Celebrating 100 Years of Innovation • 1916-2016
KOLLMORGEN

The History of Kollmorgen 1916–2016

100 Years of Innovation

Dear Kollmorgen Associates,

2016 marks Kollmorgen's 100th anniversary. With very few organizations able to accomplish this type of milestone, I find it truly an honor and privilege to work here – and with all of you, the 1389 team!

The company's longevity and innovation success demonstrates a deep commitment to our global associates and customers over a very long time.

We are building great people and our people are building a great business – in that order. Your efforts each day are appreciated. Thank you for helping us realize our vision: Enabling Innovators to Make the World a Better Place.

Congratulations and thank you for helping us achieve this success!

My best,

Dan St. Martin

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Kollmorgen Type C periscopes on USS K-8, circa 1917

Dr. Friedrich Kollmorgen's two-telescope design established the U.S. Navy's standard for periscopes into the modern day.

The two military veterans exchanged barbs and banter, each man boastfully proclaiming their branch superior, as they made their way through the Military Museum in Central New York's Sampson State Park. They reached the center of the building, where a Kollmorgen periscope rises through the roof of the museum. The younger man rolled the wheelchair up to the periscope's eyepiece, allowing the WWII vet a view of Seneca Lake. The elder is taken back to his tour of duty in the Pacific Ocean.

The essential function of a periscope is to give an officer conning a submarine a view of the surrounding horizon while his vessel remains submerged. To accomplish this, the periscope needs to be long enough to extend beyond the surface, and also to deflect rays of light, first downward, and then horizontally. In addition, the part of the periscope that is to be above water must be as inconspicuous and streamlined as possible; for this reason the periscope is made in the form of a long narrow tube.

The periscope has been the cornerstone of our success at Kollmorgen. From World War I up until the government's single-sourcing policy changed in 1958, Kollmorgen remained the preeminent designer and supplier of submarine periscopes to the U.S. Navy. Dr. Friedrich Kollmorgen's two-telescope design established the standard for periscopes into the modern day.

What inspired Dr. Kollmorgen to rise above the challenges before him to create a better life for himself, his family, and the world around him? Was he compelled by Thomas Edison's words, "Vision without execution is hallucination." Or, was he fascinated with one of the major and necessary figures in his life… the sea?

Friedrich Ludwig Georg Kollmorgan (genealogy records use the a) was born in Stettin, Pommern, Prussia, Germany on September 16, 1871. Situated on the southern Baltic Coast, the maritime province of Pomerania, or Pommern, translates from Slavic to mean Land at the Sea. The seventh of nine children, Friedrich's parents buried two of their children before he was even born. In 1875, they buried two more.

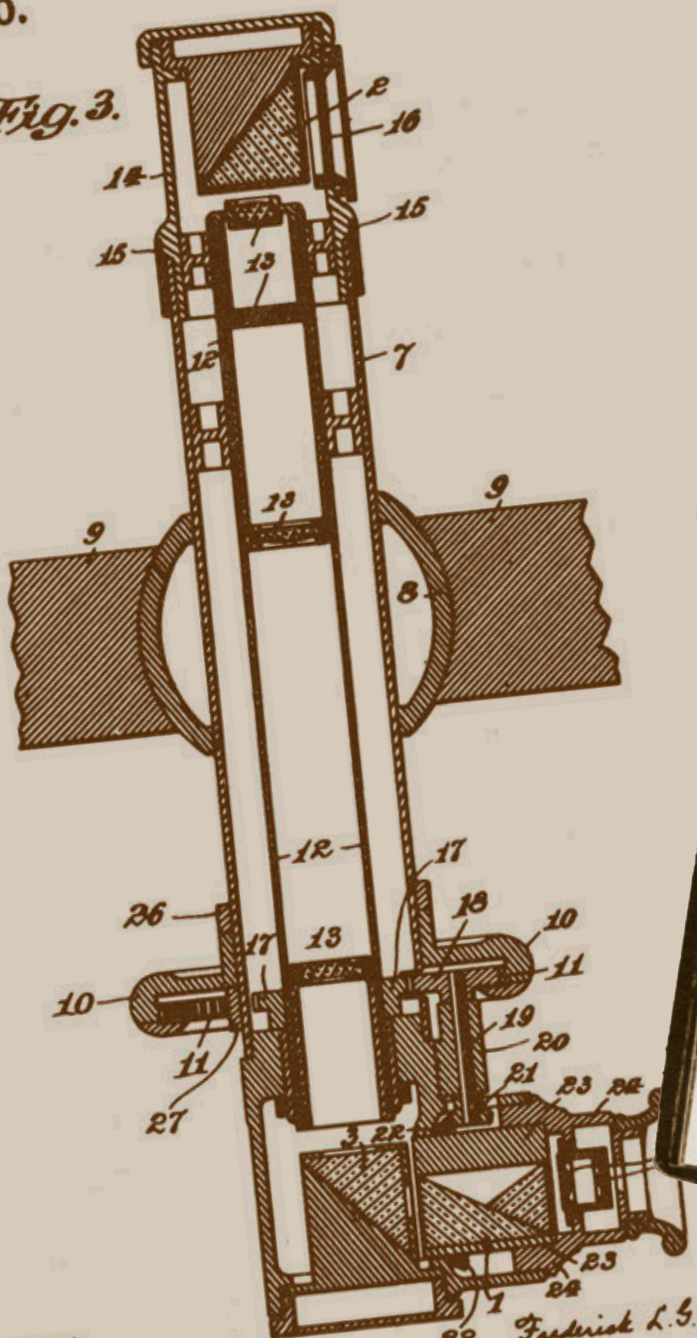
The Stettin area was impacted by the Industrial Revolution, causing many Pomeranians to emigrate, primarily to Berlin. This included the Kollmorgen family. They were living in Berlin in 1879 when Friedrich's father died at

F. L. G. KOLLMORGEN.
PERISCOPE.
APPLICATION FILED OCT. 28, 1909.

Patented Oct. 17, 1911.
2 SHEETS—SHEET 2.

06,230.

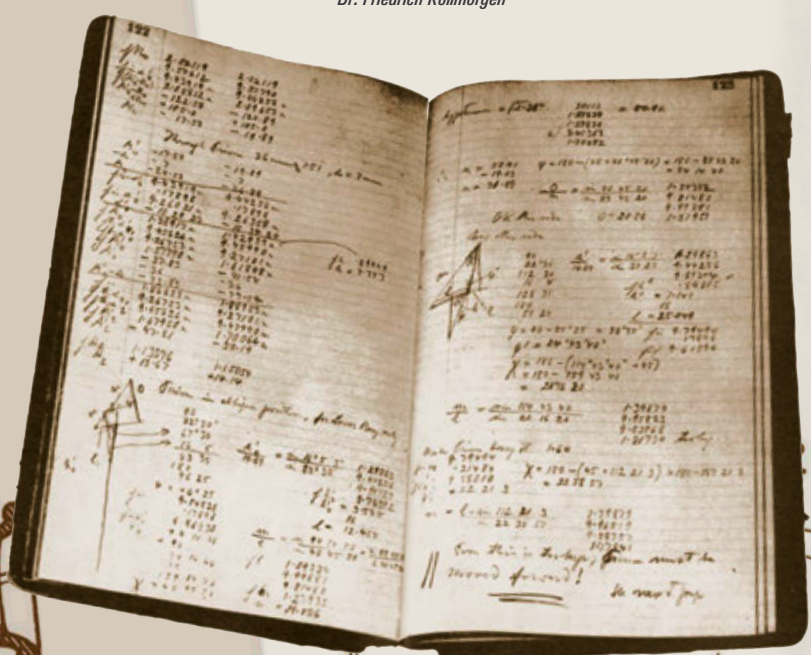
Fig. 3.



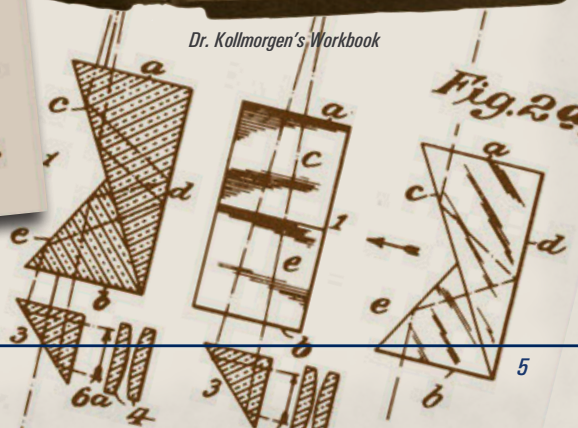
Inventor:
Frederick L. G. Kollmorgen
by William R. Baird his Atty.

Attest:
Daisy Easterwelt
Alan C. McDonnell

Dr. Friedrich Kollmorgen



Dr. Kollmorgen's Workbook



The Founder, Chapter I

the age of 43. The personal and political turmoil Friedrich and his family endured was certain to have influenced his desire to travel, navigate oceans, and design solutions to help influence world peace.

He married an English woman, Agnes Elizabeth Hunt, in Italy in April of 1896. The couple moved to Perlin, Ritteramt Wittenburg, Germany in 1900, then to London. Their first child, a son named Ernest Otto, was born in 1901 in Vienna, Austria.

In the 1900s, the number and comfort of ocean liners increased substantially, making transatlantic passageways affordable. This made it possible for Friedrich to depart from Liverpool, England to start a new life for his family in America. He arrived in New York City on October 4, 1905. Friedrich and Agnes would travel back and forth across the ocean until the entire family could be together. Ernest Otto arrived in New York in November 1907, daughter Hildegard was born in Austria in 1903 and arrived in the states in 1910. Three-month-old Dorthea arrived in November of 1914.

A strong German-American National Alliance, originally founded in Philadelphia during the 19th century, warmly welcomed Friedrich upon his arrival in the new country. In fact, between 1820 and 1870, over seven and a half million

Wilhelm J. D. Keuffel and Herman Esser

K&E Transit Scope

German immigrants came to the United States – more than doubling the entire population of the country. Pushed out of Europe due to shortages of land and religious or political oppression, many arrived seeking freedom, others for economic opportunities greater than those in Europe, and still others for the chance to start fresh in the New World.

Two other German émigrés, Wilhelm J. D. Keuffel and Herman Esser, who were active within New York's German-American community, started The Keuffel & Esser Co., the first American company solely devoted to drawing and drafting materials in 1867. The firm was successful and continually expanded, tentatively starting manufacture in 1870, opening a retail store in 1872, moving to 127 Fulton Street in 1878, and constructing a factory in Hoboken, N.J., in 1880-81. In fact, the Fulton Street building, which remained in use by Keuffel & Esser for nearly seven decades, is one of the best preserved and distinguished of the smaller late-19th-century office buildings in lower Manhattan today. Friedrich's optic skills proved to be a nice fit for the firm.

In 1911, Friedrich proposed the introduction of two telescopes into the periscope, instead of a series of lenses or prisms. Eliminating the need

" In fact, the Fulton Street building, which remained in use by Keuffel & Esser for nearly seven decades, is one of the best preserved and distinguished of the smaller late-19th-century office buildings in lower Manhattan today."

Photo credit Google Maps

The Founder, Chapter I

for prisms at the opening, or a series of lenses throughout. The new periscope could be built at a variety of lengths and the opening above the surface could be much smaller and more inconspicuous. This resulted in his first U.S. periscope patent.

By 1916, with World War I looming, the U.S. Navy asked Keuffel & Esser to design and build periscopes for the U.S. submarine fleet, but the company declined the offer. Friedrich saw a clear opportunity to attack an emerging market. He used his knowledge and imported French optical glass to develop the best periscope optical sets in the United States. He partnered with several principles from Eastern Optical Company and started his own company building periscopes destined for the K Class submarines. Their first contract was from the U.S. Navy for two periscopes.

According to reference material from Building American Submarines, 1914–1940, by Weir and Allard, "The magnitude of wartime demand and scarcity of qualified contractors presented a perpetual problem." In essence, only Kollmorgen, Keuffel & Esser, and Bausch & Lomb had the technical competence to build periscope optics. The U.S. Navy placed a request for bid for periscopes for the S-18 through S-41 build. Bausch & Lomb decided to no-bid due to limited capacity and other obligations. This left only Kollmorgen and Keuffel & Esser, who were late-comers to the periscope market. "Although the Keuffel & Esser price fell $92,400 below that of Kollmorgen, the latter could produce instruments of much higher quality," cites Weir and Allard.

Lowering periscopes to East 32nd Street, Manhattan, in front of the Kollmorgen plant in 1916.

Kollmorgen Optical Corp. was incorporated in New York on March 22, 1916. The large demand for periscopes and other optical instruments continued as World War I raged on, forcing the company to move into a larger facility in Brooklyn.

Soon after the war ended, Navy requirements for periscopes and sighting instruments dropped sharply. Friedrich, an expert of optics, began looking for opportunities in other markets. Films were really starting to blossom at the start of the 20s. In the U.S., film was being produced in or near Hollywood, California, in New Jersey, and in Astoria on Long Island (Paramount).

By the mid-1920s, movies were big business and Friedrich was able to engage with several filmmakers. By the end of the decade, there were 20 Hollywood studios, and the demand for films was greater than ever. In fact, according to the American Movie Classics (AMC) Company, the greatest output of feature films in the U.S. occurred during the 1920s and 1930s, averaging about 800 film releases in a year. This turned out to be the "bee's knees" for Kollmorgen, with many studios in high demand for quality projection lenses.

"Friedrich saw a clear opportunity to attack an emerging market. He used his knowledge and imported French optical glass to develop the best periscope optical sets in the United States."

U. S. Submarine "K-8" at rest
December 1, 1914

The Founder, Chapter I

Then the downturn of the Great Depression hit and, by 1933, some 13 to 15 million Americans were unemployed and nearly half of the country's banks had failed. Ever resourceful, Kollmorgen took rejected lenses and turned them into ashtrays to keep his machines running and a handful of people employed. It would take U.S. engagement in World War II for the economy and American industry to kick back into high gear – and when it did, government-funded development work ramped up quickly at Kollmorgen, with orders for driftmeters, bombsights, and sophisticated navigation instruments, as well as submarine periscopes.

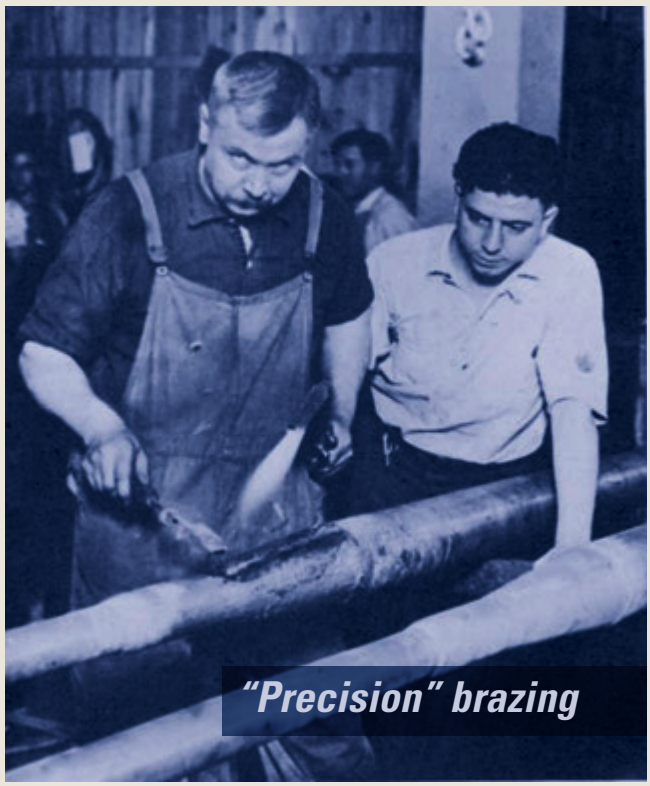
Kollmorgen also designed the first optical instruments using anti-reflective coating on lenses and was granted a U.S. patent in 1941 for making dies for molding contact lenses. According to historians, the idea behind contact lenses dates all the way back to Leonardo da Vinci. The Smithsonian notes, "in a 1509 manual, da Vinci wrote that he could alter his vision by sticking his face in a bowl of water." During the next few centuries, inventors sketched ideas such as "tubes held snug to the eyelids" and "capsules filled with animal jelly," but the contact lens wasn't actually manufactured until 1887.

A proud day for Kollmorgen workmen, as they pose with their first American-made periscope.

In the 1930s, prior to Dr. Kollmorgen's invention, contact lenses were made by molding a plastic mass, with "readily hardening character," directly to the eyeball. This process was expensive and resulted in a cast that could only be used once. The lenses also rested on the sensitive parts of the eye, including the cornea and limbus, making them uncomfortable. Dr. Kollmorgen's invention simplified and improved the die-making process, which brought down the costs and made the mold re-usable for future duplication. It also reduced wearer discomfort by avoiding putting pressure on the sensitive parts of the eye.

In 1940, submarine operators realized the major threat aircraft posed to submarines and convinced the Bureau of Ships to develop a new type of periscope that eventually became the "needle nose" Type 1 attack design. Kollmorgen offered a modified Type 1 periscope, dubbed the Type 2, that featured a tube tapered at its head which reduced the surface wake. The Type 2's field-of-view extended to 90.5 degrees of elevation, allowing the attack periscope to cover the entire sky, and it became known for superb optics and minimal wake. Although design tweaks would be made to enhance its depth, optics, and photo capabilities throughout the next few decades, the Type 2 periscope design remained a valuable asset into the 1990s. Another major innovation during this period was the advent of quality periscope photography.

