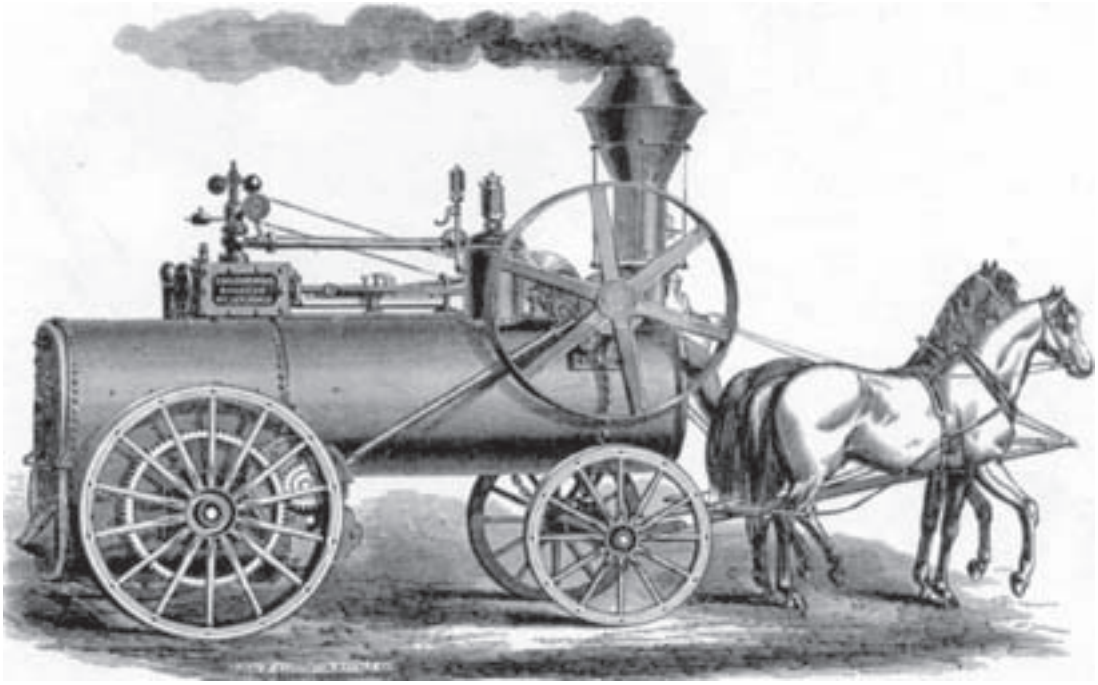


END OF A LENGTHY RUN

History of Mount Vernon facility, Ohio.Since 1833 - Cooper, from 2014 to 2018 - Siemens . 185 years of ups and downs.

By Norm Shade, Compressor tech2, October 2018, p.21-29

In September 2018, the Mount Vernon, Ohio machinery works was closed. Its last owner was Siemens Company. Before the announcement of the facility closure, it was the only manufacturing facility in the United States which had been continuously operating from the 1840s and has a great history lasting 185 years. **[1]**

