Photograph of Reaction Motors founders and early employees, taken c.1941 at the old Silver Factory building in Pompton Plains. Included in the photo are (second, third, and fourth from left, respectively) Hugh Franklin Piece, James Hart Wyld, and John Shesta. (author's collection)

POWER for PROGRESS

A Brief History of Reaction Motors, Inc., 1941-1972

by Ronald J. Dupont, Jr.

Dr. Robert H. Goddard

In any discussion of American aerospace history, some names come immediately to mind as icons: Goddard. Houston. White Sands. Cape Canaveral. NASA.

But what about: *Lawrence? Wyld? Pompton Plains? Lake Denmark? RMI?* These names would draw a blank for all but dedicated aerospace historians, yet they were critical to the early development of American rocket science. A vital chapter of early liquid-propelled rocket engine design and testing took place in the hinterlands of New Jersey. It centered on a company called Reaction Motors, Incorporated.

THE EARLY YEARS OF ROCKETRY

Rockets were invented at least 700 years ago, when the Chinese used them for both military and festive purposes. The British employed them in naval warfare in the early 19th century, but the age of modern rocketry began in the years during and after the First World War. In the United States, the great pioneer of rocketry was Dr. Robert H. Goddard, working first at Clark University in Massachusetts in 1914. In 1926, Goddard flew the first liquid-powered rocket.[1] In Germany, the German Rocket Society was established by the late 1920s, and by the early 1930s had made significant progress in the field. The American Rocket Society (see below) was established in 1930.

Though often lacking funding, and struggling with basic technological questions, these private organizations and research efforts laid down fundamental principles of modern rocketry. Rocket enthusiasts in both the U.S. and Germany enjoyed a degree of kinship and communication that, for political and military reasons, ended abruptly in 1934.

By the Great Depression, both the American public and government tended to regard rockets as the fanciful things of Buck Rogers and Flash Gordon. The military and private industry saw little practical application for rockets, and showed accordingly little interest. The Guggenheim Foundation supported rocket research at the California Institute of Technology with grants, and much rocket research and development occurred in academic environments. There were also occasional forays by rocket promoters into commercial applications, with sometimes-comical results. One such event took place at Greenwood Lake in 1936.

On February 23 of that year, Fred Kessler, founder of the "Rocket Plane Corporation of America," organized the launch of a vehicle he hoped would demonstrate the usefulness of rockets in delivering mail. The unmanned rocket plane that was built had a fourteen-foot wingspan and was made of the alloy "duralumin"; a spare vehicle was also constructed.

Willy Ley

"Gloria"

Dubbed the "Gloria," this odd aircraft was promoted by Willy Ley, a well-known German writer and journalist in the field of rocketry. Interestingly, it bore a passing resemblance to a German V-1 rocket, which in a few years would gain the world's attention. The design of the rocket, however, was apparently not on par with Ley's ability to generate public interest in it. On frozen Greenwood Lake, the "Gloria" was loaded with mail and fuel, placed on its launching catapult, and fired off. It went straight up, then down, then up, and then down–permanently.[2]

The spare "Gloria" was brought forth, the mail transferred to it, and it was launched directly from the ice. It finally rose up and flew a quarter of a mile before the force of propulsion ripped its wings off. Most importantly (to its promoters), it made it to the New Jersey state line, where the enclosed mail was postmarked for eager collectors.[3] The surviving "Gloria" long hung from the rafters of the Greenwood Lake Boat Yard, and was later donated to the Aviation Hall of Fame and Museum of New Jersey at Teterboro Airport, where it remains today.

A somewhat comical affair (newsreel snippets of the launch can sometimes be seen on television–generally used for comic effect) the Greenwood Lake rocket mail probably served to reinforce the public perception of rockets as the stuff of science fiction–intriguing, yes, but wholly impractical.