The company grew rapidly from just over 60 employees to more than 600 in a span of just five years. Kollmorgen collaborated on the optical



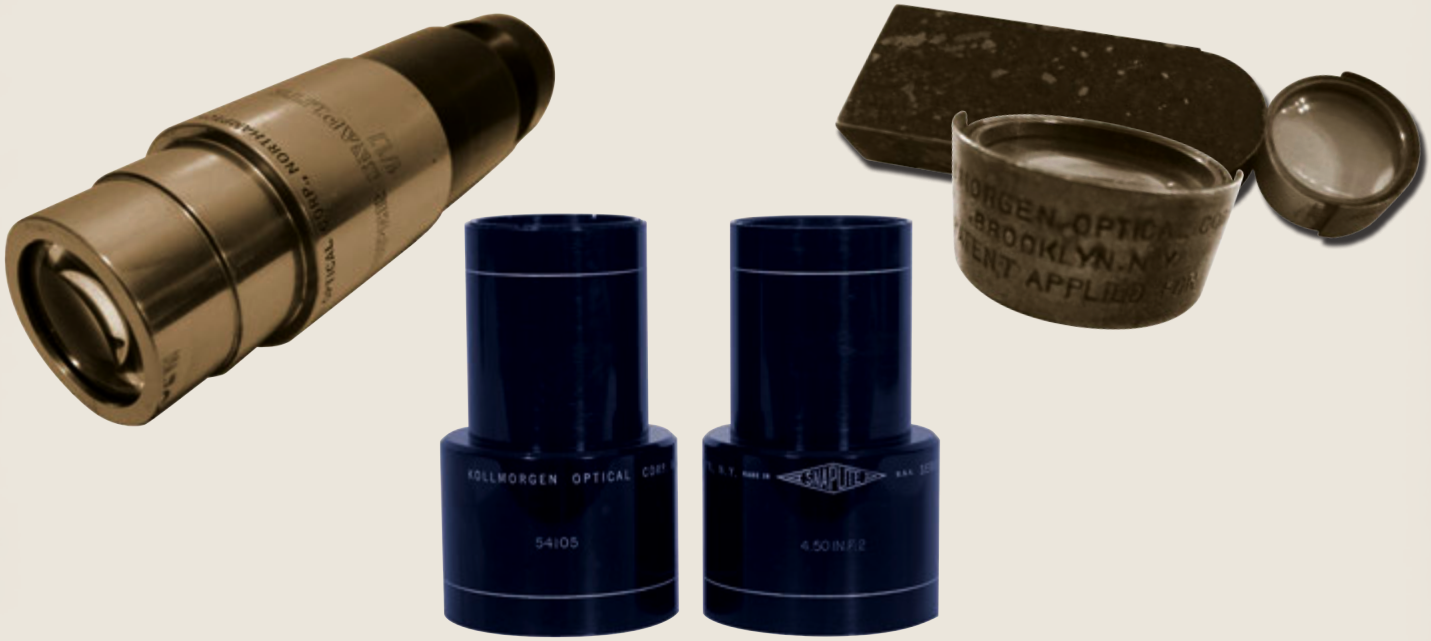
"Precision" brazing

systems for the Norden bombsight and also designed and built remote viewing devices for the "Manhattan Project."

When the war was over, business was thriving, and in 1946, Friedrich's son, Otto, was ready to take over as President of the company at 45 years old. In 1951, the company moved from Brooklyn, NY to North Hampton, MA. The father and son survived two World Wars and the Great Depression by focusing on their core talents in optics. They shifted with changing markets and came through the turmoil as a strong business.

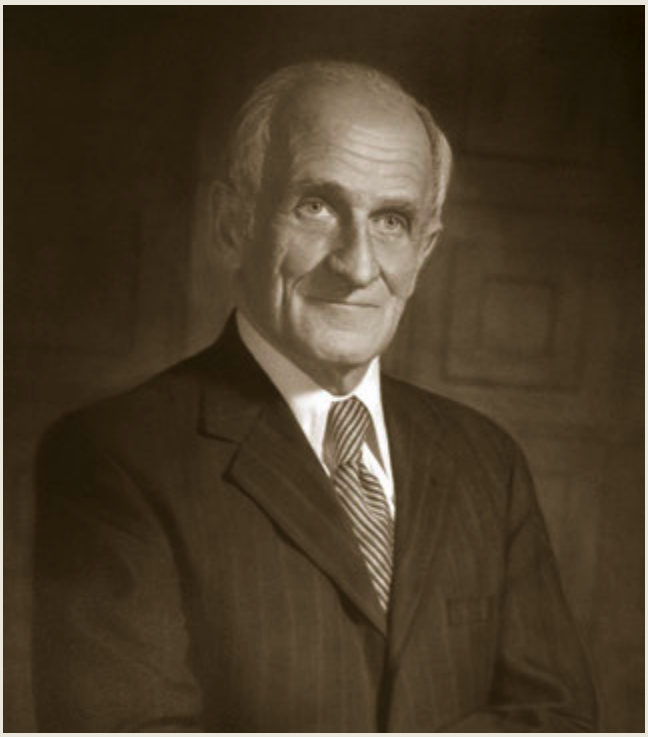
KOLLMORGEN

Kollmorgen designed the first optical instruments using anti-reflective coating on lenses and also made the first contact lenses in the U.S.



Both Presidents Dwight Eisenhower and John Kennedy admire the Kollmorgen periscopes of the day.

Hugo & Otto, Chapter II



Hugo Unruh

While Kollmorgen Optical Company continued to grow, another immigrant, Hugo Unruh, was growing up under the harsh conditions of post WWI Germany. Born in Dresden, Germany, in 1905, Hugo's family wished for him a better life and more opportunities. His parents knew he had big dreams and loved to experiment. When he was a young boy, he was always busy building things, including paper airplanes. In one experiment, he dipped cotton balls in alcohol and mounted them to the front of his airplane. He then lit the cotton ball and sent it soaring out his window, where it landed on the neighbor's roof and started a fire!

The conditions in Germany were so difficult that Hugo's family encouraged him to emigrate to the United States, despite the fact that he needed to finish his education. He arrived in America in 1924 and became a part of the German community in New York City. Hugo was able to finish high school and pay for two years of college while working as a repairman at an X-Ray company. He rented an apartment in Queens with his cousin, Walter Rothman.

He began to find his niche manufacturing various motors at Arnesen Electrical Company out of New York. Hugo was quite successful and as WWII pushed Arnesen to expand, Hugo became president of a subsidiary plant that manufactured aircraft motor generator sets in New Jersey (Ellacraft). He would move with his family to the borough of Harrington Park in New Jersey.

After the war, business dropped sharply, forcing the closing of the New Jersey plant. Hugo was pulled back into the parent company as a general manager. Soon thereafter, the original owner died and disagreements with the new owners left Hugo unemployed at the age of 42. Though his net worth was approximately $4000, it was always Hugo's dream to have his own business and he quickly saw an opportunity to purchase the used equipment and material from the remnants of Ellacraft to start his own company. He formed a partnership with Lewis Renaldi and the two men pooled their money to begin this new business venture.

The name "Inland Motor" derived from Hugo moving from being close to the ocean, living in Long Island in Queens, New York when he arrived in the U.S. and working close to the New York harbor for many years, and now his new company was landlocked "inland."

The duo's one big problem was finding an available facility, so in 1948, Inland Motor started operations out of Hugo and Lewis' basements, garages, and even the kitchens. Hugo's wife wound the first armatures and baked their insulation in the kitchen stove. The company's first employee, Tom Bain, described conditions as "quite crude."

Fortunately for the Unruh and Renaldi families, Inland Motor grew quickly, forcing production to move to an expanded garage in Pearl River, New York in 1949. Operating on a shoestring budget with no room for financial error, Hugo sharpened his already considerable skill at estimating production costs for specialty motors. Decades later, Hugo would be remembered posthumously as the best estimator in the business.

In his past job, Hugo had built generators and gyro spin motors for the MIT Instrumentation Laboratory. The laboratory continued to rely on Hugo at Inland, calling on his services to help address special rotating machine problems, such as those encountered in the early inertial guidance systems for missiles and space vehicles. The gimbal drives on these systems required an entirely new kind of motor. This led to the first "frameless torquers" designed by Hugo. The first stellar inertial navigation system developed by Dr. Charles Stark Draper, with Inland torque motors inside, are on display at the Smithsonian today. These revolutionary frameless torquers, would, in time, be available in hundreds of different shapes and sizes and become the fastest growing, most important part of Inland's business. In fact, by 1957, sales of frameless

Hugo designed the first "frameless torquers" used on early intertial guidance systems for missiles and space vehicles.

Hugo & Otto, Chapter II

torquers had increased and the Pearl River shop was bursting at the seams with 60 employees. Hugo and Lewis began to search even farther inland in hopes of reducing their operating costs through lower interest rates, building costs, and a facility able to accommodate the expanding business.

Although many cities offered to build a plant, Hugo was attracted to the city of Radford, Virginia. According to historical sources, Radford, or at least the train station area, was called Central Depot because of its central location halfway between Lynchburg and Bristol, Virginia of the original railroad, the Virginia and Tennessee Railroad (later the Norfolk and Western Railway). In addition to the railroad, Radford offered good highway connections and several trucking lines. Two area colleges would also provide a good source for technical people. Best of all, space was readily available – a city-owned building formerly occupied by Century Ribbon Mills.

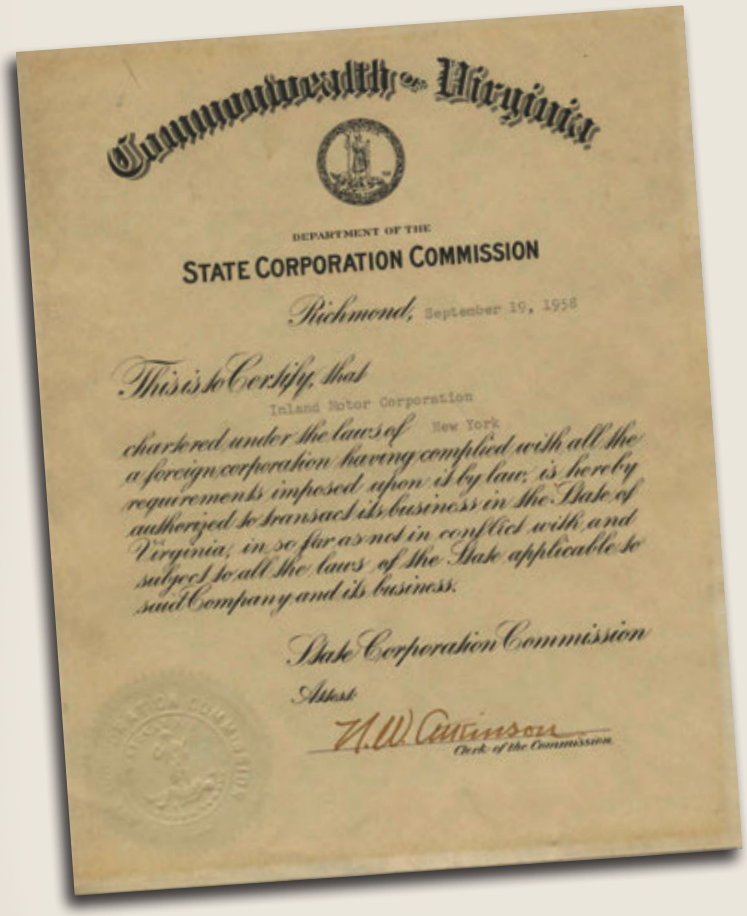
An article in the Radford News Journal reported the completion of the agreement between city officials and Lewis P. Renaldi, vice-president, secretary, and treasurer of Inland Motor Corporation on August 8, 1958. While legend has it that Hugo was able to secure the lease for the vacant mill at a rate of $1 a year, the initial contract was actually for an annual rental of $7000, with an option to purchase the building

1950's Inland Motor building in Pearl River, NY. The building is still standing and in use today.

at the end of the lease. Hugo Unruh was in town the week prior to meet with Councilmen, Radford Chamber-of-Commerce representatives, the State Chamber, industrial development director and an Appalachian Power Co. official.

On November 1, 1958, an advance party of six employees from the Pearl River plant, including Hugo, set up shop on 501 First Street.

During the period of 1948 to 1960, Inland Motor accomplished more than a dozen "firsts" in the industry. They ranged from direct drive DC torque motors and movie theatre projection motors to submarine periscope drive motors, electric drives, and Curtis Wright electric brake coils.



Commonwealth of Virginia

DEPARTMENT OF THE

STATE CORPORATION COMMISSION

Richmond, September 19, 1958

This is to Certify, that

Inland Motor Corporation

chartered under the laws of New York

a foreign corporation having complied with all the requirements imposed upon it by law, is hereby authorized to transact its business in the State of Virginia, in so far as not in conflict with and subject to all the laws of the State applicable to said Company and its business.

State Corporation Commission

Attest:

W. W. Gwinson

Clerk of the Commission

E. Otto Kollmorgen

Despite their success, Hugo thought the new Radford facility was too large for their needs. Little did he know that in just four years, the company would need all of the building's space, plus even more for administrative offices. By the end of 1960, all of Inland Motor was in Radford.

Inland Motor began to build torquers for periscopes and Kollmorgen was one of their best customers. Otto Kollmorgen, who was now president of the company, and Hugo had formed a nice friendship. A chief engineer at Kollmorgen, Herb Torberg, recalls, "In the late 1950s, Kollmorgen was very busy updating submarine periscope feature capabilities. As submarines began to delve deeper, faster, the periscope's

Hugo & Otto, Chapter II

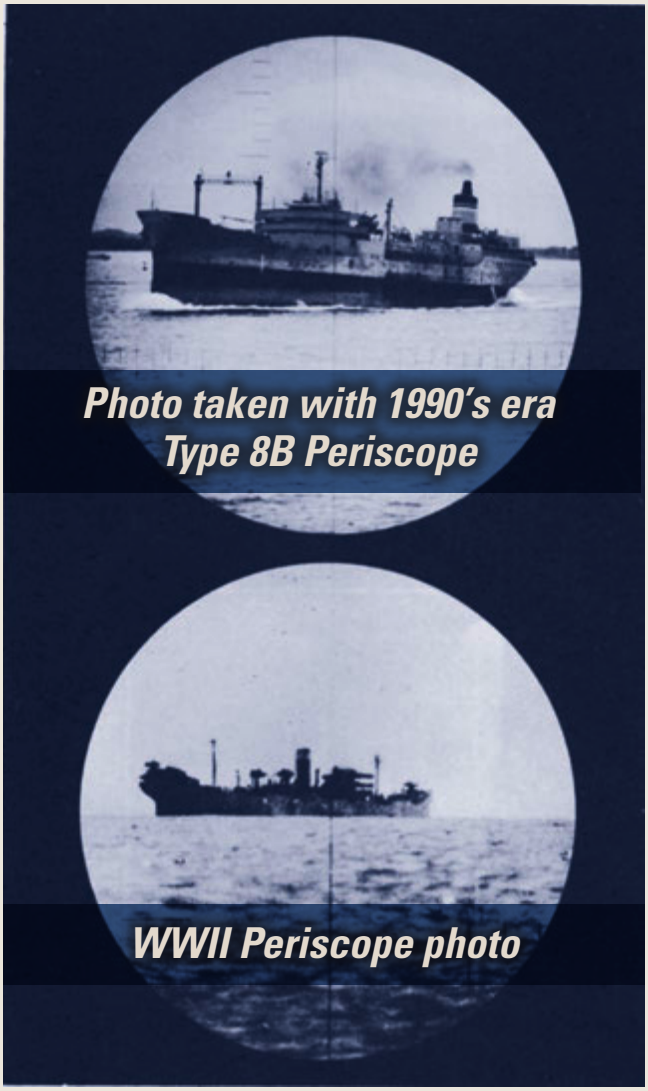


Photo taken with 1990's era Type 8B Periscope

WWII Periscope photo

role greatly expanded to include capturing clearer photographs, sextant navigation, passive electronic countermeasure, and easier turning for the operator. The company had three separate contracts to design and build periscopes for each of these functions. The training assist was an adaption of an earlier design that embodied a high-speed motor, magnetic particle clutches, and a complicated and special gear train. Additionally, we were deeply involved with the high priority Polaris program for the concept of the navigation system. At a concept meeting with Detroit Controls (Norwood, MA), the notion of supporting the periscope in hydrostatic bearings was proposed. Since a servo motor with a big hole in its axis was needed, John Harper suggested a torque motor. A torque motor? What was that? Detroit Controls had been adapting the work of Draper Lab to use torque motors for gimbal drives in gyro platforms. John put me in touch with John Luneau, the chief electrical engineer at Inland Motor, Pearl River, New York. An engineer, Art Hess and I went to Pearl River and found Inland Motor in a complex of attached garages and John Luneau in a modest office. In short order, we had a design and proposal that fit our needs for a replacement for the complicated and expensive high-speed motor drive design. The prototype worked just fine. We combined all three contracts into one that became known as the type 8B. The

Kollmorgen was key to the development of the Polaris navigation system.

Navy was delighted and pressed for accelerated delivery."

In 1960, Inland Motor celebrated its first million-dollar year with business expanding in several directions, including a new division that focused on motor generator sets. Its core product, torque motors, was still the fastest growing business. The post WWII need for periscopes continued to keep Kollmorgen busy as well. Both Inland and Kollmorgen were being stretched to the limit. Kollmorgen had the resources to help Inland and it soon became apparent to both Otto and Hugo

THE NEWS JOURNAL, Radford, Va. Mon. Oct. 29, 1962

Inland Dedicates New Building Today

Inland Motor Corp. New Office Building

Governor Harrison, Other Notables To Attend Ceremonies

Inland Motor Corporation dedicated its new $180,000 office building today.