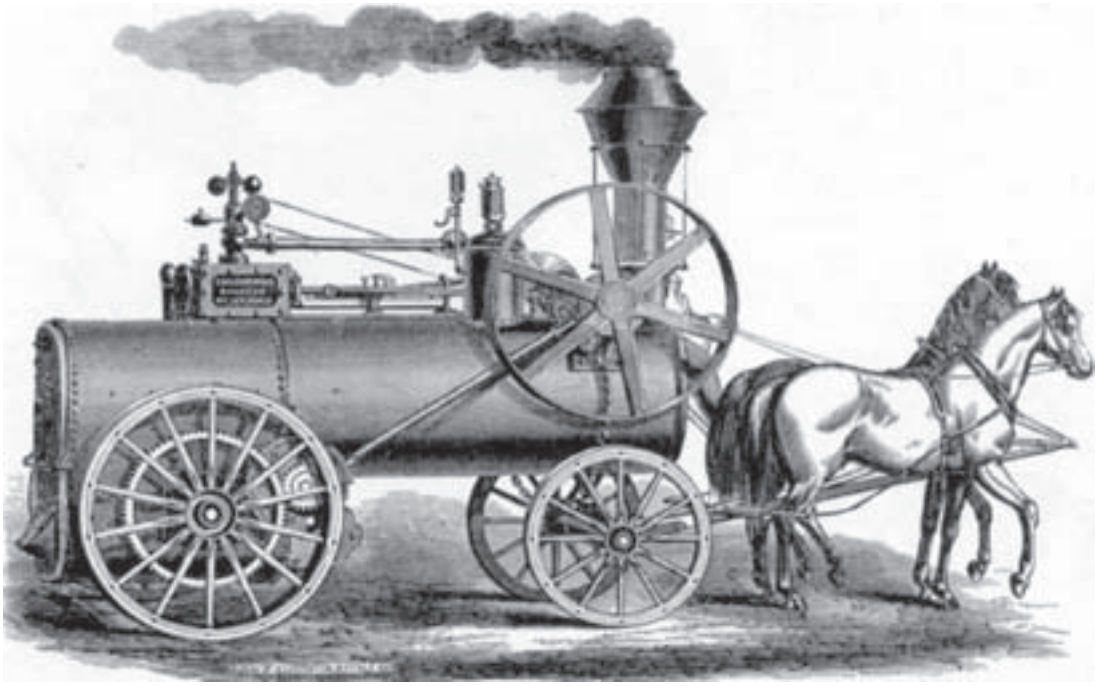
Hereinafter this document includes such references to the comments and supplementary information which the G.O.P. club editors consider pertinent.

Growing with steam

The story of the Mount Vernon works began in 1833 when Charles and Elias Cooper started an iron foundry in a small town of Mount Vernon in Ohio.In 1836, a small steam engine was built there to power the foundry. By the early 1840s, the Mount Vernon works was producing small slide valve steam engines. By 1852-53, it was producing much larger steam engines with blowing compressors for blast furnaces and even wood-burning steam locomotives. In 1869, Cooper produced its first Corliss-type steam engine.

The Corliss valve permitted full bursts of pressure and steady speeds, both assets to the power plants, textile mills and rolling mills. Corliss product lines emerged for farms, cotton gins, grist mills and nearly anything that accepts a revolving shaft. The emergence of the Corliss engine did not immediately overshadow the manufacture of Cooper's conventional slide-valve steam engines. slide-valve steam engines. In addition to stationary engines, there were many portable models that could be pulled by horses into fields or woodlands, on wagons when the ground was hard, or on skids when the ground was soft. Then, in 1875, Cooper introduced the first traction engine, a "modern" piece of farm machinery that used a bevel gear attachment to apply power from the steam engine to the rear wheels. the steam engine to the rear wheels. This first farm tractor provided excess power to pull the water wagon and grain separator from field to field. Although self-propelled, the engine had to be steered by two horses, similar to a wagon.

In the age of railroads, a device that could turn its wheels for steering wouldn't exist until 1883, when Cooper introduced the first patented arrangement for steering. As agriculture advanced into the industrial age, during a 15-year span, the Mount Vernon works built nearly 5000 traction engines.In 1895, with many competitors, some of which licensed Cooper's inventions, the company discontinued building steam tractors to focus on markets for larger Corliss engines.



A sketch of a self-propelled traction engine C & G Cooper steered by horses manufactured in 1876. Provided by Boyer R.L., the chief engineer of Cooper-Bessemer Corporation, Mt. Vernon, Ohio.

C&G Cooper Co. incorporated

The Coopers then were known as major manufacturers of spinning machines, grading machines and special purpose engines (machines). That same year, the business was incorporated as the C&G Cooper Co.

Steam reigned supreme for over a century. But the emergence of the oil and gas industry in the 1870s fueled a strong economic push for internal combustion engines, preferably burning natural gas. Cooper faced a crossroads. The demand for Corliss engines was still robust; Cooper built 15,000 stationary steam engines throughout its history. However steam turbines, growing rapidly in size and efficiency, seemed destined to dethrone the Corliss reciprocating engines. At the same time, large reciprocating engines fueled by natural gas were proving successful in the mushrooming steel industry and held promise for the compression of natural gas in pipelines. The company decided to develop natural gas internal combustion reciprocating engines.