THE AMERICAN ROCKET SOCIETY

The American Rocket Society (ARS), originally called the American Interplanetary Society, was founded in 1930, and was the first such society in the U.S. to actually build and test rockets. Four members of the Society were Lovell Lawrence, Jr., John Shesta, James Hart Wyld and Hugh Franklin Pierce. These four were among the core of the Society's Experimental Committee, and they went on to found the first commercial rocket engine company in the history of the United States.[4]

Lovell Lawrence, Jr., was a local boy. Born and raised in Pompton Lakes, he was remembered as being the local "Tom Swift"–a young genius inventor.[5] The Lawrence family developed Erskine Lakes. He had started as an engineer with IBM in 1933, and by 1938 had established his association with Wyld in rocketry. Wyld, from Pines Lake in Wayne, was a Princeton graduate with a background in design engineering. John Shesta had been an instructor of civil engineering at Columbia University, and later an engineer in private industry. Hugh Franklin Pierce, when not helping build and test rockets, had the more staid occupation of engineer and machinist on New York City's I.R.T. subway line. RMI employee Mead Stapler remembered Pierce as the "hands-on genius of early RMI. He made things work!"[6]

"In those days, we would use a moving test stand at a temporary location, launch a rocket, then get out of there as fast as we could before the police came."

–John Shesta

In addition to his three colleagues in the ARS, Lovell Lawrence, Jr., was also acquainted with a far more famous figure in early rocketry–Dr. Robert H. Goddard.

The experimental rockets built and tested by ARS members were small, and sometimes proved strikingly successful–and occasionally far less so. This roving band of tinkering rocket enthusiasts soon established a Sunday afternoon routine for testing their hobby. With no real budget, no machine shop, and no place to legally test their home-built rockets, they hardly seemed poised for greatness–yet they helped build the foundations for rocket science in America, and their early tests entered north Jersey folklore.

Their typical routine was to gather on a Sunday afternoon, load up the test rockets and gear in a car, and transport everything to an open field sufficiently removed from human habitation. By this point in time, the ARS had abandoned early efforts to launch actual rockets vehicles in favor of testing what were essentially scale-model rocket engines. They conducted "static" tests (where the engine is fastened to a stand before firing). Shesta had devised a portable test stand made of pipes, easily disassembled. When the test rocket was set up, gauges checked, and all had retreated a safe distance, the engine was ignited.

Experience soon taught the group to break down and clear out quickly–the loud noises, flashes of light, and occasional explosions of their rocket engines were often reported to the local authorities. In an interview with Wayne archaeologist Edward J. Lenik in 1977, Shesta recalled the sometimes comical maneuvering required to test their early rockets: "In those days, we would use a moving test stand at a temporary location, launch a rocket, then get out of there as fast as we could before the police came."[7] Recalled former RMI engineer Harry W. Burdett, Jr., "You can bet we never went back to the same place twice."[8]

A quick exit avoided uncomfortable questioning by police about mysterious roars, blasts, and strange lights and smells. Shesta's test stand, taken apart, looked like nothing more than an innocent pile of pipes in the trunk of a car.[9] The ARS dubbed it their "Test Stand No. 2," and it is now on display in the National Air and Space Museum in Washington, D.C.[10] Thus it was that various anonymous and now-forgotten cow pastures, hay fields, and abandoned meadows were the scenes of some of American's earliest liquid-propelled rocket testing.

In contrast with somewhat comical efforts such as the Greenwood Lake rocket mail, ARS members were making real progress in rocket engine design. By 1938, Wyld had developed what he called a "regeneratively cooled rocket engine." This was

Rocketry was considered the realm of science fiction fantasy

an engine where the combustion chamber was cooled by the incoming fuel.[11] The design was the basis for RMI's earliest motors, fundamentally contributed to future U.S. rocket engine design, and is still in use today.

