shave external spur and helical gears up to 200" in diameter. Other machines are also available for shaving internal spur and helical gears. For best results with shaving, the hardness of the gear teeth should not exceed 30 Rockwell C scale. If stock removal is kept to recommended limits, and the gears are properly qualified, the shaving process will finish gear teeth in the 7 to 20 pitch range to the following accuracies: involute profile, 0.0002"; tooth-to-tooth spacing, 0.0003" and lead or parallelism, 0.0002".

In any event, it should be remembered that gear shaving can remove 65–80% of the errors in a hobbed or shaped gear. It will make a good gear better. The final quality of the shaved gear is dependent to a large degree upon having good hobbed or shaped gear teeth.

Excellent surface finish is achieved with gear shaving. A value of approximately 25° is the normal finish obtained with production gear shaving, although much finer finishes are possible by slowing the process. In some cases, shaving cutters will finish up to 80,000 gears before they need sharpening. They may generally be sharpened from four to ten times.

To a gear designer, the shaving process offers attractive advantages in the ability to modify the tooth form. If a crowned tooth form or a tapered tooth form are desired to avoid end bearing conditions, these can be easily provided by shaving.

If modifications are desired in the involute profile, these can be made by suitable modifications in the ground cutter tooth form. If heat treatment distortions can be kept to a minimum, the most inexpensive way to produce an accurate, quiet, high-performance gear is to specify hobbing followed by gear shaving. The shaving process uses a variety of standardized production equipment ranging from hand loading to fully automatic loading and unloading.

Basic Principles

The rotary gear shaving process is based on fundamental principles. This process uses a gashed rotary cutter in the form of a helical gear having a helix angle different from that of the gear to be shaved. The axes of the cutter and the gear are crossed at a predetermined angle during the shaving operation. When the cutter and the work gear are rotated in close mesh, the edge of each cutter gash shaves a fine hair-like chip as it moves over the surface of a work gear tooth. The finer the cut, the less the pressure required between tool and work, eliminating the tendency to cold-work the surface metal of the work gear teeth.

This process is performed in a shaving machine, which has a motor-driven cutter head and a reciprocating work table. The cutter head is adjustable to obtain the desired crossed axis relationship with the work. The work carried between live centers is driven by the cutter. During the shaving cycle, the work is reciprocated parallel to its axis across the face of the cutter and upfed an increment into the cutter with each stroke of the table. This conventional shaving cycle is one of several methods.

The Crossed-Axis Principle

To visualize the crossed-axis principle, consider two parallel cylinders of the same diameter (Fig. 3). When brought together under pressure, their common contact surface is a rectangle having the length of a cylinder and width which varies with contact pressure and cylinder diameter.

When one of these cylinders is swung around so that the angle between its axis and that of the other cylinder is increased up to 90°, their common plane remains a parallelogram, but its area steadily decreases as the axial angle increases. The same conditions prevail when instead of the two plain cylinders, a shaving cutter and a work gear are meshed together. When the angle between their axes is from 10° to 15°, tooth surface contact is reduced, and the pressure required for cutting is small. As the work gear is moved away axially from the point of intersection of the axes, backlash develops. Conversely, as it is returned to the point of axial intersection, backlash decreases until the two members engage in tight mesh with the teeth of the cutter wedging between those of the work gear. Thus, each succeeding cutting edge sinks deeper into the work gear tooth until the point of axial intersection is reached.

For shaving, the cutter and work gear axes are crossed at an angle usually in the range of 10° to 15° or approximately equal to the difference in their angles.

Crossing the axes produces reasonably uniform diagonal sliding action from the tip of the teeth to the root. This not only compensates for the nonuniform involute action typical of gears in mesh on parallel axes, but provides the necessary shearing action for stock removal.

Relationship Between Cutting & Guiding Action

Increasing the angle between the cutter and work axes increases cutting action, but, as this reduces the width of the contact zone, guiding action is sacrificed. Conversely, guiding action can be increased by reducing the angle of crossed axes, but at the expense of cutting action.

Preparation Prior to Shaving

The first consideration in manufacturing a gear is to select the locating surfaces and use them throughout the process sequence. Close relationship between the locating surface and the face of the gear itself must be held. Otherwise, when the teeth are cut and finished with tooling that necessarily contacts the gear faces, the teeth will be in an improper relationship with the locating or related surface on which the gear operates. Gears that locate on round diameters or spline teeth must fit the work arbors closely or these critical hole-to-face relationships will be destroyed.

Typical manufacturing tolerances for gear blanks prior to cutting of the teeth are shown in Table 1.

Once the gear blank has been manufactured, it is necessary to cut the gear teeth. The most common methods today for rough-cutting gear teeth are hobbing and shaper cutting. Of primary concern to the shaving cutter manufacturer is the fillet produced by the roughing operation. The tips of the shaving cutter teeth must not contact the gear root fillet during the shaving operation. If such contact does occur, excessive wear of the cutter results, and the accuracy of the involute profile is affected.

The shaving cutter just finishes the gear tooth below its active profile. Thus, the height of the fillet should not exceed the lowest point of contact between the shaving cutter teeth and the teeth on the work gear.

Protuberance type hobs and shaper cutters are often used prior to shaving to produce a slight undercut or relief near the base of the gear tooth. This method assures a smooth blending of the shaved tooth profile and the unshaved tooth fillet, as well as reducing shaving cutter tooth tip wear (Fig. 4). The amount of undercut produced by the protuberance type tool should be made for the thin end of the tooth. The position of the undercut should be such that its upper margin meets the involute profile at a point below its contact diameter.

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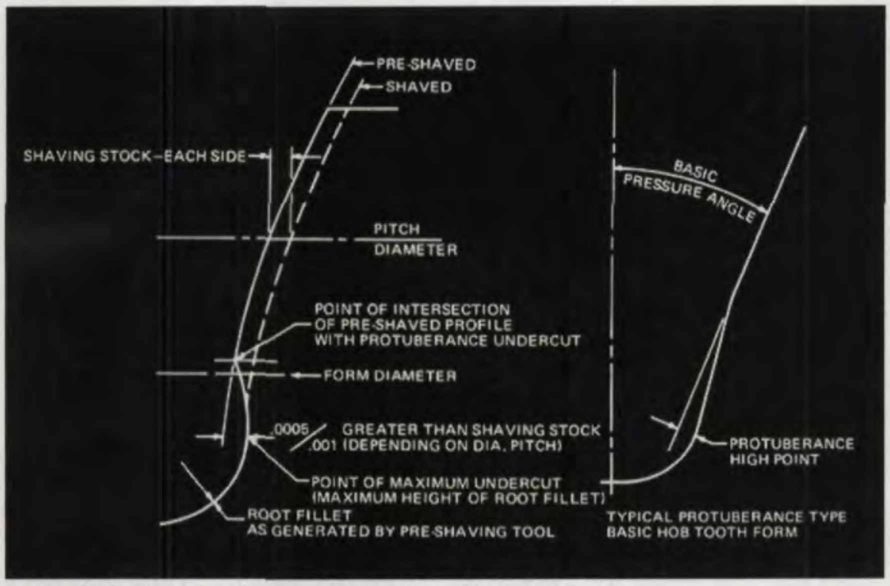

Fig. 4 — Undercut produced by protuberance hob and basic hob tooth form.

TABLE 1 – TYPICAL GEAR BLANK TOLERANCE

Blank Dia. In.	Face Runout In.	Hole Size In.	Hole Tape In./In.	Hole Roundness In.-Max.	O.D. In.-Max.	O.D. Runout In.
Up to 1 1-in Thick	0.0003–0.0005	0.0003–0.0006	0.0002–0.0003	0.0002–0.0003	0.003	0.003
1–4, up to 1 in. Thick	0.0004–0.0008	0.0005–0.001	0.0002–0.0003	0.0003–0.0005	0.005	0.005
4 to 8	0.0006–0.0012	0.0008–0.0012	0.0002–0.0003	0.0004–0.0006	0.005	0.007
8 to 12	0.001–0.002	0.001–0.0015	0.0002–0.0003	0.0005–0.0007	0.005	0.008

TABLE 2 – RECOMMENDED SHAVING STOCK AND UNDERCUT FOR PRESHAVED GEARS.

Normal Diametral Pitch	Shaving Stock (In. per Side of Tooth)	Total Undercut (In. per Side of Tooth)
2–4	0.0015–0.0020	0.0025–0.0030
5–6	0.0012–0.0018	0.0023–0.0028
7–10	0.0010–0.0015	0.0015–0.0020
11–14	0.0008–0.0013	0.0012–0.0017
16–18	0.0005–0.0010	–
20–48	0.0003–0.0008	–
52–72	0.0001–0.0003	–

Shaving Stock

The amount of stock removed during the shaving process is a key to its successful application. Sufficient stock should be removed to permit correction of errors in the preshaved teeth. However, if too much stock is removed, cutter life and part accuracy are effectively reduced.

Table 2 shows the recommended amounts of stock to be removed during the shaving operations and the corresponding amount of undercut required. ○

Acknowledgement: *Presented by National Broach & Machine at the Society of Manufacturing Engineers 1st International Advanced Gear Processing & Manufacturing Conference, June, 1996.*

The second half of this article, covering shaving methods and design, will appear in our Jan/Feb, 1998, issue.

John P. Dugas
for many years was the Chief Tool Engineer at National Broach & Machine. He is the author of numerous papers and presentations on gear subjects. He is now retired.

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TECHNICAL CALENDAR

Nov. 9–11. AGMA Fall Technical Meeting. U. S. Grant Hotel, San Diego, CA. Presentations on a variety of gear subjects by experts from around the world. Main topic groups include Advanced Gear Metrology, Alternate Stress Analysis Methods, Application and Technology and Innovations in Design & Manufacturing. For more information, contact AGMA at 703-684-0211, fax 703-684-0242, e-mail *agma@clark.net* or log on to *www.agma.org*.

Dec. 8–11. Pfauter Gear School: Basic Course. Rockford, IL. This comprehensive four-day program consists of a coordinated series of lectures by the American Pfauter/Pfauter-Maag staff. Subjects covered include gear types, ratios, involute geometry, gear tooth systems, steels, gear cutting basics, gear inspection and more, plus a tour of the Pfauter facilities. Class size is limited, so be sure to register early. Call 815-282-3000 x313, fax 815-282-3075 or register online at *www.pfauter.com*.

March 16–19, 1998. National Manufacturing Week. McCormick Place, Chicago, IL. Billed as covering "the hottest topics in manufacturing," this week-long exhibition and conference will feature over a half-million sq. ft. of exhibit space for some 65,000 visitors. The conference will offer 15 tracks in three different formats. Among the subjects covered will be 21st Century Manufacturing, CAD/CAM, Data Acquisition, Design for Manufacturability, Integrated Manufacturing Technology, Environmental/Safety, World Class Maintenance and Materials & Processes. For more information, contact Reed Exhibition Companies at 800-840-0678, fax 203-840-9678, e-mail *nmw@reedexpo.com* or log on to *http://nmw.reedexpo.com*.

April 22–27, 1998. Seoul International Machine Tool Show 98. Seoul Yoido Exhibition Center and Yoido Tongil Exhibition Center. Organized by the Korea Machine Tool Manufacturers' Association and sponsored by the Korean Ministry of Trade, Industry & Energy, this show is designed to promote international trade through the international exchange of information and technology. Both domestic and foreign machine tools and related items will be featured. For more information about exhibiting or attending, contact Korea Machine Tool Manufacturers' Association by phone at 82-2-565-2721 or fax 82-2-564-5639.

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The Product Design & Development Division of the Society of Plastics Engineers and the Plastics Steering Committee of the Emerging Technologies of AGMA is planning one to two sessions on **Plastics Gearing Technology** to be held at **ANTEC '98** in Atlanta, GA, **April 26–May 1, 1998.** The theme of ANTEC '98 is "Plastics on My Mind," and papers on any subject relevant to promoting and improving plastic gearing technology is welcome. Deadline for papers is **November 10, 1997.** For more information, contact Andrea Knapp at SPE Headquarters, 203-740-5458 or fax 203-775-8490. ○

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While we have made every effort to ensure that company names and addresses are correct, we cannot be held responsible for errors of fact or omission.

