GEAR TECHNOLOGY

SEPTEMBER/OCTOBER 2001

The Journal of Gear Manufacturing

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FEATURES

- Q&A: HIDDEN RUNOUT?
- BEVEL & HYPOID EASE-OFF
- FACE GEAR CALCULATION, PRODUCTION AND USE

GEAR EXPO SHOW ISSUE

- DETROIT DIVERSIONS
- SHOW BASICS AND MAP
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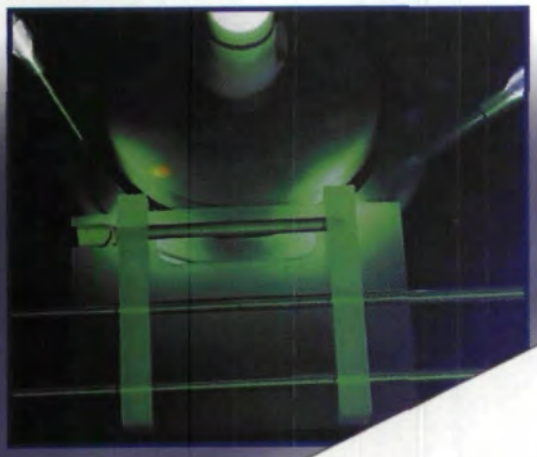

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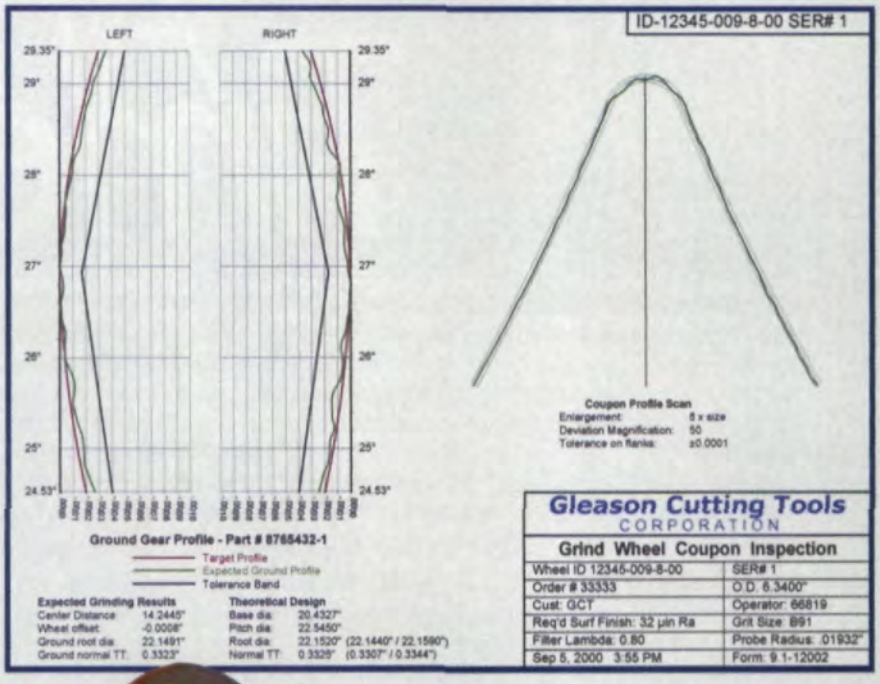

Typical grinding wheel customer test coupon inspection report.

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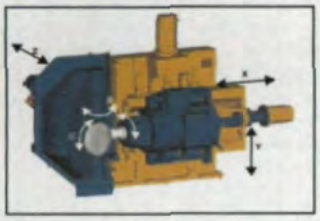

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The Journal of Gear Manufacturing

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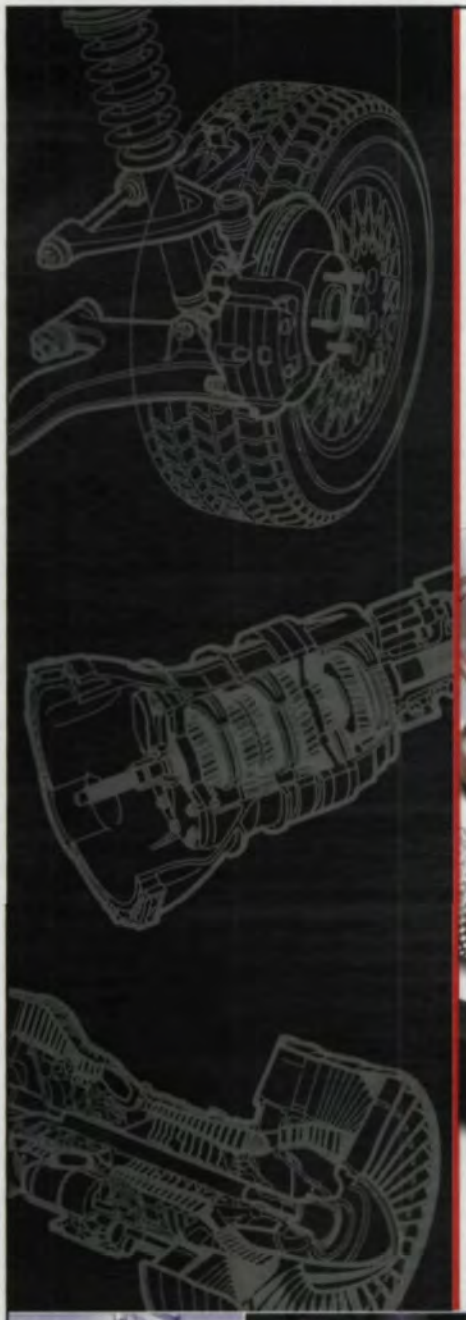

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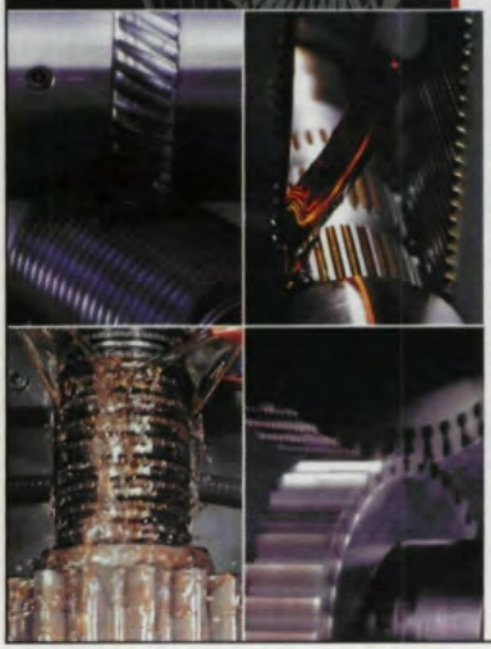

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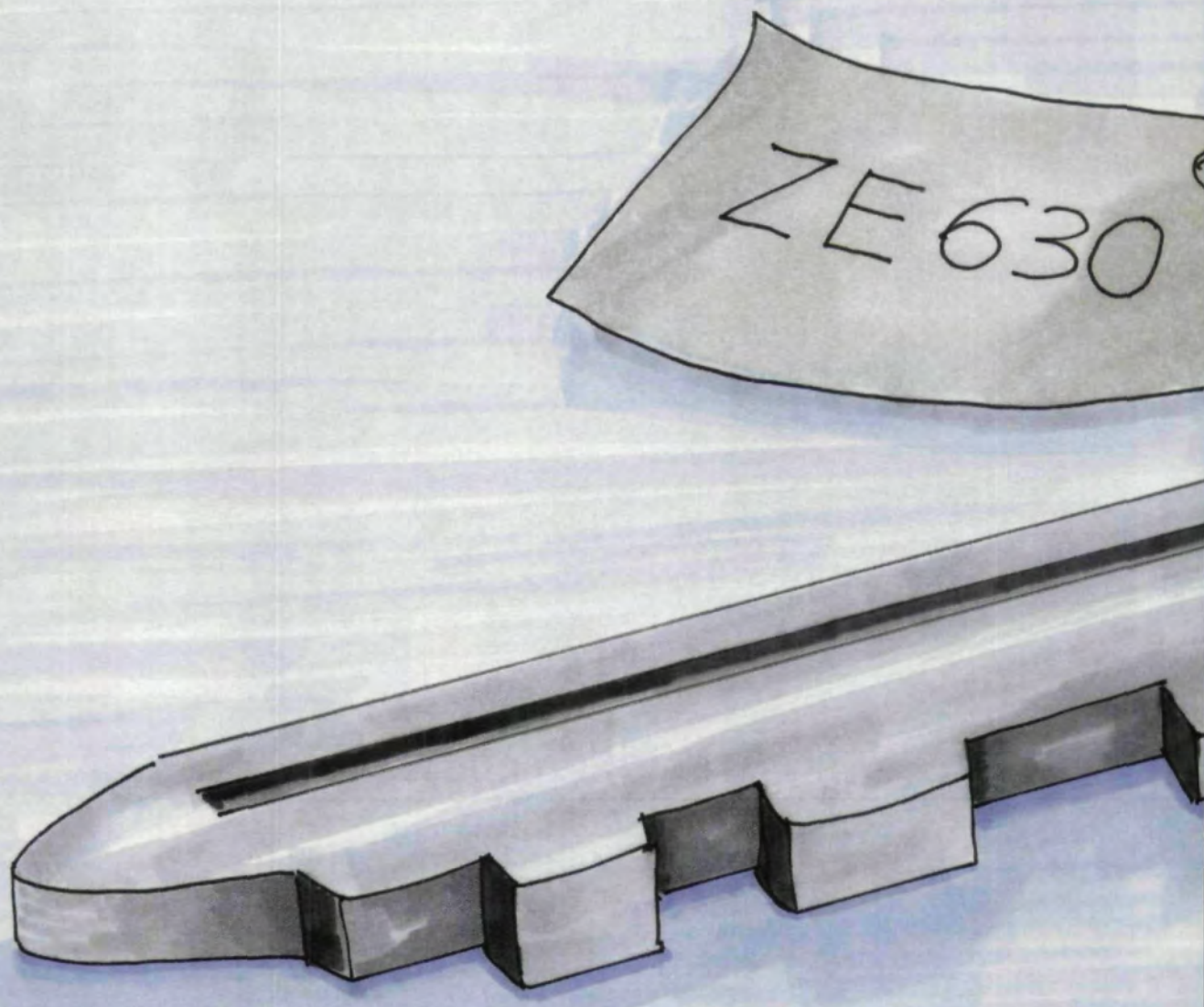

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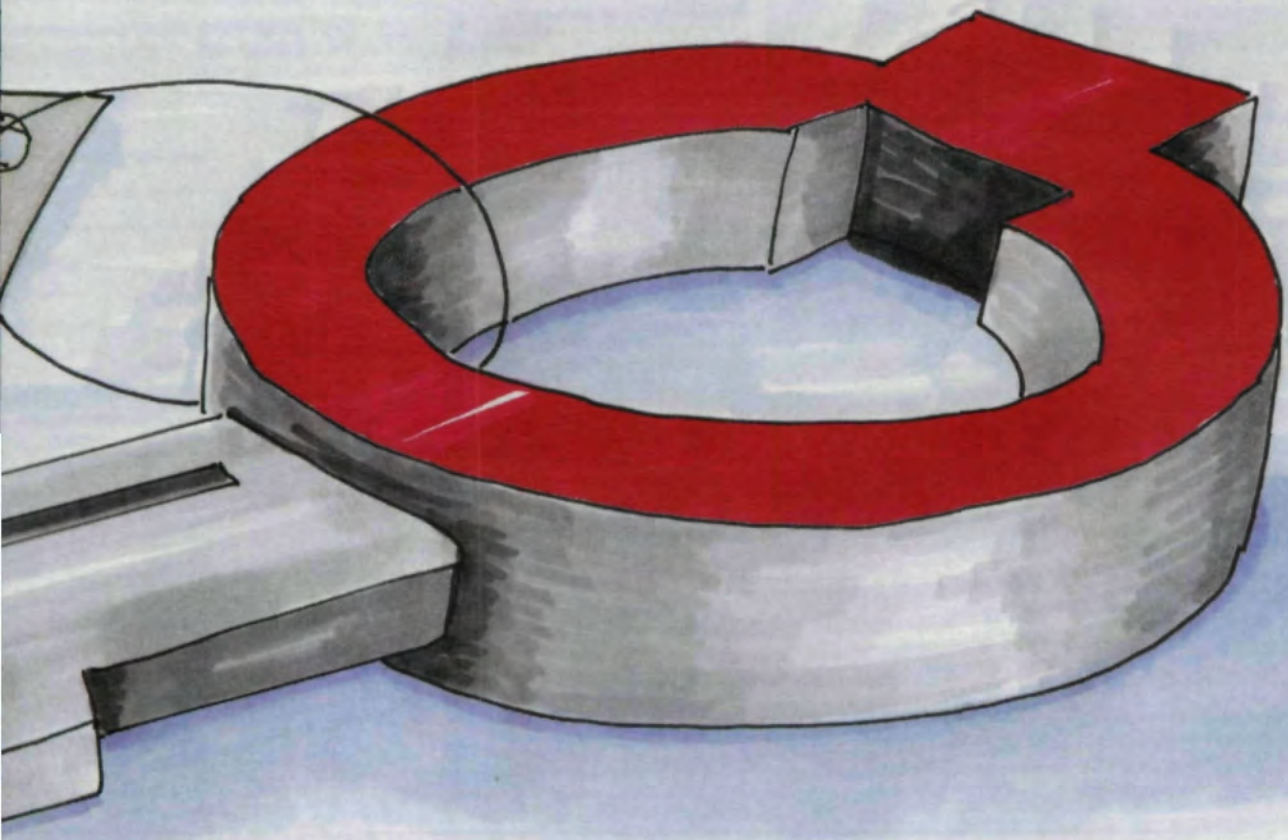

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CIRCLE 194

Gone Fishin'

—Back After Gear Expo

It's summertime in the gear industry. Out my window, I see blue skies, green grass and trees swaying in the wind. In the background, I hear crickets chirping.

I wish I *didn't* hear them, of course. The fact that I can just means everything else is too quiet. Maybe everyone's at the beach, or on vacation, or gone fishing. There's just not a lot happening to get excited about.

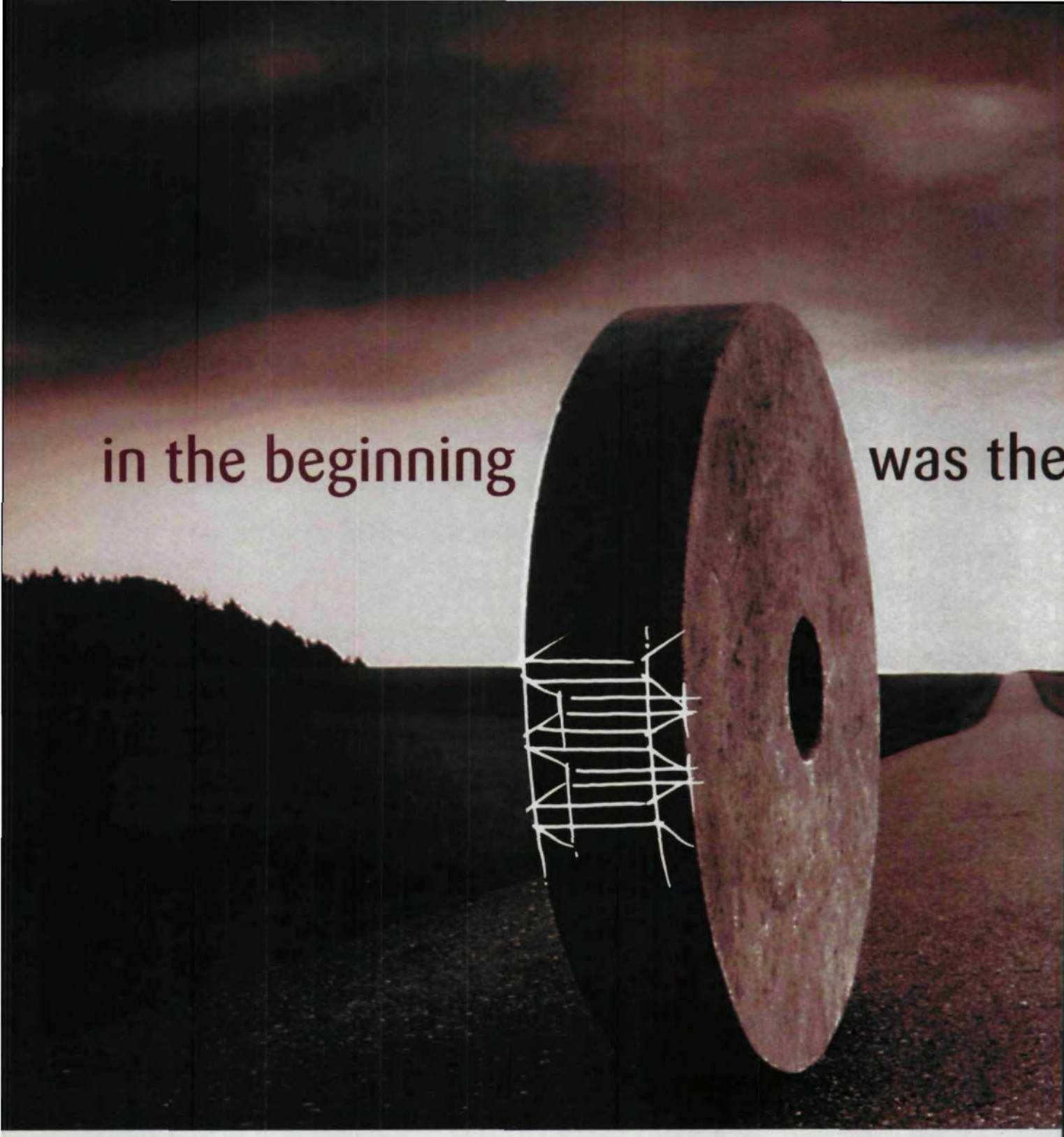
When times get slow, I often try to look at economic indicators, industry trends and other factors to help you try to anticipate what to expect from the coming months. But the indicators are quiet, too. They have nothing new to say this summer.

Fortunately, we have Gear Expo to look forward to. I'm hoping to see many of you there, looking at the exciting new products that I've heard will be at the show (see page 13 for an example from Gleason that I think makes the show worth going to).

So this year, I'm not going to try to prognosticate. I think I'll just pack my bags, head off to Gear Expo, and leave the crickets to their song.

Maybe when I get back, there'll be something to talk about.

Michael Goldstein, Publisher and Editor-in-Chief



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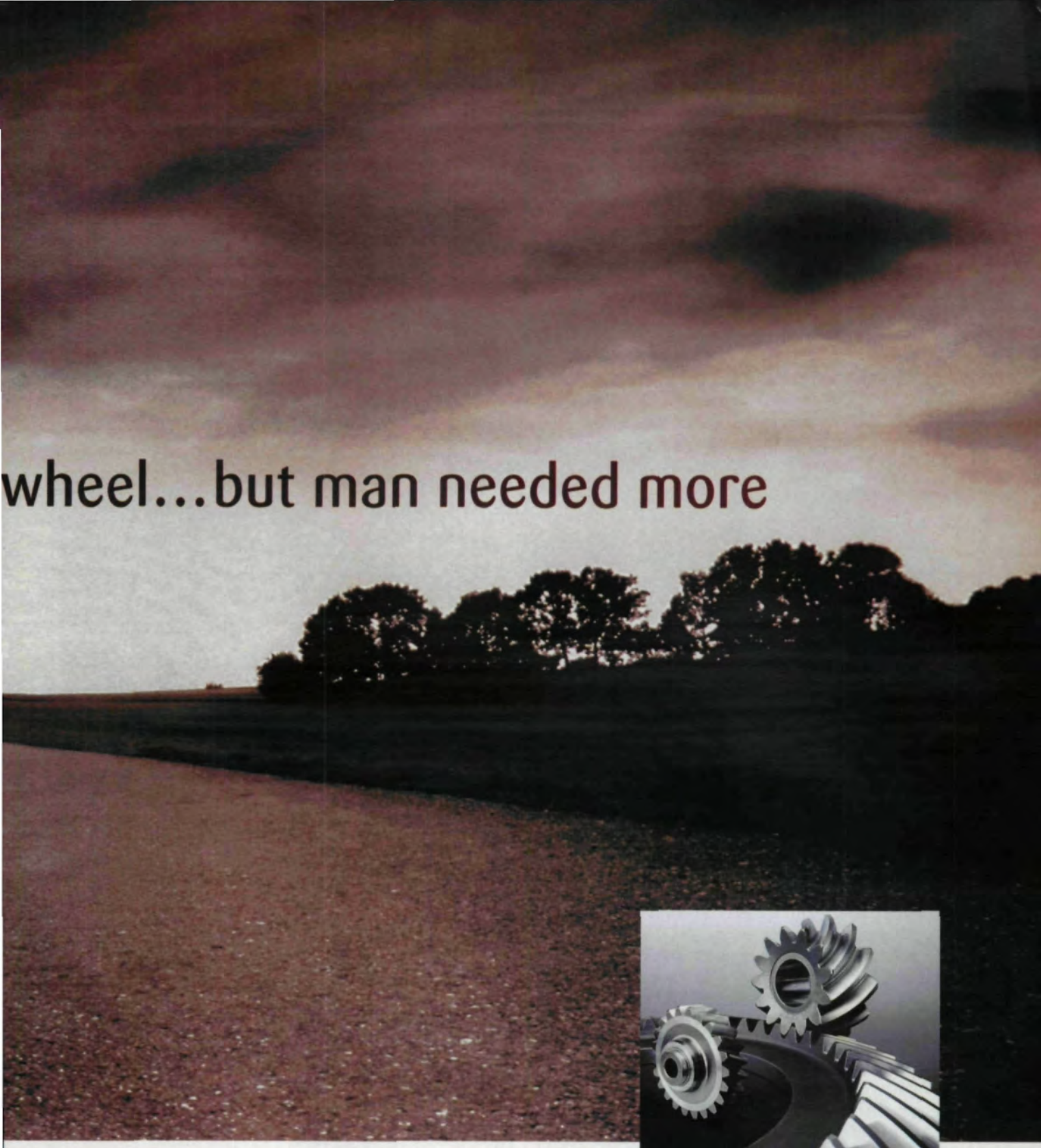

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CIRCLE 158

Phoenix Rising

Gleason Corp. of Rochester, NY, has redesigned its Phoenix® bevel gear cutting machine to take up less space but have more capacity than the previous model. The Phoenix® II 275HC will be unveiled at EMO in September and Gear Expo in October. According to Gleason, this new dry or wet cutting machine is more than an upgrade of existing technology.

"Our customers are hungry for savings, whether through elimination of coolant costs, reductions in cycle times, savings in precious floor space, lowering inventories, or maximizing the use of manpower," says Gary J. Kimmet, Gleason's vice president of worldwide sales and marketing. "We knew the next Phoenix would have to be designed from the ground up to address all of these areas ... not incrementally, but a complete technological leapfrog over anything currently available."

From the outside, with its guards in place, the Phoenix® II 275HC looks like most small machine tools. But inside, it's unlike any other bevel gear cutting machine.

The Phoenix® II is built around a stiff, monolithic cast-iron column, to which the slides and the spindles are attached.

"This presents a unique and perfectly symmetrical way of positioning the cutting tool and the workpiece, which provides advantages in ergonomics, chip removal, stiffness and accuracy," says Dr. Hermann J. Stadtfeld, Gleason's vice president of research and development.

On previous machines, including the Phoenix® 175HC, a large base sat under the rest of the machine to support the various components.

Instead of complicated, bulky mechanisms, like change gears and cams, positioning and indexing of workpiece and cutting tool are accomplished entirely by CNC-controlled direct drives.

The result of those changes is a much smaller machine—90 square feet vs. the 140 square feet of the Phoenix® 175HC. Although smaller, the Phoenix® II can cut much larger bevel gears than its predecessor—up to 275 mm in pitch diameter vs. the 175 mm of the Phoenix® 175HC.

Also, the design and the direct drives lead to several other advantages, according to Craig Ronald, Gleason's chief design engineer.

Chip removal is simplified during dry cutting, Ronald says. "Now, hot dry chips are free to fall completely clear of the machine structure into a simple chip conveyor, without the need for shrouds, vacuum systems, or even hot chip-related temperature compensation, because there's no bed to 'grow' with heat buildup.

"In addition, we're now pivoting the cutter spindle to create the root angle rather than mounting the workspindle on a swinging base. This permits the shortest possible structural overhang of both cutter and work for maximum stiffness and thermal stability."

Also, the redesign placed the work and cutter spindles much closer together. Now, both cutter and workpiece face the operator and are only 6" and 11" ***(15 and 28 cm)*** away, respectively. Ronald says the design is meant to reduce operator fatigue.

The use of direct drives also should help reduce setup and machining times, Ronald says. "In addition to the obvious benefits of eliminating mechanical adjustments, change gears or draw rod switch setups, the new spindle motors deliver high torque as well as high cutter and work speeds. This gives us the capability for wet or dry cutting, with room to spare for future process developments."

The direct-drive motors also deliver much higher acceleration and deceleration rates, Ronald says, with the spindles stopping in as little as 200 milliseconds. "Savings in stop/start times of even a few seconds quickly add up," he says. Also, direct-coupled linear-axis drives are used, with possible travel rates of 10 m/min. and a cutter pivot rate of 40 deg./sec. Those higher speeds combine with the new design's inherently shorter linear motions to result in further reductions in non-cutting time.

The Phoenix® II can accommodate all styles and types of Gleason and non-

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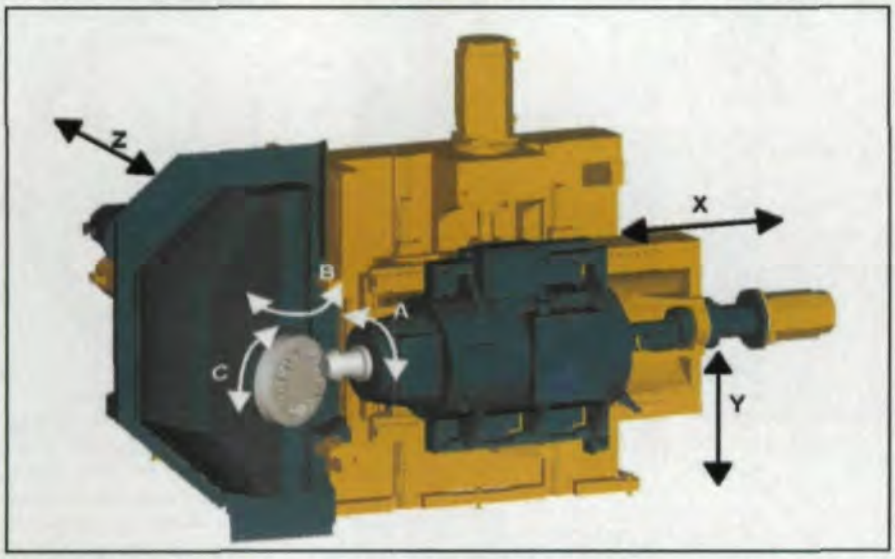

The Gleason Phoenix® II 275HC was completely redesigned. At the heart of the new machine is a cast-iron column, around which the rest of the machine is built.