In March 1938, Shesta and Wyld demonstrated a model liquid propelled rocket to the New York Railroad Club. With them was G. Edward Pendray, president of the ARS and an executive of the Westinghouse Company. The *New York Times* noted: "Defending the rocket experimenters against the gibes of those who connect them with the fanciful 'journeys to the moon,' Mr. Pendray forecast that some day a rocket would be shot across the ocean." Though the demonstration was a success, the audience remained skeptical.[12]

The limited progress made by American rocketry in the 1930s reflected the general perception of it as an impractical, sometimes comical field of theoretical endeavor. German scientists and the German government regarded it much more seriously, and in only a few years the world would realize how true Pendray's prediction would become. German rocket science had proceeded far, and practical (and deadly) applications had been found for it. America had to catch up–quickly.

REACTION MOTORS, INC., IS FORMED, 1941

By 1940, it was clear that America was edging closer to war. America's formal entry into the war in December 1941 brought a renewed interest in practical (i.e. military) applications in rocketry. For a decade, American rocket enthusiasts had pursued their interest with varying degrees of technical success, but with no practical applications. With the world rapidly being enveloped by war, the four members of ARS's Experimental Committee decided the time was ripe to put rocket research and design on a commercial basis. To form a corporation they would need capital, the most likely source of that being the military.

In November 1941, after a series of communications, Lovell Lawrence, Jr., managed to arrange a visit by a representative of the U.S. Navy Bureau of Aeronautics. The Navy was intrigued by reports of Wyld's regeneratively cooled engine, and a demonstration was set up. Lawrence, Wyld, Pierce, Shesta, and the Navy representative convened in a wooded spot near Wanaque to see a demonstration of the engine.[13]

The engine was tested multiple times, producing up to 100 pounds of thrust for up to forty seconds at a time; the Navy representative left enthusiastic. Soon after the successful testing came the fateful attack on Pearl Harbor. Less than a week later, the pioneers had their first $5,000 Navy contract for rocket engines.[14] It

The use of rockets by Nazi Germany during World War II meant the U.S. government started taking rockets seriously

was the beginning of a long and fruitful association with the United States Navy.

With the Navy contract on the way, the four entrepreneurs formed a corporation. They gave it a name grounded in solid Newtonian physics as applied to rocket engines: *to each action there is an equal and opposite reaction*. So they called the corporation "Reaction Motors." It was the first commercial rocket engine company formed in the United States.

The name "Reaction Motors" was intended to evoke such corporate behemoths as General Motors, whose success RMI hoped to emulate–although Wyld later admitted "the analogy was not very close, as we scarcely had two nickels to rub together."[15] The name also caused some confusion. "It was a grand name," noted RMI engineer Harry W. Burdett, Jr., but "motors" misled some of the public. "For months and months, we'd invariably get phone calls asking 'Do you guys do front-end jobs?'"[16]

Reaction Motors, Inc. (RMI) was formally incorporated on December 16, 1941, nine days after the Pearl Harbor attack, with Lovell Lawrence, Jr., as business manager and president; John Shesta as treasurer and chief engineer; Hugh Franklin Pierce as vice president and chief test engineer, and James Hart Wyld as secretary and director of research.[17] The founding partners were also the firm's owners.[18]

The beginning was indeed inauspicious. The firm's first headquarters were in a bicycle shop on Wanaque Avenue in Pompton Lakes, with engines being tested (literally) out the back door, or at nearby Lake Inez.[19] Launching rockets was no longer a goal; designing and testing engines themselves became the focus. In their first nine months of existence, RMI designed and produced ten different rocket engines producing between fifty and one thousand pounds of thrust.[20]

RMI'S JATO PROJECT

RMI's first Navy contract was to enlarge Wyld's original motor by a factor of ten: produce a 1,000 pound thrust engine. Moreover, it was to use commonly available gasoline, and not ethyl alcohol as the original had. The engine was to be used for a JATO (jet-assisted take off) system for aircraft.[21] Research actually focused not on jet engines as presently defined (which use atmospheric oxygen for combustion), but on rocket engines (which use liquid oxygen or another suitable oxidizer). During these critical years of World War II, it was hoped that by increasing takeoff speed, JATO would permit aircraft to use shorter, bomb-damaged runways, take off from naval ships, and lift heavier loads. JATO ultimately reduced takeoff distance by 60%.