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Shin Shin Enterprises
Textile Parts & Machine
Tifco Gage & Gear
Trogetec Inc.
Trojon Gear Inc.
Wedin Intl. Inc.
Winzeler Gear
Worcester Gear Works

Gears–Powder Metal
Aplus Engineering Inc.
Asco Sintering Co.
Ashot USA Inc.
BestMetal Corp.
Burgess-Norton Mfg. Co.
Capstan Atlantic
Carbon City Products
Cloyes Gear & Products
Dabko Industries Inc.
The Gear Works-Seattle
Great Gear Corp.
ITW Spiroid
Keystone Powdered Metal
Lyon Gear
M&M Precision Systems
Martin Sprocket & Gear
Metal Powder Components
Moore Gear Mfg. Co.
Pennsylvania Pressed Metal Inc.
Precision Gear Co.
St. Marys Carbon Co.
Shin Shin Enterprises
Tifco Gage & Gear
Trogetec Inc.
Zenith Sintered Products

Gears–Racks
ACR Industries
Allied Devices Corp.
American Mach. & Gear
American Metric Corp.
American Precision Gear
Andantex USA
Anderson International
Aplus Engineering Inc.
Asco Sintering Co.
Bevel Gears (India)
Boonville Mining Services
Boston Gear
C-B Gear & Machine, Inc.
Capstan Atlantic
Carbon City Products
Charles Bond Co.
The Cincinnati Gear Co.
Circle Gear & Machine
Commercial Gear & Sprocket

Cornell Forge Co.
Dabko Industries Inc.
Davall Gear Co. Ltd.
Dayton Gear & Tool
EMCO Gears
Engelhardt Gear Co.
Engranes Industriales Rivera
Federal Gear Corp.
Fellows Corp.
Fleet Tools Ltd.
Foote-Jones/Illinois Gear
Franke Gear Works Inc.
GW Plastics
Gear Company of America
The Gear Works-Seattle
Gears & Drive Systems
Geartronics Industries
Generated Gear & Machine
Globe Gear Co.
HMC
Harder Precision Components
Harnischfeger
Highway Machine Co.
Hua Yang Machine
Intech Corp.
J&E Hofmann Eng.
Jade Precision Gear Co.
Keystone Powdered Metal
Krupp Engineering Inc.
Lawler Gear Corp.
MO Star Gear & Machine
Maquinaria Ral, S.A.
Martin Sprocket & Gear
Modified Gear & Spline
Moore Gear Mfg. Co.
Moore Machine & Gear
National Broach
Nixon Gear
Oliver Gear
Patterson Gear & Machine
Perry Technology
Pitch Templates, Inc.
Ply-Mar Tool Co
Poly Hi Solidur
Precipart Corp.
Progressive Engineering
Pulley Manufacturers Inc.
Qualicast Corp.
Rapid Gear
Reliance Gear Co. Ltd.
Riley Gear Corp.
Riverside Spline & Gear
Ronson Gears Pty. Ltd.
STD Precision Gear
Satellite Gear
Shin Shin Enterprises
Sri Venkateshwara Gear
Trogetec Inc.
Trojon Gear Inc.
Wedin Intl. Inc.
Worcester Gear Works
Xtek Inc.

Gears–Ring

Acme Gear Co.
Amarillo Gear Co.–Russellville
American Gear & Eng.
American Precision Gear
Boonville Mining Services
C-B Gear & Machine, Inc.
Circle Gear & Machine
Davall Gear Co. Ltd.
Delroyd Worm Gear
Engelhardt Gear Co.
Hamilton Gear
Indiana Tool/Indiana Gear
Insco Corporation
Jade Precision Gear Co.
MO Star Gear & Machine
Nissei Corp. of America
Overton Gear & Tool
Production Gear & Broach
Rapid Gear
Rawling Gear
Reliance Gear Co. Ltd.
Ronson Gears Pty. Ltd.
STD Precision Gear
Santasalo Gears Service
Sri Venkateshwara Gear

Gears–Segment

Acme Gear Co.
Amarillo Gear Co.–Russellville
American Precision Gear
C-B Gear & Machine, Inc.
Circle Gear & Machine
Davall Gear Co. Ltd.
Delroyd Worm Gear
Engelhardt Gear Co.
Euclid Universal Corp.
Hamilton Gear
ITW Spiroid
Nissei Corp. of America
Production Gear & Broach
Rapid Gear
Rawling Gear
Ronson Gears Pty. Ltd.
STD Precision Gear
Sri Venkateshwara Gear

Gears–Spiral Bevel

ACR Industries
ATA Gears Inc.
Advance Gear & Machine
Aero Gear, Inc.
Amarillo Gear Co.–Amarillo
Amarillo Gear Co.–Russellville
Arrow Gear Co.
Asco Sintering Co.
Ashot Ashkelon Indust.
Astron Midwestern Inc.
Blanchat Machine Co.
Bonfiglioli Riduttori
Bonfiglioli U.K.
Boston Gear
Bourn & Koch
Burgess-Norton Mfg. Co.
CMD (UK) Ltd.
Carbon City Products
Caterpillar Industrial Products Inc.
Channel Power Transmission, Inc.
Chicago Gear-D. O. James
Ciateq, A. C.
The Cincinnati Gear Co.
Curtis Machine Co. Inc.
Davall Gear Co. Ltd.
Electrex Ltd. (India)
Engelhardt Gear Co.
Engranes Industriales Rivera
Engrecon S.A.
Fairfield Mfg. Co.
Falk Corp.
Foote-Jones/Illinois Gear
The Gear Works-Seattle
Gears & Drive Systems
Globe Gear Co.

Great Gear Corp.
Grupos Diferenciales
Hamilton Gear
Hico
Horsburgh & Scott
Hua Yang Machine
Hub City, Inc.
Intech Corp.
Keystone Powdered Metal
Krupp Engineering Inc.
Micron Instrument Corp.
Midwest Gear & Tool
Milford Gear Works
Moore Gear Mfg. Co.
Nanchang Gear Works
Nissei Corp. of America
Ohio Gear
PIC Design
Philadelphia Gear Corp.–Houston
Philadelphia Gear Corp.–King of Prussia
Precision Gear Co.
Presrite Corp.
The Purdy Corporation
Rawling Gear
Reliance Gear Corp.
Riverside Spline & Gear
Santasalo Gears Service
Shin Shin Enterprises
Tech Sales Inc.
United States Gear
Von Ruden Mfg.
Wedin Intl. Inc.
West Industries Inc.
Westech Gear
Winzeler Gear

Gears–Spur

ACR Industries
Acme Gear Co.
The Adams Company
Adobe Precision Gear, Inc.
Advance Gear & Machine
Aero Gear, Inc.
Aerocom Industries Inc.
Albro Gear & Instrument
Allied Devices Corp.
Allied Gear Co.
Amarillo Gear Co.–Russellville
American Gear & Eng.
American Mach. & Gear
American Metric Corp.
American Precision Gear
Aplus Engineering Inc.
Arrow Gear Co.
Asco Sintering Co.
Ashot Ashkelon Indust.
Ashot USA Inc.
Axicon Technologies
Barit International Corp.
Bengal Industries Inc.
Bevel Gears (India)
Bilgram Gear Co.
Blanchat Machine Co.
Bonfiglioli U.K.
Boonville Mining Services
Boston Gear
Bourn & Koch
Boxx Gear Mfg.
Buckeye Gear Co.
Bucyrus International, Inc.
Burgess-Norton Mfg. Co.
C-B Gear & Machine, Inc.
CMD (UK) Ltd.
Calicut Eng. Works Ltd.
Capstan Atlantic
Carbon City Products
Caterpillar Industrial Products Inc.
Channel Power Transmission, Inc.
Chardam Gear Co.
Charles Bond Co.
Chicago Gear-D. O. James
Chicago Gear Works
Ciateq, A. C.
The Cincinnati Gear Co.
Circle Gear & Machine
Cloyes Gear & Products
Columbia Gear Co.
Commercial Gear & Sprocket
Cornell Forge Co.
Crown Gear B.V.
Cunningham Industries
Curtis Machine Co. Inc.
Cyclo Transmissions Ltd.
Dabko Industries Inc.
Davall Gear Co. Ltd.
Dayton Gear & Tool
Dearborn Gear & Tool Co.
Dynamic Tool Grinding
E.C. Machining, Inc.
EMCO Gears
Electrex Ltd. (India)
Engelhardt Gear Co.
Engranes Industriales Rivera
Engrecon S.A.
Euclid Universal Corp.
Fairfield Mfg. Co.
Falk Corp.
Federal Gear Corp.
Fleet Tools Ltd.
Foote-Jones/Illinois Gear
Forest City Gear Co.
Franke Gear Works Inc.
GW Plastics
Gear Company of America
Gear Products Inc.
Gear Systems Inc.
The Gear Works-Seattle
Gears & Drive Systems
Geartronics Industries
General Gear Corporation
Generated Gear & Machine
Global Gear
Globe Gear Co.
Great Lakes Industry, Inc.
Greenshpon Engineering Works Ltd.
HMC
Hamilton Gear
Hand Screw Machine
Hanover Gear Mfg. Co.
Harder Precision Components
Harnischfeger
Horsburgh & Scott
Howard's Machine Shop
Hua Yang Machine
Hub City, Inc.
ITW Spiroid
Indiana Tool/Indiana Gear
Insco Corporation
Intech Corp.
Invo Spline Inc.
J&E Hofmann Eng.
Jackson Gear Co.
Jade Precision Gear Co.
KA-Wood Gear & Machine
Keller Machine Co.
Keystone Powdered Metal
Kreiter Geartech
Krupp Engineering Inc.
L + H Welding & Machine
Lampin Corporation
Lawler Gear Corp.
Lufkin Industries Gear Repair
Lyon Gear
M.J.H. Gear & Tool Co.
MO Star Gear & Machine
Maquinaria Ral, S.A.
Martin Sprocket & Gear
Merit Gear Corp.
Micron Instrument Corp.
Midwest Gear
Midwest Gear & Tool
Milford Gear Works
Milwaukee Gear Company
Mobile Pulley & Machine
Modified Gear & Spline
Molon Gear & Shaft
Moore Gear Mfg. Co.
Moore Machine & Gear
Murray Brothers Mfg.
Nanchang Gear Works
Niagara Gear Corp.
Nissei Corp. of America
Nixon Gear
Nordberg Lokomo OY
Oliver Gear
Omni Gear & Machine
O'Neill Gear
Ontario Drive & Gear
Orlandi Gear Company
Overton Gear & Tool
PIC Design
Patterson Gear & Machine
Penn Machine Company
Pennsylvania Gear Corp.
Pennsylvania Pressed Metal Inc.
Penntech
Perry Technology
Philadelphia Gear Corp.–Houston
Philadelphia Gear Corp.–King of Prussia
Poly Hi Solidur
Power Eng. & Mfg.
Precipart Corp.
Precision Gear Co.
Precision Gear Inc.
Precision Gears Inc.
Presrite Corp.
Process Industries
Production Gear & Broach
Progressive Engineering
Pulley Manufacturers Inc.
The Purdy Corporation
Putnam Precision Molding, Inc.
Qualicast Corp.
R.L. Wagner & Assoc.
Rapid Gear
Rawling Gear
Reliance Gear Co. Ltd.
Reliance Gear Corp.
Riley Gear Corp.
Riverside Spline & Gear
Rj Link International
Ronson Gears Pty. Ltd.
Ryle Manufacturing Co.
STD Precision Gear
Santasalo Gears Service
Satellite Gear
Schafer Gear Works Inc.
Shin Shin Enterprises
Sri Venkateshwara Gear
St. Marys Carbon Co.
Stock Drive Prod/Sterling Instrument
Tech Sales Inc.
Textile Parts & Machine
Tifco Gage & Gear
Trogetec Inc.
Trojon Gear Inc.
United States Gear
Von Ruden Mfg.
Walter Machine Co., Inc.
Wedin Intl. Inc.
West Industries Inc.
Westech Gear
Westerman Companies
Western Spline Gage
Windsor Gear Co.
Winzeler Gear
Wohlert Corp.
Worcester Gear Works
Worrall Grinding Co.
Xtek Inc.
Zhuhai Intercontinental Pulleys Ltd.