Gleason cutters and cutter systems for face milling and face hobbing. The new machine is available with either the Fanuc 160i or the Siemens 840D CNC control.

Also, Gleason will build a European version of Phoenix II in its factory in Ludwigsburg, Germany. That version is designed to fit European customer specifications and requirements, like CE codes.

Circle 300

Engineer Is Designing Test Stand To Measure Planetary Gear Vibration

Rob Parker sees a problem with analytical models of planetary gear vibration and dynamics: The models aren't supported by experimental data.

Parker, an engineering professor at Ohio State University, specializes in vibration and dynamics, particularly in high-speed systems and power transmission devices, such as planetary gears.

He explains that in basic research, complex systems—like planetary gears—are boiled down to a couple of mathematical equations, which means lots of approximating for analytical models.

But, complex systems need quality benchmark data to develop accurate analytical models.

Parker uses a pair of spur gears as an example. According to him, analytical single-mesh gear models had been used for about 50 years, but recent experiments showed strong nonlinearity, contact loss and—sometimes—chaotic response in single-mesh gear pairs. The experiments showed the models needed to be improved.

Planetary gears, with multiple bodies and meshes, are a lot more complicated than spur gears.

"There's a cloud hanging over any of those [planetary gear] models," Parker says, "until you get experimental investigation."

Investigation could be done with a test stand that measures planetary gear vibration and dynamics. Parker knows of no such stand. He knows of stands that measure durability and wear, but they aren't suited for measuring dynamics thoroughly because they usually lack access to the sun, planet and ring gears.

So, Parker is designing a stand to measure the gears' vibration and dynamics.

This contour plot shows a planetary gear system's maximum principal stresses, as calculated by the analysis program CALYX. Such analytical models will be verified for accuracy via a test stand that measures planetary gear vibration and dynamics, being built by Ohio State University engineering professor Rob Parker. Image courtesy of Advanced Numerical Systems of Hilliard, OH.

The test stand will have two planetary gear sets, a test set and a slave set, in a "back-to-back" configuration. Power will be circulated between the sets by locking a torque into the stand through the loading plates' relative rotation. A drive motor will control speed and provide power to overcome frictional losses.

Parker estimates the stand would be 12' long, 5'–6' wide and 6' tall.

Measurements will be taken from the planetary gear test set and would be used to support analytical models, identify the most important tolerances for making quieter planetary gears, and show the important behaviors that occur in special combinations of speed, torque and mesh phasing in operating conditions.

Parker expects to complete his design by the end of October. By that time, he expects to have contracted a company to build the stand. He estimates it will be ready for experiments in summer 2002.

But, the experiments may be limited to relatively few types of planetary gears. Parker may not have enough money to build the stand with a full set of fixtures for testing different types of planetary gears.

The stand will include an infrastructure, a torque actuator, a lubrication system, a computerized control system, a variable-speed drive motor with controller, and fixtures to operate in fixed-ring, fixed-carrier and fixed-sun configurations.

Some of those parts, like the motor, are generic. But, the fixtures aren't generic, so they aren't cheap.

Parker has $500,000 for the project, but: "Whether or not I can do what I want to do with that amount of money, I'm not sure—I think I can."

If his costs go over his budget, Parker hopes to get the extra money for a full set of fixtures from companies interested in the stand's uses.

This summer, he focused on attracting helicopter companies. Parker did so because he expects the stand to advance the dynamic models used for helicopters. He expects such advancement because helicopters' planetary gears are his main focus; $250,000 of his $500,000 is from the U.S. Army for investigating planetary gear dynamics in military helicopters.

The Army wants to reduce vibration and noise in its helicopter cabins. The vibration and noise in the cabins come partly from planetary gearboxes. The vibration can create noise greater than 110 dB. Tim Krantz of the Army Research Laboratory compares that noise to the noise near a chainsaw or in the front row at a rock concert.

Such noise hinders crewmembers' communication, fatigues them and can be a health hazard to them. "There's a need to reduce noise and vibration," Krantz says.

A mechanical engineer, Krantz specializes in gear research for the laboratory's Vehicle Technology Directorate, located at NASA's Glenn Research Center in Cleveland, OH. He is an advisor on Parker's project.

Given the Army's goal, Parker is designing his stand to operate at a mili-

tary helicopter's typical horsepower, like the 350–450 hp of the Army's OH-58 Kiowa Warrior, an armed reconnaissance helicopter. The stand's "back-to-back" configuration lets it test the gears at much higher power than the motor's rating because the motor has to overcome only frictional losses.

Military helicopters often use planetary gears because the assemblies have excellent torque/weight ratios, are compact, and have several load paths for reliability and for continued operation despite a damaged gear or load path.

Those are some of the reasons the gears are used in aircraft; automobiles; other ground vehicles, like farm and construction equipment; heavy machinery and marine applications, like submarines.

Consequently, the stand promises to benefit more than helicopters.

"The real purpose of this machine is for basic research," Parker says, adding the machine isn't really for one application. "The research questions you would ask would be the same for any application."

Ohio State University will own the test stand and its design—Parker's other $250,000 came from the university and the Ohio State Board of Regents. Each organization contributed $125,000.

Parker says the stand won't be sold commercially, but research and resulting mathematical modeling will be published.

Krantz says the Army has no set schedule for receiving data from Parker's stand or for improving its helicopters based on the data. He explains that the Army has "windows of opportunity" to upgrade or retrofit helicopter gearboxes. When the next window opens, the Army would like to have techniques—verified by experiment—for minimizing gearbox vibration and noise.

"More knowledge is good when it comes to a new design," Krantz says.

Circle 301

A New Shaper Cutter Design

A university lecturer in Romania has a model of a new type of gear cutting tool, which he says has theoretical profile errors of zero and can create perfect helical involute gears.

Márton Máté created his model and tested it for his doctoral dissertation, which he worked on from 1992 to 1998. According to Máté, the tests showed the involute profile error using his cutter was less than that obtained using a classic Fellows cutter.

Today, he holds a doctorate in the science of metal cutting and cutting tools and is a faculty member at "Petru Maior" University of Targu-Mures.

Máté created his gear cutting tool from his research on optimizing the Fellows cutter for helical gears.

The Fellows cutter has helical involute tooth flanks and cuts using a helical

motion. But, according to Máté, the classic Fellows cutter presents theoretical profile errors.

Máté's cutter has non-helical involute tooth flanks, but it cuts with a helical chipping motion. According to him, that motion allows his cutter's edges to create perfect helical involute gears.

He adds that the edges won't vary with resharpening and the cutting geometry can be adapted to conform to a workpiece material's mechanical properties.

Máté wants to offer his doctoral work to a company interested in gear cutting tools and understands the success of his work depends on it being successfully applied by a company.

But, a company would face a major undertaking to independently verify whether Máté's work is technically sound.

"We'd have to reanalyze all his work," says Walter Pluss, manager of cutter services at Fellows Corp. of Springfield, VT.

As Pluss explains, reanalysis would require understanding all of Máté's theory and spending time verifying it in a laboratory. The verification would mean obtaining and evaluating Máté's laboratory data, modeling the cutter, running it through test trials, and evaluating the trials to see if Máté's cutter shows definite improvement over a conventional cutter.

Pluss doesn't know how long the reanalysis would take or what it would cost.

Also, Pluss sees a problem with Máté's seeming view of the gear cutting process: "The process cannot be that simplistic."

Pluss says the process depends on many factors, including the cutting machine, cutting tool geometry, tool coating, fixturing, coolant, and cutting cycle. He adds that Máté's research focuses on cutting tool geometry, so it isn't clear how changing the cutting tool would affect the resulting gears' cost and quality.

Still, Pluss says he's interested in more information on the Máté cutter's applications, like test results—something that can be duplicated to check the tool's effectiveness. But, for now, Pluss says of Máté's work: "I don't have enough information to say 'Yes, you're right' or not."

Circle 302

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If you would like to respond to this or any other article in this edition of *Gear Technology,* please fax your response to the attention of Randy Stott, managing editor, at 847-437-6618 or send e-mail messages to *people@geartechnology.com.*

What "Ease-Off" shows about Bevel and Hypoid Gears

Hermann J. Stadtfeld

This article is a follow-up to "The Basics of Spiral Bevel Gears," which appeared in our January/February 2001 issue.

Introduction

The configuration of flank corrections on bevel gears is subject to relatively narrow restrictions. As far as the gear set is concerned, the requirement is for the greatest possible contact zone to minimize flank compression. However, sufficient reserves in tooth depth and longitudinal direction for tooth contact displacement should be present. From the machine—and particularly from the tool—point of view, there are restrictions as to the type and magnitude of crowning that can be realized. Crowning is a circular correction. Different kinds of crowning are distinguished by their direction. Length crowning, for example, is a circular (or 2nd order) material removal, starting at a reference point and extending in tooth length or face width.

Design philosophies connected with the particular cutting methods create additional limits by concentrating on given tools and mechanisms, although machines with expanded capabilities can be built.

Commonly Known Crowning Effects

TRADITIONAL FACE MILLING:

- crowning through differing cutter heads, 5-cut-method, through special blade arrangement and cutter head tilt;
- profile crowning through curved blade profile;
- flank twist (bias) through extra generating motions, or root angle tilt.

TRADITIONAL FACE HOBBING:

- length crowning through two-part cutter head;
- length crowning through special blade arrangement and tilted cutter head;
- profile crowning through curved blade profile.

MODERN FACE MILLING AND FACE HOBBING:

- length crowning through cutter tilt;
- flank twist through root angle tilt;
- profile crowning through curved blades;
- free form corrections through universal machine motions.

With the *CAGE*™ for Windows program for bevel gear calculation, a tool has been developed enabling precise calculation and analysis of all important gear cutting methods.

In addition to its application in plant operations for recalculation of flank compression and root tension, this complex calculation system is a suitable instrument for carrying out examinations that were impossible in the past. Hereby, it is possible to significantly reduce the amount of time required by commonly applied methodology for design, manufacture, and subsequent testing. Furthermore, it is possible to experiment with new possibilities where the manufacture of prototypes for this purpose would be extremely difficult.

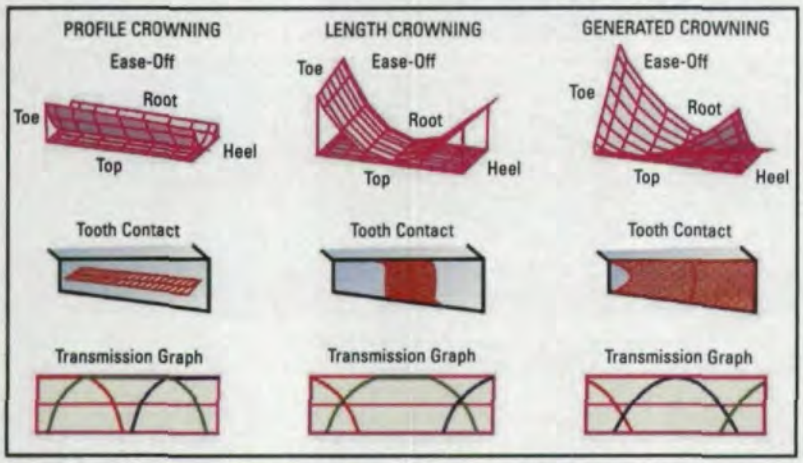

Figure 1—Basic elements for ease-off configuration: profile crowning, length crowning and generated crowning.

Crowning and Ease-Off

Continuous gear corrections emanating from the mean point of the tooth flank and radiating in all directions are called "crowning." In a first approach, the corrections may be described in terms of circular- or parabolic-shaped lengthwise "crowning" on the flank and profile crowning on the tooth profile. The direction of the contact lines has a special importance with regard to these two curvatures. Contact lines with different directions, but with the same lengthwise and profile crowning, *deliver tooth flank corrections with completely different effects.*

Through the kinematic formation in bevel gear machines, flank surfaces are always created during

the generating process that fulfill a doubly constant differentiability. The usable tooth flank ends in the region where this condition is no longer fulfilled. This is the case, for example, with flank mutilations and undercuts. Protuberance corners in the blade profile are not reflected as corners in the flank, since, through the generating process, the order of the mathematical function of the generated profile lies at least one above that of the tool profile. This rule applies to a certain catalog of blade profile shapes (Ref. 1). In the case of elimination of the generating motion (non-generated ring gears), it is possible to recognize protuberance bends, for example, based only on the contact distances or the shape of the ease-off.

Contact distances in the gear flank area of the ease-off topography show the interplay between pinion and gear flank during the mesh; they also show the corrections made by the actual generating gear versus a theoretical conjugate generating gear independent of whether this "exact" generating gear even exists for the observed method.

Geometrical Flank Corrections

Simple variations in ease-off are created by different blade profiles, cutter head radii and machine settings. This group of parameters leads to changes in the generating gear geometry. By means of the topography, it is possible to recognize directly the action that led to such a change in flank correction, both qualitatively and quantitatively. Flank direction, profile direction and lengthwise and profile crowning are hereby influenced to a large degree. The left column of Figure 1 shows a gear with profile crowning only. Pure length crowning is shown in the center of Figure 1. It is generated by different curvature of convex and concave flanks or a suitable cutter head tilt. The right sequence in Figure 1 is the result of generated crowning as it results from a third order modified ratio of roll or from a root angle tilt. Since this correction works along the path of contact, from roll position to roll position, it creates a parabolic transmission error but has no influence to the relative contact between two interacting contact lines (one of the pinion and one of the gear).

However, crowning along the contact lines and crowning in the path-of-contact direction are relevant and must be taken into consideration during the design phase. Depending on the length of the contact lines, a crowning is desired that stems from both the expected Hertzian contact and the sought-after displacement behavior. The required corrections in the path-of-contact direction are also derived from the displacement behavior of the total gear set and, in addition, from the minimization of meshing impact. The resulting orientations of the main directions of curvature of the ease-off are those along the contact lines and in the path-of-contact direction, respectively.

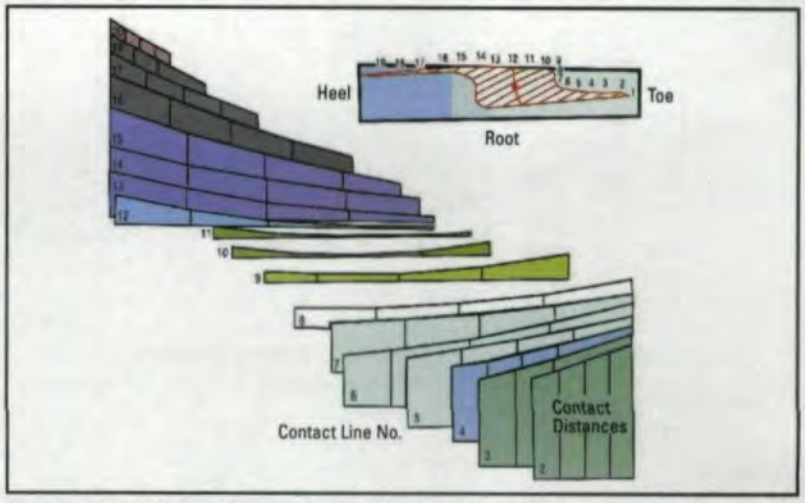

Figure 2—Relative positions of contact lines between pinion and gear flanks—straight bottom line represents the conjugate reference.

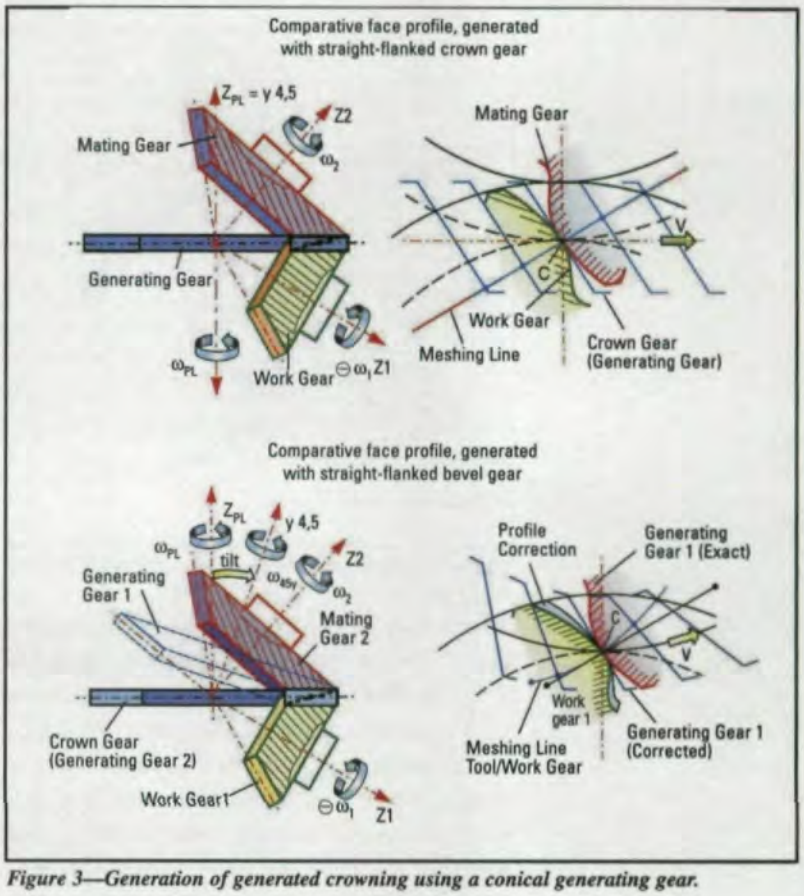

Figure 3—Generation of generated crowning using a conical generating gear.

The geometrical generating gear corrections dealt with previously do not offer the possibility of deviating from the longitudinal tooth direction or tooth profile direction as the main directions of curvature. Flank corrections thus developed always lead to tooth bearing forms as shown in Figure 1, left and center. The path of contact is developed through the low points of the contact lines caused by the curves they "cut out" of the ease-off topography. If one observes the contact distances over the

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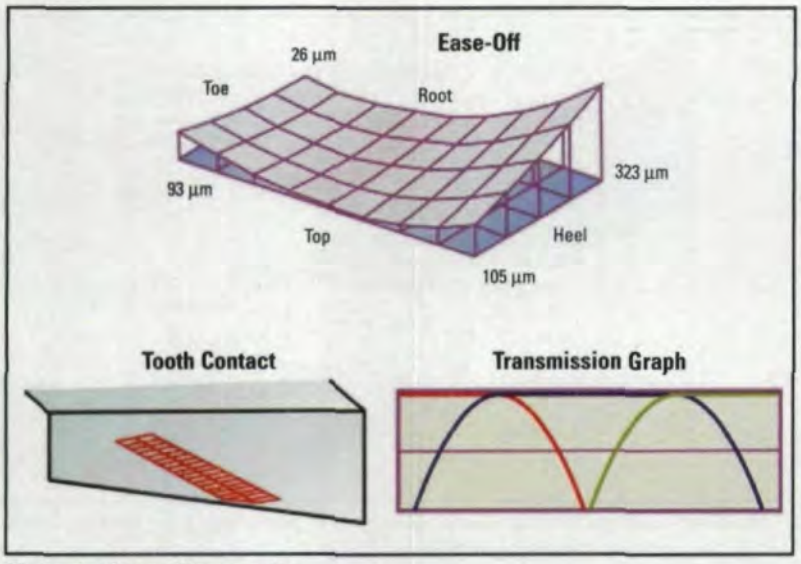

Figure 4—Contact line crowning.

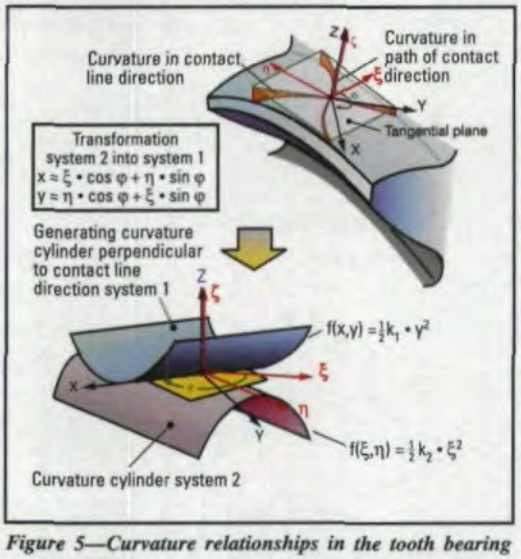

Figure 5—Curvature relationships in the tooth bearing center area.

contact lines, as seen from the ease-off topography (Fig. 2), then the point of contact can be identified by the smallest contact distance.

The smallest contact distance yields the deviation in the angle of rotation. The angled lines of contact, in combination with a symmetrical lengthwise and profile crowning, lead to the typical shapes of the crowning along the contact lines shown in Figure 2.

Accordingly, entrance and exit of tooth contact takes place at the boundaries of the gear flanks, while—only in the mean flank zone—a minimum of the circular crowning function takes place within the flank itself (contact lines 9 to 12, Fig. 2). In order to eliminate the natural twist in case of circular length and profile crowning, which is recognizable in the contact distances in Figure 2, it is necessary that a twist with opposite tendency be applied to the ease-off topography.

Kinematic Flank Corrections

Manipulation of the ease-off, in the sense of twist, belongs to the group of higher-order correction procedures. These procedures lead to changes in the kinematics of the generating gear. Additionally, one may add varied generating ratios (modified-roll, non-linear supplement motions and conical generating gears by applying cutter tilt). The way a conical generating gear functions is shown in Figure 3. The development of gear and pinion flanks by generating with a generating gear with a 90° pitch angle (crown gear) is shown in the top section of the figure. In the cross section (in the middle of the gear face width) in the right section of Figure 3, the profile of the gears is formed by generating with a straight-profiled crown gear. Because the diameters increase from inside to outside when the transmission ratios are the same, the profile curvature decreases continuously toward the heel. The difference shown in the lower right hand portion of Figure 3 occurs because the straight profiled generating flank is not moved horizontally during generation (crown gear), but a rotation of the straight profile takes place through the conical shape of the generating gear body.

The generating roll angle changes over a series of contact lines. The right-hand column in Figure 1 shows the ease-off topography resulting from this procedure. We are speaking here of a purely generated crowning; the contact lines of the tooth bearing marking compound are visible over their entire length, just as with those of the uncorrected conjugate gear. The tooth bearing covers the entire active flank region. The conical generating gear is obtained in the gear machine by tilting the cutter head perpendicular to the axis of the generating gear. An identical flank correction can be obtained through a modified, non-constant generating ratio of roll. The effects of a contact line crowning are shown in Figure 4 (Ref. 2). The effect is opposite to the generating crowning in Figure 1. No transmission error is generated along the path of contact. This effect, which results in a high bias contact, cannot be used independently but is an additional ease-off "design element."

Construction of Ease-Off Topography

For higher developed bevel and hypoid gear sets that are intended for specific uses, it is recommended that an optimal ease-off be "constructed" based on loading-induced deformation and deflection behavior. Correction topography developed in this manner can be described in all points by two curvature cylinders with certain diameters and certain orientations (Refs. 3 & 4), as shown at the bottom of Figure 5. As seen from the preceding sections, through the kinematic generation of bevel gear flanks—if one disregards bends in blade edges—

there always result correction functions that are doubly-constant differentiable, i.e. smooth and bend-free. Construction and prescription of the ease-off topography must reasonably be performed within the framework of these conditions. The ease-off must also be viewed in conjunction with the basic geometrical parameters (especially spiral angle and lengthwise tooth curvature.) To be sure, those are not recognizable on the correction surface, but, for example, they still exhibit strong influence on displacement behavior (Ref. 4).

The top portion of Figure 5 shows the flank correction in contact line and path-of-contact direction relative to the uncorrected flank point (mean point). Herefrom result the curvatures and directions of curvature for the curvature cylinder system in the bottom part of Figure 5. If only linear, generating-cradle-dependent kinematics that act symmetrically toward the mean point are used in addition to the usual geometrical generating gear corrections, then the observation of the differential curvatures of a single flank point—namely the mean point—is sufficient to describe the entire correction. For the realization of the correction surface, traditionally all that are available are the three basic crowning elements shown in Figure 4, for which the directions of curvature have already been determined. Based on that, it is now possible to further simplify the curvature system shown in Figure 5; a third curvature cylinder can now be added, whereby—in this case—the positions (orientation of the lengthwise axes) of the cylinders are fixed. In order to realize the prescribed flank corrections, therefore, only three free curvatures remain to be defined. This is relatively easy for the computer, but very restrictive for the ease-off design.

Variation of the Crowning

In the following sections, some of the examination results of practical gear examples will be discussed. In the three gear sets shown in Figure 6, changes were made only in the length crowning (Ref. 5). All other identifying magnitudes selected were identical to those in the table of Figure 6. In the center of the figure is the sequence of the load-free marking-compound tooth bearing. The length crowning increases from left to right. The starting point was the average length crowning for which the tooth bearing can be seen in the center of Figure 6. The individual reaction of the tooth bearings to changes in length crowning is entirely characteristic. The flat curve of the path of contact (left in Figure 6) twists and, with increasing lengthwise crowning, constantly becomes steeper, while the tooth bearing surface is simultaneously reduced. The entrance and exit of the path of contact in all

Pairing	Crowning	$\Delta R_{b\text{-}RI}$	$\Delta R_{b\text{-}RA}$	α_n	β_{mm}	Z_1	Z_2	M_{mn}	AV	D_{M2}
1	large	14 mm	0	20°	36.6°	11	36	12 mm	0	630 mm
2	medium	5 mm	0	20°	36.6°	11	36	12 mm	0	630 mm
3	small	2.4 mm	0	20°	36.6°	11	36	12 mm	0	630 mm

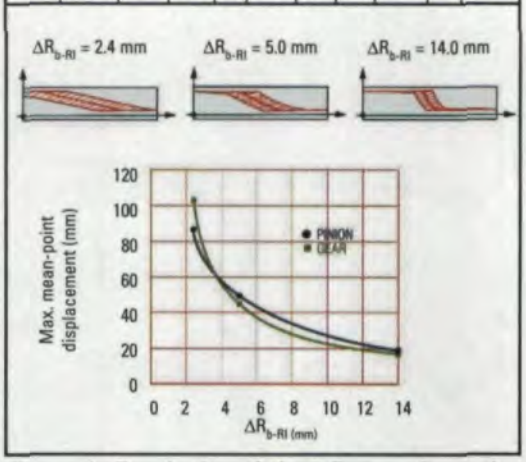

Figure 6—Examination of the influence of crowning alteration only.

cases runs precisely on the edges of the active contact area.

The objective of an increase in crowning is usually the reduction of sensitivity toward axis position displacements. By limiting the correction change to length crowning only, however, the opposite is more often achieved. When used in a gear assembly or for individual axle drives, a tooth bearing displacement resulting from deformation in the direction of heel and tooth top (gear, as opposed to pinion) through the transmitted load is to be expected. The length crowning correction, however, considers only the offset components in the longitudinal direction, i.e., toward the heel. The sensitivity of the tooth bearing in tooth-depth direction, on the other hand, has increased. This fact is exemplified in the lengthening of the entrance and exit zones. If one observes the axis-displacement spectrum (V-H Test) and measures the mean point movement in the direction of the face width, the result is shown in the graph in Figure 6. The gear set with greater lengthwise crowning appears to be highly insensitive.