Take-off of America's first "rocket-assisted" airplane, an Ercoupe fitted with a GALCIT developed solid propellent 28 pound thrust JATO (Jet Assisted Take-Off) booster. The Ercoupe took off from March Field, California and was piloted by Captain Homer A. Boushey Jr.

RMI successfully produced the enlarged engine, which they called the "Wyld Regeneratively Cooled Rocket Motor, Serial No. 2." It is today on exhibit in the National Air and Space Museum.[22] A second Navy contract in 1943 required that RMI produce a 3,000 pound thrust version of the same engine. It exceeded that specification, producing 3,400 pounds of thrust, thirty-four times that of the original motor two years earlier.[23]

These research and development contracts necessitated a permanent testing facility for RMI (their first), which was located on the eastern edge of the privately-owned Nelson airport in Franklin Lakes, Bergen County, near the shore of Lower Lake.[24]

The Franklin Lakes testing facility of RMI was constructed in late 1942, and operated for roughly sixteen months, being vacated in early 1944. The facility conducted "static" tests of rocket engines (where the engine is bolted to a testing frame).[25] Engines from 300 to 3,000 lbs. thrust were tested, using liquid oxygen, alcohol, or gasoline as fuel.[26] Engines tested at the site were primarily intended for JATO use. The Franklin Lakes facility was largely designed by Wyld.[27]

No sooner was the test facility in operation than it attracted unwanted attention. In mid-September 1942, Franklin Lakes residents heard a roar and saw a flash of light near the airport. Fearing a plane crash, they summoned the State Police and the Oakland Fire Department. A contemporary newspaper account notes: "By the time they arrived, the noise had subsided and a Pompton Lakes man [presumably either Wyld or Lawrence] emerged from a small cement building to explain that it was only an experiment." Authorities forced the entrepreneurs to obtain a building permit for their structures (which had been erected without town approval) but otherwise did not interfere.[28]

One of the tests conducted at the Franklin Lakes facility was a JATO unit for a Navy PBM (a "plane boat," designed to land and take off on water). A mockup of a PBM tail-end was constructed on the site and a rocket assembly successfully test run in late 1943. In January 1944, JATO tests were successfully demonstrated on a real PBM on the Severn River near Annapolis, Maryland.[29]

Ironically, Robert H. Goddard, was himself working on JATO under contract to the Navy. While RMI succeeding in developing a working JATO unit for the Navy, Goddard's attempt failed–quite a feather in RMI's cap.[30] Interestingly, the RMI team and Goddard enjoyed friendly, if competitive, relations in the 1940s. Goddard visited their New Jersey facilities on a number of occasions, and the two design teams dined together.[31] Goddard's legendary research career was cut short by his untimely death from cancer in 1945.

"You could hear it for miles, but I wasn't going to tell them to stop."

–Arthur Pickering

One unintended benefit of rocket motor testing at the Franklin Lakes site was the brush fires they inadvertently caused, which ultimately cleared an area 100' wide by 500' long, making for much easier viewing.[32] Potential fireballs resulting from a faulty engine test, and subsequent flying shrapnel, required a sturdy concrete blockhouse from which to view tests.

This blockhouse was the major element of the Franklin Lakes testing facility of RMI to survive into the modern era. It was roughly 12' x 12,' with reinforced cinderblock walls, poured concrete floor, and eleven shatterproof plate glass viewing portals. The eastern wall, which faced the engine tests, was of solid poured concrete. A concrete test pad, which originally had a steel test frame bolted to it, was also extant at the Franklin Lakes site.[33]

RMI–A NOISY NEIGHBOR

Rocket engines tested at the Franklin Lakes site fired out over Lower Lake; the force was sufficient to raise whitecaps. The noise and vibrations associated with engine testing was, and would remain, a constraint for RMI. Former Franklin Lakes Police Chief Arthur Pickering recalled the RMI tests: "It sounded like a real blasting, like dynamite. You could hear it for miles, but I wasn't going to tell them to stop."[34] Fortunately at the time the area was occupied only by the nearby airport and a few chicken farms.[35] The noise of the testing did, however, cause one farmer's chickens to stop laying eggs, and RMI accordingly had to reimburse him for his losses.[36]