Gears–Straight Bevel

ACR Industries
The Adams Company
Adobe Precision Gear, Inc.
Advance Gear & Machine
Aero Gear, Inc.
Allied Devices Corp.
Allied Gear Co.
Amarillo Gear Co.–Russellville
American Gear & Eng.
American Mach. & Gear
American Metric Corp.
American Precision Gear
Arrow Gear Co.
Asco Sintering Co.
Ashot Ashkelon Indust.
Ashot USA Inc.
Astron Midwestern Inc.
Bengal Industries Inc.
Bevel Gears (India)
Bilgram Gear Co.
Bonfiglioli Riduttori
Bonfiglioli U.K.
Boston Gear
Boxx Gear Mfg.
Burgess-Norton Mfg. Co.
C-B Gear & Machine, Inc.
CMD (UK) Ltd.
Calicut Eng. Works Ltd.
Carbon City Products
Caterpillar Industrial Products Inc.
Channel Power Transmission, Inc.
Chardam Gear Co.
Charles Bond Co.
Chicago Gear-D. O. James
Chicago Gear Works
Ciateq, A. C.
Circle Gear & Machine
Commercial Gear & Sprocket
Cornell Forge Co.
Curtis Machine Co. Inc.
Dabko Industries Inc.
Davall Gear Co. Ltd.
Dayton Gear & Tool
Engelhardt Gear Co.
Engranes Industriales Rivera
Engrecon S.A.
Fairfield Mfg. Co.
Falk Corp.
Federal Gear Corp.
Fleet Tools Ltd.
Foote-Jones/Illinois Gear
GW Plastics
Gear Company of America
The Gear Works-Seattle
Gears & Drive Systems
Geartronics Industries
Generated Gear & Machine
Globe Gear Co.
Great Gear Corp.
Grupos Diferenciales
Hamilton Gear
Hua Yang Machine
Hub City, Inc.
Intech Corp.
J&E Hofmann Eng.
Jackson Gear Co.
Keystone Powdered Metal
Krupp Engineering Inc.
Lawler Gear Corp.
M.J.H. Gear & Tool Co.
MO Star Gear & Machine
Maquinaria Ral, S.A.
Martin Sprocket & Gear
Mascotech-Braun
Midwest Gear & Tool
Milford Gear Works
Mitrpak Power Transmission Products
Moore Gear Mfg. Co.
Moore Machine & Gear
Nanchang Gear Works
Nissei Corp. of America
Nixon Gear
Nord Gear Corporation
Ohio Gear
Oliver Gear
PIC Design
Penn Machine Company
Perry Technology
Philadelphia Gear Corp.–Houston
Philadelphia Gear Corp.–King of Prussia
Precipart Corp.
Precision Gear Co.
Presrite Corp.
Process Industries
Progressive Engineering
The Purdy Corporation
Rawling Gear
Reliance Gear Co. Ltd.
Reliance Gear Corp.
Ronson Gears Pty. Ltd.
Santasalo Gears Service
Shin Shin Enterprises
Sri Venkateshwara Gear
Stock Drive Prod/Sterling Instrument
Textile Parts & Machine
Torque Transmission
Trogetec
United States Gear
Von Ruden Mfg.
Wedin Intl. Inc.
West Industries Inc.
Westech Gear
Windsor Gear Co.
Winzeler Gear
Wohlert Corp.
Worcester Gear Works
Xtek Inc.
Zero-Max, Inc.

Gears–Worm

ACR Industries
Acme Gear Co.
The Adams Company
Adobe Precision Gear, Inc.
Advance Gear & Machine
Aero Gear, Inc.
Allied Devices Corp.
Allied Gear Co.
Amarillo Gear Co.–Russellville
American Gear & Eng.
American Mach. & Gear
American Precision Gear
Aplus Engineering Inc.
Bengal Industries Inc.
Bevel Gears (India)
Bilgram Gear Co.
Blanchat Machine Co.
Bonfiglioli Riduttori
Bonfiglioli U.K.
Boston Gear
Bourn & Koch
Boxx Gear Mfg.
Buckeye Gear Co.
C-B Gear & Machine, Inc.
CMD (UK) Ltd.
Calicut Eng. Works Ltd.
Channel Power Transmission, Inc.
Charles Bond Co.
Chicago Gear-D. O. James
Chicago Gear Works
Ciateq, A. C.
The Cincinnati Gear Co.
Circle Gear & Machine
Columbia Gear Co.
Commercial Gear & Sprocket
Cone Drive Operations
Davall Gear Co. Ltd.
Dayton Gear & Tool
Delroyd Worm Gear
EMCO Gears
Electra-Gear
Engelhardt Gear Co.
Engranes Industriales Rivera
Euclid Universal Corp.
Falk Corp.
Federal Gear Corp.
Fleet Tools Ltd.
Flender Corporation
Foote-Jones/Illinois Gear
Forest City Gear Co.
Franke Gear Works Inc.
GW Plastics
Gear Company of America
Gear Products Inc.
Gear Systems Inc.
The Gear Works-Seattle
Gears & Drive Systems
Geartronics Industries
General Gear Corporation
Generated Gear & Machine
Globe Gear Co.
Great Gear Corp.
Greenshpon Engineering Works Ltd.
Grove Gear
Hamilton Gear
Harder Precision Components
Harnischfeger
Holroyd Machine
Horsburgh & Scott
Hua Yang Machine

Hub City, Inc.
Indiana Tool/Indiana Gear
Insco Corporation
Intech Corp.
J&E Hofmann Eng.
Jackson Gear Co.
KA-Wood Gear & Machine
Keystone Threaded Products
Lawler Gear Corp.
M.J.H. Gear & Tool Co.
MO Star Gear & Machine
Maquinaria Ral, S.A.
Martin Sprocket & Gear
Milford Gear Works
Moore Gear Mfg. Co.
Moore Machine & Gear
Nissei Corp. of America
Nixon Gear
Ohio Gear
Oliver Gear
Omni Gear & Machine
O'Neill Gear
PIC Design
Patterson Gear & Machine
Penn Machine Company
Pennsylvania Gear Corp.
Penntech
Perry Technology
Philadelphia Gear Corp.–Houston
Philadelphia Gear Corp.–King of Prussia
Poly Hi Solidur
Power Eng. & Mfg.
Precipart Corp.
Precision Gear Co.
Precision Gear Inc.
Precision Gears Inc.
Process Industries
Progressive Engineering
Rapid Gear
Rawling Gear
Reliance Gear Co. Ltd.
Reliance Gear Corp.
Renold Power Transmission Corp.
Rexnord Corporation
Riley Gear Corp.
Riverside Spline & Gear
Ronson Gears Pty. Ltd.
STD Precision Gear
Santasalo Gears Service
Satellite Gear
Schafer Gear Works Inc.
Shin Shin Enterprises
Sri Venkateshwara Gear
Sterling Electric
Stock Drive Prod/Sterling Instrument
Textile Parts & Machine
Tifco Gage & Gear
Trojon Gear Inc.
Wedin Intl. Inc.
West Industries Inc.
Westech Gear
Windsor Gear Co.
Winzeler Gear
Worcester Gear Works

Pinions

Acme Gear Co.
Adobe Precision Gear, Inc.
Amarillo Gear Co.–Russellville
American Gear & Eng.
American Precision Gear
Andantex USA
Anderson International
Bevel Gears (India)
Boonville Mining Services
C-B Gear & Machine Inc.
Capitol Stampings Corp.
Circle Gear & Machine
Delroyd Worm Gear
E.C. Machining, Inc.
General Gear Corporation
Hanover Gear
ITW Spiroid
Indiana Tool/Indiana Gear
Insco Corporation
MO Star Gear & Machine
Nissei Corp. of America
Orlandi Gear Company
Overton Gear & Tool
Poly Hi Solidur
Production Gear & Broach
Pulley Manufacturers Inc.
Rapid Gear
Rawling Gear
Reliance Gear Co. Ltd.
Ronson Gears Pty. Ltd.
STD Precision Gear
Santasalo Gears Service
Sri Venkateshwara Gear

Ratchets

Amarillo Gear Co.–Russellville
American Metric Corp.
American Precision Gear
Capitol Stampings Corp.
Circle Gear & Machine
Commercial Gear & Sprocket
Davall Gear Co. Ltd.
Engelhardt Gear Co.
MO Star Gear & Machine
Milford Gear Works
Production Gear & Broach
Rawling Gear
Ronson Gears Pty. Ltd.
STD Precision Gear
Sri Venkateshwara Gear

Serrations

Acme Gear Co.
Adobe Precision Gear, Inc.
Amarillo Gear Co.–Russellville
American Gear & Eng.
American Precision Gear
Circle Gear & Machine
Euclid Universal Corp.
Fleet Tools Ltd.
General Gear Corporation
Milford Gear Works
Orlandi Gear Company
Production Gear & Broach
Rapid Gear
Rawling Gear
Ronson Gears Pty. Ltd.
STD Precision Gear
Sri Venkateshwara Gear

Splines

ACR Industries
Acme Gear Co.
The Adams Company
Adobe Precision Gear, Inc.
Advance Gear & Machine
Aero Gear, Inc.
Aerocom Industries Inc.
Allied Devices Corp.
Allied Gear Co.
Amarillo Gear Co.–Russellville
American Gear & Eng.
American Mach. & Gear
American Precision Gear
Aplus Engineering Inc.
Arrow Gear Co.
Asco Sintering Co.
Ashot Ashkelon Indust.
Bevel Gears (India)
Bilgram Gear Co.
Blanchat Machine Co.
Boonville Mining Services
Boston Gear
Boxx Gear Mfg.
Buckeye Gear Co.
Burgess-Norton Mfg. Co.
C-B Gear & Machine, Inc.
CMD (UK) Ltd.
Calicut Eng. Works Ltd.
Capstan Atlantic
Carbon City Products
Caterpillar Industrial Products Inc.
Chardam Gear Co.
Chicago Gear-D. O. James
Ciateq, A. C.
The Cincinnati Gear Co.
Circle Gear & Machine
Cloyes Gear & Products
Cold Forming Technology
Columbia Gear Co.
Commercial Gear & Sprocket
Curtis Machine Co. Inc.
Dabko Industries Inc.
Davall Gear Co. Ltd.
Dayton Gear & Tool
Dearborn Gear & Tool Co.
Delroyd Worm Gear
EMCO Gears
Elmass North America
Engelhardt Gear Co.
Engranes Industriales Rivera
Engrecon S.A.
Euclid Universal Corp.
Fairfield Mfg. Co.
Federal Gear Corp.
Fleet Tools Ltd.
Foote-Jones/Illinois Gear
Forest City Gear Co.
Franke Gear Works Inc.
Gear Company of America
Gear Products Inc.
Gear Systems Inc.
The Gear Works-Seattle
Gears & Drive Systems
Geartronics Industries
General Gear Corporation
Generated Gear & Machine
Global Gear
Globe Gear Co.
Great Gear Corp.
HMC
Hamilton Gear
Hand Screw Machine
Hanover Gear Mfg. Co.
Harder Precision Components
Harnischfeger
Horsburgh & Scott
Howard's Machine Shop
Hua Yang Machine
Hub City, Inc.
Indiana Tool/Indiana Gear
Insco Corporation

Intech Corp.
Invo Spline Inc.
J&E Hofmann Eng.
Jackson Gear Co.
Jade Precision Gear Co.
KA-Wood Gear & Machine
Keystone Powdered Metal
Kreiter Geartech
Krupp Engineering Inc.
L + H Welding & Machine
Lawler Gear Corp.
Lyon Gear
M&M Precision Systems
M.J.H. Gear & Tool Co.
MO Star Gear & Machine
Micromatic Textron
Midwest Gear
Midwest Gear & Tool
Milford Gear Works
Milwaukee Gear Company
Modified Gear & Spline
Moore Gear Mfg. Co.
Moore Machine & Gear
Murray Brothers Mfg.
Nanchang Gear Works
Niagara Gear Corp.
Nissei Corp. of America
Nixon Gear
Oliver Gear
Omni Gear & Machine
O'Neill Gear
Ontario Drive & Gear
Orlandi Gear Company
Overton Gear & Tool
Patterson Gear & Machine
Penn Machine Company
Pennsylvania Gear Corp.
Penntech
Perry Technology
Philadelphia Gear Corp.–Houston
Philadelphia Gear Corp.–King of Prussia
Power Eng. & Mfg.
Precipart Corp.
Precision Gear Co.
Precision Gear Inc.
Precision Gears Inc.
Process Industries
Production Gear & Broach
Progressive Engineering
Pulley Manufacturers Inc.
The Purdy Corporation
R.L. Wagner & Assoc.
Rapid Gear
Rawling Gear
Reliance Gear Corp.
Riley Gear Corp.
Riverside Spline & Gear
Rj Link International
Ronson Gears Pty. Ltd.
STD Precision Gear
Santasalo Gears Service
Satellite Gear
Schafer Gear Works Inc.
Shin Shin Enterprises
Sri Venkateshwara Gear
St. Marys Carbon Co.
Tech Sales Inc.
Tifco Gage & Gear
Trogetec Inc.
Trojon Gear Inc.
United States Gear
Von Ruden Mfg.
Walter Machine Co., Inc.
Wedin Intl. Inc.
West Industries Inc.
Westech Gear
Western Spline Gage
Windsor Gear Co.
Worcester Gear Works
Xtek Inc.