The total displacement characteristic of a gear offers a complete picture of the displacement capability. From left to right in three sequences, Figure 7 shows the diametrically projected characteristic surfaces for three gears with different crowning. The three surfaces placed one above the other, belong together and include, in ordinate direction, the particular displacement of the respective axis. The supporting grid plan illustrates the gear flank, whereby the coordinate origin lies at the heel root. On the average, through a vertical comparison, it is possible to determine a progressive increasing surface inclination in the longitudinal direction. The slope in profile direction tends to decrease with increased length crowning (from ΔR_b = 5 mm to

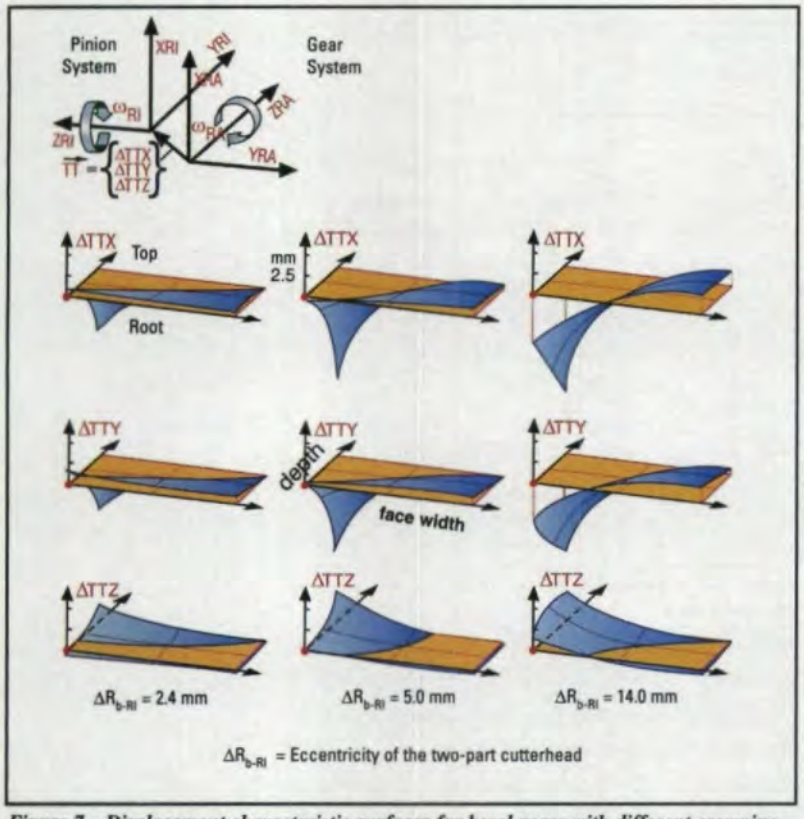

Figure 7—Displacement characteristic surfaces for bevel gears with different crowning.

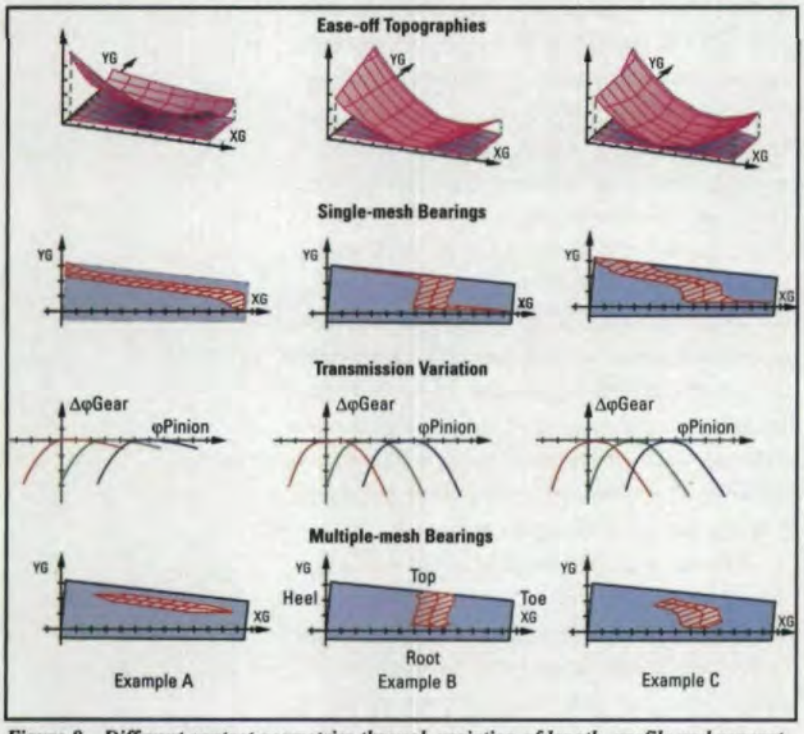

Figure 8—Different contact geometries through variation of length, profile and generated crowning.

ΔR_b = 14 mm, Figure 7). This confirms the above mentioned theoretical consideration of more profile sensitivity after increase of length crowning.

The objective of a bevel gear design that is adapted to compensate for gear assembly and shaft/bearing system distortion is obtaining agreement among the offsetting values of the loading spectrum with vertical values in a figure sequence at the desired contact position. However, any increase in crowning also increases the transmission error, particularly under light loads.

Variation of Length Crowning, Profile Crowning and Generated Crowning

This final section shows some calculation examples (contact analysis and FE strength calculation) for the most important tooth bearing types discussed in this paper. The calculations are based on a generated face milled gear set (hypoid offset = 35 mm, ratio = 7/36, shaft angle = 90°; spiral angles = 49°/29°, ring gear outer diameter = 300 mm). In order to obtain certain tooth bearing forms, the gear machine settings were calculated for a high bias (vertical, narrow) tooth bearing (Figure 8, left) and for a tooth bearing with a vertical path of contact (bias neutral, Figure 8, center.) The original machine settings calculated for an aircraft application delivered a tooth bearing as shown in the right-hand sequence of Figure 8. Example B in Figure 8 presents the classical tooth bearing design. The active region of the path of contact runs along the flank center from the top edge vertically to the root across the profile. The tooth is loaded in the region of its greatest strength. When axis deflection occurs during operation, sufficient room remains for the tooth bearing to shift in the longitudinal direction along the tooth. If a shifting of the tooth bearing in the direction of the heel (larger diameter) is expected, it is easy to make a pre-correction in the tooth bearing position by moving it toward the toe (smaller diameter). A disadvantage of this design is that compression peaks appear on the top edges of pinion and gear flanks, even under minimum loading.

A tooth bearing selection according to Example A in Figure 8 has only been used to date when the ratio of tooth depth to tooth width has been very small, for example d/w = 0.1. In this case, in order to utilize the largest possible flank region when length and profile crowning are equal, it follows that a generated crowning should be included. The advantage of that type of gear may be seen in the fact that the contact lines do not expand all the way to the top edges of both gear and pinion teeth (even under full loading); therefore, lower maximum compressions may be expected. The transmission variation curve of Example A demonstrates—in broad regions—much smaller values than that of Example B or C. It follows that the use of generated crowning not only doesn't necessarily yield an increase in rotary deviation, but can actually decrease rotary deviation due to changes in the path of contact curve.

Today, there is a tendency to select a compromise between variants A and B in order to avoid edge contact as much as possible, while still retain-

ing displacement reserves in the longitudinal direction along the tooth. The gear set C in Figure 8 shows such a compromise. The cutter geometry setting differs from gear B primarily through a small protuberance in the pinion blade (about 1° protuberance angle.) The ease-off topography in sequence C of Figure 8 differs somewhat (at the top) from the one in sequence B. This is due to the protuberance in the cutting blades (not shown). Visible in Figure 8 is just the effect, not the protuberance itself.

In order to judge the actual relationships of gearing A and gearing B under load conditions, finite element calculations for two loading levels (gear torque: T_1=500 Nm, T_2=2,000 Nm) were performed. Figure 9 shows the tooth bearings of the gear flanks under load. The surface stress distribution is shown over the active sections of the contact lines.

Example A shows a parabolic compression curve over almost all contact lines, even under heavy loading. At all load levels, Example B demonstrates the expected surface stress peaks during entrance on the gear top edge and during exit on the pinion top edge. The different maximum values for compression between gearing A and gearing B (Figure 9, bottom) permit the conclusion that gearing A can withstand significantly higher torque than gearing B, as seen from the point of view of flank loading alone. It is also interesting to note that, at 2,000 Nm, gearing A has no roll position with single mesh, but demonstrates at all times a contact ratio between 2 and 3. Gearing B, on the other hand, still has a well-defined single meshing area even at loading level 2,000 Nm.

Conclusion

Theoretical examinations with analytical calculation tools for flank generation and tooth contact analysis are possible with Windows-based personal computer programs that are easy to operate, are fast and have high flexibility for various parameter studies. The new tools offer the possibility to enter new areas of tooth bearing and ease-off design. Today, the classical tooth bearing configuration is often neglected, and horizontal tooth bearings with large profile and generated crowning are used. However, it appears that a variation of the vertical tooth bearing, the path of contact, which runs slightly inclined over the entire flank width (high bias), presents an improved tooth bearing form that is suited for broad application.

At this time, a new concept of kinematic flank correction is introduced to the bevel and hypoid gear manufacturers. The so-called Universal Motion Control (UMC) adds higher order flank modifications to the second order, mostly geometrically based corrections of this paper. In a completing environment, the new universal motions allow not

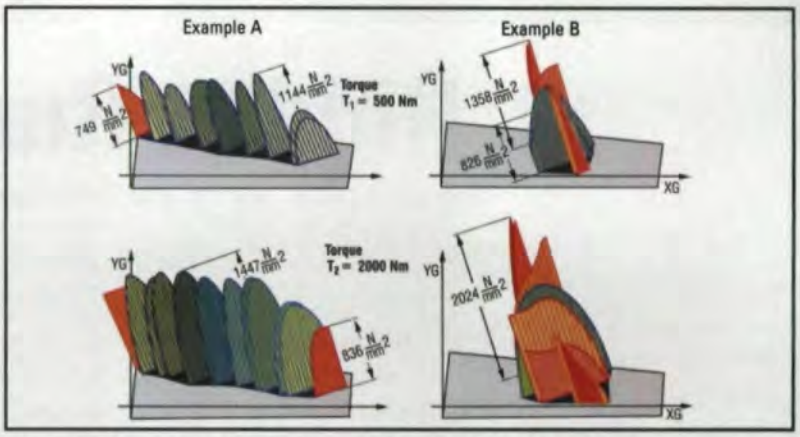

Figure 9—Compression distribution over the active contact line region.

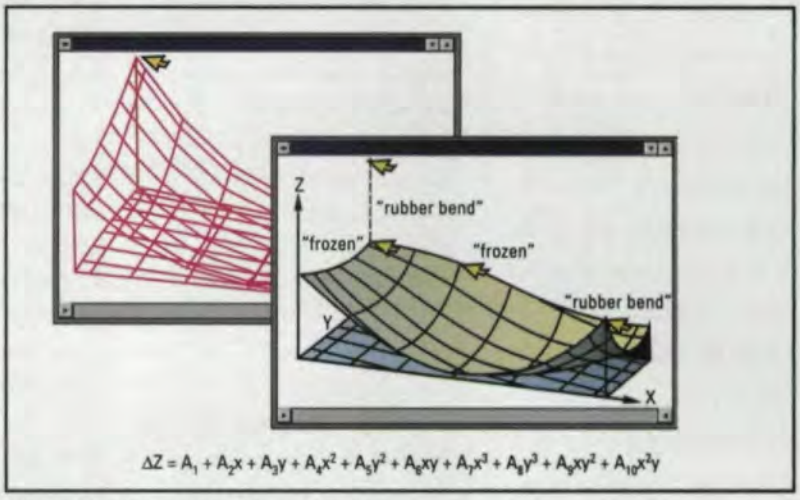

Figure 10—Ease-off by Universal Motions.

only the realizing of all combinations of the already discussed ease-offs on coast and drive side independently, but also many shapes that were impossible in the past (Figure 10) (Ref. 6).

Also, to judge flank contact and displacement characteristics, the basic flank form "face hob versus face mill" is of vital importance. The same ease-off and flank contact lead to completely different displacement and roll behavior using one or the other system.

Both a comparison of face hobbing and face milling geometry and the additional enhancement of those systems using the Universal Motion Control could be proposed as "follow-up papers" if the reader's interest is indicated. ○

References

1. Schriefer, H. *Verzahnungsgeometrie und Laufverhalten bogenverzahnter Kegalradgetriebe*, Dissertation TH Aachen, 1983.
2. Litvin, F.L. "Generated Spiral Bevel Gears: Optimal Machine-Tool Settings and Tooth Contact Analysis," SAE Technical Paper Series 851573, 1985.
3. Baxter, M.L. "Second-Order Surface Generation," *Journal of the Industrial Mathematics Society*, Vol. 23, 15.
4. Stadtfeld, H.J. *Handbook of Bevel and Hypoid Gears: Calculation, Manufacturing and Optimization*, Rochester Institute of Technology, Rochester, New York, 1993.
5. Paul, M. "Einfluss von Balligkeiten und Lageabweichung auf die Zahnfußbeanspruchung spiralverzahnter Kegelräder," Dissertation TU München, 1986.
6. Stadtfeld, H.J. *Advanced Bevel Gear Technology, For the New Millennium*, The Gleason Works, Rochester, New York, 2000.

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Hidden Runout?

Question submitted via *The Gear Industry Home Page™*

Robert E. Smith

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Q: I would like to know if too much total composite error on a scissors gear in a diesel engine could contribute to high vibration levels? I'm talking about 0.0015" over the maximum tolerance of 0.0026".

Answer submitted by
Robert E. Smith
R.E. Smith & Co.
Rochester, NY

A: How much is "too much" depends on the application. What is good for one application may not be good for another. Factors such as rpm, structural dynamics, ambient conditions, etc., all must be considered. Also, it depends on the frequency of the noise or vibration. Does it occur at "once per revolution" frequency of the gear set? Or does it cause noise or vibration at sidebands of mesh frequency? All of these questions have to be evaluated.

A total composite error of 0.0041" would not be unusual or detrimental in many automotive and vehicle drive trains. However, you possibly are being deceived by the method of quality control. Double-flank composite testing can find radial runout, which is the major component of double-flank total composite error. It cannot find accumulated pitch error, which is just as bad for once-per-revolution velocity variations. This deception in measurement is a phenomenon called "Hidden Runout." For a complete discussion of this subject, see AGMA technical paper 95FTM1, "Detection of Hidden Runout," by Smith, Laskin and Bailey. You may very well have an accumulated pitch error that is much larger than the runout that you can tolerate, or think you have.

Hidden runout occurs frequently with gears that have been hobbed with excessive runout and then had a subsequent finishing operation such as shaving or some grinding processes. It can even happen with form grinding or hobbing, when the workpiece is properly trued up, if the workspindle drive gear is mounted eccentrically or worn out.

A precision index check of pitch and accumulated pitch

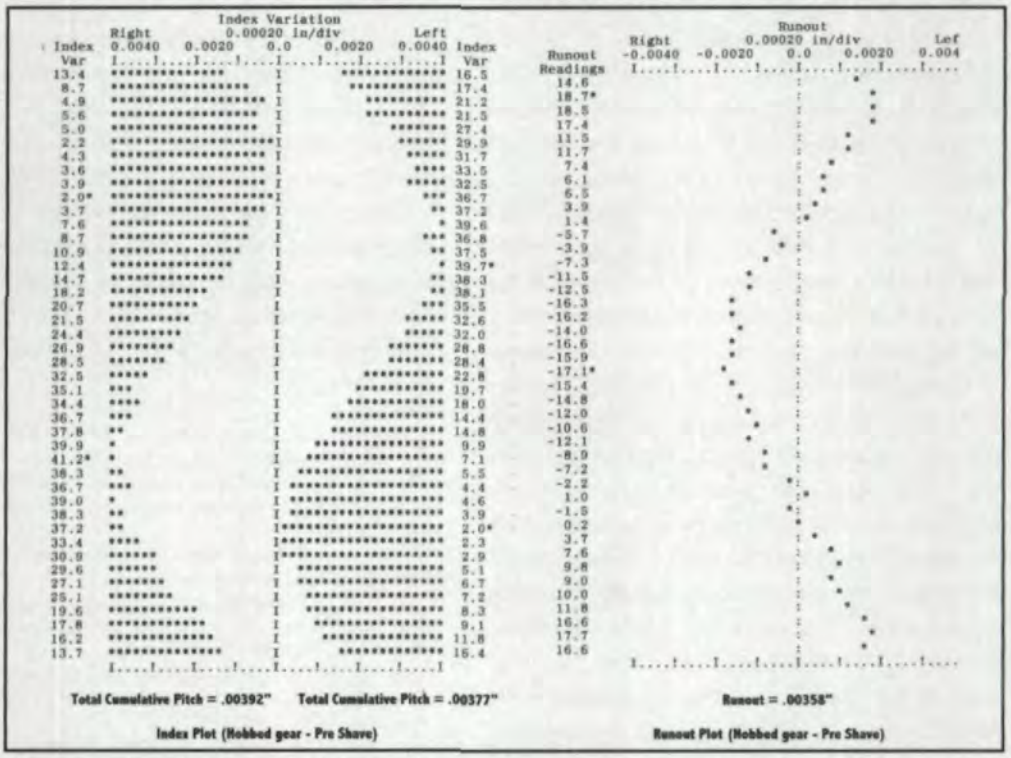

Fig. 1—Precision index check of pitch and accumulated pitch after hobbing.

Robert E. Smith

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error can find the problem. See Figure 1 for a test of such a gear after hobbing. See Figure 2 for the results of the same gear after shaving. Runout has been removed, but the accumulated pitch error still exists. Figure 3 shows the same gear checked by a single-flank composite gear tester. This is a true meas-ure of transmission error (TE) or variation in angular motion. Double-flank composite testers only measure radial motion. Unfortunately, gears do not operate in a radial mode; they operate tangentially.

Another automotive example is discussed in AGMA technical paper 84FTM2, "What Single Flank Measurement Can Do For You," by Smith. That paper discusses a pair of front-wheel-drive gears that caused excessive vibration in the vehicle, at a frequency of once per revolution of the pinion. The pinion passed the double-flank composite test with 0.0025" total composite error. However, single-flank composite testing (tangential measurement) showed 0.0135" total composite error. (The same test would also show approximately the same amount of total index error or accumulated pitch error.) No wonder it vibrated the vehicle! See Figure 4.

In the final analysis, double-flank composite testing is a poor method of quality control for gears that have had a subsequent finishing operation such as shaving and grinding. Remember that double-flank composite testing measures radially, and gears don't work that way. Single-flank composite testing is much more informative. It measures gears the way they work. Unfortunately, industry has been very reluctant to adopt this method of quality control. ○

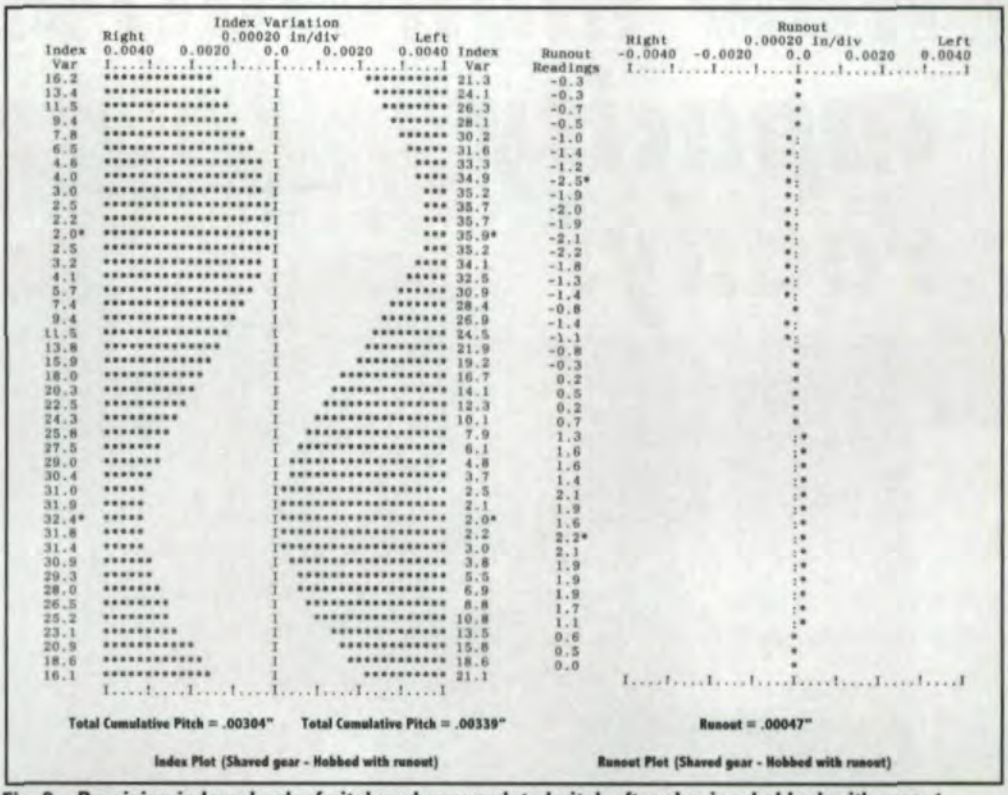

Fig. 2—Precision index check of pitch and accumulated pitch after shaving, hobbed with runout.

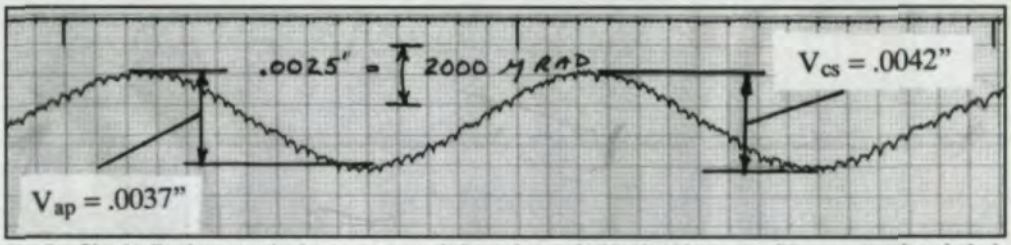

Fig. 3—Single-flank transmission error test of shaved gear, hobbed with runout. (V_{ap}=accumulated pitch variation; V_{cs}=total composite variation, single flank.)

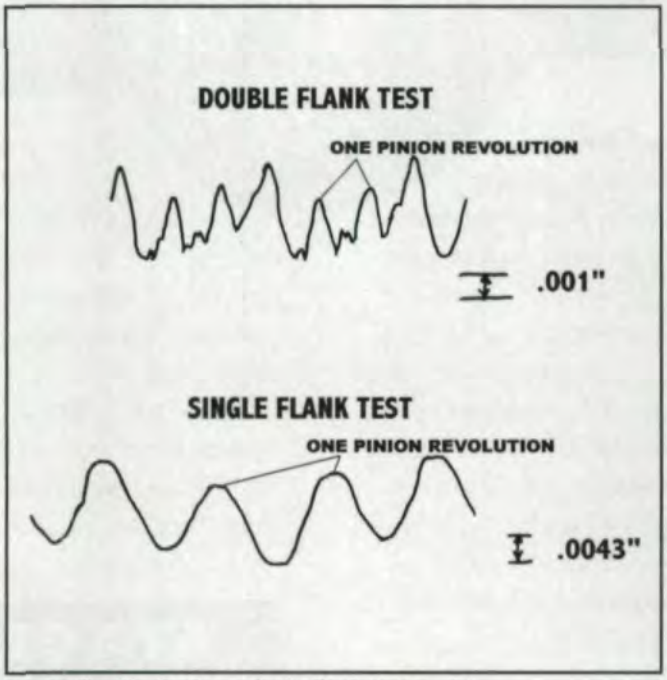

Fig. 4—Double-flank vs. single-flank test results.

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Face Gears: An Interesting Alternative for Special Applications—Calculation, Production and Use

Manfred Weck, Dietmar Mandt, Michael Meyer and Yvonne op den Dries

Introduction

Crown gearings are not a new type of gear system. On the contrary, they have been in use since very early times for various tasks. Their earliest form is that of the driving sprocket, found in ancient Roman watermills or Dutch windmills. The first principles of gear geometry and simple methods of production (shaper cutting) were developed in the 1940s. In the 1950s, however, crown gears' importance declined. Their tasks were, for example, taken over by bevel gears, which were easier to manufacture and could transmit greater power. Current subject literature accordingly contains very little information on crown gears, directed mainly to pointing out their limitations (Ref. 1).

That literature contrasts with studies and development work carried out independently in the United States and the Netherlands over the last 10 years. The research in those two countries laid the foundations for the design and calculation of crown gear trains and, particularly, developed new, competitive production processes. Overall, those trends indicate that crown gear trains again represent an interesting solution for an increasing number of applications.

Applications for Crown Gear Systems

The range of applications for crown gears is extremely wide and is practically unlimited because of all the gears' possible sizes, materials and qualities. The application of crown gears is most practical when their special properties and characteristics can be exploited systematically. The examples and pictures of the Cylkro® face gears shown in this article have been made available by Crown Gear B.V. of the Netherlands.

Angular crown gear transmissions with shaft angles from 0°–135° (Fig. 1) are used in milling machines, for example, for the positioning of the milling head, or as power is sent to the tool. Another example is the use of 17°-shaft-angle crown gears in conical mixers (Fig. 2).

Gear ratios of up to 15 can be realized with spur pinions. The use of helical pinions offers the possibility of even higher gear ratios, as seen in wheel chair drives, using a gear ratio of 19.5 (Fig. 3). Further improvements are studied and tested, in which pinions with a small number of teeth and high helix angles, like worms, are being used.

The axial freedom of the pinion is particularly useful in applications that require low backlash. The axial mounting position of the pinion does not affect the backlash. In applications where the posi-

Figure 1—45°-shaft-angle crown gears and a 135°-shaft-angle crown gear for milling machines.

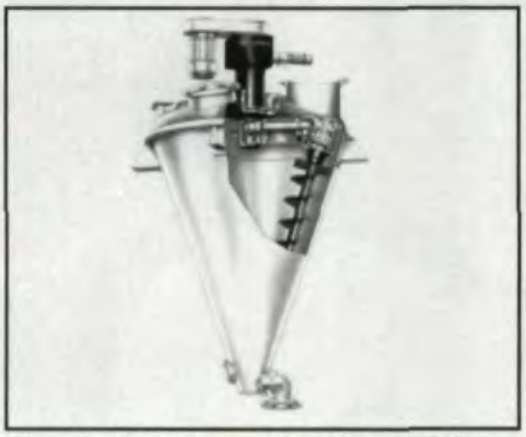

Figure 2—Conical mixer with shaft angle of 17°.

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Figure 3—High crown gear ratios in one stage.

Figure 4—Crown gears for a radar antenna with low backlash.

tion of the axes should be very accurate—in robot drives or radar antenna drives (Fig. 4)—crown gear sets with low or zero backlash are used.

Another field of application is the area of electrical hand tools. An advantage in that application is the direct mounting of the pinion on the motor shaft, whereby the axial movements of the motor shaft do not affect the contact pattern. Since the number of crown gears used in the application—as well as in other household appliances—is usually very large, alternative production methods, such as sintering, injection molding and metal injection molding, are often used (Figs. 5 and 6).