Technological prowess, a tremendous work ethic, and a zeal for rocketry were early hallmarks of RMI; few who came in contact with the firm went away unimpressed by the dedication and know-how of its staff. An ability to make money, however, was more elusive for the firm. Financial affairs in the early days seem almost comical: an apocryphal story from Pompton Plains tells that Lovell Lawrence, Jr., was shocked one day to examine RMI's books only to discover that the firm was broke, with zero operating cash. Fear gripped the company for several hours, until it was discovered that there were four large checks payable to RMI stuffed in Lawrence's pocket, and "bankruptcy" was thus avoided.[37] But financial woes would recurrently plague the firm in decades to come.

THE MOVE TO POMPTON PLAINS, 1943

RMI rapidly outgrew their original headquarters in Pompton Lakes. In late 1942, the firm purchased the former Shaw's Silver Factory in Pompton Plains, near the intersection of State Route 23 and the Boulevard. By January 1943, they had moved into the

The old Shaw's Silver Factory building in Pompton Plains, N.J. This served as Reaction Motors, Inc., first major headquarters in the 1940s. Later demolished for highway interchange construction, a plaque was recently erected commemorating the location. (author's collection).

building. They soon built three test stands in an adjacent three-and-a-half acre sand pit.

In the 1890s, the Silver Factory–a large, barn-like structure and one-time speakeasy–had produced fine silverware for the likes of Tiffany's; in the 1940s, RMI used it for decidedly more high-tech industrial production. W. Mead Stapler, a former RMI employee, recalls the energy in the air at the time: "It was truly the most exciting job I ever had, and we all knew at the time that we were participating in great historic events."[38]

After moving their headquarters to Pompton Plains in January 1943, the Franklin Lakes test site was now somewhat distant from RMI headquarters. As a result, in 1944, RMI replaced the Franklin Lakes testing facility with a new one adjacent to their Pompton Plains headquarters, in a former sand and gravel pit owned by the Dunn family. While much more convenient for RMI, the terrific noise of their tests proved to be an annoyance to neighbors. Former RMI employee Robert Holder of Parsippany recalled that everyone in Pompton Plains knew about the firm–indeed, could not fail to know about it, because of the enormous noise its testing generated.[39]

The issue of noise and vibrations generated by testing was surprising least of all to RMI: few knew better than they how unpleasant testing these motors really was, and the massive amounts of dangerous chemicals they consumed. In the mid-1940s, when RMI was designing the engine for the X-1 aircraft (see below), the firm needed a "public relations" name for the engine, which was painted black, and was astonishingly loud and guttural. The name given for press consumption was "Black Betsy," more delicate than RMI's internal appellation: the "Belching Black Bastard."[40]

This issue–noise–ultimately precipitated RMI's departure from Pompton Plains. The Pequannock Township Board of Adjustment addressed public complaints about noise and vibrations generated by RMI as early as October 1944. At that time, RMI was applying for permission to construct a new test stand adjacent to their building.[41] Damage was being done to buildings and vegetation by noise and vibrations from RMI's testing. In late 1945 Pequannock Township formally asked RMI to locate elsewhere, which they did in 1946.[42]

THE MOVE TO LAKE DENMARK, 1946

As a result of their ongoing problems operating in Pompton Plains, RMI looked around for new quarters. The answer they found seemed a godsend–a variety of large, old Navy ordnance buildings nestled in the remote hills near Picatinny Arsenal, close

Photograph of Reaction Motors, Inc., Model 6000-C4, four-cylinder, liquid propellant rocket engine, in operation on test stand at Pompton Plains, N.J., c.1949. This was the engine that would power the Bell X-1, breaking the sound barrier. (author's collection)

to Lake Denmark, in Rockaway, N.J. It was sufficiently remote for testing (or so they believed), yet close to the supplies of skilled labor and bulk chemicals they needed. That they would be leasing the property from the Navy, their primary source of business, made things all the better.