Sprockets

Acme Gear Co.
Adobe Precision Gear, Inc.
Aero Gear, Inc.
Allied Devices Corp.
Allied Gear Co.
Amarillo Gear Co.–Russellville
American Gear & Eng.
American Mach. & Gear
American Metric Corp.
American Precision Gear
Blanchat Machine Co.
Boston Gear
Bourn & Koch
Buckeye Gear Co.
Burgess-Norton Mfg. Co.
C-B Gear & Machine, Inc.
Capitol Stampings Corp.
Capstan Atlantic
Carbon City Products
Channel Power Transmission, Inc.
Chicago Gear-D. O. James
Circle Gear & Machine
Cloyes Gear & Products
Columbia Gear Co.
Davall Gear Co. Ltd.
Engelhardt Gear Co.
Fairfield Mfg. Co.
Fleet Tools Ltd.
Foote-Jones/Illinois Gear
Forest City Gear Co.
GW Plastics
Gear Products Inc.
Gears & Drive Systems
Global Gear
Globe Gear Co.
Great Lakes Industry, Inc.
Hamilton Gear
Insco Corporation
Intech Corp.
J&E Hofmann Eng.
Jackson Gear Co.
Jade Precision Gear Co.
Keystone Powdered Metal
Kreiter Geartech
L + H Welding & Machine
Lampin Corporation
Lyon Gear
MO Star Gear & Machine
Maquinaria Ral, S.A.
Martin Sprocket & Gear
Midwest Gear
Nixon Gear
Oliver Gear
PIC Design
Pennsylvania Gear Corp.
Penntech
Perry Technology
Poly Hi Solidur
Power Eng. & Mfg.
Presrite Corp.
Production Gear & Broach
Pulley Manufacturers Inc.
Putnam Precision Molding, Inc.
Rapid Gear
Rawling Gear
Reliance Gear Corp.
Renold Power Transmission Corp.
Riverside Spline & Gear
Rj Link International
Ronson Gears Pty. Ltd.
Ryle Manufacturing Co.
STD Precision Gear
Santasalo Gears Service
Satellite Gear
Schafer Gear Works Inc.
Sri Venkateshwara Gear
Textile Parts & Machine
Torque Transmission
Trogetec Inc.
United States Gear
West Industries Inc.
Wohlert Corp.
Xtek Inc.
Zenith Sintered Products
Zhuhai Intercontinental Pulleys Ltd.

Timing Pulleys

Acme Gear Co.
Adobe Precision Gear, Inc.
Amarillo Gear Co.–Russellville
American Gear & Eng.
American Metric Corp.
American Precision Gear
Circle Gear & Machine
Davall Gear Co. Ltd.
E. C. Machining, Inc.
Engelhardt Gear Co.
Euclid Universal Corp.
Fleet Tools Ltd.
Jade Precision Gear Co.
Lampin Corporation
MO Star Gear & Machine
Poly Hi Solidur
Pulley Manufacturers Inc.
Rapid Gear
Rawling Gear
Reliance Gear Co. Ltd.
Ronson Gears Pty. Ltd.
STD Precision Gear
Santasalo Gears Service

Other Gears & Drives

Andantex USA–*Cycloidal Drives*
Bevel Gears (India)–*Face Clutches, Custom-Made Gear Boxes*
Bonfiglioli Riduttori–*Planetary Gear Boxes*
C-B Gear & Machine, Inc. *–Gear Reducer Repair*
Capitol Stampings Corp. *–Steering Sectors*
Channel PowerTransmission, Inc.–*Cycloidal Drives*
Cold Forming Technology–*Prototype & Production Spline Rolling*
Commercial Gear & Sprocket–*Jaw Clutches, Large Diameter Gears*
Cone Drive Operations–*Double-Enveloping Worm Gears*
Crown Gear B.V.–*Face Gears, Cylkro Gears*
Davall Gear Co. Ltd.–*Face Clutches*
Delroyd Worm Gear–*Worm Gear Speed Reducers*
Euclid Universal Corp.–*Custom-Designed Gear Reducers*

Fairfield Mfg. Co.–*Custom Mechanical Assemblies. Design or build to print*
Federal Gear Corp.–*Gearbo x Rebuild & Recondition*
Fleet Tools Ltd.–*High-Precision Gearheads*
Flender-Graffenstaden–*High Speed & Epicylic*
Franke Gear Works Inc.–*Double Enveloping Worm & Gear Sets*
Gajra Gears Ltd.–*Gear Transmissions*
Gear Company of America–*Evoloids*
Geartronics Industries–*Generated Pinion Rod*
General Gear Corporation–*High Helix Gears, Speedometer Gears & Rotors*
Globe Gear Co.–*Metric Gears*
Hamer Gear–*Custom Gear Manufacturing*
Hand Screw Machine–*Serrations for Strapping*
Harmonic Drive Technologies–*Harmonic Drive Transmissions*
ITW Spiroid–*Spiroid Gears, Helicon Gears*
Keller Machine Co.–*Custom Gears & Sprockets*
Micron Instrument Corp.–*Gearheads*
Nixon Gear–*Ground Gears*
Ohio Gear–*Transmissions*
Oliver Gear–*Gears Up To 10' Dia.*
Orlandi Gear Company–*Hydraulic Pump Gears*
Philadelphia Gear Corp.–King of Prussia–*Epicyclic*
Production Gear & Broach–*Internal Broaching*
The Purdy Corporation–*Curvic Couplings*
R. Cushman & Associates–*Traction Drives*
Rawling Gear–*Face Clutches*
Ronson Gears Pty. Ltd.–*Face Clutches*
Spline Gauges Ltd.–*Oil Test Gears*
Sri Venkateshwara Gear–*Traction Drives*
Sussex Gear Company–*Linear Actuators*
Trogetec Inc.–*Cycloidal Gears & Harmonic Gearing*
United States Gear–*Curvic Couplings*
Wedin Intl. Inc.–*Ground Gears to AGMA 14*
Westech Gear–*Specials*
Wohlert Corp.–*Flywheel Starter Ring Gears*
Worrall Grinding Co.–*Film Sprockets*
Zero-Max, Inc.–*Torque Limiters*

GEAR MANUFACTURING MACHINES

Broaching Machines

American Broach
Colonial Tool Group Inc.
Detroit Broach Co.
Elmass North America
Fässler
General Broach & Eng.
Jack Dustman & Assoc.
Kingsford Broach & Tool
Miller Industrial Service
Mitts & Merrill L.P.
National Broach
The Ohio Broach & Machine Co.
Sales Consultants
Ty Miles Inc.

Chamfering Machines

American Wera Inc.
Ataka Engineering
Basic Incorporated Group
Best Engineering Co., Inc.
Bourn & Koch
Chamfermatic, Inc.
Eltech Inc.
GMI
Jack Dustman & Assoc.
National Broach
Ravjeet Eng. Specialties
Redin Corporation
SU America Inc.
Schenck Turner
V & R Associates
WMW Machinery

Deburring Machines

Basic Incorporated Group
Best Engineering Co., Inc.
Burlytic Systems
Eltech Inc.
GMI
Holroyd Machine
Jack Dustman & Assoc.
Progressive Technologies
Redin Corporation
SU America Inc.
Schenck Turner

EDM Machines

Basic Incorporated Group
Bluegrass Precision Machinery
Charmilles Technologies
Easco-Sparcatron
Hansvedt Industries Inc.
KGK International Corp.
Makino
Mecatool USA Ltd.
Okamoto Corp EDM Div.
Raycon Corporation
Sales Consultants

Generating Machines

American Pfauter, L.P.
Ataka Engineering
Basic Incorporated Group
The Gleason Works
Sigma Pool-Liebherr
V & R Associates
WMW Machinery

Grinding Machines

American Broach
American Pfauter, L.P.
Basic Incorporated Group
Bluegrass Precision Machinery
Bourn & Koch
Eltech Inc.
GTI Technologies Inc.
The Gleason Works
Gleason-Pfauter Maschinenfabrik
Hermes Machine Tool
Höfler Maschinenbau
Hoglund Technology
Holroyd Machine
Lapmaster Intl.
Meccanica Nova Corp
Miller Industrial Service
Mitsubishi Machine Tool
National Broach
Normac Inc.
Okamoto Corp EDM Div.
Reishauer Corp.
SU America Inc.
Sales Consultants
Sigma Pool-Liebherr
USACH Technologies
WMW Machinery

Heat Treating Equipment

Ajax Magnethermic Corp.
Bluegrass Precision Machinery
Can-Eng Furnaces Ltd.
Contour Hardening Inc.
Engineered Heat Treat
The Grieve Corporation
Holcroft
Inductoheat Inc.
K.H. Huppert Co.
McEnglevan Industrial Furnace
Pacific Industrial Furnace
Pillar Industries
Quench Press Specialists
Radyne Corporation
Surface Combustion Inc.
TOCCO Inc.
Therm Alliance Co.
Welduction Corporation

Hobbing Machines

American Pfauter, L.P.
Basic Incorporated Group
Bourn & Koch
Fayscott Co.
The Gleason Works
Gleason-Pfauter Maschinenfabrik
Hermes Machine Tool
Ikegai America Corp.
Koepfer America L.L.C.
Mitsubishi Machine Tool
National Broach
Parker Industries
Reishauer Corp.
Sales Consultants
Sigma Pool-Liebherr
V & R Associates
WMW Machinery

Honing Machines

American Pfauter, L.P.
Basic Incorporated Group
Bates Technologies Inc.
Bluegrass Precision Machinery
Engis Corp.
Fässler
GMI
The Gleason Works
National Broach
Reishauer Corp.

Inspection Machines

Alpha Precision Inc.
American Pfauter, L.P.
Basic Incorporated Group
Best Engineering Co., Inc.
Bluegrass Machinery
Bourn & Koch
D.I.G.I.T.
Dyer Company
FGT Gage & Systems Inc.
Giddings & Lewis
The Gleason Works
ITW Heartland
Jack Dustman & Assoc.
Kokusai Inc.
M&M Precision System
Mahr Corporation
Manufactured Gear & Gage
Miller Industrial Service
Moore Products Co.
National Broach
NewAge Industries Inc.
Ono Sokki Technology
Precision Gage Co.
Profile Engineering
Progressive Technologies
Reishauer Corp.
Roto-Technology Inc.
Sigma Pool-Liebherr
Spline Gauges Ltd.
United Tool Supply

Keyseating Machines

Basic Incorporated Group
Colonial Tool Group Inc.
Elmass North America
Mitts & Merrill L.P.
The Ohio Broach & Machine Co.

Lapping Machines

Basic Incorporated Group
Bluegrass Precision Machinery
Engis Corp.
The Gleason Works
Lapmaster Intl.
Sigma Pool-Liebherr

Measuring Machines

Alpha Precision Inc.
American Pfauter, L.P.
Basic Incorporated Group
Best Engineering Co., Inc.
Bluegrass Precision Machinery
Holroyd Machine
Krautkramer Branson
Mahr Corporation
Miller Industrial Service
Ono Sokki Technology
Precision Gage Co.
Profile Engineering
Roto-Technology Inc.
Sigma Pool-Liebherr
Spline Gauges Ltd.
United Tool Supply

Shaping Machines

American Pfauter, L.P.
Basic Incorporated Group
Bluegrass Precision Machinery
Bourn & Koch
Elmass North America
Fellows Corp.
The Gleason Works
Gleason-Pfauter Maschinenfabrik
Hermes Machine Tool
Mitsubishi Machine Tool
Parker Industries Inc.
Sigma Pool-Liebherr
WMW Machinery

Shaving Machines

American Pfauter, L.P.
Basic Incorporated Group
Bluegrass Precision Machinery
Elmass North America
The Gleason Works
Gleason-Pfauter Maschinenfabrik
National Broach

Spline Rolling Machines

Colonial Tool Group Inc.
General Broach & Eng.
Micromatic Textron
Mitsubishi Machine Tool
Moore Products Co.
National Broach

Testing Machines

Basic Incorporated Group
Best Engineering Co., Inc.
Fellows Corp.
The Gleason Works
Holroyd Machine
ITW Heartland
Krautkramer Branson
Labeco
M&M Precision Systems
Mahr Corporation
Manufactured Gear & Gage
NewAge Industries Inc.
Ono Sokki Technology
Parker Industries Inc.
Precision Gage Co.
Profile Engineering
Sigma Pool-Liebherr

Turning Machines

Basic Incorporated Group
Bluegrass Precision Machinery
Hermes Machine Tool
J&E Hofmann Eng.
Jack Dustman & Assoc.
Miller Industrial Service
Mitsubishi Machine Tool
Sales Consultants
V & R Associates
WMW Machinery

Worm Milling Machines

American Pfauter, L.P.
Basic Incorporated Group
Eltech Inc.
GTI Technologies Inc.
Koepfer America L.L.C.
Sigma Pool - Liebherr
WMW Machinery

Other Gear Manufacturing Machines

American Broach–*CNC Broach Sharpeners*
American Wera Inc.–*Polygon Cutting (Profilating)*
Ataka Engineering–*Cutter Sharpening Machines*
Cold Forming Technology–*Spline Rolling Automatic Loaders*
Diamonex–*Gear Coating Systems*
D.I.G.I.T.–*Gear Data Gages*
DoAll–*Sawing Machines & Blades*
Dyer Company–*Machine Vision*
GMI–*Tooth Rounding & Pointing Machines*
GTI–*Cutter Sharpeners*
Giddings & Lewis–*Coordinate Measuring Machines*
Gleason-Pfauter Maschinenfabrik GmbH–*Spline Millers & Grinders, Shobbers, Milling Machines*
Hoglund Technology Corp.–*Computerized Wheel Dressers*
ITW Heartland–*Burnishing Machines*
Ikegai America Corp.–*Hob Sharpeners*
Kapp Sales & Service–*Gear & Form Grinding Machines*
LMT-Fette Inc.–Stow–*Rack Millers & Cutters*
Mahr Corporation–*Hand Held Gear & Spline Inspection Tools*
Manufacturing Technology Inc.–*Friction Welding Machines*
Mitsubishi Laser–*Laser Cutting Machines*
NewAge Industries Inc.–*Hardness Testers–Auto Traverse*
Parker Industries, Inc.–*Cutter Sharpeners*
Progressive Technologies–*Surface Treatment*
Raycon Corporation–*Laser Welders*
Reishauer Corp.–*Thread and Worm Grinding Machines*
Sytec Corp.–*End Finishing*

United Tool Supply–
Gages
Welduction Corporation–
Induction Heating Equipment

GEAR MATERIALS

Gear Blanks

Accurate Specialties Inc.
Blanchat Machine Co.
Cornell Forge Co.
Dabko Industries Inc.
Dayton Gear & Tool
Disston Precision Inc.
Dura-Bar
EMCO Gears
Elmass North America
The Gear Works-Seattle
Generated Gear & Machine
Globe Gear Co.
Harder Precision Components
Horsburgh & Scott
Howard's Machine Shop
Intech Corp.
L + H Welding & Machine
Lufkin Industries Gear Repair
Milford Gear Works
Mobile Pulley & Machine
Moore Machine & Gear
PIC Design
Penntech
Perry Technology
Portland Forge
Power Eng. & Mfg.
Precipart Corp.
Presrite Corp.
Process Industries
Qualicast Corp.
Rj Link International
Satellite Gear
Schafer Gear Works Inc.
Stock Drive Products/Sterling Instrument
Trogetec Inc.
Wohlert Corp.
Worrall Grinding Co.