Present were the Governor of Virginia, Albertis S. Harrison, Jr., State Senator Harry Byrd, Jr., and many other notables locally and throughout the state.

[illegible]

Hugo Dersh

Gov. Albertis Harrison

[illegible]

Inland's New Home One Of City's Finest

Inland Motor Corporation's new building is one of the most attractive buildings ever built in Radford.

Located on the corner of First and Wadsworth Streets, the modern new structure replaced a three-story brick building which has stood on the site for many years.

The property was purchased by the city earlier this year in order to provide an adjacent building to the manufacturing portion of the Inland Motor Corporation plant.

Construction was begun in May of this year and the structure was completed just a few days ago.

The design was created by Winston S. Sharpley, A. I. A., Roanoke, and the contractor was A. L. Parris and Company, Salem.

The building has a concrete foundation, walls of concrete masonry units, brick faced, steel roof and floor structure, exposed brick and concrete masonry units on the inside and metal roof deck with a built-up roof.

For all year round comfort the building is air conditioned. Cooling or heating is obtained by the use of hot and chilled water which is connected to fan coil units in the individual offices with heating and cooling augmented by ducted air.

Modern lighting is used throughout the new building. It is achieved with both fluorescent and incandescent fixtures with lighting calculated to produce an optimum amount of light at each work task level. Lighting in the Basement Model shop is of high intensity for close tolerance machining.

Vinyl asbestos floor tile is used throughout offices on the main floor and the reception area. Ceilings are mainly of glass wool acoustical tiles supported on an exposed grid.

The split level reception area features a suspended stairway with open, carpeted treads and landing. The rear wall of the reception area opposite the entrance from First street is of standard concrete masonry units laid in an attractive pattern with "wall washing" lighting to accent the wall and stairway.

Colors in tones of blue were coordinated throughout the building to produce a light, pleasant but efficient atmosphere which is conductive to the type of work being performed.

Since there are a number of women employees, rest rooms were provided with vanity counters for their convenience.

The exterior features a metal fascia and a metal entrance frame one and a half stories high. Steel was used for this so that colors could be introduced to accent the main entrance. Exterior colors are slate gray and platinum white which offers an interesting contrast to the brick red exterior walls.

The building, which cost about $180,000 is a forward movement ahead for both Inland Motor Corporation and the City of Radford, both of whom cooperated on the design and construction of the new building.

This view shows the manufacturing portion of Inland Motor Corp.

Old Building Erected 1903

Today, a modern building houses the offices of Inland Motor Corporation on the site where much history of Radford passed by.

[illegible]

THIS PICTURE SHOWS the old building, razed earlier this year, to make way for Inland's building dedicated today. This old building was known for many years as "Shelor Building"

Hugo & Otto, Chapter II

that joining forces would be mutually beneficial. Hugo felt he could solve the company's capital shortage problems without losing much of his independence. The broad capital base of Kollmorgen, combined with the reputation of Inland Motor, led to a deal. In May, Kollmorgen Optical Company and Inland Motor Corporation merged and became a publicly owned company: Kollmorgen Corporation,with sales volume totalling $8.5 million.

The division also moved ahead in manufacturing motors of various types to be used in the Aerospace program. This diversification and the expanding commercial market prompted five expansions in just 12 short years of operation in Radford.

Hugo instilled a sense of family into the company. The Radford Theatre would be rented every Christmas season and Hugo would hand out gifts dressed as Santa Claus.

In 1962, an administrative wing was constructed – touted by the Radford News Journal as one of the most attractive buildings ever built in Radford. The building featured air conditioning, modern fluorescent and incandescent lighting, and vanity counters in rest rooms to accommodate a growing number of female employees.

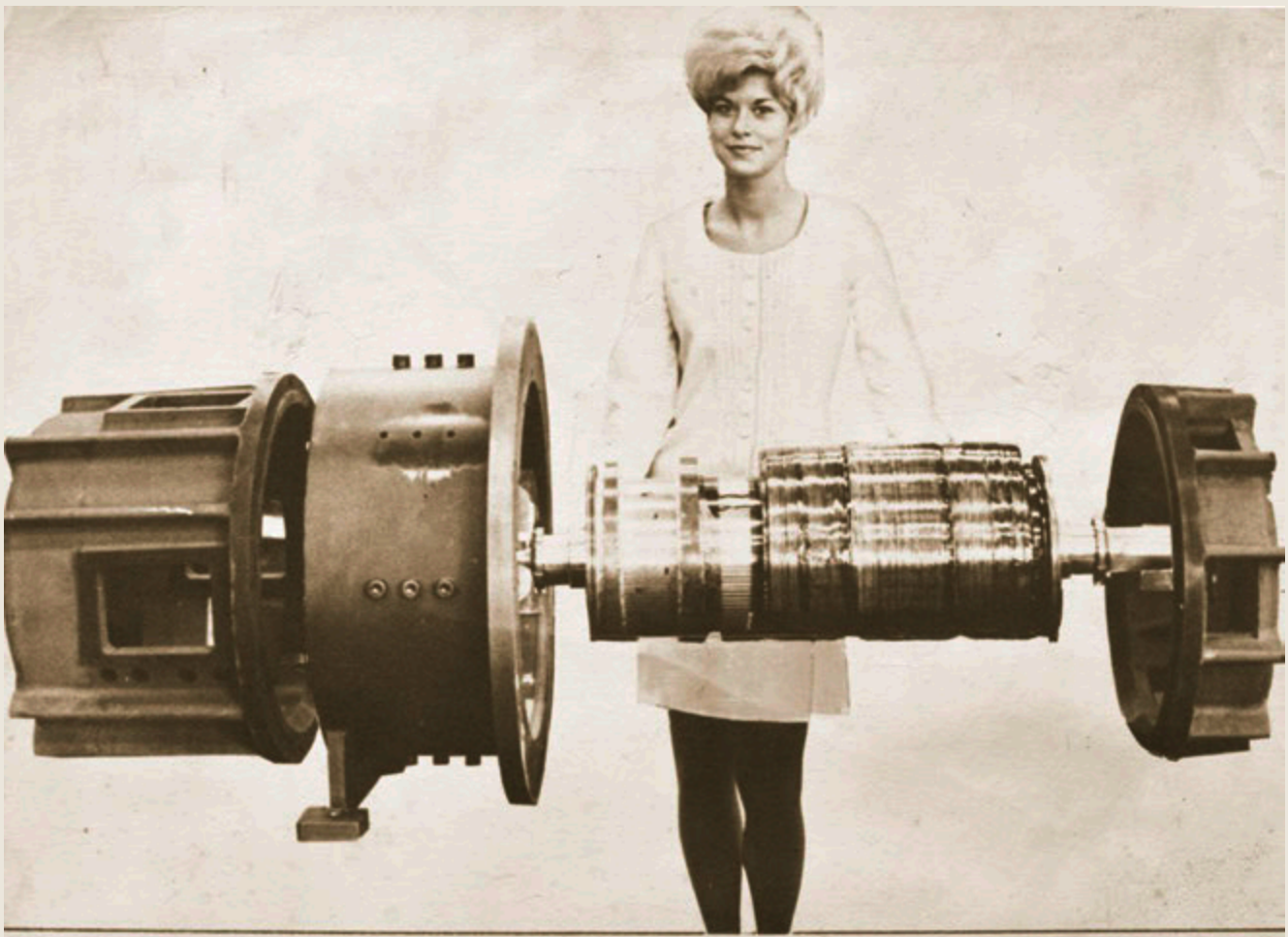
In 1965-66, an additional 8,000 sq. ft. was added on the manufacturing section of the plant. In 1968, the company occupied an additional 8,000 sq. ft. facility, known as Plant 2. In the spring of 1970, the former City Administration Building, which had been remodeled, was occupied, providing an additional 4,000 sq. ft. of manufacturing space for electronic components.

One of the women hired by Hugo in 1959 was Ute Midkiff. Ute met and fell in love with an American soldier while he was stationed in Germany. They became engaged after dating for two years, however before she was allowed to follow him to Virginia, her parents made her wait one year, until she turned 19. She came to the U.S. in 1958 to get married and in 1959, Hugo asked her to come and work for him at Inland Motors.

Hugo must have had a keen instinct for knowing a hard-working person when he met one since Ute continues to work for the company as a Quality Engineer 57 years later! She has held many positions over the years: working in the winding department and then heading up a test department where she was the supervisor for many years.

Hugo never rested on his laurels and expected others to follow suit. Whenever Otto visited the plant, the two men would walk down the center of the plant to observe operations. One day, they surprised an employee who was sitting with his feet propped up on the desk. By the time Otto and Hugo got back to Hugo's office, the gentleman no longer worked for the company.

One day, Ute asked Hugo why he still had such a heavy German accent after living in America for so many years. Hugo told her it ensured his engineers would listen closely and pay careful attention to his every word.



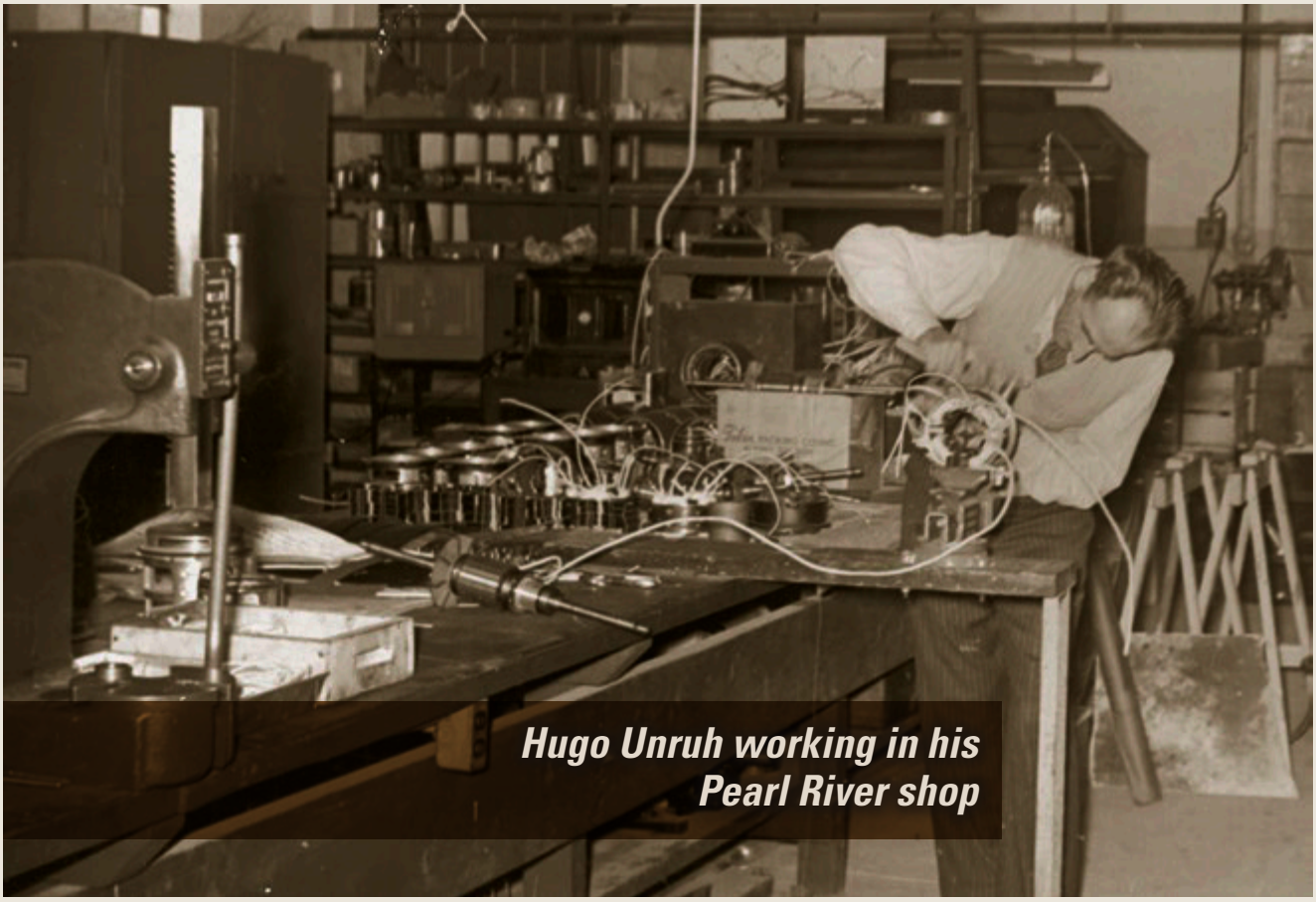
At this point the racing motor was ready to be assembled. The motor's four main parts are from the left: rear housing, field magnet housing, armature and commutator core, and front housing. The only moving part, the armature, spins freely upon ball bearings the size of billiard balls. Only four weeks were needed by Inland to build this unique motor from the designer's plans.

Hugo & Otto, Chapter II

Ute Midkiff

Ute would take a lesson from Hugo's management style to ensure her students were taking notes when she taught soldering classes. She wouldn't hesitate to shake a bat, which was a gift from a student and featured Ute's name engraved on it, to "wake somebody up" to the importance of the job before them and to adjust their attitude! While this has been a running joke among her students over the years, she remains serious when it comes to quality. "Integrity and quality are still important today," said Ute. "I'm very proud of this company… I've tested motors for parts that are sitting on the moon, used for a heart pump, X-ray machines, and Trident submarines. When soldering, there's so much on the line. If the motor quits, someone's life is on the line."

Doug Austin, another long-serving employee of 56-years, shared Ute's sentiment. "I took my family to NASA and was proud to show them the parts we made that were on the lunar rover," said Doug. At 74-years-old, Doug still enjoys the custom machine services his group provides and the challenges of what each new day and application may bring.



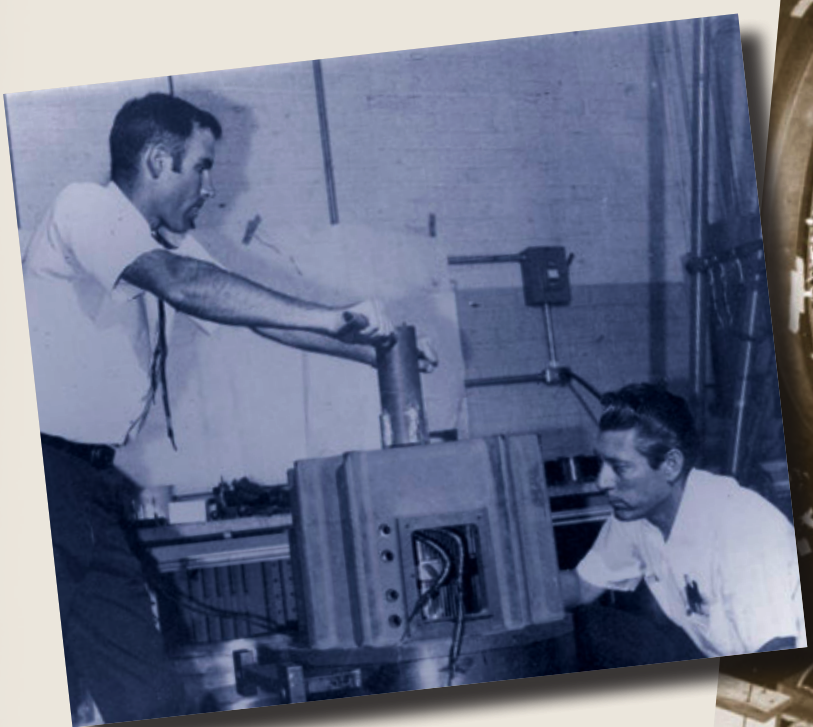
Hugo Unruh working in his Pearl River shop

Though known as a hard task master, Hugo believed in family and instilled a family environment in Radford. Employees were able to relate to him; and his fondness for them was apparent. He was not only very generous with employees, but also the surrounding community. Carrying on the German tradition of Santa Claus and Christmas, every year Hugo and Otto made the holiday a big family event. Hugo would rent the Radford Theatre and dress up as Santa Claus. The children and grandchildren of every employee would be treated to a present from Hugo.

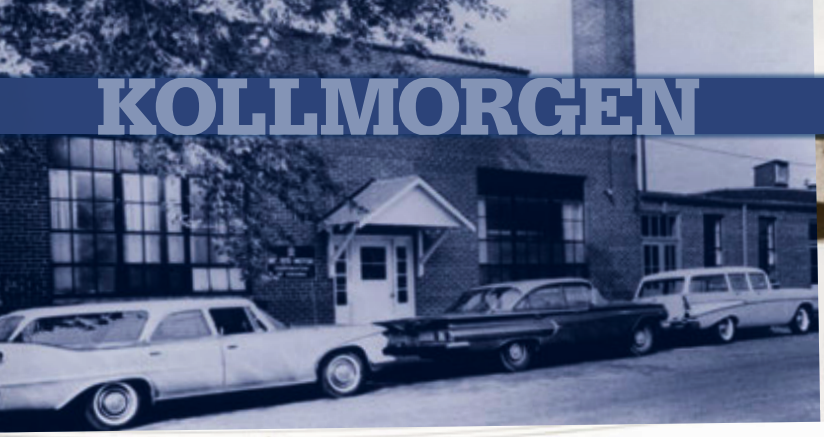
At home, Hugo's tinkering in the kitchen led to delight and discord. As a cook, his German meals and potato pancakes were legendary. Other experiments, however, didn't receive such rave reviews. One day, Hugo received a phone call from Sears, Roebuck, & Co. They needed Hugo's expertise in building a motor for a new kitchen tool, a garbage disposal. Hugo hooked up his prototype motor to the kitchen sink while his wife observed. When the tile cracked and the sink bent, Hugo stepped back and calmly said, "I guess I need to go buy a new sink."