The Navy had maintained ordnance depots at Lake Denmark, adjacent to Picatinny Arsenal, since 1891. The locale is best remembered as the place where, in July 1926, a series of catastrophic explosions destroyed much of both the Naval depot and Picatinny Arsenal. The Navy never fully rebuilt its facilities, and as such the property was ideally suited for a new use.[43]

RMI moved to the leased Navy testing property in March 1946.[44] At Lake Denmark, new and much larger engine test stands were built, the range of operations being expanded to include rocket motors of up to 20,000 lbs. thrust–nearly sixty times more powerful than the smallest engines they had tested only a few years prior.[45]

As the Second World War came to a close, the National Advisory Commission for Aeronautics (NACA, the predecessor of NASA) set as a goal the development of a research aircraft that would break the elusive sound barrier. To this end, they contracted with Bell Aircraft in March 1945.[46] Jet engines of the period were deemed insufficiently powerful for this purpose, so it was decided to employ rocket propulsion.[47] In choosing a contractor to build rocket motors for this new aircraft–to be called the X-1–Bell turned not to one of the larger firms in the field, such as General Electric or Curtiss-Wright, but to that small maverick, Reaction Motors.[48]

RMI began work on this engine while still in Pompton Plains; testing and delivery of it was delayed by the move to Lake Denmark.[49] This special new rocket engine (along with RMI's Pompton Plains facility) were featured in a large photo spread in *Life* magazine in May 1946, where the magazine noted that the engine would power an "unspecified Navy plane faster than the speed of sound."[50]

RMI ultimately developed a four-chamber engine (the 6000C-4, "Black Betsy"), fueled by a mixture of liquid oxygen and diluted ethyl alcohol, for the new aircraft.[51] On October 14, 1947, a young Army Air Force veteran–Chuck Yeager–climbed into the X-1, with its RMI-designed and built rocket engine, and proceeded to break the sound barrier–the first time in human history an aircraft had done so. That aircraft, with its engine, now hangs in the main "Milestones of Flight" gallery of the National Air and Space Museum of the Smithsonian in Washington, D.C.[52]

One of the most notable engines RMI developed in these years

Laurance S. Rockefeller

was the *Gorgon* missile motor, a fifteen-pound engine that was able to generate over six hundred pounds of thrust. It could ignite and operate in a vacuum, using only a mixture of nitric acid and aniline as fuel. These two chemicals are hypergolic (ignite spontaneously), so such an engine required no ignition system. Theirs was only the second such engine developed in the United States.[53]

THE ROCKEFELLER CONNECTION, 1947

Toward the end of World War II and immediately thereafter, RMI prospects were distinctly mixed. Business was increasing, income was rising, their work force expanding rapidly–but the firm was awash in red ink. The reason was simple: while contracts were awarded for fixed sums, expenses could be wildly unpredictable. By the end of 1946, RMI was deeply in debt.[54]

It wasn't that Wall Street investors weren't impressed by the firm whose engines helped break the sound barrier. They were simply scared to death by the company's rapacious ability to consume cash. Innovative success did not, necessarily, translate into profits. Worried that this high-tech darling might fold, concerned Navy brass made a phone call to somebody in a position to help: Laurance S. Rockefeller.[55]

The Rockefellers were at this time still mending their public image–created by John D., Sr.,–of omnivorous capitalist barons. Now they were interested in nurturing small, pioneering companies whose abilities to produce important technological breakthroughs outweighed their ability to return a steady quarterly profit.[56] For such a cause, RMI was a virtual poster child.