Horizontal gas engine-compressors emerge

In 1909, Cooper introduced its first horizontal gas engine-compressor. These are package units with gas reciprocating engine and reciprocating compressor mounted on a single frame with one crankshaft. The first horizontal gas engine-compressor by Cooper had four, four-cycle power cylinders on one crankshaft throw with a single double-acting compressor cylinder on the opposite side of the crankshaft. Hewitt A. Gehres, who joined the company in 1910 and reigned as head of engineering for 42 years, is credited with improving the original design, making it the most competitive and reliable horizontal in the industry.

The Mount Vernon works was soon among the world's largest producers of single- and twin-tandem horizontals for natural gas compression. Power cylinders on these slow-speed giants had bore diameters of 13 to 26 in. (330 to 660 mm) and strokes of 16 to 35 in. (406 to 889 mm). When production ended in 1952, almost 2600 units averaging about 500 hp (373 kW) had been produced. Horizontal engine-compressors averaged 200 lbs. (122 kg) of iron per hp. In 1929, Cooper merged with the Bessemer Engine Co. to gain prominence in the diesel engine market and to add more foundry capacity for producing horizontal gas engine-compressors. Bessemer was a major diesel engine manufacturer and had one of the largest iron foundries in the world. Management, engineering and product development for the new Cooper-Bessemer Corp. (C-B) was based at Mount Vernon, with production continuing there as well as at the large Bessemer plant in Grove City, Pennsylvania.

Four-cycle one-cylinder horizontal gas engine had been produced at Mount Vernon from 1930 to 1985.

Angle engine-compressors developed

Although the Great Depression took its toll, C-B continued aggressive product development, with most of its engine and compressor testing occurring in the famous Test House, located in the middle of the sprawling Mount Vernon works.The horizontal business boomed, but an alternative to these cumbersome behemoths was emerging. In the late 1920s, Worthington,Ingersoll-Rand and the Hope Engineering and Supply Co. (located in Mount Vernon) introduced angle engine-compressors having vertical inline power cylinders and horizontal compressor cylinders.Cooper acquired Hope in 1928. Soon after the merger with Bessemer, C-B combined Hope's angle frames with Bessemer's two-cycle engine technology to produce the GMR,an angle integral engine-compressor that produced 75 hp (56 kW) per cylinder at 300 rpm. The four-throw unit weighed 132 lb/hp (80 kg/kW), a marked improvement over the horizontals. Only 58 GMRs were built before a more revolutionary concept emerged in 1937.

The GMV V-angle integral engine-compressor employed a novel articulated connecting rod arrangement that allowed twice as many power cylinders on a frame that was not significantly larger than an inline vertical unit. The first 300 rpm GMV was rated 100 hp (75 kW) per cylinder.

As the natural gas pipeline industry grew, the14 in. (356 mm) bore x 14 in. (356 mm) stroke GMV became a favorite, produced in four- to 12-cylinder configurations. **[3]** Uprated 225% over a span of three decades, the final rating of 225 hp (kW) per cylinder at 330 rpm made the 12-cylinder GMVH capable of 2700 hp (2013 kW). Over a 55-year span, 4660 GMV integrals were produced at the Mount Vernon facility.The GMV was designated an ASME Historical Mechanical Engineering Landmark in 2006.

Diesels advance too

Cooper and then C-B developed a broad range of diesel engines for marine, locomotive and electric power generation applications, as well as a range of electric motor driven reciprocating compressors for pipeline, refinery and petrochemical applications. In the mid-1930s, the Mount Vernon engineering team, led by Ralph Boyer, developed an all-aluminum diesel engine that was needed urgently for a new U.S. Coast Guard minesweeper.Although C-B produced its prototype in only 90 days, the Coast Guard chose a larger engine manufacturer for its production needs.C-B had been producing some diesel engines for an emerging diesel locomotive market. General Electric (GE) especially favored C-B's higher-speed models. During World War II, nearly all of C-B's diesel production was allocated to the U.S. Navy, Coast Guard and Army for marine services. However, in 1944, converting the minesweeper engine design to high-grade cast iron, C-B introduced the compact 1000 rpm diesel platform that served GE's locomotive engine requirements for five decades. The Test House, which remained in use until 2003, was the site of countless breakthrough developments, as well as a tragic fatal explosion in the late 1950s.