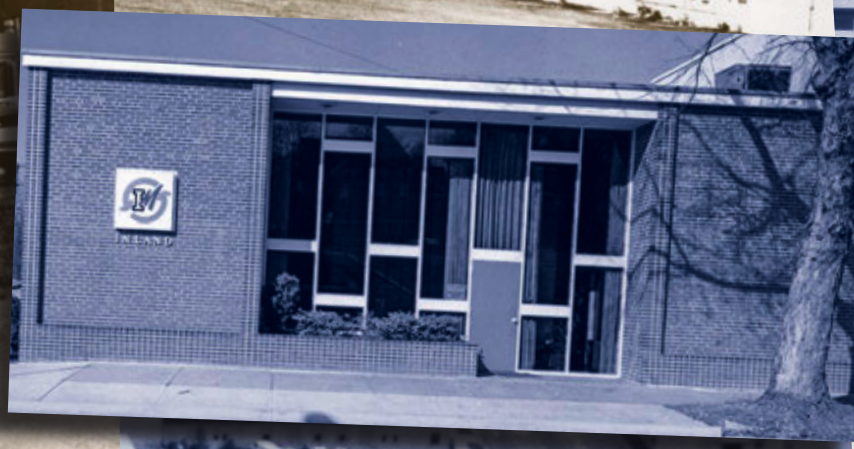
Hugo retired on December 31, 1970, ending an era based on the strength of one man's imagination, ingenuity, and dreams.

After his death in 1979, the Industrial Drives and Inland Motor division sponsored an annual Hugo Unruh Award in memory of their founder and in recognition of personal service and contribution to community development.

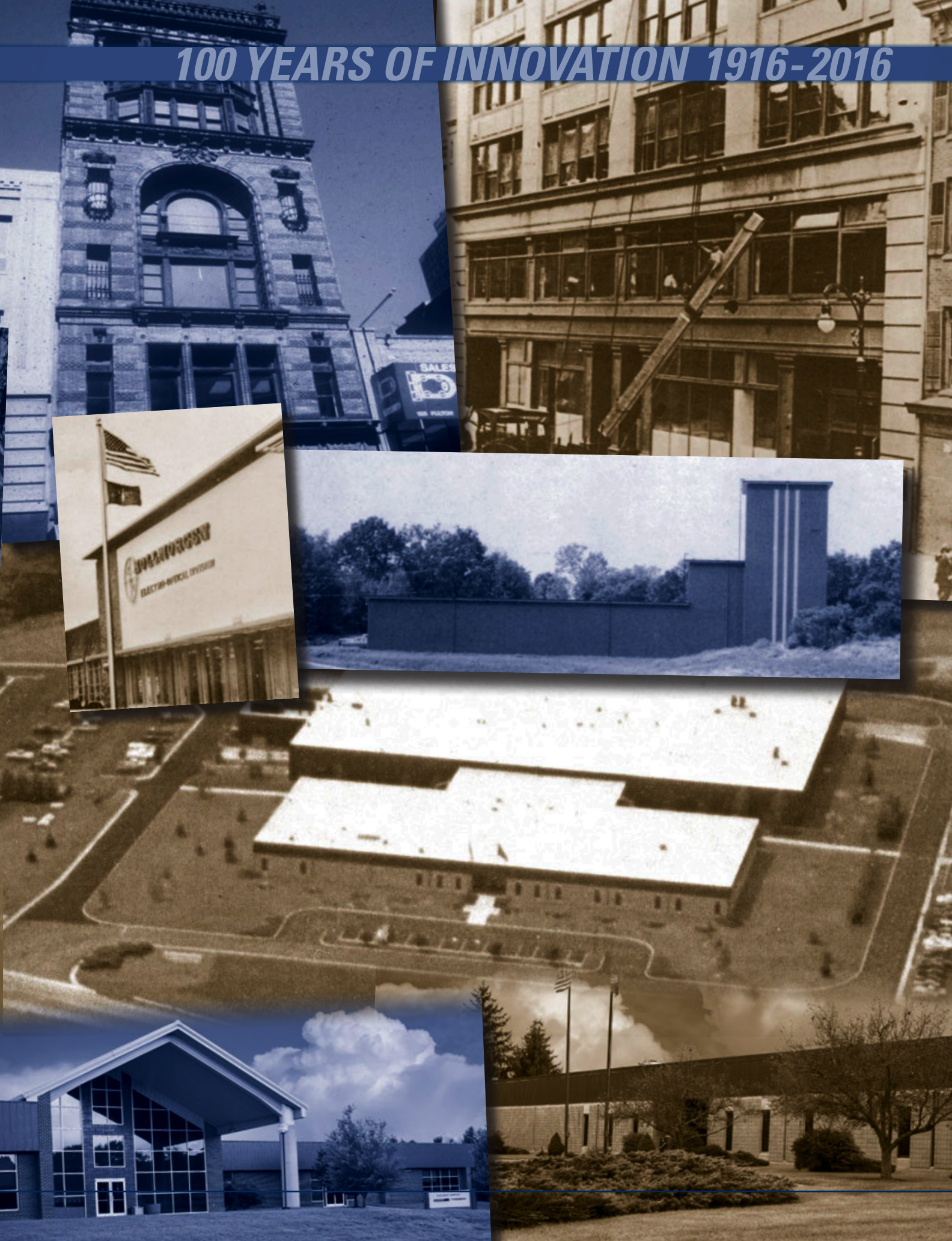


KOLLMORGEN





100 YEARS OF INNOVATION 1916-2016



IDD & EOD, Chapter III

James Howlett
President of Inland Motors 1970 - 1978

In the military sector, Inland became the preferred supplier for gimbal drives in all U.S. sea-based missile programs.

While innovations such as the floppy disk and VCR were being introduced at the start of the 1970s, Kollmorgen's Inland Motor and Electro-Optical divisions continued their growth through the introduction of numerous innovative solutions. By 1990, when the Hubble telescope was launched into space, Kollmorgen was firmly established as the leader in the markets it served.

Inland Motors post Hugo

After Hugo's retirement in 1970, James Howlett became president of Inland Motors. This was a time of prosperity and rapidly advancing technology that would include microprocessor controls and high power switching electronics. 1972 was a year of many "firsts" for Inland Motors: the first to propose a flux forcing concept in motor design; the first to use samarium cobalt and neodymium boron rare earth magnets to enhance motor performance and reduce size; and one of the first to design brushless motors.

European export business had increased, creating the need for a foreign base of manufacturing in order to better supply the overseas market as more than 20 percent of Inland's U.S. production was destined for use in European Countries. With sales offices already in England, Germany, and France, Inland was looking to the future with great promise for continued growth. Inland Motor began manufacturing at a facility in Ennis, Ireland to serve European customers in 1973. Hugo Unruh acted as a consultant for the move to Ireland.

From 1974 to 1979, Inland Motor Division experienced extraordinary growth. Sales nearly doubled, from $79.1 million to $154.5 million, while earnings almost tripled, from $3.3 million to $9.8 million.

Several name changes did not alter the employees' commitment to engineering excellence and innovation, including the development of brushless submarine motors, multi-axis drives, the first use of rare earth magnets in industrial motors, and the introduction of modified version of industrial servo motors to military applications. Renamed the Industrial Drives Division (IDD), the division was known as a technological leader in supplying motors to the machine-tool industry.

In 1979, an increasing market in the western portion of the U.S. resulted in expansion into a facility in Sierra Vista, Arizona. And by mid-1982, continued

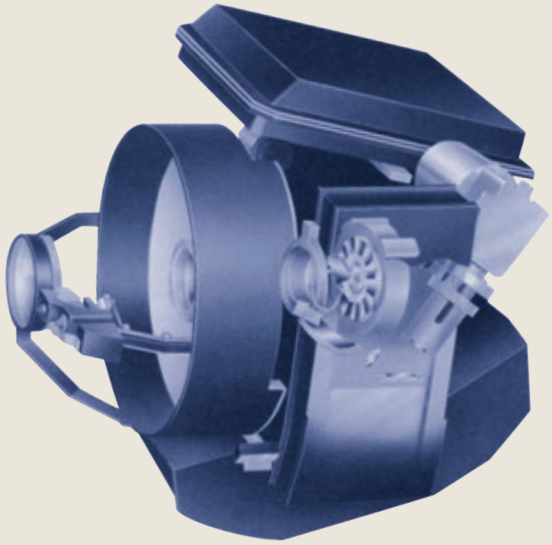
growth in the commercial overseas markets and wider military and aerospace applications affirmed the requirement for more space in both the Radford and Sierra Vista facilities.

By late 1981, the division's board members became concerned that the industry was undergoing fundamental changes, primarily from a flood of Japanese imports, and sought to diversify into more attractive market segments. In the second quarter of 1982, the national economic recession caught up with the machine-tool industry. The division's bookings dropped by 40%. Business continued to decline throughout the year until, finally, IDD reported a loss during the first quarter of 1983.

Undaunted by the losses, IDD, led by Skip Griggs, had been working diligently in groups, exploring other potential markets, including robotics, military systems, and general automation. Given the autonomy to problem solve and experiment with only guidance from the division's board of directors, Griggs and his team successfully introduced some 20 new products during the remainder of 1983. By year-end, machine tools accounted for only 40% of the division's total business, compared with 80% in 1982, as IDD's product line continued to broaden. The motor line added brush-type DC, brushless, VFAC and high-speed spindle motors. The drive line expanded as well. With SCR and PWM drives, sine wave and six-step brushless controllers, DC spindle drives, modular drives, single-board drives, variable frequency AC drives, and unity form factor SCR drives.

In 1983, the Inland Technology Group was formed to seek new markets for innovative products that had been developed by Inland engineers while the Inland Motors Defense Product Group purpose designed, marketed, and manufactured state-of-the-art electromagnetic motion control devices for the domestic and international defense industry. Defense contractors included Raytheon, General Dynamics, General Electric, Hughes Aircraft,

1980's concept of a "future" submarine control center



The MICRO-FLIR®

IDD & EOD, Chapter III

Ray Hoyt
President of Inland Motors 1978 - 1987

Texas Instruments, Singer Kearfott, and Martin Marietta. In the military sector, Inland became the preferred supplier for gimbal drives in all U.S. sea-based missile programs, from the Polaris in the 1960s, to the Trident II in the 1980s. By the late 1980s, Inland was a key supplier of torque motors on such strategic programs as the Phalanx, Goal Keeper, Sparrow, AMRAAM, and Bradley fighting vehicle.

A Specialty Products Group was responsible for the traditional product line. This group was by now globally respected for high performance and quality, and sought after by designers in aerospace, robotics, process control, machine tool, defense, and medical instruments. Customers included Westinghouse, G.E., IBM, Bendix, Eastman Kodak, DuPont, 3M, and Union Carbide. In the commercial marketplace, Inland motors were used in hundreds of diverse applications, including airborne automatic pilots, data recorders, X-ray machines, blood pumps, and numerous automated process lines where customers demanded precision motion control devices to increase productivity.

By the late 1980s, Kollmorgen's Industrial Drives Division was still the company's most consistent financial performer. Inland Motor's original patent on the torque motor, the product on which the company was founded, proved to be the first of many. Many patents were based on the innovation of casting magnets directly on the rotor, resulting in the first brush-type motor with an inside-out design; and patents on a control system for synchronous brushless motors, a laser undercutter used in the manufacture of commutators, and in electronics. Among the most important patent was one which improved output current form factor to SCR phase-controlled drives. This development solved major PWM disadvantages by allowing the use of rugged, reliable and less expensive SCRs in the production of the three-phase unity form factor drive.

Through the decades, Electro-Optical Division (EOD) continued to be the preeminent technological and experiential leader in the design and manufacture of submarine periscopes for the U.S. Navy. And at the start of the 1990s, it held the leading market position in the international marketplace as well.

In the early 1980s, the division was able to develop proprietary technology through internally funded research and development. This resulted in the development of a modern periscope, an infrared night vision system, MICRO-FLIR, and a non-penetrating mast system designed for the U.S. Navy's submarines. EOD was also the only U.S. supplier of high performance, wire-heated pressure windows for deep submergence sensor applications.

Captain David Portner, the Program Manager for the Imaging and Electronic Warfare Program Office, commented in Undersea Warfare Magazine, "Today's periscopes are based on the same fundamental principles of prisms, lenses, and telescopes of their predecessors. Over the last 100 years, submarines progressed from having to porpoise at the surface to see outside, through crude viewing devices fixed in height and direction, to present hull-penetrating, multi-purpose, camera-equipped scopes. This gave boats a clear view of the outside world from up to 60 feet below the surface, yet protected them from being revealed." Kollmorgen's revolutionary Photonics Mast was considered the next generation in submarine optics. The infrared camera was located in the lower rectangular housing, while the optical cameras and laser range finder were located directly above. A mission critical camera was on the right and the mast head was topped by the antenna assembly. It was considered a state-of-the-art system aboard the USS Virginia.

EOD was also a major supplier of armored vehicle sights for the U.S. Army M-1 Abrams main battle tank, the Bradley Fighting Vehicle and other military vehicles.

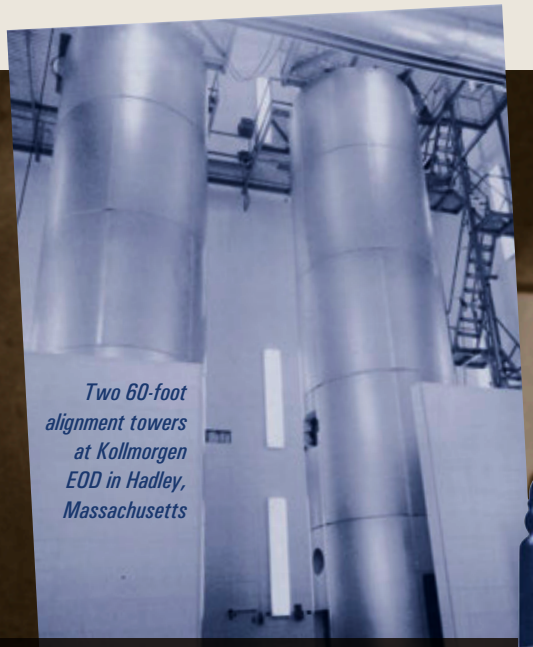
Kollmorgen's revolutionary Photonics Mast was considered the next generation in submarine optics.

KOLLMORGEN

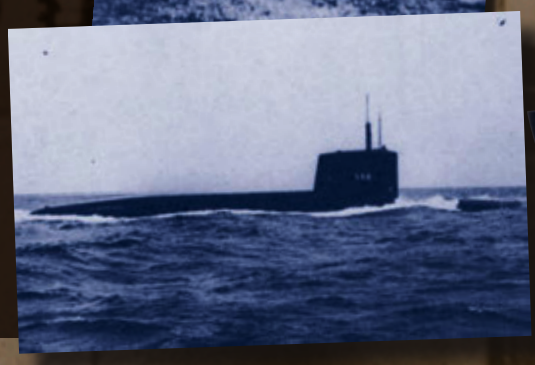
This year marks the 100th anniversary of Kollmorgen Corporation, the company that designed and built the very first submarine periscopes in this country in 1916 for the U.S. Navy. Until the periscope and optics division was sold to L3 in 2011, Kollmorgen had devoted an unbroken ninety five years of effort improving and perfecting the periscope to the fine instrument that it is today. From early WWI era K-1's to today's Virginia Class submarines, we at Kollmorgen are proud of the intimate part we have played in maintaining the superiority of the American submarine.

Model 76 Remote

Type 2A | Type 2D | Type 14 | Type 4 | Type 8B | Type 15 | Model 76



Two 60-foot alignment towers at Kollmorgen EOD in Hadley, Massachusetts



Kollmorgen's Type 11 Star Tracker Periscope pushed the technological limits in the 1960s and allowed the POLARIS missile subs to navigate with no reference to outside navigation data.

Model 90 Remote

Model 90 | Type 11 | NPP - Non-Penetrating Periscope

Mergers, Moves & Acquisitions, Chapter IV

Otto Kollmorgen and Admiral Raborn

Through the decades, Kollmorgen has experienced significant ups and downs. Its resiliency has enabled the uniting of companies that were founded by technological pioneers who were committed to being first to market with the newest and best products. Like-minded entrepreneurs joined together with the goal of growing and meeting emerging market needs. They understood the trials and tribulations of starting from humble beginnings to building companies that were technological leaders in their respective fields – and they liked to win.

The company's pioneers understood the trials and tribulations of starting from humble beginnings to building companies that became leaders in their respective fields.

Kollmorgen's diversification through acquisitions and mergers started in the 1950s when Otto Kollmorgen retained Arthur D. Little to help identify high technology companies in related fields. The smooth and successful incorporation of friend Hugo Unruh's company, Inland Motor, in 1960, could have whetted Otto's appetite for growth and expansion. The next three decades saw a flurry of acquisitions, mergers, and spin-offs for the company.

In 1961, Kollmorgen acquired Instrument Development Laboratories, a manufacturer of motor driven high-speed rotary switches, colormeters, and spectrophotometers. Then, Solid State Instruments Corporation, a manufacturer of precision rate tables, power supplies, and electronic drives for dc servo motors joined the fold in 1962. They were renamed Inland Controls to emphasize their close affiliation with the Inland Motors Division.

Kollmorgen suggested a merger with Macbeth Corporation in 1967, pointing out the synergy of its color and spectrophotometry business with the Macbeth product lines. Renowned innovator Norman Macbeth saw the opportunity as a way to fast track the realization of his dream of a complete approach to the light and color instrumentation and standards markets.

Founded in 1915 by Norman's father, the Macbeth Artificial Daylighting Company made lighting products that incorporated a filter to convert the warm tones of incandescent lamps to light that approximated daylight. Retailers in New York City quickly started buying up the company's fixtures.