Plastics

Dayton Gear & Tool
The Gear Works-Seattle
Globe Gear Co.
Hoechst Celanese Corp.
Howard's Machine Shop
Intech Corp.
Trogetec Inc.

Powdered Metals

Asco Sintering Co.
Burgess-Norton Mfg. Co.
Carbon City Products
The Gear Works-Seattle

Steels

Crucible Service Centers
Dayton Gear & Tool
Disston Precision Inc.
Elmass North America
Forging Specialties
The Gear Works-Seattle
Globe Gear Co.
Impact Strategies Inc.
Latrobe Steel Company
Lovejoy Steel Company–Charlotte
Lovejoy Steel Company–Cincinnati
Lovejoy Steel Company–Streetsboro
Lovejoy Steel Company–York
Moore Machine & Gear
Trogetec Inc.

Other Materials

Crucible Service Centers–
High Speed Steel For Cutting Tools
Dura-Bar–*Continuous Cast Iron Barstock*
Intech Corp.–*Plastic/Metal Composite*
Lovejoy Steel Company–Charlotte, Cincinnati, Streetsboro, York–*Cast Iron*
Portland Forge–*Carbon/ Alloy Steel Forgings*
SIFCO Selective Plating–
Brush Plated Stop-Off and Wear-in Coatings, Brush Plating Chemicals
Trogetec Inc.–*Special*

GEAR SERVICES

Consulting

Advance Gear & Machine
Aero Gear, Inc.
Aplus Engineering Inc.
Applied Mechaniques
Aston Metallurgical Services
Axicon Technologies
Best Engineering Co., Inc.
Bourn & Koch
C-Dot Engineering
Carbon City Products
Ciateq, A. C.
The Cincinnati Gear Co.
Contour Hardening Inc.
Dabko Industries Inc.
Dayton Gear & Tool
Drive Systems Technology
Dynamic Metal Treating
Engranes Industriales Rivera
Fairfield Mfg. Co.
GMI
GW Plastics
Gary P. Mowers, Inc.
Geartech Ltda. - Tecnologia de Engrenagens
The Gleason Works
Guy Crader Consulting
Horsburgh & Scott
Hy-Mech Systems Inc.
I.S.P.J.A.E.
Impact Strategies Inc.
Intech Corp.
J&E Hofmann Eng.
Jack Dustman & Assoc.
Labeco
McGinty Gear
Manufactured Gear & Gage
Maquinaria Ral, S.A.
Mechanical & Structural Design & Software
Milburn Engineering, Inc.
Milford Gear Works
Moore Machine & Gear
NASA Lewis Research Center
NCADT
Ontario Drive & Gear
P. F. Markey Inc.
Packer Engineering
Pennsylvania Gear Corp.
Power Eng. & Mfg.
Powertrain Engineers
Precision Engineering
Precision Gear Inc.
Profile Engineering
R. Cushman & Associates
Reilly Engineering Inc.
Riley Gear Corp.
SBR Consulting
Sales Consultants
Satellite Gear
Society of Manufacturing Engineers
Software Engineering Service
Spline Gauges Ltd.
Sussex Gear Company
Swiglo Metallurgical Consulting
Technimet Corp.
Tifco Gage & Gear
Trogetec Inc.
U.S. Tech Corp.
Ultron Incorporated
Universal Technical Systems
Van Gerpen-Reece Eng.
Wedin Intl. Inc.
Wes-Tex Gear Inc.
Westech Gear

Cryogenics

American Brazing
Best Engineering Co., Inc.
Horsburgh & Scott
Impact Strategies Inc.
Iron Bound Heat Treating
J&E Hofmann Eng.
Paulo Products Company–Bessemer
Paulo Products Company–Kansas City
Paulo Products Company–Memphis
Paulo Products Company–Murfreesboro
Paulo Products Company–Nashville
Paulo Products Company–St. Louis
Trogetec Inc.

Fault Analysis

American Stress Technologies
Applied Mechaniques
Ashot Ashkelon Indust.
Ashot USA Inc.
Aston Metallurgical
Ciateq, A.C.
The Cincinnati Gear Co.
Dayton Gear & Tool
Drive Systems Technology
Fairfield Mfg. Co.
Horsburgh & Scott
Hy-Mech Systems Inc.
I.S.P.J.A.E.
J&E Hofmann Eng.

Lufkin Industries Gear Repair
Mechanical & Structural Design & Software
Milburn Engineering, Inc.
Modern Industries Inc.
NASA Lewis Research
National Metrology
Packer Engineering
Philadelphia Gear Corp.–Houston
Powertrain Engineers
Reilly Engineering Inc.
Surface Technology, Inc.
Technimet Corp.
Trogetec Inc.
Universal Technical Systems
Wes-Tex Gear Inc.
Westech Gear

Gear Design

ATA Gears Inc.
Advance Gear & Machine
Aero Gear, Inc.
Allied Devices Corp.
Aplus Engineering Inc.
Applied Mechaniques
Arrow Gear Co.
Ashot Ashkelon Indust.
Ashot USA Inc.
Axicon Technologies
BestMetal Corp.
Blanchat Machine Co.
Boston Gear
C-Dot Engineering
CMD (UK) Ltd.
Carbon City Products
Caterpillar Industrial Products Inc.
Ciateq, A.C.
The Cincinnati Gear Co.
Columbia Gear Co.
Contour Hardening Inc.
Cunningham Industries
Dayton Gear & Tool
Drive Systems Technology
Dynamic Tool Grinding
EMCO Gears
Electra-Gear
Engranes Industriales Rivera
Fairfield Mfg. Co.
GW Plastics
The Gear Works-Seattle
Gearesearch Assoc.
Gears & Drive Systems
Geartech Ltda. - Tecnologia de Engrenagens
The Gleason Works
Global Gear
Guy Crader Consulting
HMC
Harder Precision Components
Holroyd Machine
Horsburgh & Scott
Hy-Mech Systems Inc.
I.S.P.J.A.E.
ITW Spiroid
Insco Corporation
Intech Corp.
J&E Hofmann Eng.
Kreiter Geartech
Labeco
Lufkin Industries Gear Repair
McGinty Gear
Maquinaria Ral, S.A.
Mechanical & Structural Design & Software
Milburn Engineering, Inc.
Milford Gear Works
Milwaukee Gear Company
Moore Machine & Gear
NASA Lewis Research
O'Neill Gear
Ontario Drive & Gear
PC Enterprises
Packer Engineering
Pennsylvania Gear Corp.
Penntech
Power Eng. & Mfg.
Powertrain Engineers
Precipart Corp.
Precision Engineering
Qualicast Corp.
R. Cushman & Associates
Reilly Engineering Inc.
Riley Gear Corp.
SBR Consulting
Society of Manufacturing Engineers
Spline Gauges Ltd.
Sussex Gear Company
Tifco Gage & Gear
Trogetec Inc.
Universal Technical Systems
Van Gerpen-Reece Eng.
Von Ruden Mfg.
Wedin Intl. Inc.
West Industries Inc.
Westech Gear
Winzeler Gear
Xtek Inc.

Gear Engineering

ATA Gears Inc.
Advance Gear & Machine
Aero Gear, Inc.
Allied Devices Corp.
Aplus Engineering Inc.
Applied Mechaniques
Arrow Gear Co.
Ashot Ashkelon Indust.
Ashot USA Inc.
Axicon Technologies
BestMetal Corp.
Blanchat Machine Co.
Boston Gear
Bourn & Koch
C-Dot Engineering
CMD (UK) Ltd.
Ciateq, A.C.
The Cincinnati Gear Co.
Columbia Gear Co.
Contour Hardening Inc.
Dabko Industries Inc.
Dayton Gear & Tool
Drive Systems Technology
Dynamic Tool Grinding
EMCO Gears
Electra-Gear
Engranes Industriales Rivera
Fairfield Mfg. Co.
Federal Gear Corp.
Gear Research Institute
The Gear Works-Seattle
Gearesearch Assoc.
Gears & Drive Systems
Geartech Ltda.–Tecnologia de Engrenagens
Global Gear
Guy Crader Consulting
Harder Precision Components
Holroyd Machine
Horsburgh & Scott
Hy-Mech Systems Inc.
I.S.P.J.A.E.
Insco Corporation
Intech Corp.
J&E Hofmann Eng.
Kreiter Geartech
Labeco
Lufkin Industries Gear Repair
Lyon Gear
Maquinaria Ral, S.A.
Mechanical & Structural Design & Software
Milburn Engineering, Inc.
Milford Gear Works
Milwaukee Gear Company
Modern Industries Inc.
Moore Machine & Gear
NASA Lewis Research Center
NCADT
Nixon Gear
Nordberg Lokomo OY
O'Neill Gear
Ontario Drive & Gear
Packer Engineering
Patterson Gear & Machine
Pennsylvania Gear Corp.
Penntech
Philadelphia Gear Corp.–Houston
Power Eng. & Mfg.
Powertrain Engineers
Precipart Corp.
Precision Engineering
Precision Gear Inc.
Presrite Corp.
Process Industries
Profile Engineering
Qualicast Corp.
R. Cushman & Associates
Reilly Engineering Inc.
Riley Gear Corp.
SBR Consulting
Society of Manufacturing Engineers
Software Engineering Service
Spline Gauges Ltd.
Stock Drive Products/Sterling Instrument
Sussex Gear Company
Tifco Gage & Gear
Trogetec Inc.
Universal Technical Systems
Van Gerpen-Reece Eng.

Wedin Intl. Inc.
Wes-Tex Gear Inc.
West Industries Inc.
Westech Gear
Winzeler Gear
Xtek Inc.

Grinding

ACR Industries
Advance Gear & Machine
Aero Gear, Inc.
Aerocom Industries Inc.
Allied Gear Co.
American Broach
Aplus Engineering Inc.
Arrow Gear Co.
Ashot Ashkelon Indust.
Ashot USA Inc.
Axicon Technologies
Blanchat Machine Co.
Boston Gear
Bourn & Koch
Brighton Industries Corp.
Bucyrus International, Inc.
CMD (UK) Ltd.
Caterpillar Industrial Products Inc.
Chardam Gear Co.
The Cincinnati Gear Co.
Dayton Gear & Tool
Disston Precision Inc.
Dyer Company
Engranes Industriales Rivera
Fairfield Mfg. Co.
Federal Gear Corp.
Gear Company of America
The Gear Works-Seattle
Generated Gear & Machine
Hamilton Gear
Hanover Gear Mfg. Co.
Höfler Maschinenbau
Horsburgh & Scott
Insco Corporation
J&E Hofmann Eng.
Kreiter Geartech
Lawler Gear Corp.
Lufkin Industries Gear Repair
Lyon Gear
Meccanica Nova Corp
Merit Gear Corp.
Midwest Gear
Milwaukee Gear Company
Modern Industries Inc.
Modified Gear & Spline
NASA Lewis Research
NCADT
National Broach
Niagara Gear Corp.
Nixon Gear
Nordberg Lokomo OY
Patterson Gear & Machine
Penntech
Perry Technology
Pfauter-Maag Cutting Tools, L.P.
Philadelphia Gear Corp.–Houston
Precision Gear Inc.
Pro-Gear Co. Inc.
Process Industries
The Purdy Corporation
Qualicast Corp.
Riley Gear Corp.
Riverside Spline & Gear
SU America Inc.
Satellite Gear
Tifco Gage & Gear
Trogetec Inc.
USACH Technologies
Wedin Intl. Inc.
Westech Gear
Xtek Inc.