A growing number of applications can be found in the automotive area. Those applications can be divided into low power drives, such as mirror actuators, windshield wipers and starter motors, and high power drives. The high power drives can be rear axle drives, using skived or ground helical and offset crown gears, differential gears or camshaft drives. Thanks to the cylindrical pinions, a differential using crown gears can be constructed significantly smaller in height and weight than a typical bevel gear differential of the same power. The differential used in a 4X4 vehicle, for instance (Fig. 7), is made of a small crown gear and a large crown gear with several pinions between them. By driving the pinions, the torque is not divided equally between the front and the rear axle, but the relation is proportional to the diameters of the crown gears.

Figure 5—Sintered crown gears.

Figure 6—Injection-molded crown gears.

An additional advantage, closely linked with free adjustment, is the simplicity of crown gear applications for multiple machine drives, power take-offs and power splitting, transmissions whereby after splitting the torque in the first stage, the torque comes together again in the next stage. Several of those power-split designs have been developed and patented for helicopter transmissions. One patented power split by Crown Gear B.V. (Fig. 8) shows an input pinion driving the first output crown gear. With help from a set of parallel gears (not intermediate gears), a second pinion drives the second output crown gear. The two crown gears are floating axially and are mounted together at the back face or are one part. Although more parts are needed in that design, the advantages lie in a greater system power density (gear size, bearings, shaft diameters).

Special Features and Properties of Crown Gears

Crown gears are essentially angular gear systems in which the pinion, a normal cylindrical gear, meshes with a rack-gear, the crown gear. The shaft angle may vary across a continuous range from 0° (cylindrical gear pair) to 135° (Fig. 9) (Ref. 2). The most common application is, however, a shaft angle of 90°. The following discussion will also focus on that application.

As is evident from Figure 9, the geometry of the crown gear is determined by its shaft angle, its required gear ratio and—decisively—by its pinion geometry. The pinion is a cylindrical gear. It can be a spur or helical gear and may be offset to the crown gear.

A particular characteristic of spur pinions is that no axial forces act on the pinion bearings; such systems can therefore be smaller and lower-priced. Helical pinions achieve higher overlaps and are subject to axial loads that are smaller than for spiral bevel gears.

Shaft offsets are used principally when the input and output shafts cross, for example, in a multidrive system or a power take-off. Combined with helical teeth, shaft offsets allow extreme downward gear ratios (i = 100) in a relatively small space (Ref. 2).

The most important attribute of crown gears is doubtless the axial freedom of the pinion (Ref. 3). The pinion can be displaced axially at random without altering the contact parameters or flank play (Fig. 9). That results in a number of advantages. First, assembly is greatly simplified; the pinion can be positioned with relative freedom along its shaft axis. The pinion also can be slid into place sideways during assembly. Second, the "free adjustment" of

the pinion shaft simplifies the interaction of a number of pinions with a crown gear or the use of a single pinion to drive two crown gears.

Geometry of a Crown Gear System

The most obvious external attribute of a crown gear system is the shape of its teeth. The shape changes continuously across the width of the tooth. Studies aimed at a complete description of all crown gear variants—that is, gear systems with spur, helical or offset shaft pinions at various shaft angles, have been conducted only recently in the United States (Ref. 4) and the Netherlands (Ref. 5). Numerical simulation software was developed in the Netherlands for numerical contact analysis and production simulation, laying the foundations for the use of crown gears in power gear systems.

The following sections describe the origins and characteristics of crown gear geometry. The simplest and most common case of a pinion with spur teeth and shafts intersecting at an angle of 90° is considered.

Kinematic principle. In simplified form, a crown gear may be imagined as the interaction of a spur-toothed cylindrical gear with a curved rack. Figure 10 (left side) depicts the face section of such a rack-and-pinion combination. In operation, the pinion drives the rack at a constant angular velocity, ω_1. That results in a constant peripheral velocity, v_{b1}, at the base circle diameter. From that, the translatory speed of the rack, v_{hor}, may be calculated via the rack pressure angle, α_2.

In the case of a straight rack, v_{hor} is constant. Because the crown gear revolves about its axis of rotation, however, a variable radius-dependent horizontal velocity v_{hor} results across the face width of the tooth. The velocity at the outside diameter of the crown gear must accordingly be greater than that at the inside diameter. In order for tooth contact to exist over the entire face width of the tooth, the pressure angle, α_2, of the crown gear must consequently change over the diameter of the gear. The right-hand section of Figure 10 shows the resulting tooth shape for the crown gear. The changing pressure angle is shown clearly in the section. α_2 is smallest at the inside diameter; it increases towards greater diameters.

Usable tooth flank, contact path curve and overlap. The fact that the crown gear pressure angle α_2 is variable means that the height of the tooth flank that can be used actively for transmitting rotation also varies over the diameter.

Apart from determining the usable tooth height, the pressure angle α_2 decides the feasible face width of the crown gear. Theoretically, the smallest radius d_{i2} of the crown gear is found when the pressure angle $\alpha_{i2} = 0°$. In practice, α_{i2} is restricted to higher values ($\alpha_{i2} \geq 10°$, Ref. 5) dependent on the ratio and the number of pinion teeth, to prevent undercut.

The largest pressure angle occurs at the outside diameter d_{a2} of the crown gear. It limits the outside diameter of the teeth in such a way that the tooth crests become pointed or overcut from a certain pressure angle α_{a2} onwards (Fig. 10). In practice, therefore, a maximum value of $\alpha_{a2} = 45°$ is not exceeded (Ref. 5).

The newly developed numerical contact simulations allow the tooth face of crown gear teeth to be extended further than was previously possible (Ref. 6). A greater tooth face permits a more favorable load distribution and is advantageous in terms of higher transmittable torques, especially at low gear ratios.

Crown Gear B.V. (Ref. 5) achieves a greater tooth face by applying continuous addendum modifications on the crown gear teeth, on the outside diameter to prevent pointy teeth (case hardening), and on the inside diameter to prevent contact errors

Figure 7—Interaxial crown gear differential for a four-wheel driven car.

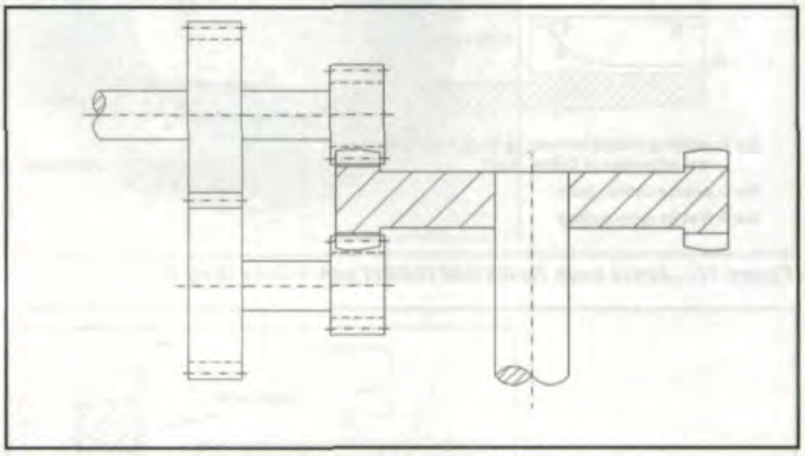

Figure 8—Patented power split from Crown Gear B.V.

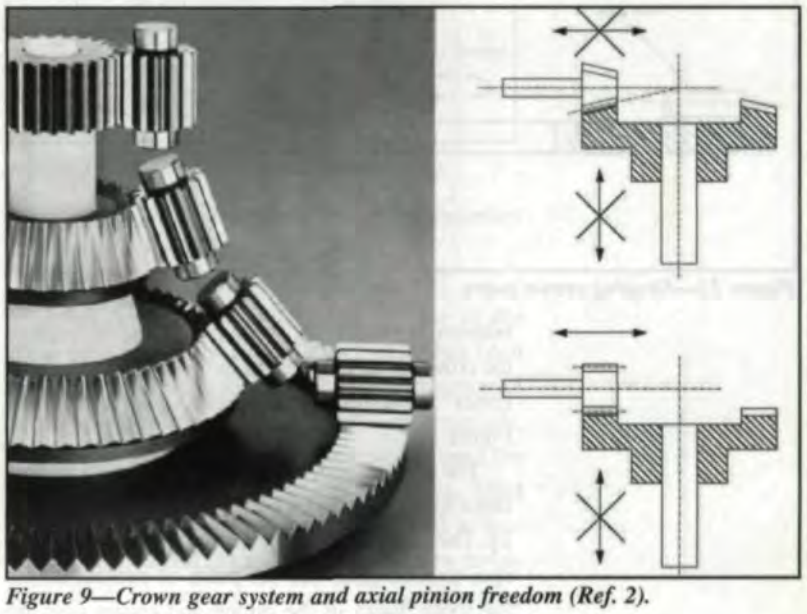

Figure 9—Crown gear system and axial pinion freedom (Ref. 2).

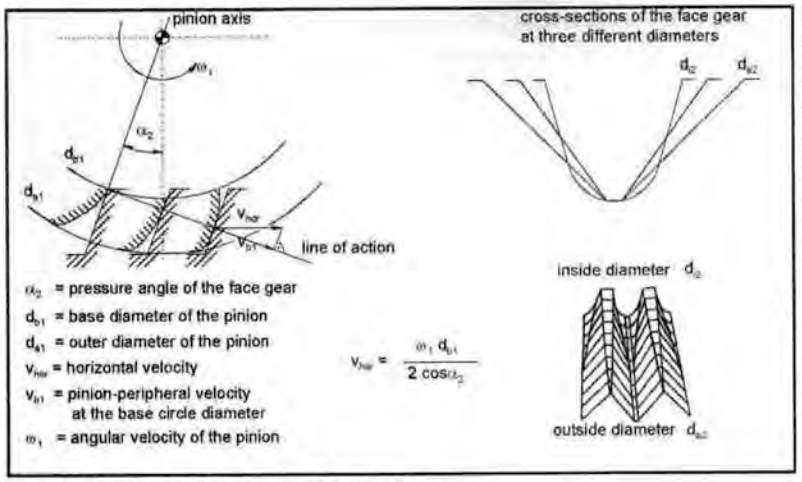

Figure 10—Path of contact and tooth shape.

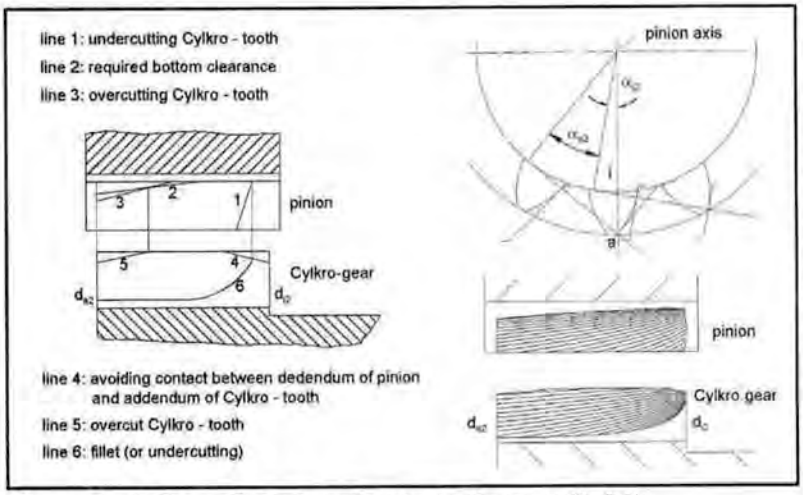

Figure 11—Active tooth flanks and contact path curves (Ref. 2).

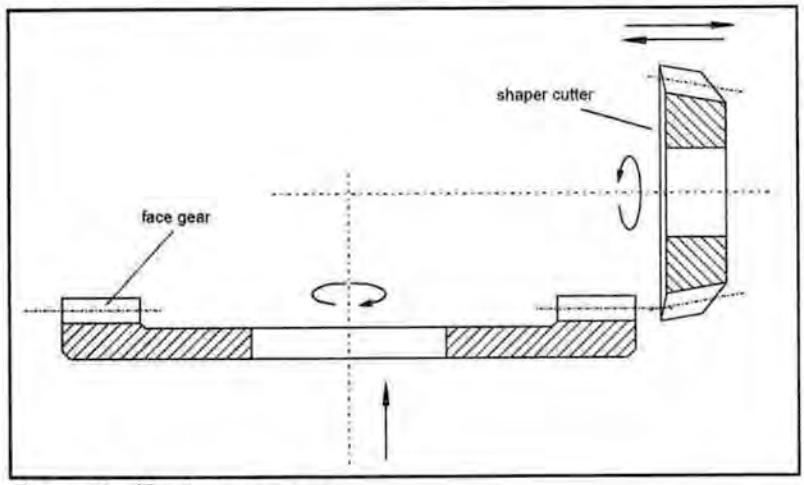

Figure 12—Shaping crown gears.

between the tooth root of the pinion and the crest of the crown gear. That results in the active tooth flank zones for pinion and crown gear shown in Figure 11.

The contact path curves of a gear are of importance for its overlap ratios and load-carrying capacity. The driving pinion of a crown gear system is a spur-toothed gear, but the paths of contact across the tooth flanks of the pinion and crown gear are helical or curved, due to the continuously varying pressure angle α_2 (Fig. 11).

The change in profile overlap across the face width and the differing values for total overlap, ε_γ, are a result of the inclined contact path curves. The helical contact paths result in an "apparent skip overlap ε_β" of the gear. As a result, higher total overlaps are attained, affecting load-carrying capacity and running behavior positively, as in the case of helical gears.

Load-Carrying Capacity

Reliable methods of determining and checking the load-carrying capacity of crown gears became necessary in order to allow their use in power gear systems. The literature identifies the pinion as the weaker element, which also determines the load-carrying capacity of the crown gear train (Refs. 5, 7 and 8).

As the pinion is a conventional cylindrical gear, its load-carrying capacity can be determined by the usual computational methods, for example, according to DIN 3990 (Ref. 9).

The calculation method developed by Crown Gear B.V. allows for the special contact paths and overlap ratios of crown gear systems. The computation is based on DIN 3990. Some of the corrective factors in the DIN standard are modified in the case of crown gears (Ref. 5). The validity of the computational method was confirmed in service life tests (Ref. 5). The following sections on tooth root stress and tooth contact stress briefly outline that method of computation.

Computing the tooth root stress. It is known from FEM simulations that the bending stresses at the tooth root of the pinion are roughly 40% greater than those on the crown gear (Ref. 5). Given the same materials for pinion and crown gear, the bending stresses at the tooth root of the pinion are therefore the deciding factor.

According to DIN 3990, the rated tooth root stress, σ_{F0}, may be calculated as follows:

$$\sigma_{F0} = [F_t/(b \cdot m)] \cdot Y_{Fa} \cdot Y_{Sa} \cdot Y_\varepsilon \cdot Y_\beta$$

The factors Y_{Fa} and Y_{Sa} are unchanged for a cylindrical gear pair. Owing to the contact line curves and overlap ratios indicated in *Usable tooth flank, contact path curve and overlap*, the overlap factor, Y_ε, and the helix factor, Y_β, for the pinion of the crown gear must be corrected accordingly.

The real tooth root stress, σ_F, can be calculated analogously with DIN as:

$$\sigma_F = \sigma_{F0} \cdot K_A \cdot K_V \cdot K_{F\alpha} \cdot K_{F\beta}$$

The application factor, K_A, and the dynamics factor, K_V, are assumed to be equal to those for helical cylindrical gears. The face factor, $K_{F\alpha}$, and the width factor, $K_{F\beta}$, were determined in running tests.

Calculating the tooth contact stress. The nominal tooth contact stress, σ_{H0}—that is, the stress exerted by the static rated torque in a perfect gearing—is calculated according to the formula given in DIN 3990:

$$\sigma_{H0} = Z_E \cdot Z_H \cdot Z_\varepsilon \cdot Z_\beta \sqrt{F_t/(b \cdot d_1)}$$

The elasticity factor, Z_E, which allows for the material, may be adopted unchanged. The zone factor, Z_H, is determined by the radii of curvature. A simplified assumption is made that the radius of curvature of the pinion is decisive for the calculation, the radius of curvature of the crown gear—considered as a curved rack—being infinite. The overlap factor, Z_ε, and the helix factor, Z_β, are again changed as in *Kinematic principle*, according to the specific contact line situation.

The real tooth contact stress, σ_H, is calculated by analogy with the data given in DIN 3990, the factors $K_{H\alpha}$ and $K_{H\beta}$ being matched to the geometry:

$$\sigma_H = \sigma_{H0} \cdot Z_B \sqrt{K_A \cdot K_V \cdot K_{H\alpha} \cdot K_{H\beta}}$$

Studies of load-carrying capacity and running behavior. There are few existing studies and findings related to the operational behavior of crown gears. An older edition of A. Müller's "Kronradgetriebe" quantifies load-carrying capacity for shaped crown gears as roughly 80%–90% of that for bevel gears with the same tooth width (Ref. 3). He presumes surface hardening of the teeth.

Crown Gear B.V. quotes the same order of magnitude for gears with spur-toothed pinions and a gear ratio greater than three as for bevel gear systems of the same size. The crown gear is again case-hardened and also has been hard-finished. Using the same pinion, the load-carrying capacity of the crown gearing falls at low gear ratios, because the usable tooth width becomes smaller.

More recent load-carrying capacity studies have been carried out in the United States on behalf of the helicopter industry (Refs. 7 and 8). Service life tests confirm the feasibility of crown gears for power gear systems. Using crown gears for a new helicopter drive concept brings about a weight reduction of 40% as compared to other types of drives (Ref. 8). It is claimed that the excitation of vibrations and noise emission are also reduced. On the service life test stand, the tooth contact frequency and higher harmonic of the crown gear system were significantly lower than those of other frequency components (Ref. 7).

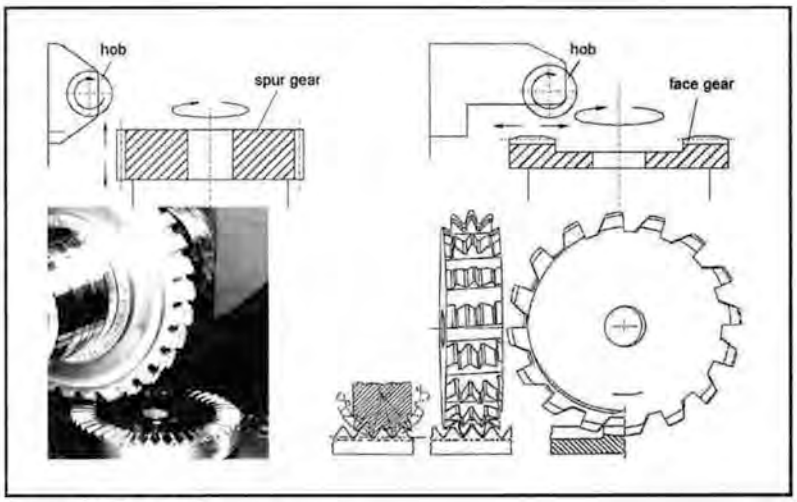

Figure 13—Hobbing crown gears.

Figure 14—Helical offset ground crown gear for a rear axle drive.

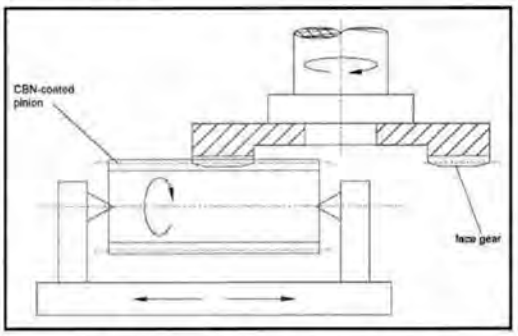

Figure 15—Principle of crown gear honing.

Manufacture of Crown Gears

Apart from load-carrying capacity, one of the main obstacles to the use of crown gears has been the problem of manufacture. With the exception of some special production methods—for example, sintering in mass production—shaping has been the only realistic industrial production process. Hard finishing after hardening has been confined to lapping. That area also has seen a number of new developments or innovations in recent years, extending the range of applications for crown gear systems.

Soft gear cutting. In the traditional shaping

process for crown gears, the crown gear is manufactured by means of a shaper cutter (Fig. 12). The shaper cutter must possess the tooth shape of the pinion. Ideally, it should have the same number of teeth, but the number of teeth may be increased to generate longitudinal crowning on the crown gear flank.

Crown Gear B.V. has developed hobbing as a new production process for crown gears (Ref. 5). The process is carried out on a slightly modified series hobbing machine (Fig. 13). Recent developments allow production on standard CNC hobbing machines without any modifications necessary.

The special feature of that type of hobbing is the toroidal hob employed (Fig. 13). The generating motion of a pinion tooth in a tooth gap on the crown gear is modelled in the face geometry of the hob. The successive cutter teeth correspond to the tooth profile of the pinion in discrete hobbing positions. After one revolution of the cutter, the crown gear has turned by one pitch.

The same restrictions apply to hobbing as to shaping. The number of teeth and tooth shape of the pinion continue to determine the cutter geometry. By simulating a rotating pinion in the production process, the hob's geometry must be closely related to the pinion used later in the gearbox. However, slight variations can be compensated, enabling the use of a tool for a larger class of pinions. Frankly, due to the kinematics, a shifting of the tool is not possible. On the other hand, production costs can be reduced by using series hobbing machines, which can be additionally employed for hard finishing the crown gear and, of course, for producing conventional cylindrical gears.

Hard finishing. Tooth flanks can be finished after case-hardening on a normal hobbing machine, as in the case of soft cutting (Ref. 5). A carbide-coated cutter is used.

Skive-hobbing achieves extremely good pitch accuracies (DIN quality 3–4) and surface roughnesses (R_a = 0.2–0.4 µm) (Ref. 5). Other finishing processes, like honing or grinding, must be used when quality requirements are greater. Crown Gear B.V. developed the continuous grinding process, using either dressable or non-dressable grinding worms. In close cooperation with a European manufacturer of grinding machines, a helical offset ground crown gear was produced (Fig. 14) as a replacement for a hypoid spiral bevel gear set for a rear axle drive. Honing with a CBN-coated pinion as the tool is already being done. Figure 15 shows the principle underlying the honing process.

During honing, material is removed due to the relative sliding motion of the flanks in the profile axis. For non-offset pinions, an additional axial motion in the pinion axis is necessary to achieve machining at the pitch cone. That is not necessary in the case of offset pinions. The surface quality of the gear can be improved by honing; an improvement in pitch accuracy is not possible.

Conclusion

The use and application of crown gears is currently in transition. Newly developed computational methods, including numerical contact simulation, provide decisive support for design and production. For the first time, numerical design and strength calculation methods are available, opening the way to applications in power gear systems.

Alongside those developments, innovative production processes provide a basis for cost-effective production of crown gear trains. Systematic exploitation of the special design features and properties of crown gears provides interesting solutions for specific applications, offering an alternative to other gear concepts in many cases.

Acknowledgments

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References

1. Beitz, W. and K. H. Küttner, *Dubbel-Taschenbuch für den Maschinenbau*, 14th Auflage, Springer-Verlag, Berlin, Heidelberg, New York, 1981.
2. Basstein, G., "Cylkro-Getriebe—eine neue Herausforderung," *Antriebstechnik* 33 (1994), Heft Nr. 11.
3. Müller, A., "Kronradgetriebe," *Technische Rundschau*, Vol. 50, Jan. 1958, Hallway Verlag, Bern, Schweiz.
4. Litvin, F.L., Y. Zhang, J. Wang, R.B. Bossler Jr., Y.-J.D. Chen, "Design and Geometry of Face-Gear Drives," *Journal of Mechanical Design, Transactions of the ASME*, Vol. 114, December 1992, S. 642 – 647.
5. Basstein, G. and A. Sijtstra, "Neue Entwicklungen bei der Auslegung und Fertigung von Kronenrädern," *Antriebstechnik* 32 (1993), Heft Nr. 11.
6. Dudley, D.W. and H. Winter, *Zahnräder*, Springer Verlag, Berlin, 1961.
7. Handschuh, R.F., D.G. Lewicki and R.B. Bossler Jr., "Experimental testing of prototype gears for helicopter transmissions," *Proceedings of the Institute of Mechanical Engineers, Part G: Journal of Aerospace Engineering*, Vol. 208, 1994.
8. Litvin, F.L., J.C. Wang, R.B. Bossler Jr., Y.-J.D. Chen, G. Heath and D.G. Lewicki, "Application of face-gear drives in helicopter transmissions," *Journal of Mechanical Design, Transactions of the ASME*, Vol. 116, September 1994, S. 672–676.
9. DIN 3990, *Tragfähigkeitsberechnung von Stirnrädern.*
10. Weck, M. and A. Landvogt, "Kronenräder," *FVA–Forschungsheft Nr. 563* der Forschungsvereinigung

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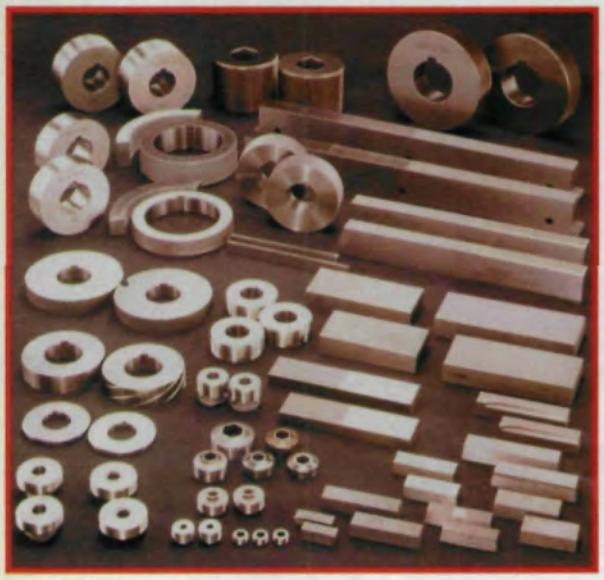

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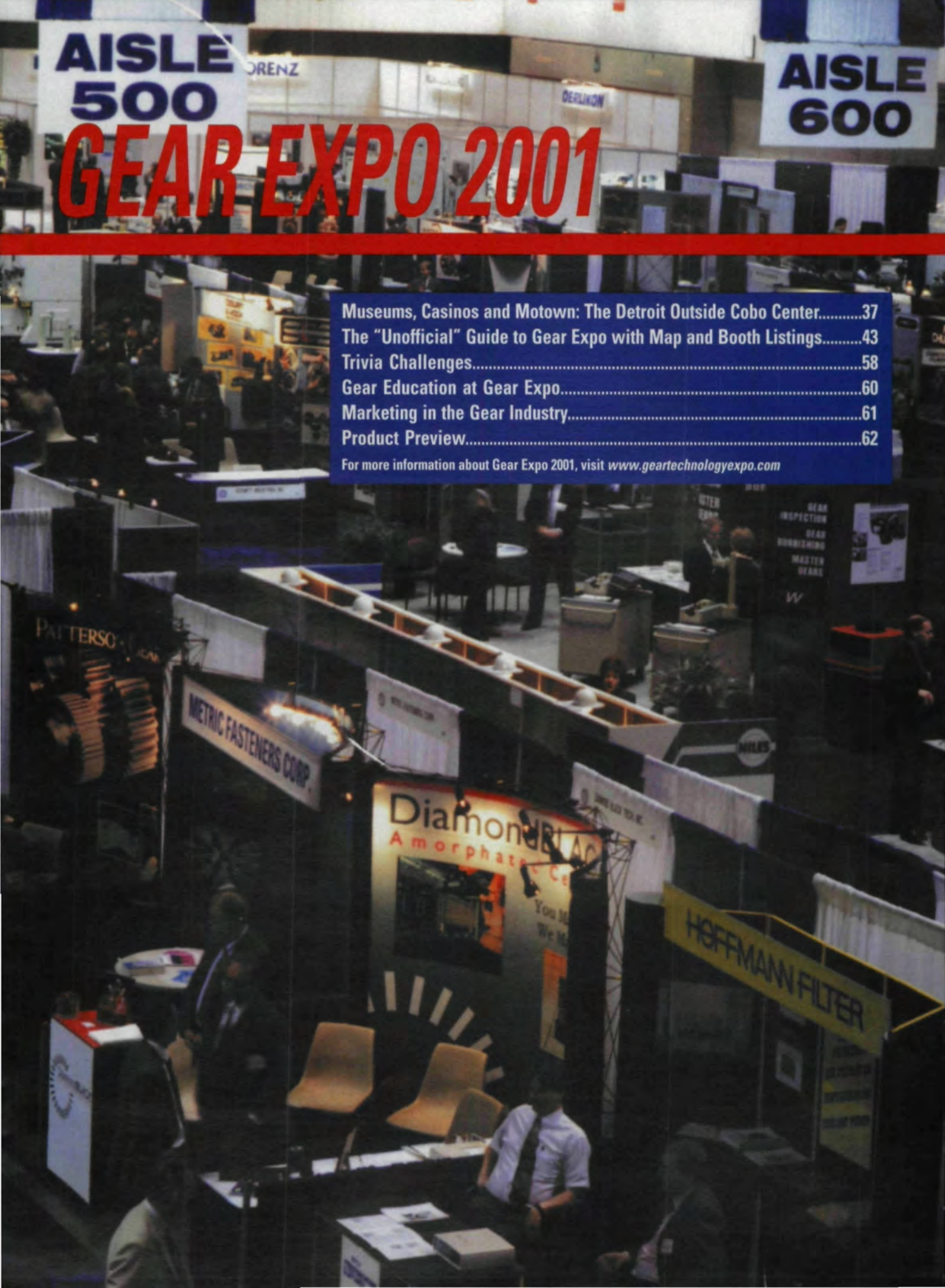

GEAR EXPO 2001

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Museums, Casinos and Motown: The Detroit Outside Cobo Center

Joseph L. Hazelton

Besides Gear Expo 2001, Detroit is home to a museum with an 1896 Durya Motor Wagon, America's first production car; home to a casino in a building that used to be Internal Revenue Service offices; and home to the studio where Diana Ross and the Supremes recorded "Stop in the Name of Love."