In 1947, the Rockefellers invested $500,000 in RMI, for which they received a 21% interest in the company. In 1953, Mathieson Chemical Corporation (later Olin Mathieson) purchased a 49% interest in RMI, which became an Olin Mathieson affiliate.[57] Olin Mathieson was a huge corporation with widely diversified interests in chemicals, metals, and explosives. These acts heralded a new age of growth and stability for RMI, but they would mark the era when control of the firm left the hands of its four founders. By the mid-1950s, all four were gone–Wyld was dead, and Lawrence, Shesta, and Pierce had left Reaction Motors, Inc. for other endeavors (see Epilogue).

In later years, RMI (and its successor, RMD) continued to provide engines for the X-series aircraft, including the X-1B, tested 1956-58, and the X-15, a research aircraft that was a developmental step toward the modern Space Shuttle.[58] RMI's success at winning Navy contracts led to a huge expansion of facilities at Lake Denmark. By 1950, RMI provided the bulk of the test facilities at the new "Naval Air Rocket Test Station" (NARTS) at Lake

Reaction Motors, Inc., headquarters at 100 Ford Road in Denville, NJ, 1951. The building still stands today; a commemorative marker has been placed nearby. (author's collection.)

Denmark, a $7.5 million facility nestled on 650 remote acres adjacent to Picatinny Arsenal.[59]

By 1957, RMI had twenty-one test stands in operation at the site. Eighteen could handle static testing of engines from eighteen to 20,000 pounds thrust. Three test stands could handle engines from 50,000 to 350,000 pounds thrust. One of these was the massive Test Stand R-2, built in 1957. One of the largest test stands on the East Coast when built, R-2 could (with modifications) test rocket engines of up to 1,000,000 pounds thrust. It was the largest test stand in America that could test engines at all attitudes (i.e. angles of fire).[60] Engines for the X-15 were tested here.[61] In less than seven years, they had come far from the little concrete blockhouse on the shores of Lower Lake.

Things only got bigger. In 1949, RMI had moved their administrative headquarters to nearby Rockaway, N.J. In 1955, they constructed a massive, 350,000 square foot plant at 100 Ford Road in Denville for administration, manufacturing, and research and development. In 1943, they had just over twenty employees; in 1947, 473 employees.[62] By 1957, RMI had 1,800 employees working largely under a cloak of secrecy (due to military contracts). They had field offices in Washington, D.C., Dayton, Ohio, and Los Angeles. Sales for 1956 were $25 million.[63] By the late 1950s, the firm was thus truly living up to its advertising slogan: *"Power for Progress."*

In these years, RMI produced propulsion and attitude control engines for a wide variety of programs: rockets, missiles, supersonic aircraft, spacecraft, and lunar probes. A select list of RMI projects over the years is presented below.

TABLE 1: CHRONOLOGICAL LIST OF SELECTED RMI PROJECTS AND ACHIEVEMENTS[64]

1941	first U.S. Corporation dedicated solely to development of liquid rocket engines.
1943	3,000 lb. thrust JATO engine for Navy PBM.
1944	350 lb. thrust hypergolic engine for *Gorgon* experimental guided rocket missile.
1944	experimental rocket boat tested for potential use as landing craft in invasion of Japan; never used.
1945	620 lb. thrust engine for *Lark* guided missile, first in U.S. to go into production.
1946	6,000 lb. thrust four-chambered engine introduced; engine achieves numerous supersonic flights over next three decades of service.
1947-57	20,000 lb. thrust engines for *Viking* missile produced.
1947	Bell X-1 powered by RMI 6000C4 engine breaks sound barrier.

Photograph of Reaction Motors, Inc., rocket engine for the Viking missile (left) as compared to an engine from the German V-2 rocket from World War II. Photo c.1951 (author's collection).

1947 "Spaghetti" combustion chamber construction developed, now used in Space Shuttle, among many other large-scale liquid fuel engines in the U.S.

1947 Experimental rocket-propelled ice sled tested on Lake Hopatcong, an off-duty private project of RMI employees; reaches speeds of 90 m.p.h. Only difficulty: stopping it.

1948 8,000 lb. thrust engine for Air Force MX-774 sounding missile, the first ICBM, precursor to the Atlas missile.