More integrals and turbochargers

As World War II ended, a demand for small mobile compressor plants arose on the iol and gas equipment market. C-B developed the GMX, a half-size GMV that could be packaged on a skid for the surging oil and field production market. This series would remain popular for almost two decades before high-speed gas engines and balanced-opposed compressors made it obsolete.

In 1947, C-B introduced the GMW, a much larger 18 in. (457 mm) bore x 20 in. (508 mm) stroke integral engine-compressor rated 240 hp (179 kW) per cylinder at 250 rpm. Continued development of the GMW series culminated in the W330, as well as the 20 in. (508 mm) bore Z330 series, rated 680 hp (507 kW) per cylinder at 330 rpm. The 20-cylinder Z330 was the largest integral ever built. More than 1000 GMW series units averaging 3000 hp (2237 kW) were produced. **[3]**

The development and application of turbochargers contributed greatly to the integral engine uprating. C-B began the design and manufacture of its own turbochargers in 1950, but it had been working with Dr. Büchi and his team in Switzerland since 1934. John Fulleman, an understudy of Dr. Büchi, came to the U.S. in 1939 as his representative. Throughout the 1940s, Fulleman and Büchi worked with Boyer and other C-B engineers to turbocharge the company's diesel engines, producing a 50% increase in power, and later 70%.

Although there were multiple benefits for turbocharging diesel engines, turbocharging gas engines was not yet viable as no materials had been developed to withstand the higher exhaust gas temperatures. In 1945, however, C-B developed the first high- compression, four-cycle, gas-diesel engine, followed quickly by a spark-ignited gas version.

Gas engine LSV 16 at the power station

It was the first turbocharged spark-ignited gas engine in the market. Subsequently, cooling of the turbocharger blower discharge air was found to be advantageous. C-B introduced a patented “turbocooling” system, where cooling took place in a conventional air-to-water heat exchanger, and secondary cooling occurred via a radial expander turbine. Hiring Fulleman in 1948, C-B began designing its own turbochargers for C-B engines. Turbocharging two-cycle gas engines began in 1950, a process more difficult than turbocharging four-cycle engines. Various developments missed the mark, until in 1964, technology improved to the point that turbocharged two-cycle gas engines became the norm.

Centrifugal compressors and gas turbines

The early 1950s were very busy times at the Mount Vernon works, dominated by the effort to introduce turbomachinery products as a complement to C-B’s traditional reciprocating engines and compressors.

Centrifugal compressor RFB 24 driven by Elliot turbine rated 4800 hp at 7550 rpm.

With the first turbocharger models in successful service, Boyer launched the development of a line of multistage centrifugal gas compressors. The design of a horizontally split compressor began in 1952. The first prototype remained in the Test House from 1955 onward and never entered commercial service.C-B's entry into the centrifugal compressor market resulted from Atomic Energy Commission's (AEC) need for large numbers of compressors for the post-WWII gaseous diffusion plants for uranium production.

The initial secret activity in 1953 involved an order for conversion components for single-stage uranium hexafluoride (a gas 13 times heavier than air) units originally produced by Chrysler, with design improvements and modification proposed by Fulleman. Subsequently, C-B was invited to bid on 44 new compressors. Despite C-B's lack of experience, AEC liked Fulleman's design using two shell heads for a casing and back-to-back impellers. C-B received the order and shipped all 44 compressors in 1954.

Gas engine compressor GMV-10 in Gas Transmission Museum at "Mostransgaz"

Oil and gas industry power and compression equipment evolved further when lighter, more compact packaged high-speed separable engines and compressors began to replace integral gas engine-compressors in field gas applications. Even earlier, pipeline compressor stations were being installed at closer intervals, which favored centrifugal compressors instead of the big integral reciprocating compressors. After the AEC order success, C-B was ready to tackle the centrifugal market and the first horizontally split centrifugal compressor being sold in 1955, C-B's presence in this industry grew steadily. Although it continued building multistage centrifugals, it discovered its niche in 1954 when it introduced the RFB-24, single-stage pipeline booster compressor. After the RFB-24, C-B developed a line of pipeline centrifugal compressors with flange diameters ranging from 12 to 42 in. (305 to 1067 mm). These were driven by four-cycle C-B gas engines with speed-increasing gears, or more commonly, by heavy frame gas turbines. C-B's lack of a gas turbine driver threatened its leadership in pipeline compression. After failed attempts to develop a free piston engine to generate hot gas for a free power turbine that C-B developed, Boyer and his team revolutionized the industry with the first aircraft derivative gas turbine. The first unit entered service in 1960. C-B and its eventual joint venture partner, Rolls Royce, were leaders in this technology for the next four decades.