For expo participants with some time on their hands, there's much to see and do in the city.

Besides the motor wagon, the Henry Ford Museum & Greenfield Village has five presidential limousines, including the one in which President John F. Kennedy was assassinated in 1963.

Located in Dearborn, the museum and village has George Washington's Revolutionary War camp bed, Edgar Allan Poe's writing desk and the chair in which President Abraham Lincoln was sitting when he was assassinated in 1865. There are also Thomas Edison's Menlo Park laboratory complex, where more than 400 inventions were produced, and the bicycle shop where the Wright brothers designed and built their first airplane.

The museum and village has a multimedia presentation that includes 100 cars and trucks from its 160-vehicle collection. The exhibit is called *The Automobile in American Life*.

Also, the Detroit Historical Museum features 100 years of automotive history in the *Motor City* exhibit. Located in Detroit, the museum has a *Glancy Trains* exhibit, an interactive display of model trains.

Detroit sports three casinos. A fourth casino is in neighboring Windsor, Ontario, Canada.

The Henry Ford Museum includes *The Automobile in American Life* exhibit. Credit: Henry Ford Museum & Greenfield Village.

The Greektown Casino has 75,000 square feet of gambling space, 2,400 slot machines and 104 table games. Also, the gambling space has a Mediterranean theme. The casino is near the Atheneum Suite Hotel and is about 12 blocks from Cobo Center, where Gear Expo 2001 will be held.

The MGM Grand Detroit also has 75,000 square feet of gambling space, with more than 2,450 slot machines, as well as blackjack, craps, roulette, baccarat and poker. The seven-story building has a gold-and-bronze exterior and used to be offices for the IRS. The gambling space is designed with an art deco theme.

The casino is about 7 blocks from Cobo Center.

The Motor City Casino has more than 68,000 square feet of gambling space, 108 tables and about 2,600 electronic gambling devices, including slot machines and video poker machines. The casino also has blackjack, roulette, craps, baccarat and poker.

The casino is about 13 blocks from Cobo Center.

Across the Detroit River is Casino Windsor, which has 100,000 square feet of gambling space, including more than 3,000 slot machines and 700 table games. Also, the casino's hotel features a 60-foot-high waterfall. Water cascades three stories into a pool surrounded by rocks and tropical plants.

GEAR EXPO 2001: THE BASICS

WHO? Anyone involved or interested in gears and gear manufacturing.

WHAT? An international industrial trade show featuring products and services of the gear industry.

WHERE? Oakland Hall, Cobo Conference/Exhibition Center, Detroit, MI.

WHEN? Oct. 7–10.

WHY? To see new and old products and services available to people in the gear industry.

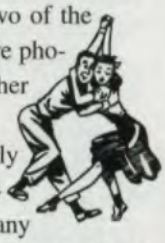
For more information, contact the American Gear Manufacturers Association by telephone at (703) 684-0211, by fax at (703) 684-0242, by e-mail at *gearexpo@agma.org*, or on the Internet at *www.agma.org*. For information on expo exhibitors and more, visit *www.gearexpo.com* or visit *Show Central* at *www.geartechnologyexpo.com*.

Hitsville U.S.A., the original home of Motown Record Corp., is part of the Motown Historical Museum. Credit: Susan Stewart.

The recording studio for "Stop in the Name of Love" was Studio A, now a part of the Motown Historical Museum.

In 1959, Berry Gordy Jr., a songwriter who wanted to manage singers, bought a two-story house in Detroit. By the 1960s, his company, Motown Records, was thriving and consisted of seven houses. The original house was named "Hitsville U.S.A."

The Motown Historical Museum occupies two of the original seven houses. The two houses exhibit rare photographs, gold records, artists' costumes and other memorabilia.

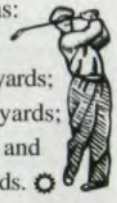


The museum is much like it was in the early '60s and includes the company's modest 1964 offices and tape library, with reel-to-reels, company manuals and newspaper clippings. A second exhibit reflects Gordy's 1959–60 apartment, where he and his staff sometimes spent all night packing records for shipping hit releases.

Besides Diana Ross and the Supremes, other musicians who recorded in Studio A were The Four Tops, The Jackson Five, Martha and the Vandellas, Smokey Robinson and the Miracles, Stevie Wonder, and The Temptations. "Dancin' In The Streets" and "My Girl" were also recorded in the studio.

The Detroit area has a diverse ethnic population with Arab, Greek, Hispanic and Polish neighborhoods, which offer a variety of foods, including baklava (a Middle Eastern pastry dessert), Greek salads, gyros, kielbasa (spicy, smoked Polish sausage), pierogis (Polish dumplings), shish kabob, spinach pie, tamales and tortillas.

Lastly, Detroit sports several golf courses, such as:



- Belle Isle golf course—9 holes, par 29, 1,881 yards;
- Chandler Park golf course—18 holes, par 71, 6,000 yards;
- Palmer Park golf course—18 holes, par 71, 6,007 yards;
- Rogel golf course—18 holes, par 70, 6,079 yards; and
- Rouge Park golf course—18 holes, par 72, 6,314 yards.

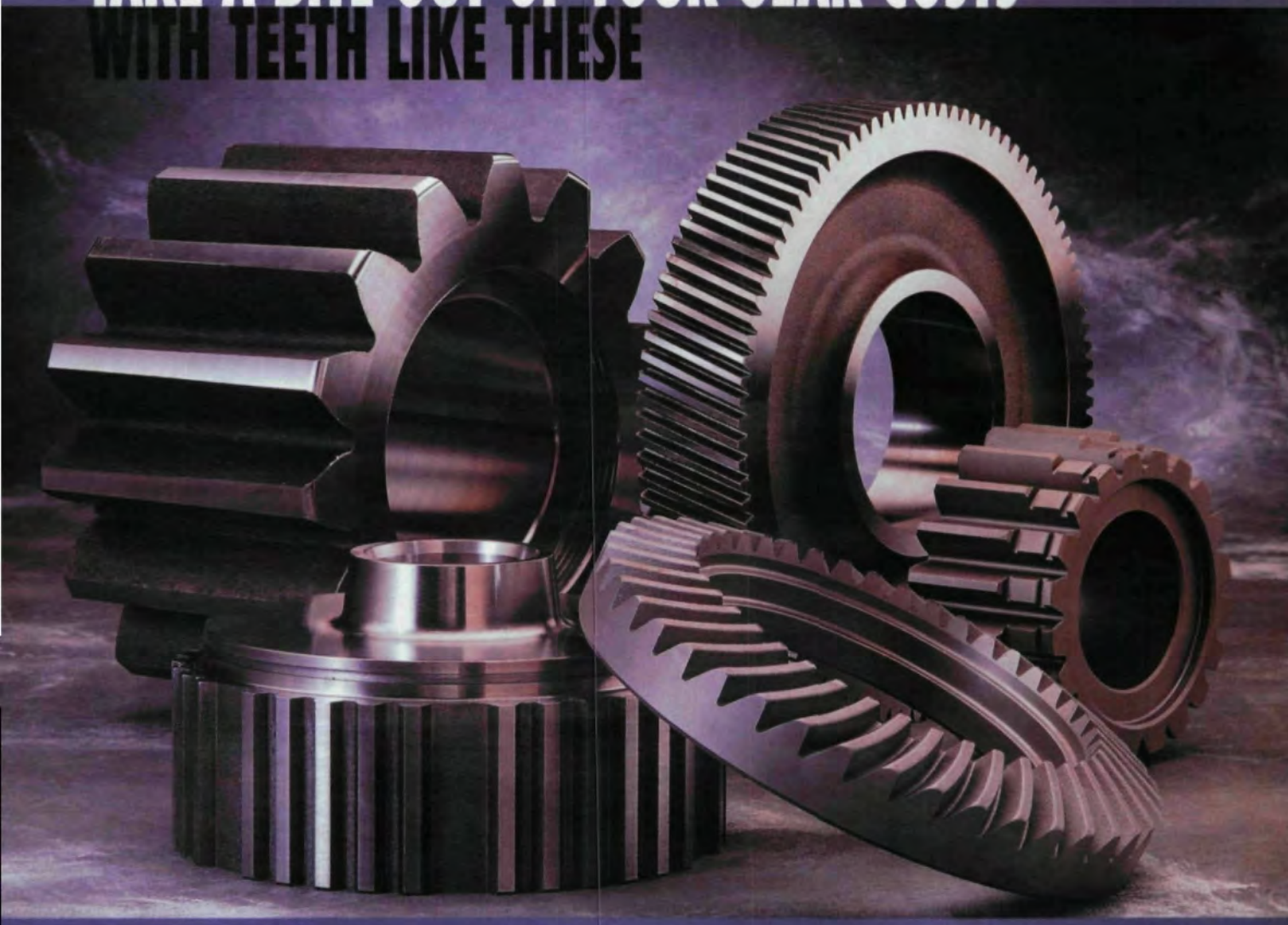
Tell Us What You Think . . .

If you found this article of interest and/or useful, please **circle 309.**

If you did not care for this article, **circle 310.**

If you would like to respond to this or any other article in this edition of *Gear Technology*, please fax your response to the attention of Randy Stott, managing editor, at 847-437-6618 or send e-mail messages to *people@geartechnology.com.*

TAKE A BITE OUT OF YOUR GEAR COSTS WITH TEETH LIKE THESE



Are you interested in reducing your gear costs while increasing their quality? Presrite hot-forges intricate gears to net and near-net shapes, so little or no hobbing is required.

PRESRITE NEAR-NET GEARS GIVE YOU THE STRENGTH OF A FORGING WITH LITTLE OR NO MACHINING.

We've invested millions to save you money and improve the performance of the gears you buy. Our dedicated gear-forging facility is equipped with a state-of-the-art gear lab, high-capacity presses, and the latest in sophisticated machinery.

See why customers from a wide range of industries and countries come to Presrite for forged gears. Contact us now for more information or a quote.

Weight Savings – As a blank, this large spur gear weighed 55 lbs. As a forged tooth gear with 1 millimeter of stock on the tooth profile for hobbing, it weighs just 37 lbs.

See For Yourself – Presrite Near-Net Gears Practically Eliminate Rough Cutting!

You'll see just how easy it is to hob or grind our forged tooth gears on a Bourn & Koch 200H CNC hobbing machine and 500VG CNC gear grinding machine.

OCTOBER 7-10, 2001 Gear Expo DETROIT, MICHIGAN

BOURN & KOCH machine tool co.

BOOTH NO. 576

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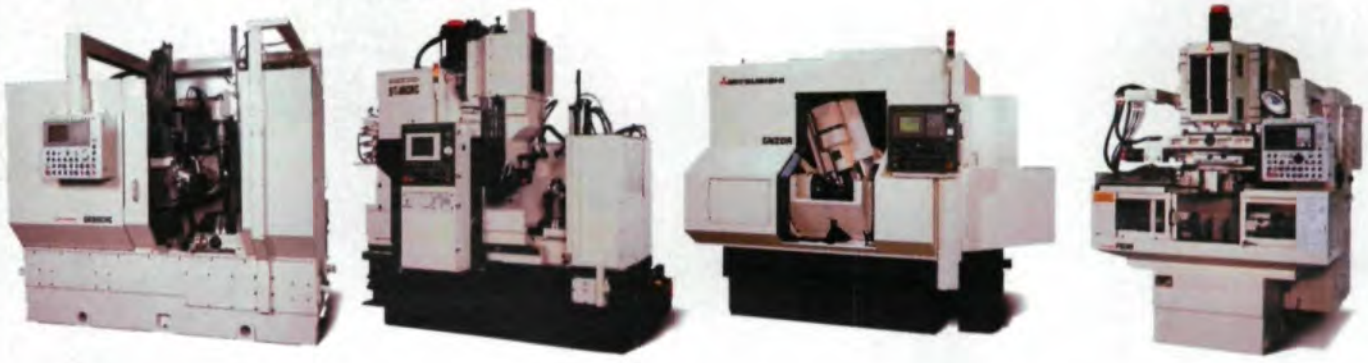
To give you a broader view.

We've consolidated all of our North American gear cutting technologies into one independent organization. And moved the entire operation to a new technology center in the Detroit area, at the hub of global powertrain engineering.

No dealers. No distributors. Rather, career specialists seasoned in every aspect of international gear production requirements and solutions.

The new Mitsubishi Gear Technology Center is your single source for the broadest array of gear production technology in the world. From our patented high-speed dry cutting machines and hobs through gear shapers, shavers, and honing machines, to complete stand-alone gear production centers.



All applied with a comprehensive understanding of the most demanding production environments. And backed with training and service by the industry's most knowledgeable and reliable engineers and technicians.

If your current manufacturing challenges require the detailed focus of the world's foremost authority on gear production, give us a call. After all, we're in the neighborhood.

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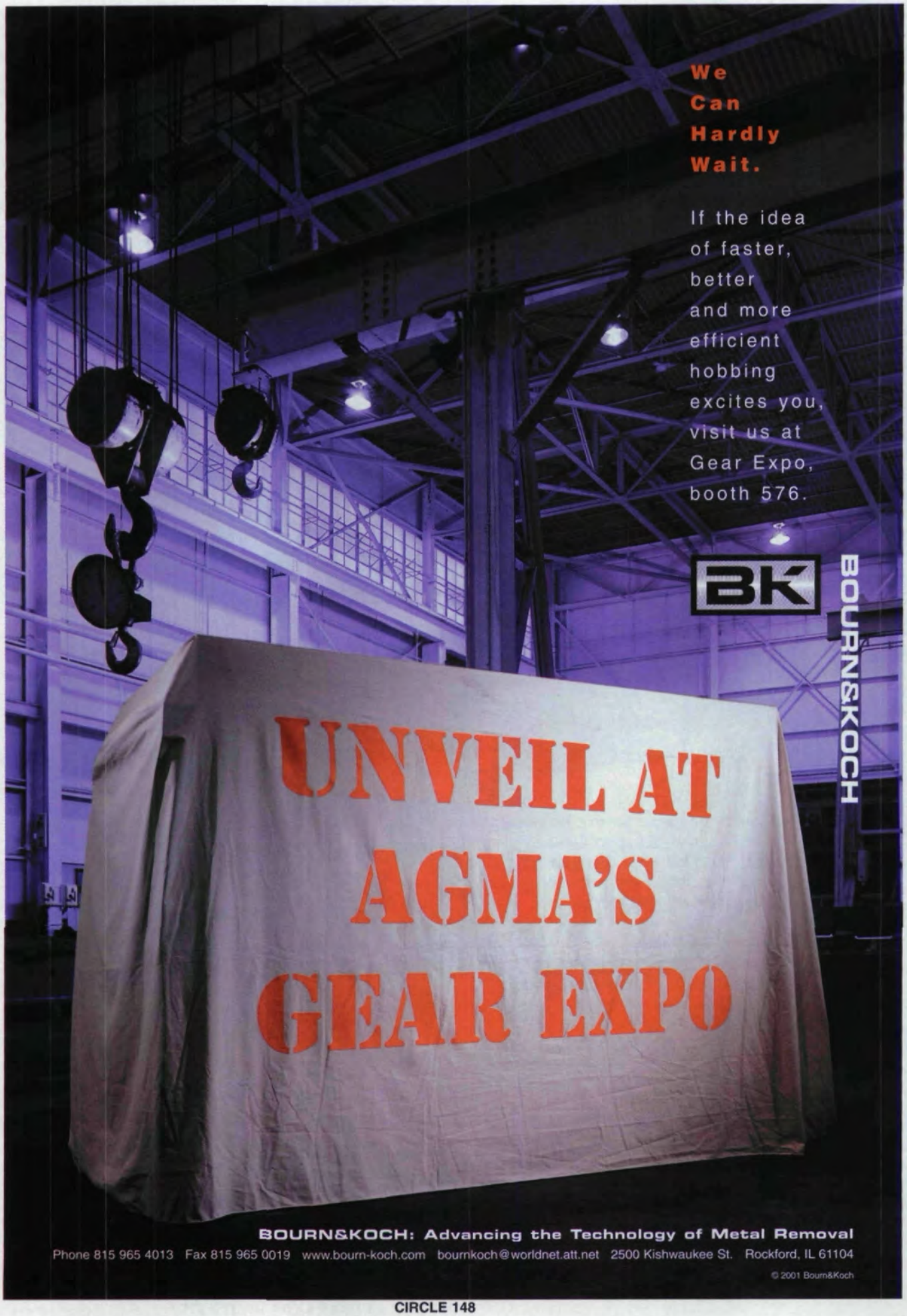
VISIT US AT GEAR EXPO BOOTH #252

CIRCLE 175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CIRCLE 148

The "Unofficial Guide" to Gear Expo 2001

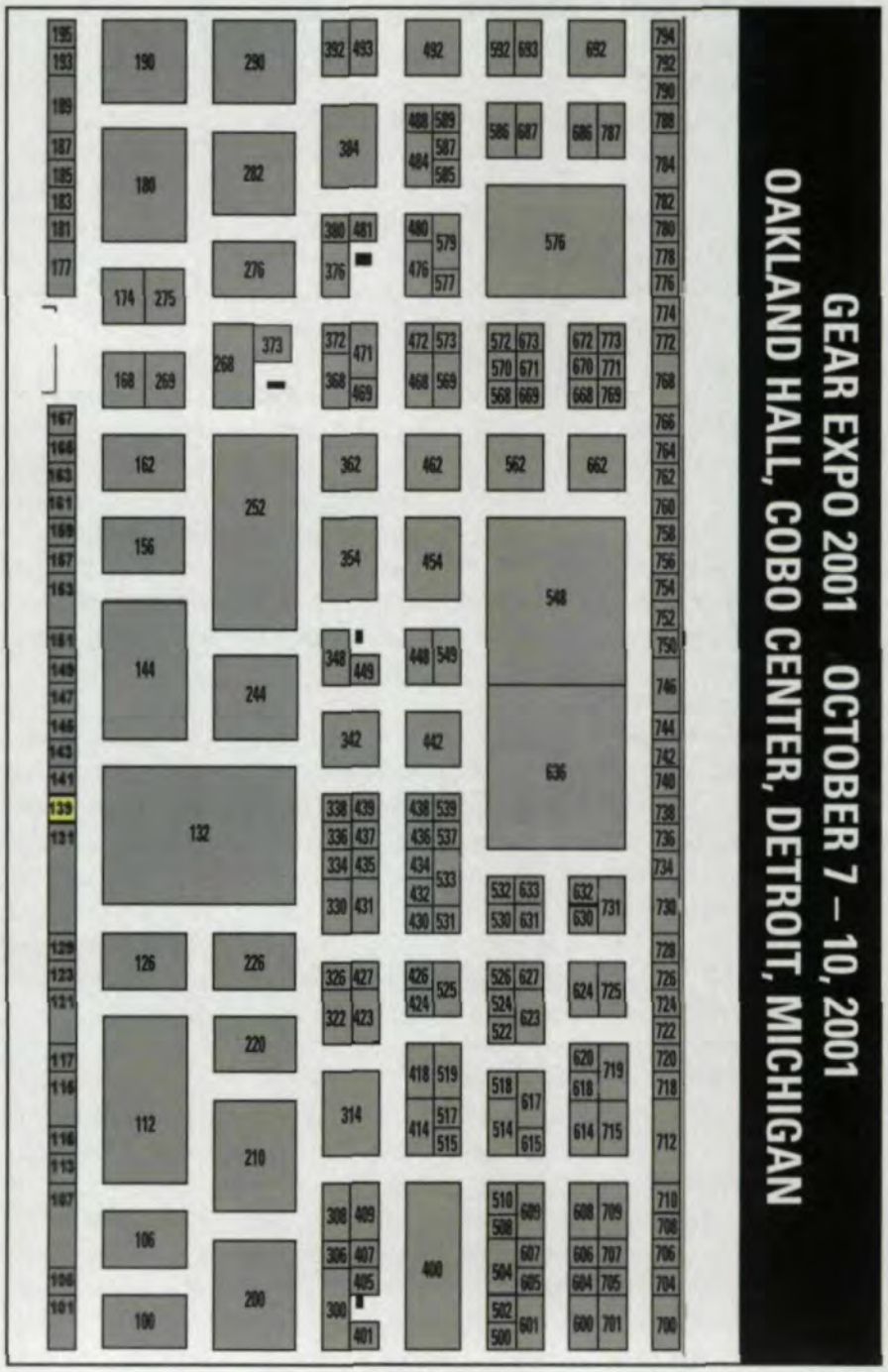
We've contacted many of the companies that will be exhibiting at Gear Expo 2001 to compile the following directory of exhibits. Use this directory to help plan your visit to the show, or to stay up-to-date on the industry's suppliers and technology. (Booth numbers are current as of August 20, 2001, but information is subject to change.)

Accurate Specialties Inc.—Booth #427. Accurate Specialties offers bronze components for the power transmission industry. The company specializes in gear bronze, producing finish-turned gear blanks, bushings and bearing materials from 1" to more than 48" in diameter. According to Accurate Specialties, spun-cast composite gear blanks offer exceptional value, and centrifugal cast components are available for critical applications and cost-effective production of low quantity orders. Standard tooling is often available, or near-net shape tooling can be designed to minimize cost and maximize value.

Accurate Specialties offers component design, alloy selection, casting and CNC machining. Tin, aluminum and manganese bronzes are produced in heats ranging from 200 lbs. to thousands of pounds.

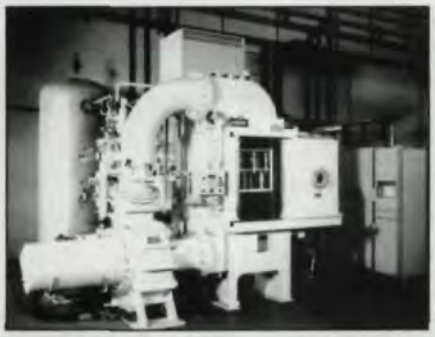
Acme Gear Co.—Booth #472. Acme Gear offers more than 70 years of specialized manufacturing experience in prototype and mass production of high-quality, precision-ground or -cut gears. Acme Gear has experience with alloy and carbon steels, as well as high-tech materials. The company serves industries including printing, transit authorities, mining, centrifuge, industrial air conditioning, and aerospace.

Acme Gear offers ground spur and helical gears up to 32.68" outside diameter; cut spur and helical gears up to 40"; worm gears up to 60"; worms from 8" to 36"; internal gears up to 32"; involute and square splines from 16" to 36";



sprockets up to 36"; ratchets up to 48" with up to 10" face widths; and timing belt pulleys up to 35".

Acme Gear is ISO 9002 registered.



ALD Vacuum Technologies Inc.—Booth #504. At Gear Expo, ALD Vacuum Technologies will introduce new advanced heat treatment processes for gears. According to the manufacturer, the processes provide superior case hardening, exceptional case uniformity, excellent reproducibility, bright parts after processing, no washing, no cleaning and a production rate of 2,200 lbs. of gears per hour at a very competitive cost. These benchmarks have qualified ALD's new processes and furnaces for the mass production of some of Germany's automotive transmissions.

The technology can be offered for case hardening or neutral hardening and tempering in one continuous process, either in a batch-type furnace or in a fully automated, continuous, in-line system with the application of a cold wall-quench chamber.

American Gear Manufacturers Association—Booth #300. The American Gear Manufacturers Association (AGMA) is a trade association representing more than 400 manufacturers of gears and related gearing and coupling products, as well as suppliers and consultants to the industry. AGMA has been approved by the American National Standards Institute (ANSI) as administrator of the technical advisory group for the International Standards Organization (ISO) standards. As secretariat of ISO Technical Committee 60, AGMA is the primary organization responsible for the development of gearing standards.

AGMA sponsors Gear Expo 2001, being held October 7–10, in Detroit. Gear Expo is international in scope and provides a biennial forum for the exchange of information on the range of machinery, supplies and services available for gear manufacturing. From software to hardware, from initial design through testing, exhibitors will be available to discuss solutions to problems associated with gear manufacturing.

American Metal Treating Co.—Booth #426. American Metal Treating Co., which specializes in induction hardening, will display samples of gear teeth that have been "single tooth contour hardened." The company invites you to stop by to discuss your current requirements. Technical staff will be on hand to help solve your distortion problems. Information on major advancements in induction hardening and capabilities also will be available.

Applied Process Inc.—Booth #449. Applied Process specializes in the austempering process, which, according to the company, can give your products extreme performance capabilities by making iron and steel tougher, stronger, lighter, quieter and more wear resistant. Stop by the company's booth to talk about austempering.