Norman grew up watching his dad run the business and when he reached his teenage years, he'd accompany his father on sales trips to help carry and demonstrate the lighting equipment system. In 1936, Norman entered MIT to become an illuminating engineer; however, the unexpected death of his father during his freshman year forced him to make a choice between seeing his father's small business fail or following his relatives' advice to continue his education. Norman, characteristically, went for broke. He became president of the Macbeth Daylighting Company with three employees at age 19 in the middle of the Great Depression.

By 1950, Macbeth had 15 employees and moved from New York City to Newburgh, N.Y. Norman secured a contract from Ansco to build color densitometers and would later negotiate a license to make and sell these instruments under the Macbeth name. From the early 1950s to mid 1960s, Norman negotiated exclusive U.S. sales and distribution rights for xenon arc lamps made by Osram in Germany. Special lighting units were manufactured for surgical field units during the Korean War. Norman made numerous long trips to Europe to set up distribution of Macbeth products there. In 1955, the company moved to New Windsor, NY. A decade later, Macbeth became a substantial and profitable company with sales of $4 million, the largest portion of which was in densitometers. Norman was a key man in the various technical societies in the field of light and color and the recipient of many industry awards for his contributions.

To Norman's delight, Kollmorgen brought the Munsell Color Company, the internationally recognized manufacturer of precise color standards, into the fold in 1971. In 1972, the Color Systems Division and Munsell Color Company were merged with Macbeth, creating the Macbeth Color and Photometry Division. In 1989, Macbeth acquired a German-based manufacturer of spectrophotometer systems and in 1997, the Gretag Color Control System Division of Gretag AG, producers of the first portable spectrophotometer, merged with the Macbeth division of Kollmorgen Instruments Corporation.

Macbeth®
A division of
Kollmorgen Corporation

Kollmorgen continued on with its diversification plan by acquiring Photo Research Corporation, a manufacturer of photometers, in 1968. One year later, three more companies involved in related technologies were brought on board. Goerz Optical Company, a manufacturer of precision lenses, rate table and cinetheodolites; Laboratoire LERES S.A., a French manufacturer of reflectance spectrophotometers; and Artus, S.A., another French company that made precision servo motors, primarily for aircraft and military applications. However, both Goerz Optical Company and Laboratoire LERES S.A proved unsuccessful. In 1971, Goerz Optical Company discontinued lens production and the remaining operations merged with Inland Controls and finally sold three years later. The unprofitable Laboratoire LERES was bought back by a former owner in 1975.

Mergers, Moves & Acquisitions, Chapter IV

Meanwhile, while the world was being revolutionized by a reinterpreted musical industry that featured the rising talent of Elvis Presley, the Beatles, and the Rolling Stones, engineering pioneer Robert Swiggett stood poised to rock the electronics industry.

Robert "Bob" Swiggett started working as a project engineer at Powers Chemco, a Glen Cove, New York manufacturer of film, chemicals, and equipment for the photoengraving industry in 1949. When a co-worker showed him a U.S. Army Signal Corps report on graphically produced patterns with crude copper patterns on a phenolic base, Bob was intrigued. He and a colleague began research and designed some etched patterns of what they thought a printed circuit would be – and then exhibited them at the Institute of Radio Engineers annual convention. The show, plus many educational sales calls, resulted in sample orders from RCA, G.E., and Delco Radio – forcing Bob and his staff of two to begin production in Chemco's basement.

Sales of printed circuit boards reached $50,000 in 1951 and Photocircuits Corporation was officially formed with John D. Maxwell as President, Bob Swiggett as Executive Vice President, and a support staff of five. Then Photocircuits developed the basic building blocks of the printed circuit process – epoxy-glass laminates and plated-through holes – in 1952. The following year, IBM received a contract for SAGE computers for the DEW radar line. Lincoln Labs, developer of the prototype computer, recommended packaging that included two-sided,

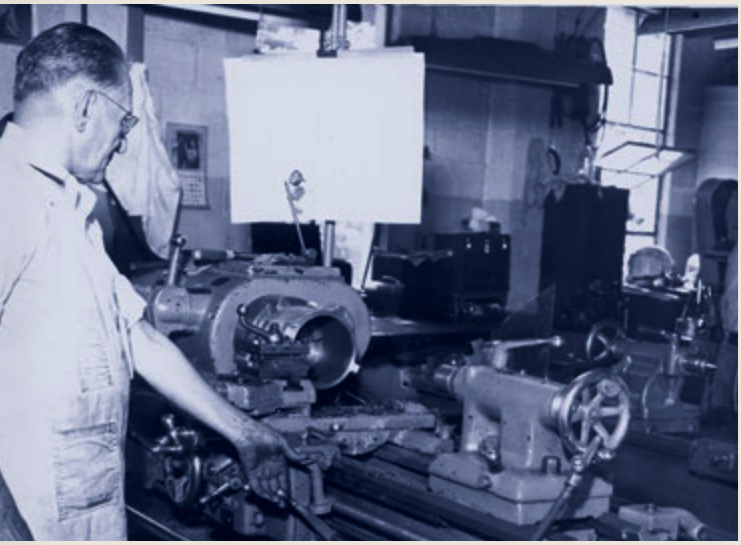
plated-through hole printed circuits. The U.S. Air Force arranged a shotgun marriage between IBM and Photocircuits, the only company with plated-through hole technology. Photocircuits would give IBM manufacturing know-how in return for orders for half the boards on the SAGE program. The contract promised to provide some $1 million per year to the company for the next 14 years. Production chaos ensued at Powers Chemco: Boards were printed in the basement, plated and etched in a garage 200 feet away, and assembled across the street in the cellar of a bar. To help form a more traditional, centrally managed structure, the loosely organized company hired a business consultant.

The company's first profitable year was in 1956. A new 32,000 sq.-ft. facility on Sea Cliff Avenue would now be home to 75 employees. They pursued an aggressive research and development program seeking to diversify the company beyond printed circuit boards. This produced a number of new technologies. By the late 1950s, however, the company faced increased competition for its printed circuit board business, especially for customized orders requiring quick design-to-delivery turnaround times. In response, Photocircuits began organizing small task forces charged with processing customized orders. By 1960, the company institutionalized the task force concept, creating a separate Proto department, with only 35 people, which operated independently of the rest of the company's rapidly expanding operations. This became a profit engine for the company.

By 1967, Photocircuits was approaching $10 million in sales, but the company was staggering under the weight of its own growth. As Bob told Inc., "Rarely did we meet promised deliveries. Quality problems were enormous; profit performance was erratic; morale was poor. Production managers burned out quickly, functional departments fought with one another. Only the rapid growth of the market and the even more disorganized condition of our large competitors sustained us."

Bob, together with younger brother James, who had joined the company in 1953, at first clung to traditional management techniques and looked to the novel computer systems technology to sort out the company's production scheduling and management difficulties. Photocircuits spent some $500,000 developing a customized version of System 70, produced by IBM, which was installed in 1969. "The complexity of our production routine was so mind-blowing that we thought

Mergers, Moves & Acquisitions, Chapter IV



something like the IBM process control system was what we needed," Swiggett told Inc. But the effort failed. "Statistically, we got everything we wanted. The computer worked beautifully, but company performance, if anything, got worse. Foremen were preoccupied with printouts instead of people. Managers spent time worrying about internal systems instead of our customers."

A recession at the start of the 1970s forced Photocircuits to make a decision: either slash its research and development spending, crucial for maintaining the company's edge in the fast-evolving printed circuit board industry, or junk System 70. The company chose the latter course; in the process of abandoning System 70, however, Jim abandoned the company's traditional, central management organization structure as well. To Bob and many of his colleagues, especially those who had worked on System 70, Jim's intuitive leap to team manufacturing was actually a stunning setback. "To give up modern management technology for something simpler," Bob said, "to throw that out meant to all of us at that time that we were giving up on another pioneering effort, and we didn't want to ever give up."

Meanwhile, Photocircuits had been seeking capital to fund its further expansion. The company looked into going public, but found itself valued at only $9 million in a public offering. In early 1970, Dick Rachals, president of Kollmorgen and an old friend and sailing buddy of Bob's, proposed a deal. At first, Dick only wanted to purchase Photocircuits' printed motor business, however, after subsequent discussions, a merger was proposed. This looked like a good fit to Bob: Photocircuits had sales of roughly $15 million, while Kollmorgen's sales were about $23 million. Moreover, both were involved with high-technology products, and the price was right -- 440,000 shares of Kollmorgen worth about $14 million, considerably better than the expected proceeds from a public offering. By February 1970, the merger was completed.

"Productization" for the 1970s

Bob was inspired by The Human Side of Enterprise, a book published by Douglas McGregor in 1960 that challenged traditional, top-down management techniques. Swiggett also found inspiration in the success of the company's Proto department. At the start of the 1970s, Swiggett, by then one of three group vice-presidents after the merger with Kollmorgen, set out to reorganize the former Photocircuits operations along the Proto model. He broke up operations into six teams, each with its own manager and responsibility for the team's production, profits, and losses. Each team dealt directly with its own customers, set

its own prices, controlled its own inventory, and negotiated with other team managers for production capacity. The company would eventually label this structure "productization."

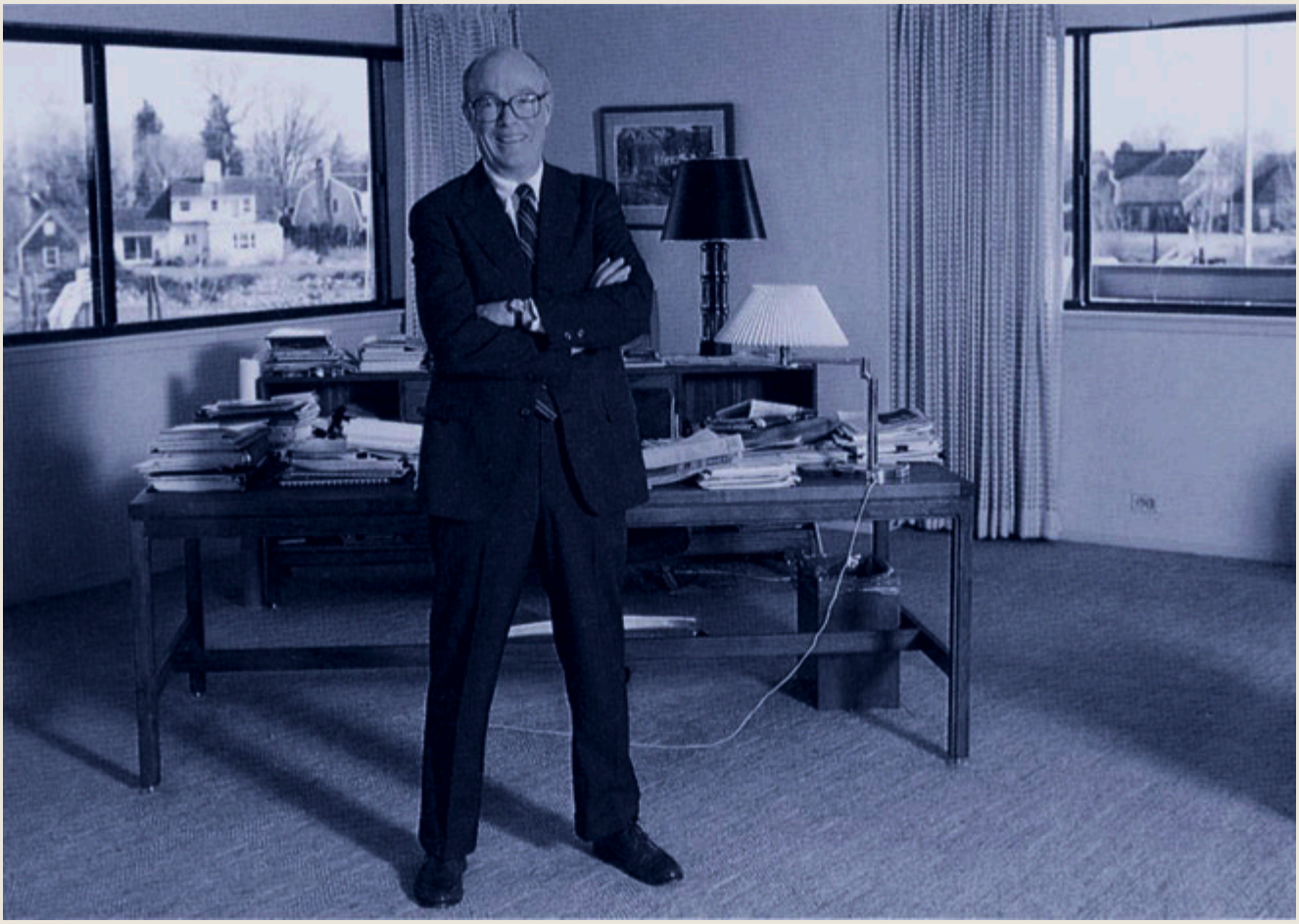
The new structure produced dramatic performance improvements. Within six months, per-employee production had doubled, on-time delivery rates rose from 60 percent to 90 percent, and Photocircuits' profits were rising. "In the middle of a depression," Swiggett told Inc., "what could've been a disaster turned into a real good moneymaker. So we really had it burned in our souls that small teams could be terribly effective."

Productization arrived just at the right time. By 1971, the newly merged Kollmorgen, hit by the recession, was posting an operating loss and revenues were stuck at around $40 million. Kollmorgen, itself divided into eight divisions, was suffering the same production problems as its Photocircuits unit. Management, shared among Maxwell, Rachals, and Norman Macbeth, was riddled with conflicting styles. "Dick Rachals was an intellectual," said Swiggett in an Inc. Magazine interview, "a solid engineer, not a great people-motivator, but very logical; Norman Macbeth, the flamboyant sales deal maker; and John Maxwell, a quiet man with a great sense of justice and order. I loved them all, but they really didn't get along so well, and they were all so polite that they really didn't work their problems out." The article went on to report how the three group vice-presidents, of which Swiggett was one, squabbled over style. Bob stood for "team manufacturing, openness, small profit-centers, and bonus-sharing," while the others fought for "strong line control and no communication other than by the chain of command."

In 1972, top management met for a weekend conference to sort out the company's difficulties. Bob, who was fired and rehired during that weekend, convinced management to let him try productization on the entire Kollmorgen operation. He divided the company's eight divisions into autonomous teams. Then the company set growth objectives for itself, including the doubling of revenues every four years and a goal of a 20 percent rate of return on equity. As an added incentive, Bob introduced a bonus plan for all levels of employees in 1975 that was based on what he called a return on net assets. This incentive spurred the company to make drastic inventory reductions. Bob quickly proved that his management philosophy could work for the company and became Kollmorgen's president and CEO.

By 1976, revenues had jumped to $82 million, providing net earnings of nearly $4.5 million. By

Mergers, Moves & Acquisitions, Chapter IV



"The process of innovation – so important to a high technology company – needs the input of many individuals…each individual can contribute his ideas freely, without having them stifled by the ideas of an organizational superior. When decisions are reached by consensus, they are acted upon more instinctively."
– Robert Swiggett

the end of the decade, sales had nearly doubled again, to $154.5 million, more than doubling net earnings to nearly $10 million.

In 1980, Bob published a seven-page pamphlet, titled The Kollmorgen Philosophy, emphasizing the company's commitment to the team management approach. Three central tenets were espoused:

- People are basically honest and good.
- People like to play a game, to play hard, and to bet on the score.
- Economies of scale are usually offset by inefficiencies of scale.

Each division had its own president and board of directors, with decisions made by consensus - not majority vote. Every product, ranging from photographic light meters to computer circuit boards, had its own manager. A division would split once it grew beyond a few hundred employees. Workers would receive a bonus for the good work that made the growth possible. "We believe that divisions which get too big lose vitality, family atmosphere, and easy, informal internal communication," Bob once explained.

All employees on product teams were eligible for bonuses, which were paid from a pool derived from 33 percent of the product's pretax profits. Managers held monthly meetings to review business conditions, and each worker conducted a "reverse review," an annual evaluation of superiors.

In the words of the Kollmorgen Philosophy: "Trusting people to be creative and constructive when given more freedom does not imply an overoptimistic belief in the perfectibility of human nature. It is rather a belief that the inevitable errors and sins of the human condition are far better overcome by individuals working together in an environment of trust, freedom, and mutual respect than by individuals working under a multitude of rules, regulations, and restraints imposed on them by another group of imperfect people."

That commitment to the team management approach, however, would eventually lead the company into trouble in the next decade. The slide into the national recession of the

early 1980s reached the company by 1982, and the company saw its earnings begin to drop. Despite doubling sales again, to $326 million in 1984, and being highlighted in the annual publication, The 100 Best Companies to Work for in America, the company was struggling to remain profitable. Just as the country was climbing out of the recession, the bottom fell out of the electronics industry – in what was called the industry's worst depression in two decades – and Kollmorgen's profits fell, too. The company

Mergers, Moves & Acquisitions, Chapter IV

The Photocircuits building in Glen Cove still sits empty after the company closed in 2007.

began posting losses in 1985 and, by 1986, the company was in the red, dragged down in part by its Multiwire division. The team management approach was faulted for some of the company's difficulties. During the first half of the decade, the company had allowed the Multiwire division to more than double its capacity, building new plants and leasing new facilities, despite signs of the coming slump in the electronics industry. Bob Swiggett, then 68 years old, stepped down as president and CEO, replaced by his younger brother, James Swiggett.

Compounding the company's losses was the sale, in 1986, of its consistently profitable Photocircuits division, which had accounted for $75 million of the company's annual sales, to that division's management. By 1987, Kollmorgen's sales had slumped to $301 million. The company managed to post a meager profit that year, of $285,000, but by then its stock had fallen from the mid-$30 range to just $13 per share. The company now found itself vulnerable to the takeover craze of the mid-1980s.