Many other significant products were developed and produced at Mount Vernon, including the first axial inlet pipeline centrifugal compressor, which produced historically high efficiencies, the 30 gas turbines that have moved the oil through the Aleyska Pipeline for four decades, and C-B's patented CleanBurn combustion process for two-cycle gas engines.

Everything has an end

The gradual decline of the Mount Vernon works can be traced to 1965, when C-B reorganized as Cooper Industries (CI) and moved its headquarters offsite to "downtown" Mount Vernon. Growing with acquisitions, CI headquarters moved to Houston, Texas in 1967. The energy services business headquarters; engineering and product development; and gas turbine, centrifugal compressor and turbochargermanufacturing operations remained at Mount Vernon. But industry maturation and evolution forced more changes. The foundry closed in the early 1970s and it was repurposed into a plant for manufacturing Superior separable reciprocating compressors. Reciprocating engineering and administration was transferred to the Grove City plant in the mid-1980s.

CI's oil and gas-related businesses were spun off as Cooper Cameron Corp. (CCC) in 1995, which led to more changes at the Mount Vernon site. In 2000, the gas turbine and centrifugal compressor business was sold to RRES, and the rest of CCC's administrative, engineering, manufacturing and aftermarket operations were moved to other locations. RRES continued to build large turbines and compressors at Mount Vernon until the 2014 sale to Siemens.

In 2014 Siemens took the helm of a legacy Mount Vernon, Ohio plant formerly in the care of Rolls-Royce Energy Systems (RRES) hoping that it would manage to breathe new life into it. Within two years, however, a soft power generation market forced Siemens to reduce its workforce and start phasing out its manufacturing operations at its Ohio facility. In 2018, Siemens announced in February that it will close its Mount Vernon facility later this year. **Everything has an end.**

Comments and supplementary information of the G.O.P. club editors

[1]

In fact, this facility accomplished the main achievements in energy industry of the 18th-19th centuries and gas industry of the first half of the 20th century.

[2]

20 such gas engine compressors with 10 power cylinders were bought in 1944 for the first long-range gas pipeline, Saratov – Moscow gas pipeline, with the total length of 830 km. Five compressor stations of the pipeline were equipped with these gas engine compressors.

Construction of Saratov – Moscow gas pipeline

[3]

In 1973, the USSR bought a production license for the Z330 gas engine compressors from Cooper-Bessemer Corporation. Licensed production of gas engine compressors DR-12 rated 7500 hp began in the city of Gorky at the plant "Dvigatel Revolutsii" (since 1993 "RUMO" plant, Nizhny Novgorod). Total number of compressor units manufactured there amounts to 14, most of them were used in the underground gas storage facilities (UGS).