Arrow Gear Co.—Booth #392. Arrow Gear specializes in the design and manufacture of spiral bevel gears. According to Arrow Gear, the company's engineers try to develop gears that overcome noise problems and provide longer life at a lower cost. Staff members will be on hand to take your application requirements and recommend a gear design for the job.

ATA Gears Inc.—Booth #330. ATA Gears has recently increased manufacturing capacity for bevel gears up to 100 inches. ATA Gears is committed to the manufacture of spiral bevel gears. The company manufactures bevel gears ranging from 2–100 inches (50–2,500 mm). The company has a large stock of high-quality raw material and modern production equipment, including in-house heat treatment. ATA can provide gear designs and strength ratings according to major international standards, including ISO, DIN and AGMA. ATA's quality system complies with ISO 9001 and is certified by Det Norske Veritas.

A/W Systems Co.—Booth #139. A/W will display a selection of cutter bodies and blades. The company will have straight bevel cutters, coniflex cutters and stick blades (high speed steel & carbide). A/W also will have bore gages, height gages, hobs, an assortment of diamond tools for hard turning and dressing, keyseat cutters, dove tails and an assortment of hardware.

Balzers Inc.—Booth #549. Balzers Inc., with headquarters in Amherst, NY, is part of the worldwide Balzers Surface Technology coating organization, which consists of 42 coating centers in 18 countries. Balzers U.S. operates nine coating centers in North America. Balzers provides a range of PVD wear-resistant, thin-film coatings for improving the productivity of cutting, forming and molding tools, as well as for improving the performance of precision components.

Balzers will introduce a new, improved version of titanium aluminum nitride, called Balinit Futura Nano. According to the manufacturer, this new coating has improved hardness and oxidation resistance and will be particularly beneficial in hobbing applications.

Barit International Corp.—Booth #372. Barit presents itself as "a one-stop solution provider" for all custom and

stock gear-cutting-tool needs, including hobs, broaches, shaper cutters, shaving cutters, milling cutters, master gears, rack-type cutters and bevel generating cutters. The company offers expedited delivery, detailed engineering and reverse engineering. Barit's staff members invite you to let them demonstrate how their commitment to quality, their technical expertise and their prompt, personalized service can give you a competitive advantage.

Bodycote Thermal Processing—Booth #468. Bodycote Thermal Processing is a part of the international metallurgical services provider Bodycote International plc. The North American network of plants includes nearly 60 heat treat facilities, nine testing facilities, six hot isostatic pressing facilities and three coating locations. Bodycote specializes in strategic partnerships either on-site at customer facilities or near them.

Commercial heat treating processes include carburizing, ferritic nitrocarburizing, induction hardening, brazing, salt-based processes, ion nitriding and others.

Bourn & Koch Machine Tool Co.—Booth #576. Bourn & Koch will exhibit with Presrite Corp. at Gear Expo 2001. A hobbing and grinding application will be demonstrated during show hours. Bourn & Koch manufactures gear hobbers, gear grinders, hob checkers, rotary transfer machines, extrusion milling machines, specialty machines and remanufacturing/retrofitting of Bourn & Koch and Barber-Colman gear hobbers, gear shapers, gear grinders, gear shavers, gear lappers, gear inspection machines and other machines.

Capstan Atlantic—Booth #615. Capstan Atlantic is a large East Coast producer of precision powder-metal gears. The company's capabilities include high-density, high-strength gears manufactured using its proprietary HP3 process. Specializing in a variety of applications, Capstan Atlantic provides solutions for the automotive, appliance, lawn & garden, power tool and power transmission industries. Capstan Atlantic

can manufacture gears to AGMA class 9 quality. High-performance gears can be made by combining high-strength alloys and unique secondary operations. Parts can be made with selective densification to 7.8 grams/cc. Capstan Atlantic's facility includes presses ranging from 4–600 tons, and the company has in-house design, engineering and tooling capabilities, as well as a metallurgical and gear laboratory. The company manufactures spur, helical and bevel gears and pinions, as well as parts with multiple gear types integrated into one part.

Chamfermatic Inc.—Booth #481. Chamfermatic, a manufacturer of gear deburring and chamfering machines, will be presenting its newest model, the Chamfermatic W.G. 2000, at Gear Expo. The machine is able to deburr, wash, dry and rustproof gears up to 14" in diameter in one cycle. It comes standard with a 6" diameter, 3-jaw manual chuck, but it can be equipped with automatic air chucking. It also comes with a built-in filtration system and two deburring head assemblies. Additional deburring heads are available.

The Cincinnati Gear Co.—Booth #423. Cincinnati Gear manufactures high-performance gearboxes and power transmission components for industrial and marine applications. Gear capabilities include hobbing, cutting, grinding, shaving, turning, boring and inspection. Gears manufactured include spur, helical, double helical, internal and worms and worm gears. Services include engineering design, analysis and testing, as well as worldwide field service.

Cold Forming Technology Inc.—Booth #276. As one of North America's leading spline and thread rolling specialists, Cold Forming Technology is committed to supplying the highest quality products and services available in the industry. The company is ISO 9001 and QS-9000 certified in the design and manufacture of new and reground spline, thread and special form tools. It is also a primary supplier of "make complete" or "partial" prototype and pre-production spline rolled parts for the automotive, truck, rear axle and other industries. High volume production capacity is available for customers with capacity limitations. Cold Forming Technology also handles service parts, machine breakdowns or product development. The company's management says, "We do not compete with you, our customers, for pre-rolling machine operations."

Dura-Bar—Booth #448. Dura-Bar is a manufacturer of continuous cast iron bar stock, an engineered metal with noise and vibration damping properties. According to the manufacturer, continuous cast iron bar stock can be 3–10 times quieter than steel and 20–40% more machinable. The continuous casting process produces a uniform, fine-grained microstructure. Dura-Bar says that the

material has none of the shrinkage, porosity and tool-wearing inclusions that frequently occur in traditional castings.

Dura-Bar material can be austempered, through-hardened, flame-hardened or induction-hardened for added wear resistance. It is available in ductile, gray or special alloyed irons, in round bars with diameters of 5/8" to 20" and lengths of 6' to 20'. It also is available in machined gear blanks.

Dura-Bar, a division of Wells Manufacturing Co., has a nationwide network of distributors that maintain inventories.

Euro-Tech Corp.—Booth #569. Euro-Tech Corp. sells a range of spline gaging and workholding products, including those manufactured by Frenco GmbH, such as Frenco's SPC-compatible indicating spline gages and a new version of its hand-held spline gage. Euro-Tech will demonstrate URM gages simultaneously analyzing multiple shaft profiles (splines, gears, etc.) in eight seconds in the factory. The company will also exhibit Frenco spline gage systems completely measuring an internal or external spline over its length. Visitors also will be able to see Euro-Tech's hydraulic expansion gear arbors, chucks for quick-change hobbing or shaving, and inspection arbors. According to the manufacturer, runouts of these rupture-proof tools is less than 0.0001".

New products on display will include hob holding production arbors, Mytec hydraulic nuts and a Mytec arbor/chuck pressure control system.

Fairfield Manufacturing Co. Inc.—Booth #442. Fairfield Manufacturing Co. Inc. is a leading one-source supplier in the industry, offering a range of gear producing capabilities in North America. From 1–120 inches, Fairfield's products include loose custom gears (bevel, spur, helical, internal and external), custom mechanical assemblies, planetary axles, Torque-Hub planetary final drives and new Fairfield brakes. Services include design engineering, heat treating and testing.

Products displayed at the show will include loose and enclosed gears for applications in the rail, automotive, off-highway, mining, defense and marine industries.

Fässler A.G.—Booth #190. Fässler A.G. is a leading company in the development, production and sales of dressing devices, gear honing and hard broaching

machines and the related tools and fixtures for hard gear finishing. The company's headquarters are in Dübendorf, Switzerland.

According to the company, its highly skilled staff members are experienced in honing technology and able to serve their customers by defining the most accurate and economic machining process available to suit customer needs.

Fässler A.G. will present new honing technology at Gear Expo 2001. With the Combi-Hone process, Fässler introduces direct honing as a combination of roughing and finishing. This process allows customers to hone parts directly into final quality after hobbing and heat treatment. According to the manufacturer, the process is economical and reliable.

Gear Technology*—Booth #418.** Stop by our booth for a chance to win a custom-made, one-of-a-kind gear clock. We're offering free marketing consultations for companies trying to reach the gear industry. We'll give you secrets to reaching gear manufacturers or gear buyers—without overextending your budget. Learn about the industry-leading resources, *Gear Technology* magazine, ***The Gear Industry Home Page™ and ***powertransmission.com™***. See our special promotion on page 61 for more information. Also, we'll hand out free copies of our first-ever CD-ROM buyers guide, the complete directory of the gear industry.

Gleason Corp.—Booth #132. Gleason's new, 3,500 sq. ft., double-decker booth will debut four new machine models. The cylindrical gear program will include the P60 horizontal hobbing machine and the GP300ES electronic helical guide shaping machine.

For bevel gear production, Gleason will introduce the Phoenix II 275HC bevel cutting machine. *(Editors' note: See the related article on the Phoenix II on page 13.)*

Also on display will be bevel and cylindrical cutting tools, workholding and a plasma screen running the latest application videos.

Great Taiwan Gear Ltd.—Booth #701. Great Taiwan Gear is a leading

gear-related products supplier in Taiwan. The company is capable of handling customer needs for gear cutting tools, gears and gearboxes. According to the company, its "experienced team and modern equipment" can accommodate prototype to production runs, from one piece to thousands of pieces. Great Taiwan Gear manufactures a range of gears, from fine to coarse pitch.

Höfler Maschinenbau GmbH—Booth #210. Höfler will demonstrate the Helix 400K gear grinding machine, capable of grinding both internal and external spur and helical gears without machine changeover. The Helix 400K handles gears up to 16" in diameter and is equipped with an inspection system for profile, lead and spacing.

Also, the company will have staff on hand to discuss other gear grinding solutions, including Höfler's Porta machine for grinding internal and external gears up to 120" in diameter. The Porta comes with an 80" machine table capable of handling 77,000 lbs. The machine grinds internal and external gears without changing the grinding head. The Porta comes with an on-machine dresser and a built-in gear checker.

Inductoheat—Booth #620. Inductoheat is a global supplier of induction heat treating equipment and supplies, with equipment for heat treating crankshafts, camshafts, gears and other critical components.

ITW Heartland—Booth #342. For more than 60 years, ITW (Illinois Tool Works) has been a leader in the design, manufacture and service of functional gear inspection equipment and gear burnishing equipment. ITW Heartland offers a line of manual, semi-automatic and fully automated machines. This year, ITW Heartland will feature two machines.

One of the machines will be a Model 3500 computerized gear analyzer that will be set up to demonstrate both center distance gear error and lead and taper gear errors. The second machine will be a 2901V vertical automatic gear burnisher. This machine will demonstrate the effect that burnishing has in reducing nicks, burrs and heat-treat scale. ITW also will have a video display showing additional ITW machine models. The company invites you to stop by and see how ITW Heartland can help you in your gear processes. Also, ITW staff members can explain their turnkey system, which incorporates a burnisher, washer and checker all in one unit.

Kapp Technologies—Booth #244. Kapp offers a variety of machines for hard and soft finishing of parallel axis gears, threaded worms, rotor profiles and many other complex, accurate forms up to 500 mm in diameter. Machine processes include form grinding, generating grinding and Coroning using CBN, diamond or vitrified abrasives.

Niles grinders are also included in the product line for large diameter requirements, starting at 500 mm and going up to 4.2 meters. The new Niles 630 machine will be introduced at the show. The 630 is a high-quality form grinder fully equipped as a standard machine ready for the shop floor.

Kapp Technologies also offers a line of Kapp CBN-plated grinding wheels, worms and Coroning tools.

The Kapp Group consists of Kapp GmbH and Kapp 2 Technologies, both located in Coburg, Germany; Niles GmbH, located in Berlin; Kapp Technologies, located in Boulder, CO; Kapp Tec, located in Sao Paulo, Brazil; and Kapp Tools, located in Nagoya, Japan.

Koepfer America L.L.C.—Booth #290. Koepfer has served the gear industry since 1867. The company offers hobbing machines, automation, cutting tools and sharpening machines. Koepfer machines are designed for gears up to 180 mm (7.087") in diameter. Koepfer's automation can handle pinion gears, bore parts or shafts on one system.

The Koepfer KFS100 CNC hob sharpening machine is designed for hobs of high speed steel or carbide. Koepfer also offers a hob sharpening service.

Koepfer cutting tools are manufactured from high speed steels, powdermetals and carbide. In addition, the company sells Saazor coarse pitch hobs—either solid or segmented—to 1.25 DP and Haug honing wheels, gears and dressing tools, which are suitable for all honing machines, according to Koepfer.

LeCount Inc.—Booth #143. LeCount expanding mandrels are designed for gripping on the inside diameter of parts to be inspected. Once a part is loaded on the mandrel, the unit is loaded between centers and the part is ready for inspection. The construction of the LeCount expanding mandrels incorporates the principle of parallel expanding jaws sliding uniformly on incline "ways." Controlled accuracy of manufacture produces precision holding devices with concentricity of 0.0001" T.I.R. or better.

According to LeCount, the "inclined way" expanding principle permits a wider range of diameters to be held accurately and securely. Type A step-jaw mandrels have a range of expansion, with 12 precision mandrels covering sizes from 3/8" to 7" in diameter.

The work is placed on the mandrel over the jaws, and the dog end of the mandrel is tapped lightly against a softer metal or wood block. The precision ground jaws expand readily and grip the work securely. Tapping the tailstock end of the mandrel releases the work. An arbor press isn't used.

Leistritz Corp.—Booth #709. Leistritz is a German machine tool builder specializing in whirling equipment. Whirling is a process for machining gear worms, screws and other related parts. Qualified technical staff will be on hand at the Leistritz booth to discuss your applications.

Liebherr Gear Technology Co.—Booth #548. Liebherr Gear Technology Co. is the North American access point to the Sigma Pool's range of gear manufacturing technologies and processes,

including gear hobbing, generating, shaping, inspection and testing.

Products exhibited at this booth will include Klingelnberg CNC gear cutting and measuring centers, Liebherr gear hobbing and shaping machines, and Oerlikon spiral bevel gear cutting, grinding, lapping and testing equipment.

M&M Precision Systems Corp.—Booth #144. M&M Precision will introduce the new Sigma 3 CNC gear inspection system, featuring 3-D probe technology, linear motor direct drives and four-axis generative motion, with Windows-based software. Also featured will be M&M Precision's new Microtop gear inspection system, featuring low-cost, shop-hardened, four-axis generative motion, with Windows-based software.

Metal Improvement Co.—Booth #510. Metal Improvement Co. is a premium provider of controlled shot peening, C.A.S.E.[sm] superfinishing, heat treating and related metal finishing operations with close to 40 service centers throughout North America and Europe.

Controlled shot peening is primarily used to improve metal fatigue properties. For gearing applications, the area of most concern is usually the gear root, which is subject to bending fatigue. Typical improvements in fatigue life for gears are 300%, 500% or more, according to the company, and typical improvements in fatigue strength range from 10-30%.

C.A.S.E.[sm] superfinishing removes the asperities left from shot peening to provide resistance to pitting failure through a superior gear flank finish.

The company invites you to visit its booth, where staff will be on hand to discuss your specific needs.

Metal Powder Products Co.—Booth #436. Metal Powder Products Co. (MPP), based in Carmel, IN, draws on the specialized powder metallurgy technologies and manufacturing capabilities of its operating units to provide custom-engineered, net-shaped products for a variety of industrial and off-highway applications. MPP provides a range of powder-metal material technology using ferrous, nonferrous, stainless steel and

aluminum alloys. MPP manufactures high-strength, high-density gears.

mG miniGears North America—Booth #522. mG miniGears specializes in the field of small- to medium-sized gears for mass production, with experience that blends the traditional technology of steel cutting and the latest technology of sintering. mG miniGears also has created its own research and development department, which is committed to experimenting with new applications for sintered gears. The support that mG offers its clients starts in the planning and designing phase, with calculation and development of gears or of entire kinematic mechanisms, and also includes choosing the best technology to obtain the desired results, producing and testing of prototypes, and mass producing of the product. mG miniGears concentrates especially in the areas of power tools, garden equipment, bicycles, motorcycles and automobiles.

Midwest Gear Corp.—Booth #518. Founded in 1972 in Twinsburg, OH, Midwest Gear has been manufacturing high-quality products for both large and small manufacturers. Industries currently serviced include construction, agriculture, packaging, transportation, steel, automotive, paper and mining.

Midwest Gear's product offering includes spur, helical and herringbone gears. Pinions also are manufactured.

Services offered include tooth grinding to AGMA class 12 quality, tooth shaving, broaching and splining. Hard copy documentation of AGMA quality levels for gears up to 50" in diameter is available on Midwest Gear's Höfler gear checker. Inquiries for complete gear manufacture or just tooth grinding are welcomed.

Midwest Gear is located between Cleveland and Akron, minutes from Interstates 80, 271 and 480, in the heartland of industrial America.

Milwaukee Gear Co.—Booth #662. Milwaukee Gear is an established company with a variety of machining capabilities. Engineering, heat treating and gear grinding expertise allow the company to design and manufacture spur, helical and internal parts. Milwaukee Gear can produce in-house carburized, hardened and ground parts to a pitch diameter of 63". Also, the company welcomes inquiries for needs that can't be met by standard catalog gear drives. The Milwaukee Gear design engineering team will work closely with customers to design and build custom gear drives to meet specific needs.

Mitsubishi Gear Technology Center—Booth #252. Mitsubishi will have a diverse array of gear production equipment, which should satisfy every sector of the gear industry, according to the manufacturer. Machines will include the GD20 "jobber hobber," the ST40 programmable lead shaper, and a fully automated GN20 dry hobber. Mitsubishi says filling out the lineup will be the latest synchronized honing and shaving machines, demonstrating cost-effective methods for gear finishing. Backing up all the equipment will be the Mitsubishi service pavilion. The Gear Technology Center is emphasizing customer service, and demonstrations will be given to show the company's "Service First" philosophy.

Nachi Machining Technology Co.—Booth #200. Nachi will present the newest version of its vertical roll-forming machine, the PFM610E, a semi-dry spline rolling machine.

Also, Nachi will focus on its DuAl brand hobs, which are specially manufactured and coated to be able to hob with or without coolant.

Other Nachi machines on display will include the HyB-35 gear checker, which is designed to inspect spiral bevel and hypoid gears by contact scanning the tooth surface, and the KN-151 gear hobbing machine, which has hob-head travel of up to 400 mm.

National Gear Metrology Center—Booth #627. The National Gear Metrology Center provides NVLAP-accredited, NIST-traceable gear standards calibrations. The center currently provides calibrations on 12 different gear artifacts.

On-Line Services—Booth #480. On-Line Services offers a variety of standard deburring machines, from simple to complex. OLS can custom configure one of its standard bases to meet customers' deburring needs.

The Model 815 base is designed for high-volume production of smaller parts. It is a through-feed machine that is height-adjustable for incorporation into a manufacturing cell. The Model 2800 base is designed for deburring large parts.

OLS machines may be fitted with the OLS Auto Amp Compensation System, a technology that provides uniform brush pressure throughout the useful life of the brush. According to the manufacturer, that technology helps ensure consistent quality.

Perry Technology Corp.—Booth #600. Visit the company that calls itself "The Gear and Spline Experts" at Booth #600. Perry Technology invites you to bring your odd or unique gear or spline tooth forms to give the company's staff members a challenge and see how they can help with your machining requirements. Perry Technology manufactures for high or low production and can provide prototypes and fast delivery. The company's capabilities include CNC hobbing, shaping, grinding, turning and milling.

Precision Gage Co. Inc.—Booth #380. Precision Gage manufactures the Vari-Roll gear inspection system and the Vari-PC composite gear analysis system. The combined systems provide composite inspection of spur, helical, bevel or internal gears, as well as pinion shafts, worms and throated worms.

Presrite Corp.—Booth #576. Presrite Corp., a producer of minimum-draft, net- and near-net-shape forgings, will have a demonstration at its booth at Gear Expo 2001. Two Bourn & Koch

machines will show visitors how little hobbing and grinding are necessary with near-net forged tooth gears.

According to Presrite, its near-net gears are forged so close to desired tolerances that there is virtually no need for rough cutting: Hobbing and grinding of the gears is minimized. Near-net gears are designed to reduce gear costs while increasing their quality.

Presrite has invested in equipment and processes to help its customers save money and improve gear performance. The company's dedicated gear-forging facility is equipped with a state-of-the-art gear lab, high-capacity presses and the latest in machinery.

The booth demonstration will involve a Bourn & Koch 200H CNC hobbing machine and a Bourn & Koch 500VG CNC gear grinding machine.

Presrite forges net and near-net gears for a range of industries in countries around the world. Its parts are used in transmissions, engines and undercarriages of track-type tractors, excavators, wheel loaders and other off-highway vehicles. Presrite is an ISO 9002- and QS 9000-registered company.

Process Equipment Co.—Booth #362. Process Equipment Co. will demonstrate the ND430 "Next Dimension®" gear measurement system.

The ND430 uses a Renishaw® 3-D scanning probe head to measure tooth alignment, profile, index and root radius relative to other geometric features, such as bores, bearing journals and faces in its linearly, thermally and volumetrically compensated measuring envelope.

Analysis of the results can be viewed according to AGMA, ISO, DIN and user-defined standards. The company also will display information about its laser and capacitor discharge welding machines, used to join gears or other rotary components to like or dissimilar metals in high-production environments.

Profile Engineering Inc.—Booth #476. Profile Engineering plans to unveil its Profile gear analyzer.

The analyzer replaces existing strip chart recording systems and paper drive mechanisms. According to the company, operator-friendly software and a touch-screen system enhance the standard operation of the instrument, virtually eliminating training requirements for gear checking and calibrating—with no misleading algorithms, filters or error-eliminating programs.

Profile Engineering also will display, courtesy of Rockwell Automation, the PC-4W Worm & Wheel Gear Analyzer® as an example of the company's specialty design and manufacturing capabilities.

Quality Transmission Components—Booth #434. Since 1985, Quality Transmission Components (QTC) has been a leading supplier of medium- and coarse-pitch metric gears throughout the United States, Canada and Mexico. A division of Designatronics Inc., QTC is

the exclusive North American distributor for Kohara Haguruma Kogyo K.K. (KHK Gear Industry Co. Ltd.) of Saitama, Japan. A leading, independent Japanese gear manufacturer, KHK produces more than 3,600 standardized, medium- and coarse-pitch metric gears and related items. KHK's modern, ISO 9001:1994 certified facilities utilize gear cutting and grinding equipment to serve the needs of many Japanese OEMs.

QTC's 456-page catalog, *Q410: The Handbook of Metric Gears*, contains a comprehensive technical reference section entitled "Elements of Gear Technology." The topics covered include the principles of involute gearing, gear dimension calculations, the definition of backlash, plastic gear design, elements of gear accuracy, principles of surface contact, methods of lubrication and methods for noise reduction.

The catalog's product section includes detailed specifications for QTC's offerings, including spur gears, helical gears, ring gears (internal and external), racks (straight, helical and flexible), miter gears (straight and spiral), bevel gears (straight and spiral), worms and worm wheels (standard and Duplex™), screw gears, involute splines (internal and external), ratchets and pawls, and gear couplings.

The products are offered in sizes from module 1 through module 10, in materials that include alloy steel, carbon steel, stainless steel, cast iron, aluminum bronze, brass, cast bronze, nylon and acetal. An inventory of KHK's product line is maintained at QTC's warehouse in New Hyde Park, NY. The warehouse replenishes its stock from the factory's inventory on a biweekly basis. In addition to its standard product line, QTC can supply build-to-print custom gearing in quantities from prototype to production.

Raycar Gear & Machine Co.—Booth #437. Raycar Gear & Machine is a privately owned gear manufacturer located in Rockford, IL. The company specializes in low-volume orders of 1–100 pieces. It manufactures many types of spur gears, helical gears, spline shafts, gear shafts and gear segments. According to Raycar, the company can fill all alloy requirements, including those for cast, ductile and unusual materials, such as nylon or phenolic.

Raycar's capabilities include hobbing, shaping, shaving, tooth chamfering and gear grinding, as well as general machining. The company can grind teeth on spur or helical gear up to 12" in diameter, offering up to AGMA class 12 quality. The company's NC hobbing machines allow hobbing of parts up to 16" in diameter. Raycar also can shape internal teeth when hobbing is not an option.

According to the company, "Quality is not an accident at Raycar." The company uses a Höfler ZP350 analytical gear analyzer to provide customers with gear charts. Raycar performs regular inspections after each operation, as well as a

final inspection before shipping.

Redin Corp.—Booth #384. Redin Corp. will demonstrate computer-controlled servo motion designed to virtually eliminate setup times in deburring and reduce costs associated with part changeover and tool setting.

According to the manufacturer, machine operators can be productive in minutes with a basic orientation on machine controls. A typical changeover consists of installing the workholding device, placing the appropriate carbide bit in the tool and selecting the corresponding part program. The programs are written and tested at Redin Corp. to ensure high performance control.

The machine operates on the principle of inverse kinematics. Motions are programmed based on the shape of the part being deburred. According to Redin, with eight axes of motion, the machine can handle the most difficult shapes and can repeat helical, elliptical and 3-D arcs with accuracy and precision.

Reishauer Corp.—Booth #692. Reishauer Corp. is a leading manufacturer of CNC gear and thread grinding machines. The company's gear grinders are designed and built to accommodate spur and helical gears up to 820 mm in diameter, with a maximum helix angle of +/- 45° and up to AGMA class 15 quality. Thread grinders are capable of grinding standard threads, worms, rotors, gages, taps and ball screws up to 2 m in length. Technical information on video display will be available on Reishauer's newest gear grinder, Model RZ 400.

Reishauer also represents the Richardon line of gear cutting machines, including a six-axis CNC hobbing machine, available in up to 500 mm capacity.

REM Chemicals Inc.—Booth #537. REM Chemicals says the REM® process is a cost-effective alternative to an engineered, machined surface in many applications where surface finish, increased wear and friction reduction are important considerations. The REM® process is an isotropic surface finishing process that produces a nonlinear, low-Ra finish that improves wear properties and reduces friction. It is a chemical mechanical process that sequentially removes the "peaks" of a ground, cut or honed finish while leaving the "valleys" unaffected. According to REM, the result is a dramatically improved surface finish with little dimensional change of the part.

Russell, Holbrook & Henderson Inc. —Booth #471. Russell, Holbrook & Henderson is a leading manufacturer of fine-pitch gear cutting tools and metrology products, with more than 50 years of experience providing tooling solutions and services.

The company's Tru-Volute hobs, shaper cutters and master gears offer the highest level of quality and accuracy, according to the manufacturer. Class AAA and AA hobs in solid carbide and super high speed steel can be manufactured to AGMA, ISO, DIN and JIS hob standards.

Russell, Holbrook & Henderson will introduce a new CNC hob sharpener at the show. Also, the company will present solutions in nanogear technology, with 0.01 module (2,540 DP) microgears. Other products to be presented include the company's GRT-04 dual-flank gear rolling tester with personal-computer analyzing software and DIN class 1 master gears (with less than 1.0 micron total composite error).