Heat Treating

ACR Industries
Ajax Magnethermic Corp.
American Brazing
American Metal Treating
Aplus Engineering Inc.
Applied Process Inc.
Arrow Gear Co.
Ashot Ashkelon Indust.
Ashot USA Inc.
Axicon Technologies
Blanchat Machine Co.
Boston Gear
Caterpillar Industrial Products Inc.
The Cincinnati Gear Co.
Commercial Steel Treating
Contour Hardening Inc.
Dayton Gear & Tool
Detroit Flame Hardening
Disston Precision Inc.
Dynamic Metal Treating
Engineered Heat Treat
Euclid Heat Treating Co.
FPM Heat Treating
Fairfield Mfg. Co.
Fellows Corp.
Foote-Jones/Illinois Gear
Gear Company of America
The Gleason Works
Hamilton Gear
Harder Precision Components
Horsburgh & Scott
Hudapack Metal Treating–Addison
Hudapack Metal Treating–Elkhorn
Impact Strategies Inc.
Iron Bound Heat Treating
J&E Hofmann Eng.
Kolene Corporation
Kreiter Geartech
Lufkin Industries Gear Repair
Merit Gear Corp.
Milwaukee Gear Company
Modern Industries Inc.
Molon Gear & Shaft
NASA Lewis Research Center
National Broach
Nordberg Lokomo OY
Patterson Gear & Machine
Paulo Products Company–Bessemer
Paulo Products Company–Kansas City
Paulo Products Company–Memphis
Paulo Products Company–Murfreesboro
Paulo Products Company–Nashville
Paulo Products Company–St. Louis
Penn Machine Company
Pennsylvania Gear Corp.
Penntech
Pfauter-Maag Cutting Tools, L.P.
Philadelphia Gear Corp.–Houston
Pillar Industries
Progressive Engineering
Qualicast Corp.
Richter Precision Inc.
Satellite Gear
Shore Metal Technology
Surface Technology, Inc.
TOCCO Inc.
Trogetec Inc.
U. S. Axle Inc.
Welduction Corporation
West Industries Inc.
Westech Gear
Xtek Inc.

Inspection

ACR Industries
Advance Gear & Machine
Aerocom Industries Inc.
Allied Devices Corp.
Alpha Precision Inc.
American Stress Technologies
Aplus Engineering Inc.
Ashot Ashkelon Indust.
Ashot USA Inc.
Axicon Technologies
Best Engineering Co., Inc.
Blanchat Machine Co.
Bourn & Koch
Brighton Industries Corp.
Bucyrus International, Inc.
The Cincinnati Gear Co.
Contour Hardening Inc.
D.I.G.I.T.
Dayton Gear & Tool
Disston Precision Inc.
Dyer Company
Engranes Industriales Rivera
Euro-Tech Corporation
Fellows Corp.
Forest City Gear Co.
Gear Company of America
The Gear Works-Seattle
Giddings & Lewis
Harder Precision Components
Horsburgh & Scott
Interstate Tool Corp.
Invo Spline Inc.
J&E Hofmann Eng.
Krautkramer Branson
Kreiter Geartech
Lawler Gear Corp.
Lufkin Industries Gear Repair
Lyon Gear
M&M Precision Systems
Manufactured Gear & Gage
Merit Gear Corp.
Midwest Gear
Modern Industries Inc.
NCADT
National Broach
National Metrology
Niagara Gear Corp.
Nixon Gear
PC Enterprises
Patterson Gear & Machine
Paulo Products Company–Kansas City
Penntech
Pennsylvania Gear Corp.

Perry Technology
Philadelphia Gear Corp.–Houston
Precision Gage Co.
Precision Gear Inc.
Precision Gears Inc.
Pro-Gear Co. Inc.
Process Industries
Profile Engineering
The Purdy Corporation
Qualicast Corp.
Riley Gear Corp.
Riverside Spline & Gear
Roto-Technology Inc.
Satellite Gear
Schafer Gear Works Inc.
Scott Machine Tool Co.
Spline Gauges Ltd.
Tifco Gage & Gear
Trogetec Inc.
Ultron Incorporated
Wedin Intl. Inc.
West Industries Inc.
Westech Gear
Xtek Inc.

Shot Peening

ACR Industries
Ashot Ashkelon Indust.
Ashot USA Inc.
Blanchat Machine Co.
Dayton Gear & Tool
Fairfield Mfg. Co.
Harder Precision Components
Hydro Honing Laboratories, Inc.
J&E Hofmann Eng.
Kreiter Geartech
Metal Improvement Co.
NASA Lewis Research Center
Patterson Gear & Machine
Paulo Products Company–Memphis
Penntech
Pennsylvania Gear Corp.
Progressive Technologies
U. S. Axle Inc.
West Industries Inc.

Tool Coating

Balzers Tool Coating Inc.
Best Engineering Co., Inc.
Dynamic Metal Treating
Eltech Inc.
Fellows Corp.
General Magnaplate Corp.
The Gleason Works
LMT-Fette Tool Systems–Brookfield
Multi-Arc Inc.
P. F. Markey Inc.
Pfauter-Maag Cutting Tools, L.P.
Reid Tool Service Inc.
Richter Precision Inc.
Star Cutter Co.
Surface Technology Corp.

Other Services

ASM International–*Training, Education, Books*
Abrasive Technology Inc.–*Gear Honing*
American Brazing–*Brazing*
American Broach–*Broach Sharpening*
American Metal Treating–*Induction Hardening*
American Stress Technologies–*X-Ray Stress Testing, Non-destructive Testing*
Aston Metallurgical–*Metallurgical/Mechanical/Chemical Testing*
Bourn & Koch–*Hobbing*
The Cincinnati Gear Co.–*Gearbox Overhaul & Field Service*
Detroit Flame Hardening–*Flame Hardening*
Diamond Black–*Boron Carbide Gear Coating*
Diamonex–*Gear Coating*
Eltech Inc.–*Hob Sharpening*
The Gleason Works–*Tool Sharpening/Tool Reconditioning*
Globe Gear Co.–*Cut Teeth, Reverse Engineering*
Hamer Gear–*Custom Gear Manufacturing*
Horsburgh & Scott–*Gear Drive Rebuilding (All Manufacturers)*
Intech Corp.–*Gear Durability Calculation*
J&E Hofmann Eng.–*On-Site Gear Installation*
James Reid Gear Services–*European Fine Pitch Machine Specialist*
Kolene Corporation–*Molten Salt Bath Heat Treating*
Koro Sharpening Service–*HSS, & Carbide Hob Sharpening*
McGinty Gear–*Spline Design*
Manufacturing Technology–*Friction Weld Gears Together*
Mechanical & Structural Design & Software–*Gear Failure Analysis*
Modern Industries Inc.–*Metallurgical Evaluation*
Moore Products Co.–*Program Management Gage Systems*
NASA Lewis Research Center–*Gear and Transmission Testing*
NCADT–*Conditioned-Based Maintenance*
Nye Lubricants Inc.–*Synthetic Lubricants for Gears*
Packer Engineering–*Failure Analysis & Testing*
Paulo Products Company–St. Louis–*Brazing*
Pfauter-Maag Cutting Tools, L.P.–*Sharpening*
Precision Engineering–*Error Analysis of Backlash–Position Error for Gears & Entire System*
SIFCO Selective Plating–*Job Shop Plating*
Spline Gauges Ltd.–*Plotting & Analysis of Gear Stresses*
Star Cutter Co.–*Hob Sharpening & Recoating*
Surface Technology Corp.–*Deburring, Gear Coating*
Sussex Gear Company–*Gear Box & Actuator Design*
Tri-Wire, Inc.–*Wire EDM Job Shop*
Trogetec Inc.–*Feasibility and/or conceptual gear design & mfg.*

GEAR SOFTWARE

Custom Software

American Stress Technologies
Aplus Engineering Inc.
C-Dot Engineering
Ciateq, A.C.
Gearesearch Assoc.
Hoglund Technology
I.S.P.J.A.E.
Koepfer America L.L.C.
Moore Products Co.
Roto-Technology Inc.
Scott Machine Tool Co.
Software Engineering Service
Trogetec Inc.
Universal Technical Systems
User Solutions Inc.
Van Gerpen-Reece Eng.

Gear Design Software

AGMA
Bluegrass Precision Machinery
C-Dot Engineering
Ciateq, A.C.,
Dabko Industries Inc.
Fairfield Mfg. Co.
GW Plastics
Gearesearch Assoc.
Geartech Ltda.–Tecnologia de Engrenagens
The Gleason Works
I.S.P.J.A.E.
Lemur Enterprises
Mechanical & Structural Design & Software
NASA Lewis Research Center
Software Engineering Service
Stock Drive Prod/Sterling Instrument
Trogetec Inc.
Universal Technical Systems
Van Gerpen-Reece Eng.

Inspection Software

Alpha Precision Inc.
American Machinery
Brighton Industries Corp.
GW Plastics
Gearesearch Assoc.
Giddings & Lewis
The Gleason Works
Krautkramer Branson
Lufkin Industries Gear Repair
M&M Precision Systems
Moore Products Co.
NCADT
Precision Gage Co.
Roto-Technology Inc.
Scott Machine Tool Co.
Sigma Pool-Liebherr
Software Engineering Service
Trogetec Inc.
Worrall Grinding Co.

Shop Management Software

Best Engineering Co., Inc.
The Gleason Works
JobBoss Software Inc.
Manufacturers Technologies
Power Eng. & Mfg.
Scott Machine Tool Co.
U.S. Tech Corp.
User Solutions Inc.

Other Software

American Gear Mfgrs. Assn.–*Gear Rating, Gear Capacity*
American Pfauter, L.P.–*HobTime Software*
Bourn & Koch–*Gear Manufacturing*
D.I.G.I.T.–SPC Programs
Drive Systems Technology–*Software Available Through Seminars*
Euro-Tech Corporation–*Spline Inspection Software*
Extrude Hone–*Surface Finish Measurement Software*
GB Gear Shop Tools–*Calculations*
Gearesearch Assoc.–*Gear Scoring Analysis*
Geartech Ltda.–Tecnologia de Engrenagens–*Mechanical Design*
The Gleason Works–HobTime Software
Hoglund Technology–*Gear Manufacturing Software License*
Krautkramer Branson–*Inspection Data Management*
Meccanic Nova Corp.–*Grinding Machine Software*
Mechanical & Structural Design & Software Strength & Fatigue Analysis Software
NASA Lewis Research Center–*Bearing/Seal*
Normac Inc.–*Form Grinding*
Pfauter-Maag Cutting Tools, L.P. *HobTime*
Trogetec Inc.–*Shop Floor Gear Design & Manufacuring Software*
User Solutions Inc.–*Quality*
Van Gerpen-Reece Eng.–*Tooling Recycling*

GEAR TOOLING & ACCESSORIES

Abrasives

Abrasive Technology Inc.
Best Engineering Co., Inc.
Bluegrass Precision Machinery
Clipper Diamond Tool Co.
Dianamic Abrasive Products Inc.
Engis Corp.
Ernst Winter & Son Inc.
Extrude Hone
GMI
Lapmaster Intl.
Meccanica Nova Corp
Meister Grinding Tech.
P. F. Markey Inc.
Redin Corporation
Reishauer Corp.
Rex-Cut Products Inc.
Sidley Diamond Tool Co.
Universal Superabrasives
W. E. Litwin Assoc.

Broaching Tools

American Broach
American Machinery
Apex Broach & Machine
Barit International Corp.
Best Engineering Co., Inc.
Brighton Industries Corp.
Colonial Tool Group Inc.
Detroit Broach Co.
Elmass North America
Fässler
GTI Technologies Inc.
General Broach & Engineering Co., Inc.
Jack Dustman & Assoc.
Kingsford Broach & Tool
LMT-Fette Tool Systems–Stow
Miller Industrial Service
National Broach
The Ohio Broach & Machine Co.
P. F. Markey Inc.
Parker Industries Inc.
Ply-Mar Tool Co
Reid Tool Service Inc.
Ty Miles Inc.