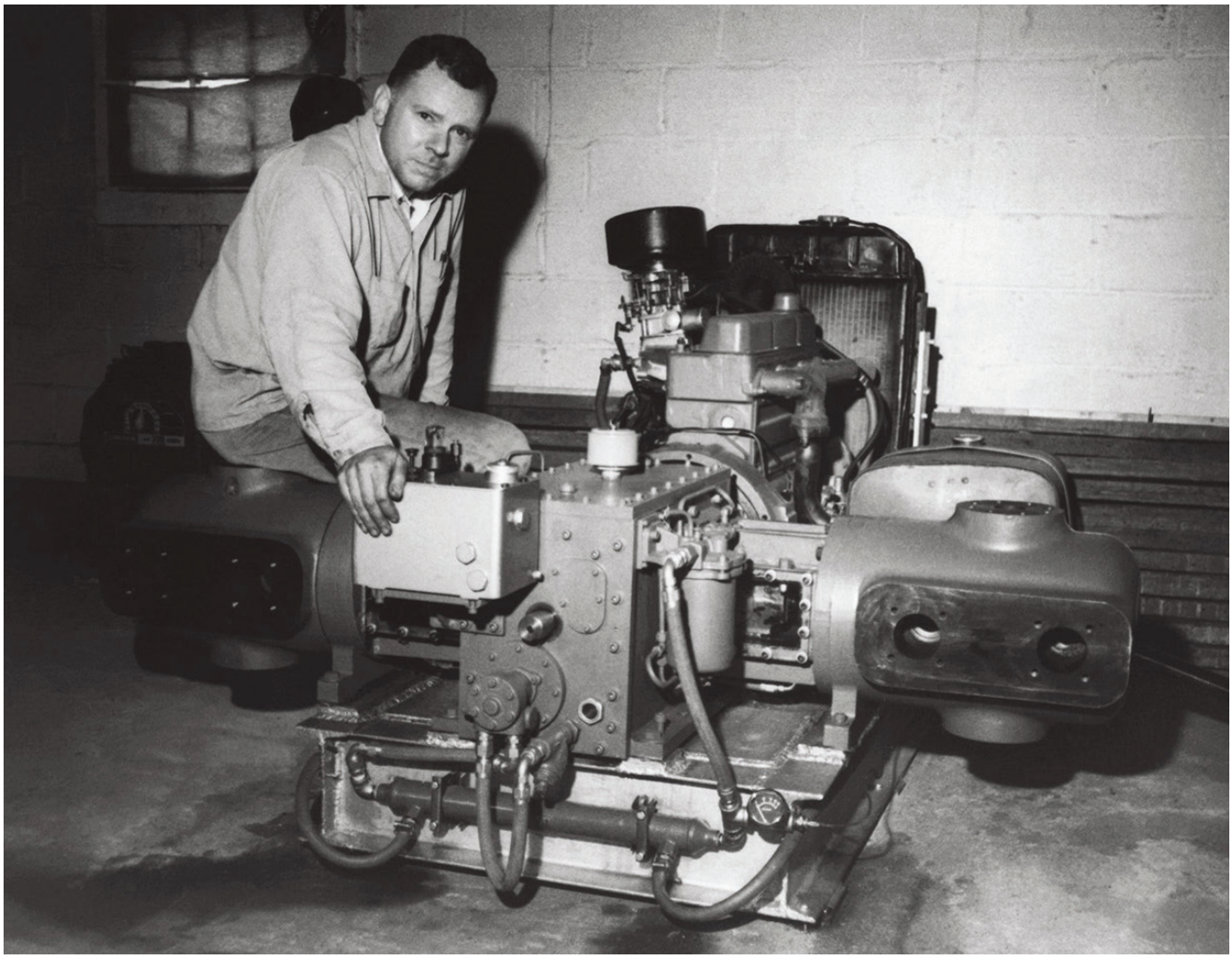
So, Cooper-Bessemer plant in Mount Vernon:

- predetermined the initial stage of gas industry development in the USSR;

- is the creative cradle of the founder of Ariel Corporation Jim Buchwald and unintentionally lays the basis of Ariel Corporation;