The company invites you to visit to discuss the latest hard hobbing, dry cutting, coating or gear production technologies, as well as its "ultra-precision" gears.

S.L. Munson & Co.—Booth #269. S.L. Munson & Co. is the exclusive North American distributor of Dr. Kaiser products. Dr. Kaiser specializes in the design and manufacture of precision rotary diamond dressers for the gear industry. Dr. Kaiser products are designed for continuous generating, single-tooth, spiral, bevel and plunge grinding applications. The products are offered in both natural diamond and polycrystalline diamond (PCD) versions.

Schafer Gear Works Inc.—Booth #525. Schafer Gear Works is a QS9000/ISO9002 company specializing in gears. Products include hobbed, shaped, shaved, crowned, ground, internal, external, spur, helical, bevel and worm gears and worms, in many materials.

Hobbed spur and helical gears are manufactured from 3 to 200 pitch, in sizes up to 52" in diameter. Shaped gears are manufactured up to 36" in diameter.

According to Schafer Gear Works, the company strives to meet and exceed customer expectations through a market-driven philosophy. In addition to CNC machinery and testing equipment, Schafer has EDI to accept customer orders, SPC for quality assurance, bar coding and other software and hardware.

Besides gears, Schafer offers screw machine products and precision machined components.

Schütte TGM L.L.C.—Booth #141. Schütte products allow you to grind stick blades and standard tooling on the same machine. A video presentation of the WU305 CNC tool & cutter grinder will highlight the machine's ability. Custom demonstrations can be arranged on the days of the show, at the company's facility in Jackson, MI.

Service Network Inc.—Booth #336. Service Network Inc. offers the SN-Series and 2X-Series grinding machines. These internal and external production or multisurface CNC grinders are capable of producing the highest quality product, according to the manufacturer. Twin-spindle simultaneous bore and face grinders are available. The company can review specific applications and supply the equipment as well as develop the grinding process. SNI also provides Heald replacement parts, field service and modernization packages.

Since 1984, Service Network has designed and built precision grinding solutions. The company is located in Auburn, MA.

Star Cutter Co.—Booth #536. Star Cutter will display a CNC tool grinder. Other products are hobs, milling cutters, carbide preforms, gun drills, coolant drills and reamers, which can be either carbide head, solid carbide or PCD design. Also offered will be thin-film coatings used on cutting tools or wear parts, depending on the particular application. The company also will display imported Stieber chucks and Lorenz shaper cutters and shaving cutters.

SU America Inc.—Booth #112. SU America of Oak Park, MI, will exhibit two machines at Gear Expo, with its North American distribution partner, Meritage Inc. A new Samputensili robotic bevel gear deburr/chamfer center and the Samputensili S372G gear grinding machine will be the focus of SU America's booth.

According to David Goodfellow, SU America's president, Meritage distribution representatives will be on hand with the Samputensili and Hurth-Modul specialists to give demonstrations, review applications, answer questions and present the products and services available through SU America.

Several gear cutting tool displays, including a new bevel cutter design, and DVD wide-screen presentations also will be exhibited. SMW Systems, a Meritage unit, will display a working model of its quick-change chuck for gear cutting machines.

SU has partnered with Meritage distribution, sales and service. Meritage has 30 office and showroom centers in North America, with approximately 200 certified machine tool sales engineers who represent additional and complementary lines of metalworking equipment.

Toolink Engineering—Booth #101. Toolink Engineering is the exclusive North American distributor of königdorn hydraulic arbors, chucks and other specialized workholding devices manufactured by König mtm in Wertheim, Germany. For more than 30 years, König mtm has manufactured customized tooling to meet customer specifications. Whether the application is turning, milling, grinding, balancing, drilling, measuring or inspection, König mtm can fabricate tooling that will hold the workpiece securely and accurately.

Visitors to the Toolink booth can inspect samples of the company's tooling, view a short movie showing the company's manufacturing facility in Germany, and discuss the tooling requirements of their companies.

Ty Miles Inc.—Booth #601. Ty Miles Inc. manufactures high speed broaching systems that can be integrated into an automated manufacturing cell or used as stand-alone machines. Miles broaching systems—vertical, horizontal and table-up—range from 2-ton to 30-ton force and from 12" to 72" stroke. The table-up models require no pits or plat-

forms, and part loading/unloading is done at operator waist height. Standard or interchangeable broach tooling includes fixtures, holders and broach cutting tools. Other services offered are broach sharpening and reconditioning, internal and external production broaching, and ballizing systems.

United Tool Supply—Booth #106. United Tool Supply manufactures the Unite-a-Matic, which the company refers to as "the gear industry's most accurate pitch diameter inspection gage." United Tool Supply has been in business for 30 years, with more than 6,000 units in the field. The company offers a variety of pitch diameter gages capable of measuring inside diameter, spline and shaft applications. The latest model, equipped with hydraulically controlled gear contact during measurement, will be on display. United Tool Supply offers gages in 0–3", 0–6", 0–9" and larger sizes.

Viking Forge Corp.—Booth #530. Viking Forge's precision forging technology can produce flashless and near-net forgings that the company says will eliminate fixturing problems and save machining time and expense. ○

Tell Us What You Think . . .

If you found this article of interest and/or useful, please **circle 311**

If you did not care for this article, **circle 312.**

If you would like to respond to this or any other article in this edition of *Gear Technology*, please fax your response to the attention of Randy Stott, managing editor, at 847-437-6618 or send e-mail messages to *people@geartechnology.com.*

Detroit Trivia Challenge

You've been to Detroit several times for Gear Expo, so you think you know Motown pretty well. Prove it. *Gear Technology* has a quiz to test your knowledge of the Motor City.

The answers are on page 79, but no one who really knows Detroit will look there until *after* finishing the quiz.

Your knowledge will be rated by the number of questions you correctly answer. The ratings are:

18–20 Motown is *my* town!

15–17 I've been to so many Gear Expos, Detroit is like my second home.

11–14 I grew up in Detroit, but we moved when I was in eighth grade.

5–10 First-time tourist, who can fool lesser first-time tourists.

0–4 First-time tourist, with camera and *really handy* city map!

1. Detroit is home to ____.
a) the International Hockey Hall of Fame
b) the only floating post office in the world
c) the Midwest's oldest zoo
d) the country's only lawnmower museum

2. Detroit is known as ____.
a) the home of the first professional football team
b) the jazz capital of the Midwest
c) the home of the banana split
d) the potato chip capital of the world

3. Detroit is the city where ____, James Joyce's scandalous book, first entered the United States.
a) *Ulysses* b) *Lolita* c) *Tropic of Cancer*
d) *Lady Chatterley's Lover*

4. Detroit was settled in 1701 by ____.
a) Antoine de la Mothe Cadillac b) Chief Pontiac
c) René-Robert Sieur de la Salle d) Henry Hudson

5. Except for one stone warehouse, Detroit was destroyed by a fire in ____.
a) 1906 b) 1871 c) 1805 d) 1763

6. How many structures were destroyed in that fire?
a) 350 b) 250 c) 200 d) 500

7. Detroit was incorporated as a city in ____.
a) 1823 b) 1859 c) 1815 d) 1837

8. Henry Ford introduced the assembly line to his automobile plant in____.
a) 1896 b) 1900 c) 1922 d) 1913

9. Of all U.S. cities, Detroit has the most ____.
a) registered flyfishermen b) registered drivers
c) registered bowlers d) registered voters

10. "Invented in Detroit" can be used to describe ____.
a) the toaster b) the typewriter
c) the automobile d) the saxophone

11. Detroit was famous in pre-Civil War America because ____.
a) it was an important station in the Underground Railroad
b) *Uncle Tom's Cabin* was written there
c) it was a major munitions depot
d) it was the boyhood home of John Brown

12. Detroit is from the French word d'etroit, which means ____.
a) the shore b) the strait c) the forest
d) a great place for a large, automotive city

13. In what year were the Detroit Lions the National Football League champions, the Tigers the World Series champions, and the Red Wings the Stanley Cup winners?
a) 1944 b) 1935 c) 1959 d) 1978

14. Detroit became the first U.S. city to assign individual telephone numbers in ____.
a) 1901 b) 1879 c) 1911 d) 1898

15. Detroit built the first urban freeway in the U.S. in ____.
a) 1942 b) 1954 c) 1939 d) 1948

16. Detroit was turned over to the ____ in 1760 as a spoil of the French and Indian War.
a) the Americans b) the French c) the British d) the Indians

17. George Washington forced the British out of Detroit and the American flag was raised over Fort Pontchartrain at Detroit in ____.
a) 1777 b) 1780 c) 1783 d) 1796

18. Coleman Young became Detroit's first black mayor in ____.
a) 1962 b) 1956 c) 1972 d) 1974

19. Detroit is home to America's oldest state fair, the Michigan State Fair, which was first held in ____.
a) 1836 b) 1849 c) 1856 d) 1777

20. By 1850, Detroit's leading industry was the manufacture of ____.
a) buggies and carriages b) Great Lakes cargo ships
c) printing presses d) stoves and kitchen ranges

Gear Expo Trivia Challenge

You've attended Gear Expo so many times that you think you're an expert on it. Test your expertise with this quiz.

The answers are on page 79, but you don't really need them, do you?

The number of questions you correctly answer will expose your expo expertise. (Try saying that phrase seven times really fast.)

The ratings are:

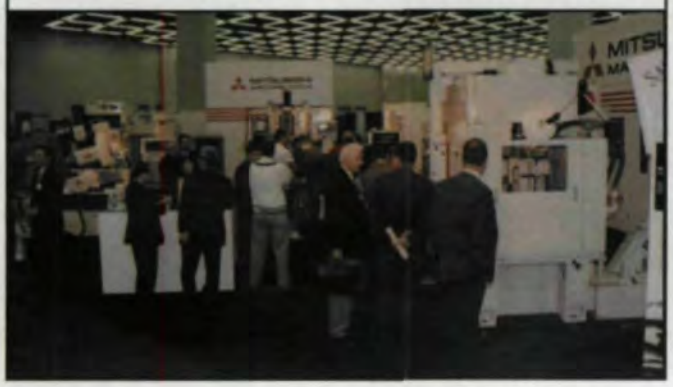
8–9 Gear Expo is my life!

6–7 I've been to so many Gear Expos, I know where all the bathrooms are in Cobo Center.

4–5 I don't know all the exhibitors, but I know which ones have the good candy.

2–3 I can wander the aisles with an appearance of knowledge—just don't ask me any questions.

0–1 I just learned that Cobo Center is in Detroit and that I need to go there.



1. In what city was the first AGMA show held that included only tabletop displays?

a) Chicago b) Cincinnati c) Detroit d) Pittsburgh

2. In what year did AGMA hold the first Gear Expo as a full trade show that included machinery exhibits?

a) 1985 b) 1986 c) 1987 d) 1989

3. In what city was this first Gear Expo machinery show held?

a) Cincinnati
b) Detroit
c) Pittsburgh
d) Toledo, OH

4. Including this year's show, Gear Expo has been held in how many different cities?

a) 3 b) 4 c) 5 d) 6

5. Including 2001, how many times has Gear Expo been held in Detroit?

a) 2 b) 3 c) 4 d) 5

6. By which of the following has Gear Expo become known?

a) The World of Gearing
b) The Only Trade Show Devoted to the Gear Industry
c) The Worldwide Gear Industry Event
d) All of the above

7. Where will Gear Expo 2003 be held?

a) Charlotte, SC
b) Columbus, OH
c) Indianapolis
d) Milwaukee

8. How many continents are represented by Gear Expo 2001 exhibitors?

a) 4 b) 5 c) 6 d) 7

9. How many pounds of freight will be brought into Cobo Center by exhibitors for Gear Expo 2001?

a) 50,000 b) 100,000 c) 500,000 d) 1,000,000

Tell Us What You Think . . .

If you found this article of interest and/or useful, please **circle 313.**

If you did not care for this article, **circle 314.**

If you would like to respond to this or any other article in this edition of *Gear Technology*, please fax your response to the attention of Randy Stott, managing editor, at 847-437-6618 or send e-mail messages to *people@geartechnology.com.*

Gear Education at Gear Expo

Gear Expo provides an opportunity to learn from the industry's experts by walking the aisles and talking to exhibitors. Visitors to Gear Expo 2001 also can take advantage of some formal training and educational opportunities sponsored by AGMA and SME.

AGMA'S FALL TECHNICAL MEETING

This year's fall technical meeting will be held in Detroit just prior to Gear Expo, from October 3–5, allowing visitors to attend both events in just one trip.

About a dozen papers are scheduled to be presented at the meeting. The titles include:

- "Carbide Hobbing Case Study," Yefim Kotlyar, Bodine Electric Co.;
- "Helical Guide Constraints on the Gear Shaping Process: How a CNC Guide Will Change the Way the Gear Manufacturing Community Views Shaping," Dr. Klaus Peiffer, Gleason-Pfauter Maschinenfabrik;
- "The Ultimate Motion Graph for 'Noiseless' Gears," Dr. Hermann Stadtfeld, The Gleason Works;
- "Automated Spiral Bevel Gear Pattern Inspection," Son Nguyen, IIT Research Institute;
- "Traceability of Gears, New Ideas, Recent Developments," Frank Hartig, Franz Waldele, Physikalisch-Technische Bundesanstalt;
- "How to Inspect Large Cylindrical Gears with an Outside Diameter of More Than 40 Inches," Guenter Mikoleizig, Klingelnberg Söhne GmbH;
- "The Application of Chemically Accelerated Vibratory Finishing for the Elimination of Wear and Pitting of Alloy Steel Gears," Lane Winkelmann, Dr. Gary Sroka, REM Chemicals Inc. & Al Swiglo, IIT Research Institute;
- "The Effect of Spacing Errors and Runout on Transverse Load Sharing and the Dynamic Factor of Spur and Helical Gears," Husny Wijaya, Donald Houser, Jonny Harianto, The Ohio State University;
- "New Opportunities with Molded Gears," Roderick Kleiss, Alexander Kapelevich & Jack Kleiss Jr., Kleiss Gears Inc.;
- "Design Technologies of High Speed Gear Transmission," Jeff Wang, Nuttall Gear;
- "Performance-Based Gear-Error Inspection, Specification, and Manufacturing—Source Diagnostics," William Mark, Cameron P. Reagor, Drivetrain Technology Center, Penn State University; and
- "Kinematic and Force Analysis of a Gear System with Separation of Sliding and Rolling Between Meshing Profiles," Dmity Tananko, Eugene Rivin, Wayne State University.

In addition to the technical papers, the fall technical meeting will include several presentations on topics of interest to the gear industry. The topics are:

- "Current Trends in the Gear Market Place," presented by Terry Orr, Lufkin Industries Inc.;
- "Important Trends in Standards for Gear Tolerances," panel discussion presented by Edward Lawson, M&M Precision Systems Corp., Robert Smith, R. E. Smith & Co. Inc. & William Bradley, AGMA; and
- "The Gear Engineer's Relation to Product Liability," presented by Peter Lamb, AGMA legal counsel.

For information about attending AGMA's fall technical meeting, contact the American Gear Manufacturers Association by telephone at (703) 684-0211 or fax at (703) 684-0242.

AGMA Seminar

The American Gear Manufacturers Association will hold a special session of the basic course from its Training School for Gear Manufacturing.

The course will be presented Oct. 8–10 alongside Gear Expo 2001 at the Cobo Center in Detroit. The special session will consist of the classroom-training part of the regular course, held at Richard J. Daley College, in Chicago, IL.

The session costs $450 for AGMA members and $575 for nonmembers. Session hours are from 8 a.m. to 12 p.m. For more information about the session, contact AGMA by telephone at (703) 684-0211 or by sending e-mail messages to *gearexpo@agma.org*.

SME Seminars

The Society of Manufacturing Engineers will present four gear-related seminars Oct. 8–10 alongside Gear Expo 2001. The seminar titles, with a description of each seminar, appear below.

Gear Metrology, Oct. 8, presented by Edward Lawson, director of metrology at M&M Precision Systems Corp. This seminar begins with a brief history of gear technology and an overview of gear inspection and types of gearing. It continues with single- and double-flank composite testing, the involute profile, tooth alignment, pitchline runout, and pitch and index errors. Lawson will cover the gear inspection standard, ANSI/AGMA 2000-A88, and alternative testing methods and measurement validity.

The Preliminary Gear Design Thought Process, Oct. 9, presented by Raymond Drago, chief engineer of Drive Systems Technology Inc. and a senior technical fellow of Boeing Co. This course addresses the development of the preliminary gear design and is intended for design, product and process engineers who are new to the industry. It is also

intended for gear users, buyers and specifiers who don't design gears, but who are required to understand the engineering principles of gear design.

Gear Shaping Manufacturing Dynamics, Oct. 9, presented by John Lange, a product manager for Gleason Corp., and Glenn Schlarb, an engineering manager for Gleason Cutting Tools Corp. This seminar covers the basics of the shaping process, including the kinematics of the machine tool, the importance of gear shaping without helical guides, the concepts of shaper cutting tool design and other technical aspects of gear shaping.

Advanced Gear Processing and Manufacturing, Oct. 10, a forum and discussion with seven topics scheduled for presentation. The program contents and participants will include:

- "Finish Hobbing of Hardened Gears," Dennis R. Gimpert, Koepfer America L.L.C.;
- "The Prediction of Worm Gear Contact and Transmission Error Based on Tooth Surface Measurement," Dr. Michael Fish, Holroyd;
- "Fahrenheit 451: Gear Up for Induction Hardening," Daniel J. Williams, Welduction Corp.;
- "Near-Net Forged Gears," Dale Debeljak, Presrite Corp.;
- "Improving Gear Manufacturing Through Better Parts Washer Management," Rick Terrien, Universal Separators Inc.;
- "Shaving: A Successful Gear Finishing Process," Dennis A. Sine, Nachi Machining Technology Co.; and
- "Efficient Hard Gear Finishing Utilizing Non-Dressable Tools," Tom Lang, Kapp Technologies.

Each SME seminar costs $395 for SME members and $445 for nonmembers. Program hours are from 8 a.m. to 2 p.m. For information about attending any of the SME seminars, contact Lynn Albertson, senior program developer, by telephone at (313) 271-1500, extension 2131, or by e-mail at *albelyn@sme.org*.

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The Broach Masters/Universal Gear

Booth Number: 438

Products
High precision Gear & Spline Broaches; Hex; Keyway, etc.
Shank & Disk Shaper Cutter; Spline Plug Gages; Tapered Spline Mandrels, Master Gears, Specials.

Services
Pull Through & Blind Hole Broaching, Gear Grinding, Wire EDM, Tool Sharpening, Gage Re-calibration.

Company Profile
The Broach Masters (est. 1978) and Universal Gear (est. 1971) combined forces in 1997 to form the nucleus of an emerging dominant player in the gear industry. Using state-of-the-art CNC grinding equipment and developed technologies designed to give superior performance, we achieve success through continuous improvement.

U.G.C. MADE IN U.S.A.

QUALITY TOOLS & SERVICE
The Broach Masters, Inc.
"DEDICATED TO EXCELLENCE"

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Phone: (530) 885-1939 • Fax: (530) 885-8157 • E-mail: SALES@BROACHMASTERS.COM

Circle 188

Dr. Kaiser
Diamond Dressing Tools

Booth Number: 269

Product Line
Dr. Kaiser Diamantwerkzeuge, located in Celle, Germany, specializes in the design and manufacture of precision rotary diamond dressers for the gear industry. ***Dr. Kaiser*** precision diamond products are unsurpassed in quality, accuracy, and innovative design.

Company Profile
Dr. Kaiser provides dressing solutions for continuous generating, single tooth, spiral, bevel, gear, and plunge grinding applications in both natural and polycrystalline diamond versions. ***Dr. Kaiser*** PCD reinforced dressers significantly extend dresser life when compared with standard non-reinforced direct plated dressers, especially in fine-pitch applications. ***Dr. Kaiser*** offers quick delivery and the highest accuracy at competitive prices. Relapping and replating services are available.

S.L. Munson & Company is the exclusive distributor for ***Dr. Kaiser*** products in North America.

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Phone: 800-775-1390
Fax: 803-929-0507
E-mail: *info@drkaiser.com*
Circle 127

Accurate Specialties Inc

Booth Number: 427

Product Line
Bronze components for the power transmission industry. Specialists in gear bronze, producing finish-turned gear blanks, bushings and bearing materials from 1" to more than 48" in diameter. Spuncast composite gear blanks offer exceptional value, with centrifugal cast components for critical applications and cost-effective production of low quantity orders. Standard tooling often available, or near net shape tooling can be designed to minimize cost and maximize value.

Company Profile
Accurate Specialties is North America's leading manufacturer of cast bronze gear materials. Innovative and integrated manufacturing capabilities provide you unparalleled service, value and quality through component design, alloy selection, casting and machining. Tin, aluminum and manganese bronzes produced in heats ranging from 200 to thousands of pounds. Our CNC machining and broaching services maximize your throughput and profit by eliminating queue and set-up time wasted on non-core operations at your facility.

Accurate Specialties Inc

N12 W24360 Bluemound Road
Waukesha, Wisconsin 53188-1631
Phone: (262) 547-5450 • Fax: (262) 547-5892
E-mail: sales@accuratespecialties.com
Circle 185

Russell, Holbrook & Henderson

Booth Number: 471

Product Line

When you're looking for the ultimate in fine pitch gear tool products, look no further than Russell, Holbrook & Henderson Inc.

Our Tru-Volute hobs, shaper cutters and gear metrology products deliver the superior precision you demand. HSS and solid carbide hobs are available for immediate delivery. Introducing our "NEW" HBS-1520 CNC hob sharpening machine designed specifically to maintain the highest level of accuracy found in Tru-Volute hobs, including our Class AAA.

Company Profile

RH&H has been providing innovative products and solutions for over 50 years. Our parent company, Ogasawara Precision Laboratory Ltd., Japan, is a world leader in manufacturing fine pitch gear tools and related products.

Contact

RUSSELL, HOLBROOK & HENDERSON, INC.

Sales and technical service is now available from our "new" location:

17-17 Route 208 North
Fair Lawn, NJ 07410
Phone: (201) 796-5445
Fax: (201) 796-5664
sales@tru-volute.com
www.tru-volute.com

Circle 197

Chamfermatic Inc.

Booth Number: 481

Company Profile

Chamfermatic Inc. was started in 1996 with the goal of building the best, easy-to-set-up gear deburring machines on the market. We have, by listening to our customers' needs, accomplished this goal.

Product Line

Chamfermatic Inc. offers a complete line of gear deburring machines with capacities up to 36 inches in diameter, from manual to fully automated systems. We also incorporate parts washing along with deburring operations to remove oil, lapping compound and chips from your parts, while adding a rust preventative. All of our equipment has as standard: automatic air-operated door, operator interface, P.L.C. and a filtration system. Also, they are all portable.

Our service and customer response time is second to none. We also offer contract deburring of your gears, making Chamfermatic a full-service supplier to the industry.

Contact

Chamfermatic Inc.

7842 Burden Road
Machesney Park, IL 61115
Mike Magee, President

Phone: (815) 636-5082
Fax: (815) 636-0075
E-mail: chamfer96@aol.com

Circle 149

OLS

Booth Number: 480

Product Line

OLS offers a wide variety of standard deburring machines, from simple to complex. Our BOB machine (pictured) is an economical, off-the- shelf deburring system that can greatly enhance the productivity of CNC machines by removing the deburring operation from the CNC and letting BOB do it. OLS can also custom configure one of our standard machine bases to meet your deburring needs. The Model 815 base is ideal for high volume production of smaller parts. It is a through-feed machine that is height-adjustable for easy incorporation into an existing or proposed manufacturing cell. The Model 2800 base is ideal for deburring large parts. These bases and others in our inventory may be fitted with the OLS Auto Amp Compensation System, an innovation that provides uniform brush pressure throughout the useful life of the brush, assuring consistent quality. Our design staff can also provide "clean-sheet" custom designs for virtually any part that requires deburring.

Company Profile

On-Line Services has been manufacturing innovative deburring technologies since 1993. OLS starts with your specifications and applies our knowledge to design and build turn-key systems that deliver high productivity and exceptional quality.

Contact

OLS

Eric Mutschler
3370 West 140th St.
Cleveland, Ohio 44111
Phone: (800) DEBURR3
Fax: (216) 472-0204
E-mail: eric@olsmachines.com
Circle 144

Service Network Inc.

Precision Grinding Machines

Booth Number: 336

Products and Services

New Machines: SNI's capabilities are best exemplified by its proprietary product offering, particularly its SN-Series and 2X-Series grinding machines. These modern internal and external production or multisurface CNC grinders are capable of producing the highest quality product. Various arrangements, including twin spindle simultaneous bore and face grinders, are available. Upon thorough review of the specific application, we can take an engineered approach, supplying the equipment as well as developing the grinding process.

Heald Support: Having more than 1,000 man-years of Heald experience, SNI offers total support for the entire Heald product line. This includes replacement parts, field service, full rebuilding and modernization packages. Our services cover all model Heald grinders, including 171/271, Rotary, 273A, CF, EF, Cinternal and Cinex.

Company Profile

Since 1984, SNI has capitalized on a wealth of experience in designing and building precision grinding solutions. It is the mission of SNI to respond to our customers' requirements by providing leading-edge technology at a superior value.

SNI

160 Southbridge Street
Auburn, MA 01501
Tel: (508) 754-2739
Fax: (508) 797-9453
E-mail: sni1@sni-grinders.com
Website: www.sni-grinders.com
Circle 111

Randall Publishing Inc.

Booth Number: 418

Win a One-of-a-Kind Gear Clock

Randall Publishing Inc., producers of *Gear Technology, the Journal of Gear Manufacturing*; ***The Gear Industry Home Page™***, and ***powertransmission.com™***, are offering visitors to Gear Expo a chance to win this one-of-a-kind, custom-crafted gear clock. The clock is an original by Chicago artist Jay Lensink, who provided a similar clock for Gear Expo 99.

Learn About Marketing in the Gear Industry

Randall Publishing experts will offer suggestions about how visitors can achieve their companies' marketing goals in the industry. We have custom-tailored programs available for those who want to reach gear buyers, gear manufacturers or any other part of the gear industry.

Contact

Gear Technology, 1425 Lunt Ave., P.O. Box 1426, Elk Grove Village, IL 60007 U.S.A.
Ph: (847) 437-6604 • Fax: (847) 437-6618 • E-mail: *people@geartechnology.com*

Gear Technology

Booth Number: 418

Get Your CD-ROM Buyers Guide at Gear Expo

Gear Technology is proud to present its first ever annual buyers guide on CD-ROM. This comprehensive directory includes contact information for more than 500 gear industry companies, including manufacturers of gears and gear drives, gear cutting machinery, cutting tools, workholding, inspection equipment and many other products. The directory also includes providers of services important to the industry, including commercial heat treating, consulting services and gear-related training.

Special Features

Many of the companies in the directory have listings with live hyperlinks. On computers with Internet access, clicking on the companies' web addresses will launch those websites in the user's browser.