Vernitron vs. Kollmorgen

In 1988, Kollmorgen was approached by Vernitron Corporation, a Long Island-based industrial electronics company, to merge the two firms. Kollmorgen declined the offer, and Vernitron, which, with approximately $100 million in sales, was only one-third the size of Kollmorgen, went public with a $20 per share takeover bid. Kollmorgen introduced a shareholder's rights plan as a "poison-pill defense," leading the two companies into a legal and corporate takeover battle that would last for nearly two years, and rejected the bid. Vernitron countered with a $23 per share offer, then threatened a proxy battle, offering to raise the purchase price to $25 per share if the proxy fight were successful. Meanwhile, Kollmorgen had managed to turn the company around during 1988, raising revenues to $344 million and posting a profit of more than $14 million.

By April 1989, however, Kollmorgen gave in to Vernitron and offered to negotiate a merger of the two companies. Vernitron stayed with its $23 per share offer, and the companies agreed to merge at that price. But, over the next several months, Kollmorgen, which had seen the costs of the takeover battle compound a renewed struggle for profitability, began a restructuring of the company, which included selling off part of its troubled Multiwire division and then combining Multiwire's leftovers with another division and selling off the newly formed division as well. The costs of discontinuing these operations forced the company into a third-quarter loss of nearly $10 million. In response to Kollmorgen's mounting losses, Vernitron broke off its merger with

Kollmorgen. By the end of the year, Kollmorgen's revenues had fallen to just below $228 million and the company's loss for the year neared $19 million. Kollmorgen's stock, which had neared $24 per share during the takeover battle, crashed to $12 per share. By then, James Swiggett turned over the presidency of the company to John L. Youngblood.

Vernitron, however, was not quite finished with Kollmorgen. As soon as a standstill agreement between the companies expired in May 1990, Vernitron renewed its bid for Kollmorgen, organizing a proxy fight to replace Kollmorgen's board of directors and offering to purchase Kollmorgen for $15 per share. This time, however, Vernitron, weakened by the battle (its own sales had slumped to $80 million and its losses from the takeover attempt mounted to $20 million), proved to be easier to resist.

When the battle was over, the New York Times reported, "the struggle for control of the Kollmorgen Corporation, which has been going on for more than a year, may come to a conclusion next week as shareholders decide whether to keep current management or vote in directors from the Vernitron Corporation, a rival maker of electric motors. It is a fight that all sides may wish had never begun."

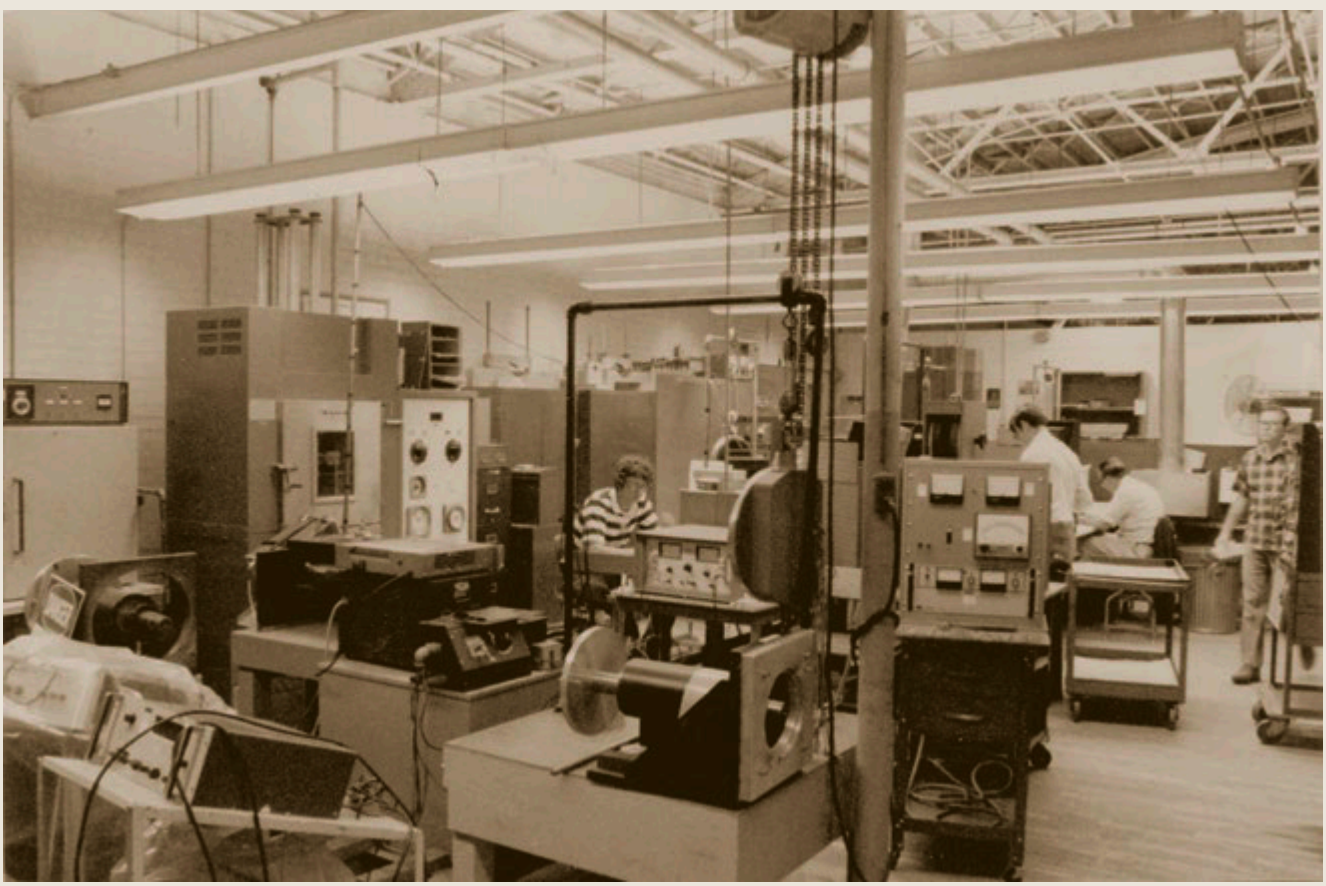
John Youngblood,
President of Kollmorgen 1989 - 1991

Mergers, Moves & Acquisitions, Chapter IV

Gideon Argov, Chairman, president and CEO of Kollmorgen Corporation 1991-2000

Kollmorgen emerged as the winner of the proxy contest, yet was confronted with a new reality: the ending of the Cold War spelled trouble for the company's critical defense-related business. The company continued to slim down its operations, shedding the rest of its interconnections business, worth nearly $100 million in 1988, and restructuring around its two remaining core businesses, electro-optical instruments and motion control. Youngblood left the company in early 1991, replaced by Gideon Argov. As the new decade got under way, Kollmorgen ran first into the global recession and then into the economic uncertainty surrounding the Persian Gulf War. By the end of 1991, the company's revenues barely cleared $200 million and its losses, compounded by restructuring costs, sank to $36 million.

The company's losses continued into 1992, as its revenues continued to slide, to $195 million. By 1993, however, Kollmorgen was back in the black, posting a net profit of $4.8 million on $185.5 million in sales, helped by new defense contract awards totaling some $50 million. Toward the mid-1990s,



the company continued to rebuild, and it began steering operations toward the commercial sector. In 1995, after its Electro-Optical division received a $35 million contract to build the U.S. Navy's "photonic" mast system, a type of periscope system that does not penetrate a submarine's hull, Kollmorgen's revenues began to climb again, reaching $228 million.

Rebuilding in the 1990s – from Seidel to the Pacific Scientific tango

"At the end of the '80s and in the early '90s, we had a very difficult time after we went through a failed takeover attempt by Vernitron," Mark Petty, president of Kollmorgen's Motion Technologies Group U.S., stated in a 1997 New River Newspaper article.

"The company went through a period of about three years when we lost a lot of people." In 1992, a new management team came on board. "Subsequent to that, from 1993 on, we've done well, and in 1996, did very well," Petty explained. "Kollmorgen stock had been selling in the mid $20 range prior to Vernitron's takeover effort. In the midst of the fallout from that takeover attempt in 1992, stock was selling in the $5 range. As of yesterday, (Feb. 3, 1997) stock was at $14-3/4. That's reflective of a slow and steady growth." After the rollercoaster ups and downs of the past decade, Kollmorgen looked forward to the company's future survival and growth.

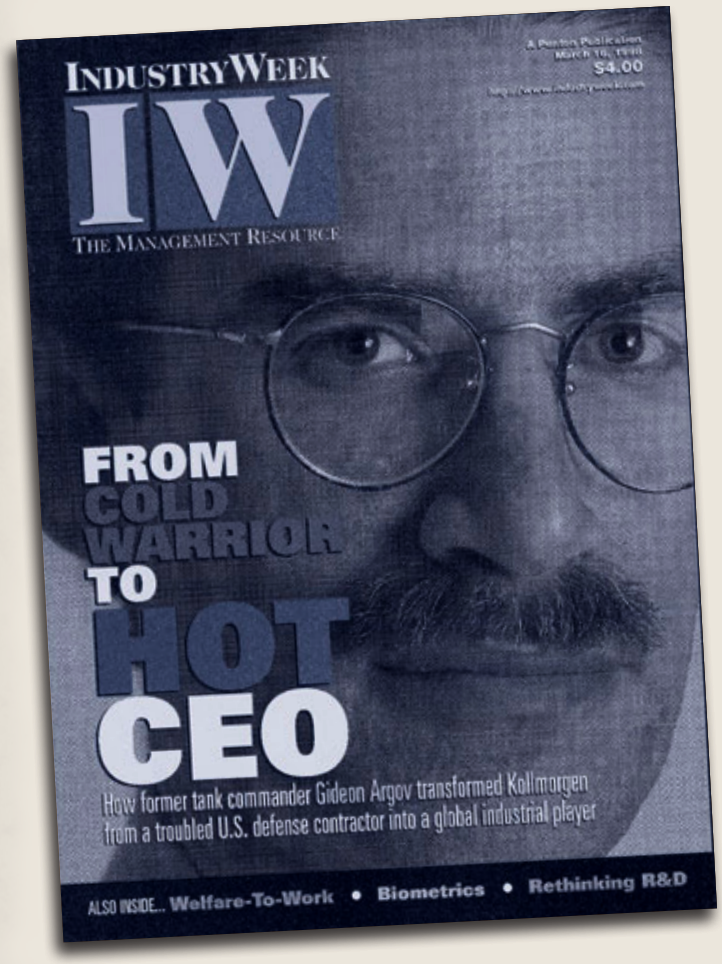
In 1996, Kollmorgen sought a larger European presence for its industrial/commercial-products division, which at the time accounted for about 60% of its sales (aerospace/defense sales comprised the rest). Fritz A. Seidel Elektro-Automatik GmbH of Dusseldorf, Germany, was a 50-year-old, family-owned business that had solid products and a strong sales and marketing base, but needed to join forces with a multinational organization in order to survive amid increasing consolidation.

Despite this motivation, Reiner Seidel, the German company's CEO, was at first standoffish to Kollmorgen's offers. Seidel had already spent three years talking to five other suitors. "But none of them brought any synergies... or a cohesive European strategy," Seidel recalled in a 1998 *Industry Week* article.

Chairman, president, and CEO of Kollmorgen Corp., Gideon Argov, who at the age of 18 was a tank commander in the Isreali Army, was set on convincing Seidel that their firm wasn't like the other companies. Kollmorgen executives spent six months building a relationship with Seidel before attempting any serious negotiations. The deal was finalized in July, 1997.

The acquisition gave Kollmorgen immediate access to the European market and its line of electronic motion-control products through Seidel's well-established organization of nearly 50 sales representatives and application engineers.

Kollmorgen Seidel became the hub of Kollmorgen's industrial/commercial activities in central Europe, with exclusive access to Kollmorgen's high-performance motors to complement its product mix. At the same time, the Seidel organization supplied the rest of



Kollmorgen with European-style high-voltage drives, a preeminent product area for the company.

Near the end of the nineties, another company seemed especially appealing for expansion opportunities in Europe and the Pacific Rim. It was the Newport Beach, California-based company Pacific Scientific, makers of motors and generators, electronic ballasts, fire-detection equipment and flight-control components.

Pacific Scientific had a strong lineage of talented people and product innovations that emanated from within the company and through acquisitions. One such acquisition, IMEC, was founded by MIT's Draper Labs and introduced the first servos.

Another acquisition for Pacific Scientific was Sigma Instruments in 1987. Sigma made many giant leaps in innovation, with product introductions that included the Enhanced Stepping Motor in 1984. This was a revolutionary design where magnets were placed within the stator teeth.

Sigma was also connected to the invention of the Boston Whaler, a fiberglass flat-bottom boat that was widely regarded as being unsinkable. These boats were used by the Navy Seals in Viet Nam and more popularly seen on the 1960s Flipper films and TV series.

In the late nineties, Kollmorgen found itself bidding against Pacific Scientific over a new product the American inventor Dean Kamen was proposing. The successful and wealthy inventor, famous for creating the first drug infusion pump and all-terrain electric wheelchair known as the iBOT, had approached Kollmorgen to help apply motion expertise to one of his newest ideas: a self-balancing human transporter.

In a meeting, Gideon Argov offered to buy the iBOT technology from Dr. Kamen, based on the supposition that an inventor would not want to build and operate a factory. Dr. Kamen did not agree and essentially showed Gideon the door. With Kollmorgen out of the picture, Pacific Scientific had an opening.

Engineers from Pacific Scientific, Brad Trago, now Director of Engineering at Kollmorgen, and George Yundt, now Chief Engineer, Drive Technology at Kollmorgen, were asked to provide their motor, drive design, and system expertise to the Segway project, which was being designed in top secret.

The prototype was designed with two motor-drive boards, one for each of the independent electric servomotors. The motors, about the size of a pop can, were each 2 hp, making them the most powerful in the world for their size. In the book, *Code Name Ginger: The Story Behind Segway and Dean Kamen's Quest to Invent a New World*, one of the Segway design engineers, J.D. Heinzmann, referred to George as an expert who "knew motor controllers the way Clausewitz knew war." George's contributions to the Segway design led to him being a co-inventor on one of its core patents.

Kollmorgen made an offer to buy Pacific Scientific Co. on December 15, 1997, for about $20.50 a share in cash, or $258 million. Pacific Scientific described the offer as inadequate. The next day, Kollmorgen made a hostile cash-and-stock offer, valued at $264 million. Kollmorgen then sought a special shareholders meeting to consider ousting Pacific Scientific's board and electing a new slate to evaluate its offer – while also filing a suit to make sure shareholders got the chance to vote on the proposal. Kollmorgen's chairman, chief executive and president at the time, Gideon Argov, was quoted in the Los Angeles Times saying he had hoped the talks between the companies turned friendly but that "it takes two to tango."

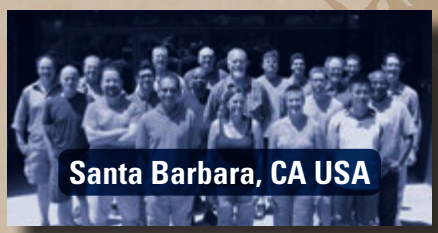
On December 29, 1997, The Wall Street Journal reported that Pacific Scientific had sold its Automation Intelligence Inc. subsidiary to Sanyo Denki Co. Ltd. of Japan for an undisclosed price. Furthermore, Pacific Scientific's board unanimously rejected the Kollmorgen bid and authorized preliminary talks with other parties about the potential sale of the firm in an attempt to elude Kollmorgen.

When the required waiting period under the Hart-Scott-Rodino federal antitrust law expired in January of 1998, one of the conditions to Kollmorgen's hostile tender offer to pay $20.50 apiece for 51% of the shares outstanding of Pacific Scientific was fulfilled. Kollmorgen could merge with Pacific Scientific and acquire each remaining Pacific Scientific share for stock valued at $20.50 each once the tender offer was complete.

On January 31, 1998, Kollmorgen increased its offer for Pacific Scientific by $3.25 a share, to $23.75, or $294 million total and also extended its offer to Feb. 13. However, on February 3, the Los Angeles Times reported that an "outgunned" Kollmorgen withdrew from pursuing Pacific Scientific to top bidder Danaher. "Danaher emerged as the best solution to Pacific Scientific's frantic attempts to avoid a shotgun marriage with Kollmorgen," the paper reported. Danaher's offer, valued at $460 million, included an assumption of debt as well as the cash payment of $30.25 a share to shareholders.

Kollmorgen was acquired by Danaher two years later.

The Kollmorgen Family



Santa Barbara, CA USA

Boxborough, MA USA

Radford, VA USA

Vista, CA USA

Tijuana, Mexico

San Paulo, Brazil


Gothenburg, Sweden


Bretten, Germany

Balingen, Germany

Ratingen, Germany

Celebrating 100 Years of Innovation • 1916-2016 KOLLMORGEN

Brno, Czech Republic


Beijing, China & SE Asia


Milan, Italy


Istanbul, Turkey


Mumbai, India

Over the past 100 years, the Kollmorgen family has expanded around the globe. And without the hard work and dedication of each and every member of the team, Kollmorgen would never have achieved the success it enjoys today.

"I took my family to NASA and was proud to show them the parts we made that were on the lunar rover" – *Doug Austin, Custom Machine Services*

Exploring New Frontiers, Chapter V

"Since its founding, Kollmorgen has unfailingly displayed an innate ability to apply core technology to new products and leverage its manufacturing expertise in new frontiers," noted Jim Eder, Vice President Legal Counsel, Kollmorgen.