- Early history of the gas industry of the USSR is inexorably associated with application of reciprocating compressors. The most rational reciprocating compressors for the gas and oil industry of 1940-50s all over the world were considered the gas engine compressors with a gas reciprocating engine and reciprocating compressors mounted on a single frame with one crankshaft. As it has been pointed out in comment **[2]**, the compressor stations of the first gas pipeline in the USSR, Saratov – Moscow gas pipeline (put into operation in 1946) were equipped with foreign gas engine compressors GMV-10 by Cooper-Bessemer rated 746 kW (1000 hp). The first gas processing plant in the USSR, Moscow Gas Processing Plant, was equipped with the gas engine compressors by Clark and Ingersoll-Rand. In 1948-1949, the production of gas engine compressors was launched at the plant “Dvigatel Revolutsii” in Gorky (“RUMO” plant in Nizhny Novgorod at present). There were produced gas engine compressors 8GK rated 300 hp and 10GK rated 1000 hp. 8GK compressors were supposed to be applied in oil industry, for gas industry high-power (!) 10GK were urgently manufactured, which were identical to GMV-10 model. Other Moscow plants “Borets” and “Komressor” and a heavy machinery plant in Kolomna were involved to speed up production of 10GK. The first 10GK was produced in 1949-1950. These compressors were utilized in the first UGS in the USSR and in all the compressor stations constructed in 1949-1955. Production of centrifugal compressors rated 4 MW was launched in Leningrad in the mid-1950s. From that very moment only compressor packages with centrifugal compressors are utilized for large gas pipelines. So, glory days for the gas engine compressors came to an end. But only one plant in the USSR continued producing these compressors - “Dvigatel Revolutsii”. In 1962-1964 this plant had implemented turbocharging for 10GK compressors which resulted in uprating it to 1100 kW (1500 hp) and started producing 10GKN gas engine compressors. Such gas engine compressors without any significant redesign have been produced for almost three decades. They were used for equipment of UGS and small compressor stations not only in the USSR but also some compressor stations in Poland, Romania, Hungary, Bulgaria, Afghanistan. As it has been mentioned in comment **[3]**, in the early 1970s the USSR resumed its relationships with the C-B in MV and bought the production license for Z-330 series gas engine compressors. The plant “Dvigatel Revolutsii” produced 14 DR-12 units of the series for several large UGS. Nowadays we can judge if the production license for the gas engine compressors had been appropriate and essential then. As it is stressed out in the book “Gorky diesel: the outline of “Dvigatel Revolutsii” history” (Moscow, 1985), launching production of DR-12 compressors facilitated solving urgent macroeconomic objectives and allowed saving million cubic meters of gas…

- Jim Buchwald is the founder, chief designer, first CEO and president of Ariel Corporation. Jim Buchwald graduated with a B.S. in Mechanical Engineering and worked in Cooper-Bessemer at Cooper works in Mount Vernon from 1954 to 1958. These were the formative years for the young professional which turned him into a creative engineer and manager able to enter into details of designing, manufacturing and operating engines and compressors. Among his teachers and mentors were the key specialists of C-B: Bill Crooks – Head of the Research department of C-B, Robert Ramsey, John Konkler, etc. One of other fathers-cofounders of Ariel Jim Doane also worked in C-B. Jim Doane and Jim Buchwald were on friendly terms, they were fond of camping in the mountains. Doane was supportive of Buchwald's idea to establish his own Compressor Company and assisted him in the years since. He helped Buchwald to build a prototype of the compressor in the basement of the Buchwald family home.



Jim Buchwald with the first Ariel compressor

In his book “Letters to Alex. A history of Ariel Corporation”, published for Ariel's 50th anniversary, James P. Buchwald (Jim Buchwald) describes in details 27 years of Ariel Corporation. One more book was published to celebrate Ariel's 50th anniversary “Ariel: A Great American Company” by Sarah Morgans which gives insight into the history of Ariel from the year of its incorporation to 2016. Digest of this book is available on the website of the G.O.P. club. Both books touch upon the relations between C-B and Ariel. For the sake of convenience the product lines of Ariel compressors are assigned names, there is a tradition to include in the names of the lines the initial letters of the names of the people who are prominent to Ariel.

Giving credit to the years spent in C-B, Buchwald included the initials of his first mentors in the names of the first line - Robert Ramsey (JGR line) and Bill Crooks (JGC line). As it is mentioned in the book “Letters to Alex. A history of Ariel Corporation”, there was a short period when C-B rendered services to Ariel related to heat treatment of crossheads. But in fact, Ariel and C-B were real competitors, and Ariel compressors pushed out of the market the gas engine compressors by C-B. Objective reality, advancement of technology and laws of the market are inevitable…

Norm Shade, the author of the article “The End of the Lengthy Run” and the expert in compressor equipment, believes that the decline of Cooper works in MV began in 1965, several years before Ariel was founded and before it began producing its compressors. C-B works in MV was actively producing centrifugal compressors and then gas turbines. Unlike Ariel, Cooper, Cameron and subsequent owners of the works in Mount Vernon were producing a wide range of products.

We recommend to those who are interested in the subject a book published by Techno-Press “From C & E Cooper to Cameron Compression. History of a corporation” D. Keller.