Contact

Gear Technology, 1425 Lunt Ave., P.O. Box 1426, Elk Grove Village, IL 60007 U.S.A.
Ph: (847) 437-6604 • Fax: (847) 437-6618 • E-mail: *people@geartechnology.com*

INDUSTRY NEWS

Dana Sells Forging Operation

Dana Corp. sold its Marion, OH, forging facility in June to Sypris Solutions Inc. of Louisville, KY, according to a Sypris Solutions press release. Terms of the agreement included payment of $11.5 million from Sypris to Dana and a contract for Sypris to supply drive components for use by Dana in North America.

Dana itself acquired the Marion facility as part of the company's 1998 acquisition of Eaton Corp.'s heavy axle and brake business. The 258,000-square-foot facility produces fully machined axle shafts and a variety of forgings, such as ring and helical gears, for heavy-duty truck applications. The facility employs approximately 200 people.

Sypris Solutions provides specialized industrial products. The company's subsidiary Tube Turns Technologies produced approximately 587,000 Class 5–8 truck axles for customers during 2000.

The acquisition adds manufacturing capability that will allow Sypris to increase its capacity for axles and enter the market for ring gears, helical gears and pinions.

Bingham Takes Over Northeast for Mitsubishi


Roger W. Bingham

The Mitsubishi Gear Technology Center in Wixom, MI, named Roger W. Bingham its Northeast regional sales manager.

Bingham will be responsible for sales of Mitsubishi's gear cutting machines and systems in New York, Vermont, Maine, Connecticut, Massachusetts, New Jersey, Maryland, Pennsylvania, Quebec and the Canadian Maritime Provinces. His office will be in Preston, MD.

Bingham worked previously as a regional sales manager for The Gleason Works and American Pfauter L.P. He has multiple language skills and sales experience in Russia, Europe and South America.

Mahr Federal Appoints New President


Craig Crossley

Mahr Federal Inc. appointed Craig Crossley its president, replacing recently retired Joe Golemme.

Crossley worked previously for Russell Reynolds Association, an executive consulting firm. Prior to that, he worked for Furon as president of a strategic business unit and for Eaton Corp. as a business unit manager and a marketing and sales director.

Mahr Federal manufactures dimensional metrology products, including a gear metrology line.

Ashok Leyland to Manufacture ZF Gearboxes

Ashok Leyland Ltd., India's second-largest truck manufacturer, announced plans to manufacture six-speed, synchromesh gearboxes designed by the German company ZF Friedrichshafen.

Ashok Leyland plans to manufacture the gearboxes at its factory in Maharashtra, India. The company has been manufacturing ZF gearboxes, under license, for two decades.

Firms to Develop Advanced Hybrid Powertrain

Azure Dynamics Corp., a developer of commercial vehicle energy management systems from Vancouver, British Columbia, has entered a strategic alliance with Tesma International Inc., a supplier of automotive engine, transmission and fueling systems from Concord, Ontario.

The companies intend to work together to develop and commercialize a proprietary planetary gear interface for a parallel hybrid system. The system would be used for medium-duty commercial vehicles, such as postal trucks, delivery vans and shuttle buses.

According to a release issued by Azure Dynamics, Tesma will be responsible for designing and manufacturing the planetary gearbox and related components.

Falk Names New VP of Finance

Falk Corp., a unit of United Technologies Corp. subsidiary Hamilton Sundstrand, announced the appointment of Dean P. Freeman as vice president of finance.

Prior to joining Falk, Freeman worked for DeZURIK/Copes-Vulcan, a manufacturer of industrial and municipal valve equipment.

BGA to Support Graduate Study in Gearing

The British Gear Association has committed itself to supporting the University of Cranfield in its development of a master of science program with gearing content, according to a BGA press release issued in July.

As part of that support, the BGA has relocated its five-day gear design course to the university.

AGMA Plastics Gearing Committee Gets New Chair

Ed Williams

Ed Williams, lead application development engineer at LNP Engineering Plastics, was elected chair of the AGMA Plastics Gearing Committee.

Williams and the committee will be working on the development of a new document on inspection practices of molded plastic gears.

Williams is the author of several papers on the tribological performance of internally lubricated thermoplastics in gear applications.

Letters to the Editor

"SPIROID®" Used Incorrectly

Dear Editor:

David Dooner's article, "Design Formulas for Evaluating Contact Stress in Generalized Gear Pairs," which appeared in the May/June 2001 issue, uses "spiroid" in a generic and/or misleading sense to refer to a specific type of gear form.

In fact, the term "SPIROID®" is a registered trademark owned by Illinois Tool Works (ITW). ITW has rights in the trademark "SPIROID®" dating back to 1956 for skew axis gearing and machines for lapping and testing reduction gearing incorporating a tapered worm and face worm gear. Under the law, ITW (and its ITW Spiroid division) have the exclusive right to use the mark "SPIROID®" in connection with these goods and related goods.

Moreover, the gears referred to in the article as "spiroid" are not true "SPIROID®" gears. The author incorrectly refers to a SPIROID® gear pair as "a hypoid gear pair with high spiral angle." SPIROID® gears are unique gears and do not have the same geometry as hypoid gears. A major advantage of SPIROID® gears is that multiple teeth are in contact throughout mesh. Typically about 10% of the SPIROID® gear teeth are in contact. Also, the article does not give complete design parameters, but a 47.80° normal pressure angle is extremely high for SPIROID® gears, which further indicates that the gear pair in the article is not representative of SPIROID® gears.

By using the word "spiroid" in a generic sense, the article gives a very misleading representation and an inaccurate analysis of the contact stress levels of "SPIROID®" gears compared with other gear forms. Many years of field service have proven that SPIROID® gears will handle greater loads than spur, helical, hypoid or bevel gears of comparable size, yet the article claims just the opposite. One reason may be that the author's calculations don't consider multiple tooth contact, which is an important contributor to the load-carrying capacity of SPIROID® gears.

The main point is that the example used in the article was not a SPIROID® gear, offered exclusively by ITW Spiroid, and therefore did not give an accurate description of SPIROID® design or features. SPIROID® gears provide very high power density and have many other performance benefits over other gear forms.

Sincerely,
James Honan
Vice President & General Manager
ITW Spiroid

KISSsoft Remains *KISSsoft*

Dear Editor:

With a certain astonishment, I've read news on your home page (which is a jewel among the other stuff on the World Wide Web, by the way) telling me that our gear and engineering software, *KISSsoft-Hirnware*, has changed its name. Since we are currently building up a market in the United States for our product, it is essential to correct some things, so I'd like to clarify the following points:

1) Hornet GmbH, the company featured in the announcement I read, has no rights to the *KISSsoft* name. They were using the software for some engineering purposes and planned to sell it under a different name, combined with a specialized material database.

2) *KISSsoft-Hirnware* will remain *KISSsoft-Hirnware*, whatever happens. The name *KISSsoft* is derived from the name L. Kissling & Co. AG, the Swiss gear manufacturing company that started programming the software in the early '80s. Since 1998, KISSsoft AG has owned all the rights to the software and has improved it together with our partner, Hirn Verzahnungen, whose software *Hirnware* was integrated into *KISSsoft* in 1999, resulting in *KISSsoft-Hirnware*. That is complicated enough, so we do not plan to change the name into something else.

3) There are many changes in the May 2001 release of *KISSsoft-Hirnware*. For example, the graphical shaft generator was improved, the gear calculation was extended (that was a hard job, since it was already very extensive), and the new version of *KISSsys* is now available for testing purposes. *KISSsys* gives the engineer the ability to look at a whole system of machine elements (e.g., a whole gearbox) and to perform strength analysis and related calculations on the complete system, certain variants of the system or a single machine element.

The new demo version of *KISSsoft-Hirnware* is available on the Internet at *www.KISSsoft.ch/english/demo.htm* and a test version of the *KISSsys* can be ordered by e-mail at *info@KISSsoft.ch*.

Kind regards,
Stefan Beermann, Marketing Director
KISSsoft AG
Frauwis 1
CH-8634 Hombrechtikon
Switzerland

Editors' Note: NORA is the name of an engineering service offered by Hornet GmbH. The company uses KISSsoft-Hirnware and other software to teach people how to develop new products. We apologize for any confusion.

Tell Us What You Think . . .
If you would like to respond to this or any other article in this edition of *Gear Technology*, please fax your response to the attention of Randy Stott, managing editor, at 847-437-6618.

GEAR EXPO 2001

The World of Gearing

Sponsored by the
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DETROIT, MICHIGAN
OCTOBER 7 - 10, 2001

FOR MORE INFORMATION, CONTACT:
AMERICAN GEAR MANUFACTURERS ASSOCIATION
- PHONE (703) 684-0211
- FAX (703) 684-0242
- EMAIL: GEAREXPO@AGMA.ORG
- WEBSITE: WWW.AGMA.ORG

VISIT US AT GEAR EXPO BOOTH #300.

CIRCLE 133

TECHNICAL CALENDAR

Sept. 10–11—Gear Failure Analysis Seminar. Big Sky Resort, Big Sky, MT. Examine types of gear failure, like macropitting, micropitting, scuffing, tooth wear, and breakage; learn what causes them, how to prevent them and how to fix them. AGMA seminar taught through lectures, hands-on workshops and question-and-answer sessions. Attendees welcome to bring examples of their gear failures for examination and discussion. $625 for AGMA members, $795 for nonmembers. Contact AGMA by telephone at (703) 684-0211 or by e-mail at *tech@agma.org*.

Sept. 12–19—EMO HANNOVER 2001: World of Machine Tools and Metalworking. Hannover Fairgrounds, Hannover, Germany. Scheduled to have many exhibition programs, including programs on abrasives, coolants, industrial robots, diamond tools and measuring tools, as well as machine tools for thermal, electrochemical and other processes. Event organizers are the German Machine Tool Builders' Association and Deutsche Messe AG. The U.S. contact is Donna Hyland, project director, who can be reached by mail at Hannover Fairs USA Inc., 103 Carnegie Center, Princeton, NJ 08540, by telephone at (609) 987-1202, by fax at (609) 987-0092, and by e-mail at *emo@hfusa.com*.

Oct. 7–10—Gear Expo 2001. Cobo Center, Detroit, MI. See page 35 for complete Gear Expo show coverage.

Oct. 8–10—AGMA Seminar. Cobo Center, Detroit, MI. Held in conjunction with Gear Expo 2001. See page 60 for more details.

Oct. 8–10—SME Gear Seminars. Cobo Center, Detroit, MI. Held in conjunction with Gear Expo 2001. See page 60 for more details.

Oct. 15—Powder Metallurgy Gear Technology Tutorial. Ypsilanti Marriott at Eagle Crest, Ypsilanti, MI. Tutorial includes topics for gear designers who want to learn more about powder metal gearing, and it includes topics for powder metal gear manufacturers who want to learn more about gear metrology, tooling issues and secondary processes. Sponsored by the Metal Powder Industries Federation. $395 for MPIF members, $445 for members of APMI International, $495 for nonmembers. Additional discount rates available to attendees of the International Conference on Power Transmission Components. Contact Sandy Leatherman at MPIF by telephone at (609) 452-7700 or by e-mail at *leatherm@mpif.org*.

Oct. 16–17—International Conference on Power Transmission Components—Advances in High Performance Powder Metallurgy Applications. Conference covers the latest advances in powder metallurgy technology for manufacturing and processing power transmission components. Provides forum for exchanging technical information about P/M power transmission components, including gears, planetary carriers and sprockets. Sponsored by the Metal Powder Industries Federation. $750 for MPIF members, $850 for members of

APMI International, $950 for nonmembers. Contact Sandy Leatherman at MPIF by telephone at (609) 452-7700 or by e-mail at *leatherm@mpif.org*.

Oct. 16–19—Plastic Gear Design and Manufacturing. Universal Technical Systems Inc., Rockford, IL. Teaches basic and advanced gear design and theory. Includes an hour of gear consulting on last day of training course. $995. Contact Phil Cooper by telephone at (815) 963-2220 or by e-mail at *sales@uts.com*.

Oct. 17–19—Bevel Gear Systems. University of Wisconsin—Milwaukee, Milwaukee, WI. Seminar provides an overview of bevel gear design, application and use. Intended for gear users, gear designers and beginning to intermediate gear technologists. Emphasis on proper selection, design, application, quality control, assembly, installation and maintenance of bevel systems. Manufacturing and inspection topics covered briefly. $1,095. Contact Richard Albers, program director, by telephone at (414) 227-3125 or by e-mail at *rgalbers@uwm.edu*.

Oct. 22–26—AGMA Training School for Gear Manufacturing: Basic Course. Richard J. Daley College, Chicago, IL. Classroom and hands-on training in gearing, nomenclature, principles of inspection, gear manufacturing methods, hobbing and shaping. $650 for AGMA members, $775 for nonmembers. Contact Susan Fentress by telephone at (703) 684-0211 or by e-mail at *fentress@agma.org*.

Oct. 23–26—Metal Gear Design and Manufacturing. Universal Technical Systems Inc., Rockford, IL. Teaches basic and advanced gear design and theory. Includes an hour of gear consulting on last day of training course. $995. Contact Phil Cooper by telephone at (815) 963-2220 or by e-mail at *sales@uts.com*.

Nov. 15–17—JSME International Conference on Motion and Power Transmissions. ACROS Fukuoka, Fukuoka, Japan. Technical papers presented will cover a variety of gear-related topics. Conference includes forum on future of gears in the 21st century. Conference's official language is English. Papers should be written and presented in English. Sponsored by the machine design and tribology division of the Japan Society of Mechanical Engineers. Contact the conference secretariat by e-mail at *secretariat@MPT2001.mech.kyushu-u.ac.jp*.

Tell Us What You Think . . .
If you found this column of interest and/or useful, please **circle 319.**

If you did not care for this column, **circle 320.**

If you would like to respond to this or any other article in this edition of *Gear Technology*, please fax your response to the attention of Randy Stott, managing editor, at 847-437-6618 or send e-mail messages to *people@geartechnology.com*.

Fairfield Puts Free Gear Software Online

Fairfield Manufacturing Co. Inc., a Lafayette, IN, manufacturer of custom gears, gear assemblies and planetary drives, announced the creation of a free and downloadable Windows-based version of its gear design software, available at *www.fairfieldmfg.com*.

The new version was created by modifying and updating Fairfield's DOS version of the software, which has been sold commercially since 1985 by Fairfield and AGMA.

The online version of the software is free. Website visitors need only register to download the program. Periodically, registration will need to be renewed.

Also online, Fairfield is offering a beta version of a dimensional analysis program to aid in performing and keeping track of assembly stackups during a project's design phase.

Circle 350

Redesigned Koepfer Hob Sharpener

The Koepfer KFS 100.3 CNC hob sharpening machine is a redesign from the 100 series model. The machine's new version comes with a vertical high-speed direct-drive grinding spindle capable of speeds up to 12,000 rpm.

The coolant filtration system of the KFS 100.3 has been integrated into the machine bed to provide a 40% smaller footprint.

The machine can sharpen straight-gash hobs up to 4" in diameter, 8" face and maximum 5 DP. It has optional capacity for helical-gash hobs. It will sharpen hobs to AGMA class "AAA" quality. A pneumatic tailstock provides positive clamping pressure while grinding. The machine is capable of grinding high-speed steel and carbide tools using CBN or diamond abrasives.

For more information, contact Koepfer America L.L.C., by mail at 635 Schneider Dr., South Elgin, IL 60177, by telephone at (847) 931-4121 or by e-mail at *sales@koepferamerica.com*.

Circle 351

New Marposs Gear Roll Tester

The new M62 gear rolling inspection bench is the latest addition to Marposs's line of gear checking products. The M62 is a double-flank gear roller for measuring test gears against a master gear. It is designed for the shop floor and can be combined with the Marposs E9066 industrial PC workstation.

The M62 can be equipped with internal bore measurement, fixed nosepiece or expandable arbor. It comes standard with ambient temperature compensation and harmonic analysis that displays part acceptability, as well as diagnostic tools for total composite error. The system can also display center distance, bore size and geometry.

For more information, contact Marposs Corp. by mail at 3300 Cross Creek Pkwy., Auburn Hills, MI 48326, by phone at (248) 370-0404, by fax at (248) 370-0621 or by sending e-mail messages to *marposs@us.marposs.com*.

Circle 352

BGA Announces Gear Stress Software

The British Gear Association has completed production of new software titled *The Analysis of Stress and Transmission Error Analysis*.

The software includes automatic finite element analysis for mesh stiffness of each gear; interactive input of "micro-geometry" and mounting and operating conditions for tooth contact analysis; and automatic tooth contact analysis, which takes account of tooth contact and bending compliances for all teeth engaged, assembly misalignment and all geometric contributions to gear geometry and alignment.

The software was developed for design optimization and refinement that is outside the capability of the gear stress analysis standard BS-ISO 6336, which is embodied in the BGA *Gear Geometry and Stress Analysis Programme* software.

The new software is available at reduced rates to BGA members. More information is available at the BGA website, *www.bga.org.uk*.

Circle 353

New Plastic Materials for Gears

Ticona has added two grades of materials with improved wear resistance and coefficients of friction to its line of Fortron® polyphenylene sulfide resins. The new materials, Fortron 6345L4 PPS and Fortron 6450A6 PPS, are designed for parts—such as gears, bearings and shafts—that move against other parts.

Fortron 6345L4 PPS has a coefficient of friction 15% lower than the existing low-wear grade, Fortron 1342L4, and it provides 55% less total system wear in unlubricated system testing.

Fortron 6450A6 PPS has the lowest coefficient of friction of any commercial grade of Fortron PPS, and it provides 65% less total system wear than Fortron 1342L4 in unlubricated testing.

For more information, contact John Dole by mail at Ticona, 90 Morris Ave., Summit, NJ 07901, by telephone at (908) 598-4139 or by sending e-mail messages to *john.dole@ticona.com*.

Circle 354

Airblast Shot Peening for Gearshafts

Wheelabrator Sisson-Lehman has introduced a new manufacturing cell for airblast shot peening of gearshafts. The CFX 600 can handle 400 parts per hour for components up to 120 mm in diameter and 600 mm in height.

Peening is controlled and monitored by a programmable controller with all processing parameters instantly selectable, according to component type. An in-cycle shot recovery, classification and recycling system ensures that shot size and shape is governed to maintain peening consistency. Rejected shot is automatically replaced with virgin media.

The machine can be provided with options, which include automatic loading and unloading conveyors, universal gripper or robot systems and a noise suppression enclosure that keeps noise levels to 80 dB or lower.

The machine is sold in North America by USF Surface Preparation Group. For more information, visit the group's website at *www.surfacepreparation.com* or send e-mail to *info@usfspg.com*.

Circle 355

Nachi Announces New Roll Forming Machine

Nachi Machining Technology Co. has announced a new Nachi-Red Ring PFM series of rack roll form machines.

According to a press release, the semi-dry roll forming machine is 200% faster than its predecessor, with speeds up to 30 m/min.; has new PFM rollers that use about 67% less energy; and needs about 50% of the floor space previously required for roll forming machines.

For more information, contact Nachi Machining Technology Co. by telephone at (810) 263-0100 or by fax at (810) 263-4571, or visit the company's website at *www.nachimtc.com*.

Circle 356

***Gear Technology* welcomes your new product announcements for gears, gear drives and products for the design, manufacture and testing of gears.**

Send your new product releases to:
Gear Technology
1401 Lunt Avenue
Elk Grove Village, IL 60007
Fax: 847-437-6618
E-mail: *people@geartechnology.com*

Tell Us What You Think . . .

If you found this column of interest and/or useful, please **circle 357.**

If you did not care for this column, **circle 358.**

If you would like to respond to this or any other article in this edition of *Gear Technology*, please fax your response to the attention of Randy Stott, managing editor, at 847-437-6618 or send e-mail messages to *people@geartechnology.com.*

GEAR ROUGHING AND FINISHING CUTTERS

A/W Systems Co. manufactures new spiral cutter bodies in diameters of 5" through 12". A/W can also supply roughing and finishing cutters for most 5"–12" diameter bodies.

For more information contact:
A/W Systems Co.
Royal Oaks MI, 48067
Phone: (248)544-3852
Fax: (248)544-3922

CIRCLE READER SERVICE #178

COMPONENT GEAR MANUFACTURING

Literature available from The Cincinnati Gear Company provides information covering its facilities and expertise in component gear manufacturing, including hobbing and cutting, grinding, turning, boring, milling and inspection. The brochure includes product photos and specifications, as well as manufacturing capabilities.

CIRCLE READER SERVICE #181

GLEASON INTRODUCES THE ELECTRONIC GUIDE SHAPER

Small-lot helical gear production will never be the same with the New GP300 ES Revolutionary Electronic Guide System. Users of the GP300 ES Gear Shaper can increase their chipmaking time by eliminating the need to change guides for new workpiece leads.
For more information, contact:
The Gleason Works
716-473-1000

CIRCLE READER SERVICE #199

INDUCTION FIXTURES

The LR-PAK data sheet describes induction lift rotate fixtures useful for heat treating parts such as transmission O.D. races, I.D. cams, hubs, spindles, C.V. joints and gears. LR-PAKs are completely assembled and interconnected.

Ajax Magnethermic Corp.
1745 Overland Avenue
Warren, OH 44482
800-547-1527 • Fax: 330-372-8608
E-mail: *ajaxsales@ajaxmag.com*
www.ajaxmag.com

CIRCLE READER SERVICE #179

VISIT US AT GEAR EXPO BOOTH #434 CIRCLE 192

GLEASON CUTTING TOOLS CORPORATION

A full color catalog showing the product capabilities of our worldwide and Loves Park, Illinois facilities. We manufacture high-speed steel and carbide hobs, shaper cutters, shaving cutters, bevel blades, form cutters, CBN wheels and thin film coatings. Heat-treat, resharpening and recoating services are available.

Gleason Cutting Tools Corporation
Telephone 815-877-8900
E-mail: *gctc@gleason.com*

CIRCLE READER SERVICE #202

CBN ELECTROPLATED WHEELS

SU is now producing CBN wheels for gear profile and generating grinding. The brochure outlines SU's design capabilities, complete manufacturing process and inspection practices. The wheels are suitable for use on SU gear grinding machines, as well as on other brands. Please contact:

SU America
Phone: (248) 548-7177
Fax: (248) 548-4443
or sales@suamerica.com

CIRCLE READER SERVICE #183

GEAR TECHNOLOGY

The Journal of Gear Manufacturing (SEPT/OCT 2001)

INFORMATION REQUEST FORM

1. Find advertisements or articles in this issue about which you would like to receive more information.
2. Circle the corresponding numbers on the form below.
3. Fax this page to 1-847-437-6618.

Name:_____

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CLARIFICATIONS & CORRECTIONS

Regarding the article "Design Formulas for Evaluating Contact Stress in Generalized Gear Pairs," by David Dooner, published in the May/June 2001 issue of *Gear Technology*, we would like to make the following clarifications and/or corrections:

1. Illinois Tool Works Inc. (ITW) is the owner of and has the exclusive right to use the trademark "SPIROID®."
2. We have been informed by Mr. Dooner that the gear pair presented in the article and identified as "spiroid" is not an ITW "SPIROID®" gear pair. The gear pair presented can be considered as a tapered worm and face worm gear in mesh. Mr. James Honan, vice president and general manager of ITW Spiroid, gives further details in his letter to the editor on page 68.

Regarding the article, "Material Properties and Performance Considerations for High-Speed Steel Gear-Cutting Tools," by Ed Tarney and Joanne Beckman, published in the July/August 2001 issue of *Gear Technology*, we would like to make the correction:

In Figure 6, in the caption, the sentence in parentheses should read: Conventional grades shown in red, P/M grades in blue.

We apologize for any inconvenience.

—The Editors

Detroit Trivia Challenge

Answers: 1. b) 2. d) 3. a) 4. a) 5. c) 6. c) 7. d) 8. d) 9. c) 10. b) 11. a) 12. b) 13. b) 14. b) 15. a) 16. c) 17. d) 18. d) 19. b) 20. c)

Gear Expo Trivia Challenge

Answers: 1. a) 2. c) 3. a) 4. c) 5. c) 6. d) 7. b) 8. b) 9. d)

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PUZZLING TOGETHER
A Gear Pioneer

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

The *Dictionary of American Biography* describes him as "one of the founders of the gear-cutting industry in the United States." He built the first hobbing machine for cutting spur gears. He founded the companies that are now Boston Gear and Philadelphia Gear Corp.

"He certainly was a dominant force in the gear industry in the early 1900s," says Jim Devine. A retired Philadelphia Gear sales manager, Devine wrote a history for his company's centennial in 1992.

That founder and dominant force is George Barnard Grant, and puzzling together his history was a little difficult.

The Addendum team happened to learn about Grant while looking into the history of the involute curve. We searched the Internet, but found the World Wide Web wanting for information about Grant.

We were able, though, to gather some information on this gear pioneer, thanks to Devine, gear consultant Richard L. Thoen and Steven Lubar of the Smithsonian Institution.

According to Devine, Grant's hobbing machine substantially improved gear technology.

"The hobbing machine allowed them to cut gears from steel," he says. "That was the real advancement."

Steel gears could withstand more vibration than cast-iron gears and could transmit more horsepower.

"Cast gears could be quite brittle," Devine says. "Cast gears could break and become inoperable." He adds that Grant's machine affected the railroad, steel mill and textile machinery industries—"and, of course, the automotive industry."

Grant applied for a patent on his machine in 1887, receiving the patent in 1889. But, the idea for hobbing gear teeth doesn't appear to have been his.

According to a history by Barber-Colman Co., Christian Schiele first thought of generating gear teeth via a hobbing process in 1856, developing the idea that a rack cutter in cylindrical form might be synchronized with a rotating gear blank to generate a gear tooth form. But, according to the Barber-Colman history, Schiele's process was so far ahead of contemporary mechanical technology that no one could build a machine to carry out that process.

In 1856, Grant was just a boy. Born Dec. 21, 1849, Grant prepared for college at the Bridgton Academy in Maine. He later studied at Dartmouth College's Chandler Scientific School and at Harvard College's Lawrence Scientific School. He graduated from Harvard with the class of 1873, receiving a bachelor-of-science degree.

After his graduation, Grant started a machine shop for gear cutting in Charlestown, MA.

By 1885, he supported the involute form instead of the epicycloidal form for gear teeth, according to the booklet "A Note on Early Gears and Gear Cutting Machines," written by N.J.C. Peres.

According to Peres, Grant's support came at the height of the involute-epicycloidal debate. Peres writes that the involute form superseded the cycloidal form because the involute form could be easily generated by a straight-sided rack cutter or a gashed hob's approximate straight-sided racking section and because the involute gear would transmit uniform rotation at different center distances.

"HE CERTAINLY WAS A DOMINANT FORCE IN THE GEAR INDUSTRY IN THE EARLY 1900s."

An inventor and mechanical engineer, Grant held a number of patents from his work in gear cutting and its machinery.

Despite those accomplishments, Grant's gear work isn't detailed in the *Dictionary of American Biography* as much as his work on creating a calculating machine for doing addition, subtraction, multiplication and division.

The dictionary entry on Grant says he made his money in gear cutting and gear-cutting machinery, but its longest paragraph on him is about his work on a time- and labor-saving calculating machine.

The entry adds that Grant never stopped studying calculating machines and conducted considerable experimental work on their development during the last years of his life. Grant died Aug. 16, 1917, in Pasadena, CA.

But, the entry notes that Grant still owned Grant Gear Works Inc. of Boston, MA, when he died, and that it continued after his death. ○

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