Jim Eder's statement has been witnessed throughout the decades through the persistent delivery of groundbreaking technology. Innovators at Kollmorgen have looked at challenges and utilized their core competencies to conquer the frigid depths of the north Atlantic, the weightlessness of space, the efficiency of the human circulatory system, and the intense heat and pressure of an oil drilling operation.

Like the college football rivalry between the Virginia Tech Hokies and the University of Virginia Cavaliers, Kollmorgen engineers are determined to always win, and to be the best while doing so, by tackling the most difficult of motion challenges. This has led to engineering excellence and true product differentiation. Some of the company's biggest "wins" of the eighties, nineties, and today include:

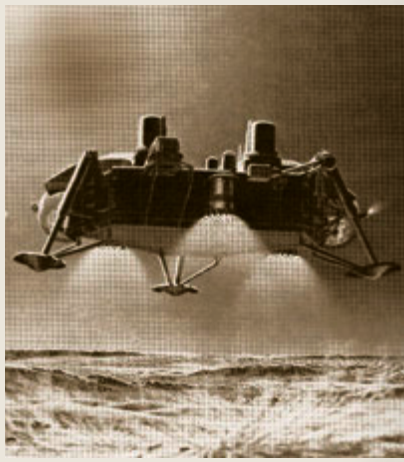
Space exploration

The invention of the first "frameless torquers" that were designed by Hugo Unruh, began a long history of the company supporting space applications. Throughout the 1950s and 1960s, Kollmorgen provided rocket inertial guidance systems for the Saturn, Gemini, Apollo, and Titan programs.

Kollmorgen products were involved in critical applications on every Space Shuttle mission – spanning three decades and 135 flights – and also the Apollo Lunar Module and Mars Rover programs. Our engineers have also been involved with implementing satellite programs for NASA, European Space Agency and many private companies; and a variety of space station applications have been implemented in programs like Skylab, Freedom, and ISS (International Space Station).

Journey to the Titanic with the ROV Jason Jr.

In 1985, underwater archaeologist Dr. Robert Ballard led a team of researchers in a joint French-American expedition and found the final resting place of the R.M.S. Titanic. Since deep water is inhospitable for



Mars Viking Lander 1976

"Kollmorgen has unfailingly displayed an innate ability to apply core technology to new products and leverage its manufacturing expertise in new frontiers," – Jim Eder, Vice President Legal Counsel, Kollmorgen

Exploring New Frontiers, Chapter V

human divers, and the weight of water overhead exerts intense pressure, Dr. Ballard sought to pioneer a new way to explore the bottom of the ocean through "telepresence," which would allow a person to travel anywhere in "spirit" while the body experienced it all from a safe viewing area. The engineers at Kollmorgen were tasked with creating a Remotely Operated Underwater Vehicle (ROV) that could explore the depths of the ocean. Fiber optic cables would permit transmission of vast amounts of color imagery and other data. Implementing Dr. Ballard's vision in 12,460 feet of water, where the water pressure at that depth is 6000 lbs. per square inch, was a major challenge in 1986. No one had successfully operated an ROV in very deep water, nor used a fiber optic cable system in the deep sea.

In collaboration with a team of engineers and the Woods Hole Oceanographic Institution, Kollmorgen combined a brushless dc motor with an integral six-step amplifier built in an oil-filled, pressure-compensated housing that was capable of operating at pressures approaching 10,000 psi. Dr. Ballard's new paradigm with automation was achieved on July 26, 1986, when the specially designed robot, Jason Jr., explored and transported images of the Titanic wreckage. In a later interview, the Acting Woods Hole Oceanographic Institution President and Director James Luyten said, "They proved that small unmanned vehicles could be used in very deep water, in tight spaces and amid wreckage too dangerous for humans to explore in larger submersibles…. this paved the way for the routine use of remotely operated vehicles, and now autonomous underwater vehicles, for scientific, military and commercial needs."

Members of the 1985-1986 Jason Jr. engineering team received the GlobalSpec Great Moments in Engineering award in 2006. This award is presented annually to a person or group whose singular moment of engineering ingenuity produces a significant turning point for the application of technology and resulting benefits to people, science and industry.

Driverless vehicles

Meanwhile, automated guided vehicles (AGVs) were in development for use on land by a company called NDC, which was founded in 1962, became a part of Danaher in 2001 and rebranded as Kollmorgen in 2009.

Kollmorgen AGV Systems Product Manager, Kenneth Palm, recalled the first global application of AGVs in 1976, "NDC was a trusted technology provider for Tetra Pak. They needed to increase output. We suggested an AGV solution and although they really believed in us, they were very skeptical since, after all, what we were proposing was a driverless vehicle."

In this case, what the market actually needed was more flexibility and adaptability. We could give them that with something that was entirely new and unheard of – the AGV. We just had to convince them that it was safe." Kenneth and his colleagues were able to overcome the doubters, and a large-scale rollout of AGVs was implemented at Tetra Pak's factories.

"We have always listened to our customers, but our job has never been to do exactly what a customer tells us to do. To quote Henry Ford, 'If I had asked people what they wanted, they would have said faster horses.' "
– Kenneth Palm, Kollmorgen AGV Systems Product Manager

NDC continued to further develop the AGV by teaming up with technical universities. Part of the collaboration process also involved working with a partner company in France who was in the process of installing an AGV system in the Kremlin to help the ailing General Secretary Leonid Brezhnev get around. The installation was halted though when Breshnev died in 1982.

Then, in 1997, laser navigation debuted in Singapore and quickly became incredibly popular in Asian and global markets. Designed for forward compatibility and future upgradeability, this system, is still being used successfully today. In 2007, Kollmorgen collaborated with Sky-Trax Inc., to jointly develop and market the world's first Indoor Collision Avoidance System (ICAS) for industrial vehicles.

Building a "bridge to transplant" with a Left Ventricular Assist Device

A left ventricular assist device (LVAD) is a surgically implanted, battery-operated, mechanical pump-type device that helps maintain the pumping ability of a heart when it can no longer work on its own. This was designed to help a person on the heart transplant list endure the long waiting period of searching for a suitable donor. The already-weakened heart typically deteriorates during this timeframe and if left unassisted, would be unable to pump enough blood to sustain life.

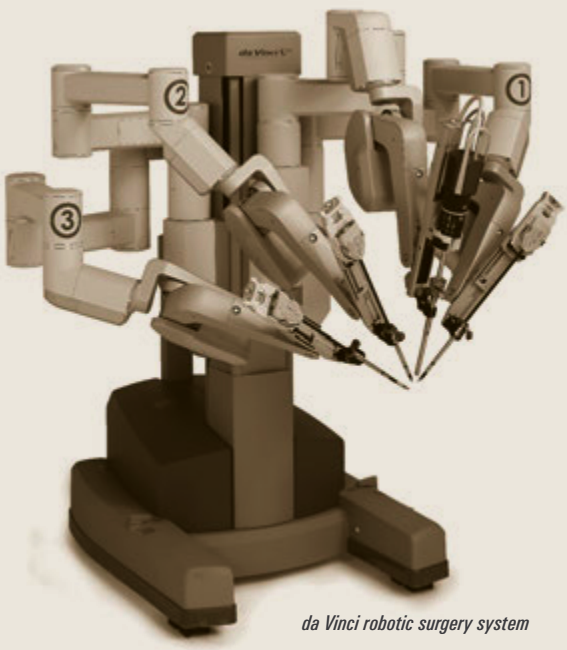
In the 1980s, Kollmorgen worked with Thermo Cardiosystems to create an implantable heart pump that would aid the ailing heart, rather than replace it. Initially referred to as a "bridge to

Exploring New Frontiers, Chapter V

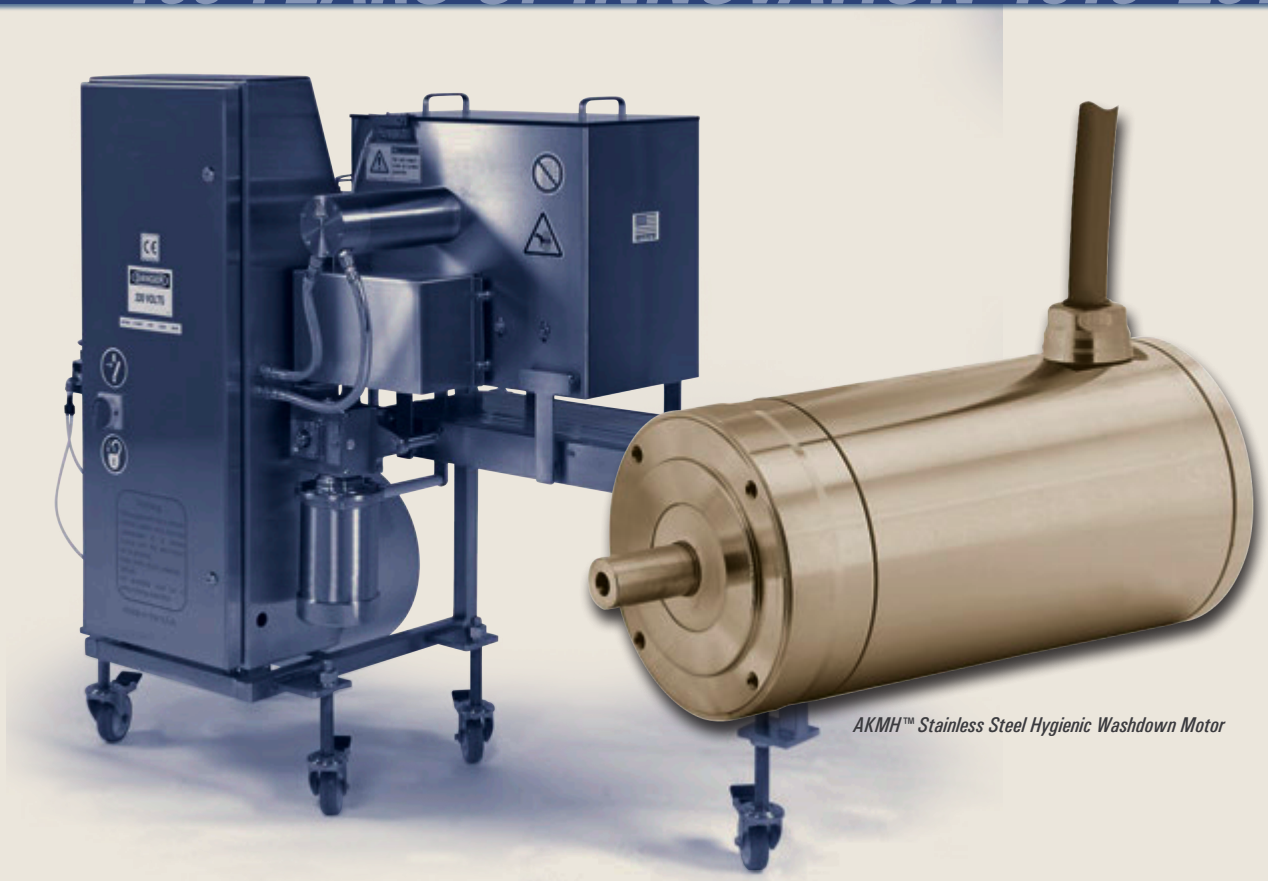
transplant," the LVAD can assist the weak heart and "buy time" for the patient. Kollmorgen was asked to develop a valve control and electric motor that would power a spinning blade through hydraulic fluid. Clinical trials were initiated in 1986 and the outcomes were published in a National Center for Biotechnology Information (NCBI) report that stated, "The LVAD was capable of supporting individuals in end-stage heart disease for extended periods of time (longer than 14 days). While supported by this device, patients were hemodynamically stabilized for future transplant and were afforded an opportunity to improve their overall health status. At initiation of support these patients were in New York Heart Association class IV, and within approximately 2 weeks, improved to class I. Their nutritional status improved, they were able to exercise regularly, and they became the "healthiest" candidates for cardiac transplant. In one patient, the device was explanted after spontaneous left ventricular recovery; the LVAD gave adequate circulatory support over extended periods of time and reversed the vital organ dysfunction"

The first robotic surgery system, da Vinci

In 2000, the da Vinci Surgery System broke new ground by becoming the first robotic surgery system approved by the FDA for general laparoscopic surgery. This was the first time the FDA approved an all-encompassing system of surgical instruments and camera/scopic utensils. Its predecessors relied upon the use of endoscopes and numerous surgical assistants to perform surgery. The da Vinci robotic surgery



da Vinci robotic surgery system



AKMH™ Stainless Steel Hygienic Washdown Motor

system's three dimensional magnification screen allowed the surgeon to view the operative area with the clarity of high resolution. Miniaturized operating arms removed the need to leverage the sides of the incision walls. This advancement enabled less contact between exposed interior tissue and the surgical device, greatly reducing the risk of infection. The "Endo-wrist" features of the operating arms precisely replicated the skilled movements of the surgeon at the controls, improving accuracy in small operating spaces. The da Vinci system also received approval for cardiac procedures in addition to prostate and gynecological treatments.

The da Vinci robotic surgery system has been in respected medical centers across the country, such as the New River Valley Carilion Clinic, the Ohio State University Wexner Medical Center, whose surgeons were the first in North America to perform a robotic-assisted procedure with the da Vinci robot; Boston Medical Center, known for completing the highest number of surgeries in the state to successfully treat prostate cancer; and UC Davis Medical Center.

These successes were then applied to hygienic procedures in pharmaceutical and food processing applications, establishing Kollmorgen as a thought leader in hygienic equipment design.

Food industry thought leader

"We spent a lot of time at the end-users, or going to gemba, the place were the action is, to see how the equipment was being used by the customer. This opened our eyes to a whole bunch of things that our customers were not able to articulate and allowed us to create a solution that needed no maintenance, no protection, and could survive hot water washdown," said Tom England, former Vice President of Market Development, Kollmorgen.

Exploring New Frontiers, Chapter V

The Virginia Tech Food Science and Technology Department was engaged to learn more about microbiology. Considerable time was spent developing testing processes to see how easy it was to clean Kollmorgen's motors. An advisory council of end-users, such as Coca-Cola, Maple Leaf Foods, and Tyson, were asked to develop a priority list and agenda for testing.

Reliability was identified as a real problem in this market: The continuous cycle of up/down pressure would constantly cause the motor to fail. To solve this, the engineering team applied a technique that has been used on aircraft for many years; they put a breather tube in the cable and ran it out in the cabinet, ensuring pressure remains at zero at all times.

The end result is the AKMH™, a superior product that the end-user wanted. It's solving multiple problems while saving them money, directly contributing to higher overall equipment effectiviness (OEE) for machines, conserving water, reducing inventory and spare parts as well as cleaning time and maintenance, and providing end-users with the peace-of-mind that they've reduced the risk of a food recall.

Gearless, oilless elevator helps lift profitability

In 2000, Kollmorgen worked with Otis Elevator Company to create the Gen2, short for Generation 2, a gearless, oilless machine pulled up and down by a device that used rubber belts to hoist elevator cars. For the past century, elevators mostly used steel ropes. The Gen2 system eliminated the need for a separate machine room above the shaft and provided a smoother, quieter ride. This feature saved developers money and gave building owners more rentable space. The system could also be installed more cost-effectively, and would operate more energy efficiently due to smaller electrical motors that were mounted inside the shaft.

Protecting human life with the CHIMP robot (Carnegie Mellon)

Kollmorgen was a contributing partner to the National Robotics Engineering Center (NREC)/ Carnegie Mellon University team's entry in the Defense Advanced Research Projects Agency (DARPA) competition in 2013. The challenge

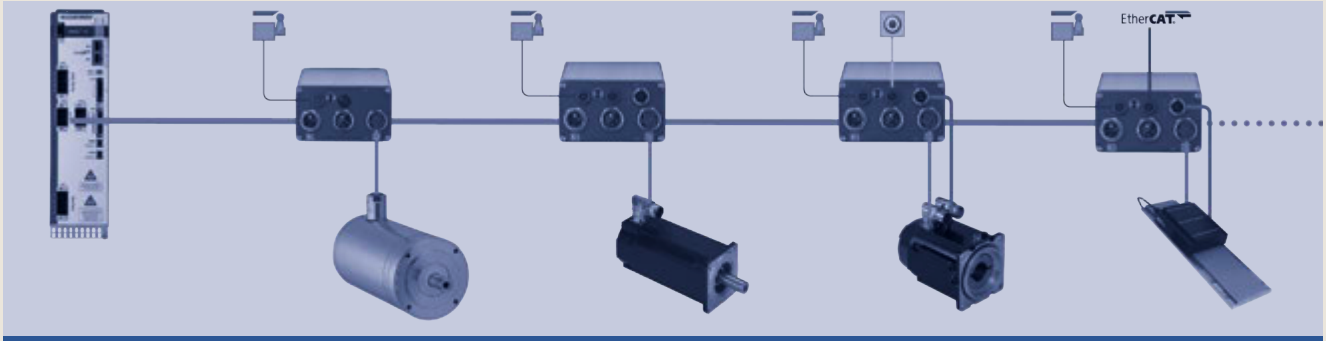
CHIMP (CMU Highly Intelligent Mobile Platform)

Multi-modal head and joint sensors provide feedback to safely move, handle objects, and remove debris

Drive joints allow human-like grasping and can be used in mobile manipulation and manufacturing

Tracks on all four limbs improve mobility and stability

was to develop robotics technology that could eventually replace the need for humans to enter into very dangerous environments to keep a bad situation from growing worse, such as cleaning up after the tragic earthquake and subsequent tsunami that devastated the Fukushima Prefecture in Japan. The DARPA project objectives required the robots to perform some pretty remarkable things, such as drive a utility vehicle to a site, dismount and remove rubble blocking entryways, open doors, climb ladders, traverse walkways, breakthrough solid surfaces as needed, locate and close leaking valves, and replace components.