Chamfering Tools

Best Engineering Co., Inc.
Chamfermatic, Inc.
GMI
The Gleason Works
P. F. Markey Inc.
Pfauter-Maag Cutting Tools, L.P.
Ply-Mar Tool Co
Ravjeet Eng. Specialties
Redin Corporation
Reid Tool Service Inc.
SU America Inc.
Schenck Turner

Deburring Tools

Best Engineering Co., Inc.
Burlytic Systems
Chamfermatic, Inc.
Extrude Hone
The Gleason Works
GMI
JRM International Inc.
Jack Dustman & Assoc.
P. F. Markey Inc.
Pfauter-Maag Cutting Tools, L.P.
Progressive Technologies
Redin Corporation
Reid Tool Service Inc.
Rex-Cut Products Inc.
SU America Inc.
Schenck Turner

EDM Tooling & Supplies

Bluegrass Precision Machinery
Charmilles Technologies
Easco-Sparcatron
Extrude Hone
Hangsterfer's Labs
KGK International Corp.
Mecatool USA Ltd.
Perry Technology

Form Grinding Wheels

Abrasive Technology Inc.
Best Engineering Co., Inc.
Bluegrass Precision Machinery
Brighton Industries Corp.
Clipper Diamond Tool Co.
Dianamic Abrasive
Engis Corp.
Ernst Winter & Son Inc.
The Gleason Works
GMI
Hoglund Technology
Kapp Tech L.P.
Meccanica Nova Corp
Meister Grinding Tech.
P. F. Markey Inc.
Pfauter-Maag Cutting Tools, L.P.
Sidley Diamond Tool Co.
Star Cutter Co.
Wendt Dunnington

Gages

A/W Systems Company
Automated Precision Inc
Best Engineering Co., Inc.
Colonial Tool Group Inc.
Comtorgage Corp.
D.I.G.I.T.
Dyer Company
Euro-Tech Corporation
Globe Gear Co.
Invo Spline Inc.
JRM International Inc.

M&M Precision Systems
MTI Corporation (Mitutoyo)
Mahr Corporation
Moore Products Co.
P. F. Markey Inc.
Parker Industries Inc.
Perry Technology
Ply-Mar Tool Co
Precision Gage Co.
Reid Tool Service Inc.
Russell, Holbrook & Henderson
Spline Gauges Ltd.
Sytec Corp.
Trogetec Inc.
United Tool Supply
Western Spline Gage

Hobs

Axicon Technologies
Barit International Corp.
Best Engineering Co., Inc.
Chowgule Matrix Hobs
Eltech Inc.
Fellows Corp.
GMI
The Gleason Works
Great Gear Corp.
Interstate Tool Corp.
JRM International Inc.
Koepfer America L.L.C.
Kromhard Twist Drill Co.
LMT-Fette Inc.–Stow
LMT-Fette Tool Systems–Brookfield
Mitsubishi Machine Tool
National Broach
P. F. Markey Inc.
Parker Industries Inc.
Pfauter-Maag Cutting Tools, L.P.
Ply-Mar Tool Co
Rebco Industrial Products
Reid Tool Service Inc.
Russell, Holbrook & Henderson
SRP Tools Ltd.
SU America Inc.
Sigma Pool-Liebherr
Star Cutter Co.

Keyseat Cutters

Best Engineering Co., Inc.
Colonial Tool Group Inc.
Elmass North America
LMT-Fette Tool Systems–Brookfield
Mitts & Merrill L.P.
P. F. Markey Inc.
Reid Tool Service Inc.
Star Cutter Co.
Trogetec Inc.
W. E. Litwin Assoc.

Lapping Compounds

Dianamic Abrasive
Engis Corp.
GTI Technologies Inc.
Hangsterfer's Lab
Lapmaster Intl.
National Broach
P. F. Markey Inc.
Reid Tool Service Inc.
Sidley Diamond Tool Co.

Lubricants/Coolants

Abrasive Technology Inc.
D. A. Stuart Co.
DoAll
Engis Corp.
Etna Products Inc.
Hangsterfer's Labs
Houghton International
Kluber Lubrication
Lapmaster Intl.
Lubriplate
Meccanica Nova Corp
P. F. Markey Inc.
Nye Lubricants, Inc.
Texaco Lubricants Co

Shaper Cutters

American Machinery
Barit International Corp.
Best Engineering Co., Inc.
Chowgule Matrix Hobs
Elmass North America
Eltech Inc.
Fellows Corp.
GMI
The Gleason Works
Interstate Tool Corp.
JRM International Inc.
Koepfer America L.L.C.
Kromhard Twist Drill Co.
Mitsubishi Machine Tool
National Broach
P. F. Markey Inc.
Parker Industries Inc.
Pfauter-Maag Cutting Tools, L.P.
Ply-Mar Tool Co
Rebco Industrial Products
Reid Tool Service Inc.
Russell, Holbrook & Henderson
SRP Tools Ltd.
SU America Inc.
Sigma Pool-Liebherr
Star Cutter Co.
Tri-Wire, Inc.

Shaver Cutters

American Machinery
Barit International Corp.
Best Engineering Co., Inc.
Eltech Inc.
Fellows Corp.
GMI
The Gleason Works
JRM International Inc.
LMT-Fette Tool Systems-Brookfield
Micromatic Textron
National Broach
P. F. Markey Inc.
Parker Industries Inc.
Pfauter-Maag Cutting Tools, L.P.
Ply-Mar Tool Co
Rebco Industrial Products
Reid Tool Service Inc.
SRP Tools Ltd.
SU America Inc.
Star Cutter Co.
Tri-Wire, Inc.

Worm Milling Cutters

Barit International Corp.
Best Engineering Co., Inc.
Chowgule Matrix Hobs
GMI
The Gleason Works
Interstate Tool Corp.
JRM International Inc.
Koepfer America L.L.C.
LMT-Fette Tool Systems–Brookfield
Pfauter-Maag Cutting Tools, L.P.
Ply-Mar Tool Co
Rebco Industrial Products
Reid Tool Service Inc.
Russell, Holbrook & Henderson
Star Cutter Co.

Other Tooling & Accessories

A/W Systems Company– ***Spiral Gear Cutters***
Bates Technologies Inc.– Honing Tools
Best Engineering Co., Inc. *–Maag Type Rack Cutters*
Cold Forming Technology– *Spline Rolling Tools*
D.I.G.I.T.– ***Variable Force Plastic Gear Data Gages***
Fässler–*Diamond Wheels, Honing Stones*
GMI– *Diamond Dressing Tools*
General Broach & Engineering Co., Inc,– *Gear Rolling Tools*
The Gleason Works– ***Bevel Gear Cutters, Milling Cutters, Band Saw Cutters***
Hermes Machine Tool– *Tooling Packages for Specific Machine Tool Purchase*
ITW Heartland– ***Burnishing Dies***
Interstate Tool Corp.– *Rotary Gear Cutters, Maag Cutters*
JRM International Inc.– ***Hydraloc Clamping***
Kapp Tech L.P.– ***CBN Gear & Form Grinding Wheels***
Koolant Koolers Inc.– *Industrial Liquid Coolers*
Manufacturers Technologies Inc.– *Cost Estimating & Process Planning*
Mastertech Diamond Products– *CBN Inserts*
Mayfran International– *Filtration Equipment, Conveyors, Chip Processing Equipment*
Meccanica Nova Corp– *In-/Post-Process Machine Gages*
Micromatic Textron– *Spline Rolling Tools*
Multi-Arc Inc.– *Coating Services*
Oberlin Filter Co.– *Coolant Filtration Equipment*
Parker Industries, Inc.– ***Cutting Tools for Bevel & Spiral Bevel Gears***
Pfauter-Maag Cutting Tools, L.P.–*Milling Cutt-*

ers, Bandsaw Cutters
Pitch Templates, Inc–*Pitch Template Inspection Racks*
Portland Forge–*Forgings*
Reishauer Corp.–*Diamond Dressing Rolls*
SIFCO Selective Plating–*Brush Plating Equipment & Solutions*
S.L. Munson–*Diamond Gear Dresser*
SRP Tools Ltd.–*Rotary Coniflex Cutters*
Sensor Products, Inc.–*Film used to detect pressure distribution and magnitude for measuring gear tooth contact.*
Sidley Diamond Tool Co.–*Diamond Dressing Tools, Rolls, CBN Plated Wheels*
Spline Gauges Ltd.–*Powder Metal Gear & Spline Form Tool Sets*
Star Cutter Co.–*Thin Coatings*
Wendt Dunnington–*Diamond Dressing Rollers, Dressing Equipment*

GEAR WORKHOLDING & FIXTURING

Arbors

Alpha Precision Inc.
American Pfauter, L.P.
Best Engineering Co., Inc.
Bluegrass Precision Machinery
Bourn & Koch
Emuge Corp.
Euro-Tech Corporation
Fellows Corp.
The Gear Works-Seattle
The Gleason Works
Harder Precision Components
Hermes Machine Tool
Invo Spline Inc.
JRM International Inc.
Jack Dustman & Assoc.
Koepfer America L.L.C.
LeCount Inc.
M&M Precision Systems
Mahr Corporation
Manufactured Gear & Gage
Maquinaria Ral, S.A.
National Broach
P. F. Markey Inc.
Parker Industries Inc.
Profile Engineering
Reid Tool Service Inc.
Reishauer Corp.
Schunk Inc.
Spline Gauges Ltd.
Tifco Gage & Gear
Toolink Engineering
W. E. Litwin Assoc.
Western Spline Gages

Chucks

Alpha Precision Inc.
American Pfauter, L.P.
Best Engineering Co., Inc.
Bluegrass Precision Machinery
Brighton Industries Corp.
Emuge Corp.
Euro-Tech Corporation
The Gleason Works
Harder Precision Components
Hermes Machine Tool
Invo Spline Inc.
Jack Dustman & Assoc.
Manufactured Gear & Gage
P. F. Markey Inc.
Reid Tool Service Inc.
Schunk Inc.
Star Cutter Co.
Tifco Gage & Gear
Toolink Engineering
Trogetec Inc.
W. E. Litwin Assoc.

Modular Fixtures

Alpha Precision Inc.
Best Engineering Co., Inc.
Bluco Corp.
Bluegrass Precision Machinery
Emuge Corp.
Hermes Machine Tool
JRM International Inc.
Jack Dustman & Assoc.
Koepfer America L.L.C.
Meccanica Nova Corp
Moore Products Co.
P. F. Markey Inc.
Paul W. Marino Gages Inc.
Scott Machine Tool Co.
Sigma Pool-Liebherr
Sytec Corp.
Trogetec Inc.
W. E. Litwin Assoc.

Toolholders

Alpha Precision Inc.
Best Engineering Co., Inc.
Bluegrass Precision Machinery Brighton Industries Corp.
Elmass North America
Emuge Corp.
Euro-Tech Corporation
General Broach & Eng.
Hermes Machine Tool
Interstate Tool Corp.
JRM International Inc.
Jack Dustman & Assoc.
Mahr Corporation
P. F. Markey Inc.
Miller Industrial Services
Reid Tool Service Inc.
SU America Inc.
Schunk Inc.
Toolink Engineering
Trogetec Inc.
W. E. Litwin Assoc.

Other Fixturing & Workholding

A/W Systems Company–*Cutter Bodies for Spiral Gears*
Apex Broach & Machine *Broach Holders/Fixtures*
Bluco Corp.–*Expanding Mandrels For Broaches*
Detroit Broach Co.–*Workholders for Broaches*
Euro-Tech Corporation–*Compensating Washers for Hobs*
Meccanica Nova Corp–*Custom Grinding Fixturing & Workholding*
Schunk Inc.–*Hydraulic Tool Holders*
Sytec Corp.–*Pitch Line Workholding Roller Cages*
Trogetec Inc.–*Single & Double Eccentrics*

MACHINERY/EQUIPMENT DISTRIBUTORS

American Machinery–*Fellows, Apex Broach, Höfler, Star*
American Wera Inc.–*Wera Werk, Hurth Modul, Samag*
Ashot USA Inc.–*Ashot Ashkelon Industries*
Ataka Engineering–*Saikuni Mfg. Co., Ltd.*
Best Engineering Co., Inc.–ITW Heartland
Bluegrass Precision Machinery–*Mitsubishi*
Brighton Industries Corp.–***Normac Inc.***
Commercial Gear & Sprocket–*U.S. Tsubaki*
Eltech Inc.–*Kapp, Niles, SU America, MGF GmbH*
Euro-Tech Corporation–Frenco, Mytec
Geartech Ltda. - Tecnologia de Engrenagens–*Hexagon Software*
Harder Precision Components–*H.P.C. Compontents*
J&E Hofmann Eng.–*Kluber Gear Lubricants*
JRM International Inc.–*Kesel, Saazor, Schrem*
Meccanica Nova Corp–*Meccanica Nova S.P.A.*
Miller Industrial Service–*Tornos Technologies,*
National Metrology–*Metronics*
Ohio Broach & Machine–*Tesa Measurment Systems, UVA Machine Co.*
Ontario Drive & Gear–*KTR*
Paul W. Marino Gages Inc.–*Alufix, Koba-Stet*
Precision Gage Co.–*Vari-Roll gear testers*
Reid Tool Service Inc.–*Fellows Corp.*
Sigma Pool-Liebherr–*Liebherr, Lorenz, Oerlikon, Klingelnberg*
Spline Gauges Ltd.–*M & M Precision Systems, Inc.*
Tech Sales Inc.–*Arrow Gear Co.*
Toolink Engineering–*König-MTM GmbH*
V & R Associates–*Laschet & Partner*
W. E. Litwin Assoc.–*Speedgrip Chuck Professional Tool Grinding*

TRAINING & EDUCATION

Colleges/Universities

I.S.P.J.A.E.
Mississippi State Univ.
NCADT

Gear Schools

AGMA
American Pfauter, L.P.
Aplus Engineering Inc.
Best Engineering Co., Inc.
Boston Gear
Drive Systems Technology
Educational Systems Workshops
Euro-Tech Corporation
The Gleason Works
Hane Industrial Training
Hy-Mech Systems Inc.
I.S.P.J.A.E.
Koepfer America L.L.C.
Lufkin Industries Gear Repair
M & M Precision Systems
Manufacturers Technologies Inc.
National Broach
Pfauter-Maag Cutting Tools, L.P.
Philadelphia Gear Corp.
Roto-Technology Inc.
Salem Company
Van Gerpen-Reece Eng.
Xtek Inc.