The AKD®-N distributed servo drive for the machine design of tomorrow

Distributed Servo Technology Bends Panels into Better Shape in 2015

The Italian machinery manufacturer Salvagnini, the world's leading manufacturer of panel bending machines, achieved a new first by replacing the central hydraulic pump with a synchronized network of electrically driven AKD-N series servos. Salvagnini worked with Kollmorgen engineers in Milan and around the world to simplify the design of its machines by using distributed servo amplifiers for positioning instead of keeping drives installed centrally in the control cabinet. Moving the servo technology out of the control cabinet also dramatically minimized the energy needed to keep the cabinet cool while also dramatically reducing the cost of the cabling for the seven distributed servo axes. The total solution generated cost savings throughout the whole value chain.

"We always try to elevate the conversation with customers and help them differentiate themselves from their competitors. As a result, we have found ourselves applying our knowledge in markets such as bottling, food processing, and pharmaceuticals," said Alberto Favalessa, General Manager, Kollmorgen Italy.

Next generation products and a new chapter under Fortive

Today, there are engineering centers of excellence and customer service in all major regions of the world that support Kollmorgen's global customers' needs. Over 500,000 controls have shipped globally out of the Kollmorgen Center of Excellence for Electronics, since Motion Engineering (MEI) was founded in 1990. The Kollmorgen Center of Excellence for Electronics has also shipped over 1,200,000 axes of SynqNet (the world's first 100BaseT Real-Time Motion Network) controls into Medical, Semi, SMT, and Material Handling systems since the network was first invented, patented and delivered to the market in 1998. Low-cost manufacturing facilities in North America, Europe and Asia ensure cost-effectiveness, continuity, and timeliness of supply. A global supply chain, with multiple sources, provides greater flexibility and reduces risk.

Kollmorgen's motion solutions play a key role in nearly every aspect of our everyday life, from packaging Little Debbie® Cupcakes to detecting cancer using an MRI scan. This has proven to be both a rewarding and fun aspect for Kollmorgen employees.

"When I'm talking to new customers, I always tell them when you wake up in the morning and

Exploring New Frontiers, Chapter V

turn on the faucet, Kollmorgen is making sure the water is clean and clear," said Jens Depping, Sales Director for Private Label and Export, Kollmorgen Europe. "We are also responsible for the smooth roller coaster ride, too," he added.

Bob White, Manager of Training and Digital Services at Kollmorgen, feels lucky to have been aboard the Atlantis Submarine Expedition in the Caribbean. His participation on the very first Atlantis submarine made his trip especially thrilling. Bob recalled, "The customer wanted a sub that could give tourists a view of the coral reefs, fish and old ship wrecks. The only known propulsion system at the time was hydraulic, however the customer wanted to use a 230 Volt electric system and inert oil to protect the environment. We not only had to redesign our electronics and have the motors wound correctly, but it needed to be completed in 13 weeks."

"The innovative spirit is very much key at Kollmorgen," stated John Boyland, Vice President of Engineering. "If a young engineer is looking for a variety of exposure -- nuclear power plants, wind generators, oil exploration, life sciences, healthcare -- Kollmorgen is everywhere. Oftentimes, ideas come to us, or someone comes to us with a problem, and we end up helping develop a next generation benefit for mankind. In our job, we get to talk to some very smart people about what they want to do, and we are always eager to help them. It's a lot of fun!"

Valerie Garrison, Operations Manager, Kollmorgen, agreed, "In the five years that I have been here, I have been able to contribute through multiple roles in the organization. This cross-functional experience inherently instills a better understanding of the impact we all have on the process and the freedom to think creatively."

After a microburst caused a plane crash in Texas, the FAA asked Kollmorgen to help develop antennae for the radar systems to use to scan for microbursts. Kollmorgen's solution is now

implemented in airports everywhere, eliminating this type of hazard from even being of any concern today.

Kollmorgen motors enabled connection to WIFI on commercial aircrafts, noted Cathy Biltz, Acting Vice President of Operations and Supply Chain. This has allowed her to answer emails and set up meetings while en route to customer visits across the country.

"It's easy to ask the customer what they want: they tell us, 'the best technology, just cheaper,'" said John Boyland, Vice President of Engineering, Kollmorgen. "But we need to look at the application in its actual usage to determine how to make it better, more efficient, with features that are valuable to them, and in a smaller footprint. We do this by becoming an extension of our customer's engineering department. This ensures the application, in collaboration with the customer, meets their needs. And this is how we bring next generation products to market."

The highly diversified manufacturing conglomerate Danaher Corporation purchased Kollmorgen in May, 2000, for about $237 million, or $23 a share. Danaher is named after a creek in Montana where the company's founders, brothers Steven M. and Mitchell P. Rales, spent time when they were young. For sixteen years, the Danaher Business System approach has helped Kollmorgen achieve success. Based on the Japanese business mantra of Kaizen, which preaches constant improvement and the great learning opportunities at "gemba," the place where work happens. DBS is a huge part of the culture.

100 years later, Kollmorgen continues to diligently work toward solving the biggest motion challenges of the future under a new venture born from Danaher, Fortive. The Fortive team, led by longtime Danaher executive, Jim Lico, will seek to make continuous improvement a part of everything it does. Fortive is committed to embracing and building upon the principles of DBS with their own operating model called the Fortive Business System, or FBS, to drive long-term shareholder value.

The move under the Fortive umbrella places Kollmorgen among a distinguished group of brands, respected as established leaders in the markets they serve. Kollmorgen will now be uniquely positioned to anticipate, create, implement and accelerate solutions that meet their customers' most critical needs.

Timeline – 1916-2016 – Celebrating a Centennial

Oct. 4, 1905	A 34-year-old lens and optics designer from Germany, Friedrich Kollmorgen, arrived in New York, NY.
1911	Friedrich Kollmorgen introduced the design of two telescopes into a periscope, instead of a series of lenses or prisms, which resulted in his first U.S. periscope patent.
1916	Kollmorgen Optical Corp. was founded and received its first contract from the U.S. Navy for two periscopes. Became the dominant U.S. periscope manufacturer from World War I until 1958.
1920s	After WWI ended, Kollmorgen found success making projection lenses for the film industry.
1933	During the Great Depression, Kollmorgen took rejected lenses and turned them into ashtrays to keep his machines running and a handful of people employed.
1940	Kollmorgen designed a modified Type 1 periscope, dubbed the Type 2, which featured a tube tapered at its head to reduce the surface wake. The Type 2 periscope remained in use through the 1990s.
1941	The engagement of the U.S. in WWII Kollmorgen ramps up orders for driftmeters, bombsights, and sophisticated navigation instruments, as well as submarine periscopes. Kollmorgen introduced the first optical instruments using anti-reflective coating on lenses and was the first to make contact lenses in the U.S.
1946	Friedrich's son, Otto, took over as President of the company.
1948	Inland Motor was formed in the basements and garages of Hugo Unruh and Lewis Renaldi.
1949	Inland Motor moved to an expanded garage in Pearl River, New York.
1949	Robert "Bob" Swiggett created a prototype of a printed circuit board and exhibited it at the Institute of Radio Engineers annual convention.
1951	Sales of Swiggett's printed circuit boards reached $50,000 in 1951 and Photocircuits Corporation was officially formed with John D. Maxwell as President, Bob Swiggett as Executive Vice President, and a support staff of five.
1951	Kollmorgen moved from Brooklyn, NY to North Hampton, MA.
1952	Photocircuits developed the basic building blocks of the printed circuit process – epoxy-glass laminates and plated-through holes.
1953	The U.S. Air Force arranged a shotgun marriage between IBM and Photocircuits, the only company with plated-through hole technology.
1956	Hugo designed the first "frameless torquers, which were used by Dr. Charles Stark Draper to develop the first stellar inertial navigation system. This system can be seen on display at the Smithsonian today.
Nov. 1,1958	Six employees, including Hugo, set up shop on 501 First Street, in Radford, VA.
1958	Otto Kollmorgen received patent for inventing mechanism for eliminating parallax from telescopic sights.
1960	Inland Motor celebrated its first million-dollar year. In May, Kollmorgen Optical Company and Inland Motor Corporation merged and became a publicly owned company: Kollmorgen Corporation. Sales volume totalled $8.5 million. By the end of 1960, all of Inland Motor relocated to Radford.
1961	Kollmorgen acquired Instrument Development Laboratories, a manufacturer of motor driven high-speed rotary switches, colormeters, and spectrophotometers.
1962	Solid State Instruments Corporation, a manufacturer of precision rate tables, power supplies, and electronic drives for dc servo motors was purchased.
1967	Photocircuits approached $10 million in sales, but the company was staggering under the weight of its own growth.
Sept. 1967	Kollmorgen acquired Macbeth Corp., which was founded by the father of renowned innovator, Norman Macbeth, inventor of artificial daylight.
Mid 1960s	NASA Gemini Titan programs with Kollmorgen providing inertial guidance systems.
1967	13-foot diameter motor, built in segments, and assembled on site, is installed at Sun Spot, New Mexico to power a new observatory drive system.
1968	Photo Research Corporation, a manufacturer of photometers, was acquired.
1969	Goerz Optical Company, a manufacturer of precision lenses, rate table and cinetheodolites; Laboratoire LERES S.A., a French manufacturer of reflectance spectrophotometers; and Artus, S.A., another French company that made precision servo motors, primarily for aircraft and military applications were purchased.
Early 1970	Dick Rachals, president of Kollmorgen, and an old friend and sailing buddy of Bob Swiggett, proposed a deal to purchase Photocircuits' printed motor business; however, a merger of the entire company was signed in February.
1971	Kollmorgen brought the Munsell Color Company, the internationally recognized manufacturer of precise color standards, into the fold in.
1972	Inland Motors was the first to propose a flux forcing concept in motor design; the first to use samarium cobalt and neodymium boron rare earth magnets to enhance motor performance and reduce size; and one of the first to design brushless motors.
Mid-1970s	Became the leading supplier of submarine periscopes in international markets.
1976	Viking spacecraft MARS soft landing, contained electromechanical throttle valve comprising of a drive unit consisting basically of gearless DC torque motors.
1976	Kollmorgen AGV Systems (NDC at the time) installed the first global application of AGVs at Tetra Pak's factories.
1979	Pioneered rare earth magnet motors and servo-controlled bearings that used the force of a magnetic field to levitate a rotor and eliminate mechanical contact.
1980s	The sole source supplier of auxiliary sights for the M-1 tank and Bradley Fighting Vehicles throughout the 1980s
Early 1980s	The Electro-Optical division (EOD) introduced a modern periscope, an infrared night vision system, MICRO-FLIR, and a non-penetrating mast system designed for the U.S. Navy's submarines. EOD was also the only U.S. supplier of high performance, wire-heated pressure windows for deep submergence sensor applications.
1986	Sold the Photocircuits division.
1986	Clinical trials for a left ventricular assist device (LVAD) were initiated in and proven capable of successfully supporting individuals in end-stage heart disease for extended periods of time (longer than 14 days).
July 26, 1986	Powered a specially designed Remotely Operated Underwater Vehicle (ROV), the Jason Jr., July 26, 1986, the specially designed robot, Jason Jr., explored and transported images of the Titanic wreckage.

Late 1980s	Combined viewing sensors and electro-magnetic sensors in a single, non-penetrating mast for the Defense Advanced Research Projects Agency (DARPA).
1988	Kollmorgen was approached by Vernitron Corporation, a Long Island-based industrial electronics company, to merge the two firms; Kollmorgen declined the offer.
April, 1989	Kollmorgen reconsidered Vernitron's proposal and offered to negotiate a merger of the two companies. Vernitron stayed with its initial $23 per share offer, and the companies agreed to merge at that price.
Sept. 1989	Kollmorgen posts a third-quarter loss of nearly $10 million. In response to Kollmorgen's mounting losses, Vernitron broke off its merger.
1989	Macbeth acquired a German-based manufacturer of spectrophotometer systems.
May 1990	Vernitron renewed its bid for Kollmorgen, organizing a proxy fight to replace Kollmorgen's board of directors and offering to purchase Kollmorgen for $15 per share.
1995	The Electro-Optical division received a $35 million contract to build the U.S. Navy's "photonic" mast system, a type of periscope system that does not penetrate a submarine's hull, Kollmorgen's revenues began to climb again, reaching $228 million.
July 1997	Acquired Fritz A. Seidel Elektro-Automatik GmbH of Dusseldorf, Germany. The acquisition gave Kollmorgen immediate access to the European market and its line of electronic motion-control products through Seidel's well-established organization of nearly 50 sales representatives and application engineers.
1997	The Gretag Color Control System Division of Gretag AG, producers of the first portable spectrophotometer, merged with the Macbeth division of Kollmorgen Instruments Corporation.
1997	Laser navigation for AGVs debuted in Singapore and was adopted in Asian and global markets.
Dec 15, 1997	Kollmorgen made an offer to buy Pacific Scientific Co. for about $20.50 a share in cash, or $258 million. Pacific Scientific declined the offer.
Dec 16, 1997	Kollmorgen made a hostile cash-and-stock offer to buy Pacific Scientific Co., valued at $264 million.
Jan. 31, 1998	Kollmorgen increased its offer for Pacific Scientific by $3.25 a share, to $23.75. However, on February 3, the Los Angeles Times reported that an "outgunned" Kollmorgen withdrew from pursuing Pacific Scientific to top bidder Danaher. "Danaher emerged as the best solution to Pacific Scientific's frantic attempts to avoid a shotgun marriage with Kollmorgen," the paper reported. Danaher's offer, valued at $460 million, included an assumption of debt as well as the cash payment of $30.25 a share to shareholders.
Feb.3, 1998	Kollmorgen withdrew from pursuing Pacific Scientific to top bidder Danaher.
2000	The da Vinci Surgery System became the first robotic surgery system approved by the FDA for general laparoscopic surgery. This was the first time the FDA approved an all-encompassing system of surgical instruments and camera/scopic utensils.
May 4, 2000	Danaher acquired Kollmorgen.
2001	Helped build the world's first successful self-contained artificial heart and Left Ventricular Assist Device (LVAD).
2001	Launched SynqNet®, a fast, interoperable motion and I/O network that enabled a synchronous real-time connection between the motion controller, servo drives, I/O modules, and custom nodes. SynqNet was the first platform to use industry and consumer proven 100 BaseT CAT 5 cabling with standard connectors and a wide array of custom and other robust industrial connector types to drive the world's most demanding motion applications.
2002	The first Segway models, powered by a Kollmorgen electric motor that delivered 40% more torque per unit of volume than comparably sized motors, were sold to the public.
2004	Motion Engineering (MEI) was acquired, which included powerful integrated motion control solutions with industry-leading, multi-axis motion platforms and SynqNet™ communications network for ultra-reliable machine performance.
2005	G&L Motion Control, a premier supplier of CNC Controls was acquired. The G&L PLC focused on motion-centric control and PiCPro became one of the leading control software in applications focusing on precision motion. From 1995 to 2005, over 750,000 controls were shipped.
2007	CT Series Step Motors introduced, using less power to provide more torque than comparable standard hybrid step motors.
2007	Introduced the world's first Pick-n-Go concept in Marktkauf, Germany, automating standard forklifts in order picking processes.
2007	SynqNet motion and I/O network exceeded 225,000 installed axes. The milestone and the aggressive adoption rate indicated broad market acceptance for SynqNet's high performance fault-tolerant digital architecture.
2009	The LS5 Navigator was the first sensor designed not only for indoor use but also for outdoor environments and cold storage, paving the way for new applications with automated guided vehicles.
2009	The Ethernet-based AKD® Servo Drive introduced. AKD delivers best-in-class performance with industry-leading flexibility, scalability and power range to meet the unique performance requirements of nearly any application
2010	Design News Golden Mousetrap Award Finalist in the Motion Control/Automation category.
2010	Kollmorgen introduced the Power Generation System - a complete, robust power platform that can be optimized to meet virtually any military vehicle's energy demands, with the flexibility to fit in applications where space is at a premium.
2012	KAS was launched.
Feb. 2012	Company completed the sale of its Kollmorgen Electro-Optical business for a sale price of approximately $205M in cash.
June 2012	Kollmorgen is the only U.S. supplier recognized by Toyota Industries Corporation in FY 2011 for operational excellence.
April 2013	Kollmorgen Expands Global Sales, Engineering and Manufacturing Footprint by Acquiring Elsim Electrotechnical Systems A.S.
2013	Kollmorgen was a contributing partner to the National Robotics Engineering Center (NREC)/Carnegie Mellon University team's entry in the Defense Advanced Research Projects Agency (DARPA) competition Chimp robot.
June 2013	Acquired MCS Engenharia Ltda in São Paulo, Brazil.
2014	Stainless Steel AKMH Series Motor designed for strict aseptic machine applications.
2015	Produced an energy efficient motor stator in 2015, reducing the power consumption of the HeartAssist5® Left Ventricular Assist Device (LVAD) by 50%.
July, 2016	Danaher, parent of Kollmorgen, executes a spin-off transaction of several businesses within their portfolio forming a new $6B public entity, Fortive Corporation. Kollmorgen is one of those businesses and now is pleased to become part of Fortive.
2017	AKD® & AKM® GEN 2.

Interviewees

John Boyland
Jim Eder
Kenneth Palm
Tom England
Alberto Favalessa
Jens Depping
Bob White
Valerie Garrison
Cathy Biltz
Ute Midkiff
Roger Acton
Doug Austin
George Yundt
Mike Crowe
Randy Kinder
Brad Trago
Paul Coughlin
Jim Dunlea

Acknowledgements

Selected content and images taken from the following:

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