Research Institutions

Ciateq, A.C.
Gear Research Institute
Gearesearch Assoc.
I.S.P.J.A.E.
Mississippi State Univ.
NASA Lewis Research Center
NCADT

Trade Associations

ASM International
American Gear Mfgrs. Assocation
Metal Powder Industries Federation
Society of Manufacturing Engineers

COMPANY INDEX

Welcome to the 1998 *Gear Technology* Buyers Guide Company Index. Use this index to locate contact information for each company listed in the Product & Services Index. *Gear Technology* advertisers are shown in boldface type. To find the pages on which their ads appear, see the Advertisers Index on page 68 .

While we have 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 is not listed and you would like to be included in next year's directory, e-mail *people@geartechnology.com*, call 847-437-6604, or fax 847-437-6618 and we will add you to our mailing list.

A

ACR Industries, Inc.
15375 Twenty-Three Mile Road
Macomb MI 48042
Ph: 810-781-2800
Fax: 810-781-0152

ASM International
Materials Information
Materials Park OH 44073
Ph: 216-338-5151
Fax: 216-338-4634
mem-serv@po.asm-intl.org

ATA Gears, Inc.
River Square Plaza
19645 Detroit Rd.
Rocky River OH 44116
Ph: 216-356-0284
Fax: 216-356-0289
postmaster@ata-gears.fi

A/W Systems Company
612 Harrison
P.O. Box 1344
Royal Oak MI 48068-1344
Ph: 248-544-3852
Fax: 248-544-3922

Abrasive Technology Inc.
8400 Green Meadows Dr.
Westerville OH 43081
Ph: 614-548-4100
Fax: 614-548-7617

Accurate Specialties Inc.
N12 W24360 Bluemound Rd.
Waukesha WI 53188
Ph: 414-547-5450
Fax: 414-547-5892

Acme Gear Co., Inc.
130 W. Forest Avenue
Englewood NJ 07631
Ph: 201-568-2245
Fax: 201-568-0282
info@acmegear.com
www.acmegear.com

The Adams Company
100 E. Fourth St.
Dubuque IA 52001
Ph: 319-583-3591
Fax: 319-583-8048

Adobe Precision Gear, Inc.
211 W. Wood
P.O. Box 520
Carlsbad NM 88220
Ph: 505-885-8322
Fax: 505-885-1568
adobe@caverns.com
www.gears.com

Advance Gear & Machine Corp.
16201 S. Broadway
Gardena CA 90248-1906
Ph: 213-770-1951
Fax: 213-770-1955

Aero Gear Co., Inc.
1050 Day Hill Rd.
Windsor CT 06095
Ph: 860-688-0888
Fax: 860-285-8514
buygears@aerogear.com
www.aerogear.com

Aerocom Industries, Inc.
2870 Wilderness Place
P.O. Box 17027
Boulder CO 80301
Ph: 303-440-8106
Fax: 303-440-8108

Ajax Magnethermic Corp.
1745 Overland Ave.
Warren OH 44483
Ph: 330-372-8511
Fax: 330-372-8608

Albro Gear & Instrument
86 Horseblock Rd.
Yaphank NY 11980
Ph: 516-345-0657
Fax: 516-345-0660

Allied Devices Corp.
2365 Milburn Avenue
P.O. Box 501
Baldwin NY 11510
Ph: 516-223-9100
Fax: 516-223-9172
allieddv@linet.com
www.allieddevices.com

Allied Gear Co.
4901 W. Arthington Street
Chicago IL 60644
Ph: 773-287-8742
Fax: 773-287-4720

Alpha Gear Drives Inc.
1440 Howard St.
Elk Grove Village IL 60007
Ph: 847-439-0700
Fax: 847-439-0755
alphagd@idt.net

Alpha Precision Inc.
11500 Rockfield Ct.
Cincinnati OH 45241
Ph: 513-772-4266
Fax: 513-772-6950

Amarillo Gear Co.
2401 Sundown Lane
P.O. Box 1789
Amarillo TX 79105
Ph: 806-622-1273
Fax: 806-622-3258
amagear@arn.net
www.amarillogear.com

Amarillo Gear Co.– Russellville
2401 East 16th Street
P.O. Box 2048
Russellville AR 72811
Ph: 501-967-0844
Fax: 501-967-6221

American Brazing
Paulo Products Co.
4428 Hamann Parkway
Willoughby OH 44094
Ph: 440-946-5900
Fax: 440-946-3091
Memerson@paulo-us.com

American Broach & Machine Co.
4600 Jackson Road
P.O. Box 2030
Ann Arbor MI 48106
Ph: 313-761-5021
Fax: 313-761-7626
amerbroach@aol.com

American Gear & Engineering
38200 Abruzzi Drive
Westland MI 48185
Ph: 313-595-6400
Fax: 313-595-0149

American Gear Mfgrs. Assn. (AGMA)
1500 King St., Suite 201
Alexandria VA 22314-2730
Ph: 703-684-0211
Fax: 703-684-0242
franklin@agma.org
www.agma.org

American Machine & Gear Inc.
735 Northwest 16th Ave.
Portland OR 97209
Ph: 800-423-7345
Fax: 505-226-3526

American Machinery
16 Promontory
Dove Canyon CA 92679
Ph: 714-888-8518
Fax: 714-888-8519

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

American Metric Corp.
RR 1, Box 1122
Laurens SC 29360
Ph: 864-876-2011
Fax: 864-876-2630
service@ametric.com
www.ametric.com

American Pfauter, L.P.
Gleason Corporation
1351 Windsor Rd.
Loves Park IL 61111-4294
Ph: 815-282-3000
Fax: 815-282-3075
sales@pfauter.com
www.pfauter.com

American Precision Gear Co.
1029 American Street
P.O. Box 906
San Carlos CA 94070
Ph: 800-432-7710
650-595-3664
Fax: 650-595-0388
amgear@pacbell.net
www.amgear.com

American Stress Technologies, Inc.
267 Kappa Drive
Pittsburgh PA 15238
Ph: 412-963-0676
Fax: 412-963-7552
ast@sgi.net

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

Andantex USA
1705 Valley Road
Wanamassa NJ 07712
Ph: 800-713-6170
908-493-2812
Fax: 908-493-2949
info@andantex.com
www.andantex.com

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

Apex Broach & Machine Co.
6401 E. Seven-Mile Rd.
Detroit MI 48234
Ph: 313-891-8600
Fax: 313-891-5083
apex1@apexbroach.com
www.apexbroach.com

Aplus Engineering Inc.
Rm. 521, No. 144
Min Chuan E. Rd. Sec 3
Taipei
Taiwan ROC
Ph: (886)-2-7181811
Fax: (886)-2-5451679

Applied Mechaniques
12 Tallarook Close
Toronto NSW 2283
Australia
Ph: (61) 49593573
Fax: (61) 49504538

Applied Process Inc.
12238 Newburgh Rd.
Livonia MI 48150-1046
Ph: 313-464-2030
Fax: 313-464-6314
jkeough@appliedprocess.com
www.appliedprocess.com

Arrow Gear Co.
2301 Curtiss St.
Downers Grove IL 60515
Ph: 630-969-7640
Fax: 630-969-0253
gl@arrowgear.com
www.arrowgear.com

Asco Sintering Co.
2750 S. Garfield Ave.
Commerce CA 90040
Ph: 213-723-5121
Fax: 213-888-9968

Ashot Ashkelon Industries
Gear Systems Division
P.O. Box 21
78100 Ashkelon
Israel
Ph: (972) 767-21525
Fax:(972) 767-28167
udiashot@inter.net.il

Ashot USA Inc.
485 Madison Ave. 14th Floor
New York NY 10017
Ph: 212-223-4050
Fax: 212-223-4156

Aston Metallurgical Services
4201 N. Ravenswood Ave.
Chicago IL 60613
Ph: 773-528-9830
Fax: 773-929-0773
as@mos.com

Astron Midwestern Inc.
6201 East Avenue
Hodgkins IL 60525
Ph: 708-354-2800
Fax: 708-354-2810

Ataka Engineering Co., Ltd.
2-218 Kamiyashiro Meito-Ku
Nagoya Aichi
Japan
Ph: (81) 52-772-0690
Fax: (81) 52-772-0692
ataka@mxb.meshnet.or.jp

Automated Precision, Inc
7901-C Cessna Ave.
Gaithersburg MD 20879
Ph: 301-330-8100
Fax: 301-990-8648

Axicon Technologies, LLC
2857 Banksville Road
Pittsburgh, PA 15216
Ph: 412-531-7500
Fax: 412-531-7035
axicon@aol.com

B

Balzers Tool Coating,Inc.
661 Erie Ave.
N. Tonawanda NY 14120
Ph: 716-693-8557
Fax: 716-695-1995

Barit International Corp.
3384 Commercial Ave.
Northbrook IL 60062
Ph: 847-272-8128
Fax: 847-272-8210
people@barit.com
www.barit.com

Basic Incorporated Group
Machine Tools Division
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Guide for Gear Giving

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

The Addendum team hates to admit it, but we're coming up hard on the holiday season again, and that means straining the old brain cells to come up with a good gift list. Once you've taken Aunt Maude's fruit cake brick out of the freezer to recycle it to the least-favorite person on your list, things start to get tricky. Then there's the concern that you're going to end up getting yet another ugly sweater, body-of-steel home exercise gadget (special TV offer; three payments of $29.95; no CODs, please) or commemorative Elvis plate.

But never fear. As a public service, the Addendum Shopping Team has been scouring the landscape for the season's "must-have" items for gear giving and receiving. Put these items on your list, or circle your favorites and leave the column where your own personal Santa will find it.

For the serious-minded among you (and who's not serious about gears, besides the Addendum Team, that is?), there's the *Maag Gear Book*. This staple of the gear engineering library *is in print* and available from Global Engineering Documents for $95.00. (Call 800-854-7179.) If that's not serious enough for you, remember that major technical societies like AGMA, SME and ASM have big catalogs of all sorts of engineering books, CD-ROMs and software. ASM is offering four volumes of its massive metals *Handbook*® on CD for $443.00. The entire twenty volumes will be available by December of next year.

For a bit less strenuous reading, our book review editor recommends a little gem called *Longitude* by Dava Sobel (Walker & Company, New York). This is the true story of John Harrison, the self-taught carpenter, clock-maker, mechanic and engineer who solved the problem of calculating longitude, one that had stumped such luminaries as Galileo, Edmund Halley, Christiaan Huygens and Robert Hooke. The crux of the problem is that to calculate longitude, you need to be able to tell time precisely in two places at once, no mean feat in a time before electronic communications and satellites. The story is not just one of engineering ingenuity, but politics, professional jealousy, idealism, class struggle and lots of money.

If your tastes run to the more unusual (like the Addendum staff's), you will want to check out the catalog from American Science & Surplus (847-982-0870 or *www.sciplus.com*). Here you can order everything from a tabletop-sized dry pellet steam plant to a "talking duck faucet," which apparently is just what it sounds like, an animal-shaped plastic spout to be attached to your regular faucet to make "more or less appropriate" animal sounds when the water flows through. Other must-have items include neon-colored sand paper, make-your-own slime & ooze kits, small motors and gearboxes, French Foreign Legion uniform buttons, army-green "pocket spittoons" and your very own Archimedes pump (for pumping up dead Greek scientists?). Many items are sold in quantity and are remarkably inexpensive. Lots of good educational kits and toys for your budding engineers, plus odd, but useful, office and lab supplies. This place could solve your stocking stuffer problems.

What would the holidays be without toys? And what's the point of buying stuff for the kids you wouldn't want to play with? For example, Hasbro is relaunching a few of the original Tonka trucks in its Classic Edition series. The 1949 Dump Truck and the 1956 Pickup are back in real metal with real heft, just right for dropping on Grandma's foot, floor-and-furniture scratching and other fun stuff. Then there's the Mercury Astronaut doll, 12" high, complete with spacesuit, helmet, gloves and dog tags. The astronaut's compatriots include a Tuskegee Fighter Pilot, General Patton and, for your own G.I. Jane, the U.S. Army Helicopter Pilot, who just happens to be a girl.

Finally, our staff doesn't want to make your shopping any harder than it has to be. Just send us money. One size fits all, and the color's always right.

The Addendometer: If you've read this far on the page and enjoyed it, please **circle 225.**