1949 Internal Combustion Catapult Powerplant developed.

1950 Engines for *Viking* No. 5 sounding rocket produced; reaches record-setting altitude of 108 mi.; also first large U.S. rocket launched at sea.

1951 6,000 lb. thrust engines (6000C-4) for Navy *Skyrocket* research plane.

1951-53 50,000 lb. thrust engine for *Super Viking* rocket developed; never became operational.

1952 6,000 lb. thrust engine (modified 6000C-4) for first fully supersonic combat aircraft, Republic XF-91.

1953 6,000 lb. thrust engines (6000C-4) for Bell X-1A produced.

1953 6,000 lb. thrust engine (6000C-4) for D-558-2 No. 2, first aircraft to exceed twice the speed of sound.

1954 Uprated 21,750 lb. thrust engine for *Viking* 11 produced; rocket sets new altitude record of 158 mi.

1954 40 lb. thrust engines for helicopters developed.

1955 Vernier engines produced for Atlas ICBMs; never adopted.

1958 12,000 lb. thrust Navy Bullpup-A missile engine developed; over 33,000 are produced by RMD.

1956-63 59,000 lb. XLR-99 engines for X-15 hypersonic space plane produced, the largest man-rated rocket aircraft engine ever produced; plane ultimately exceeds Mach 6.7, and an altitude of 67 miles.

1960 Engines for Navy Bullpup-B missile go into production; RMI produces 17,000.

1963 RMD receives NASA-Air Force Trophy for its contributions to the success of the X-15 hypersonic space plane project. Development of vernier TD-339 attitude-control rockets for seven NASA *Surveyor* lunar soft landers.

RMI Merges with Thiokol Chemical, 1958

Modern rockets utilize one of two types of propellants: liquid or solid. RMI had always focused on liquid propellant rocket engines. As a small but pioneering leader in that field, it attracted

X-15 touching down on its skids.

the attention of one of the biggest producer of solid rockets: Thiokol Chemical.

Thiokol was founded in Kansas City, Missouri, in 1929, and was the first producer of liquid synthetic rubber, which found applications as a sealant and waterproofer. The firm moved to Trenton, N.J., in 1935, and in later years established facilities in Maryland, Alabama, and Utah. During World War II, the firm became curious about large quantities of its synthetic liquid rubber that were being purchased by rocket firms. As it happens, these firms had discovered that the liquid rubber, when mixed with other chemicals and allowed to harden in a casing shell, was excellent solid rocket propellant. Thiokol soon decided to enter the field itself, and by the post-World War II period, its future in rocketry was established.[65]

That a small but distinguished liquid propellant company should merge with the dominant solid propellant company perhaps seemed a perfect match; at least it did so to the management of the two firms.[66] The merger of RMI with Thiokol was proposed in January 1958, and approved that year by an overwhelming majority of shareholders. Soon thereafter, the Reaction Motors Division (RMD) of Thiokol established a manufacturing facility in Bristol, Pa., where they produced Guardian missile engines for the Navy's Bullpup missiles.[67] A deal with North American Aviation led to the development of engines for the X-15 hypersonic rocket powered airplane, a high-altitude research aircraft that was a developmental step toward the modern Space Shuttle.[68]

RMI's merger with Thiokol to form RMD proved somewhat problematic. The propellant technologies they employed (liquid vs. solid) were very dissimilar (mechanical vs. chemical), and engendered different mindsets. The corporate cultures of the two firms (one New York-oriented, one solidly Midwestern) were likewise different, and Thiokol proved to be a somewhat impatient and unsympathetic corporate parent. RMI had been happily rescued by the quasi-altruistic Rockefeller ten years earlier. Thiokol's attitude was not so generous: "Santa Claus," said management, was not coming to the rescue any more. RMD had to "carry its weight and produce a profit for Thiokol." [69]

By the 1960s, an overriding problem facing RMD was the difficulty of testing large (over 50,000 lb. thrust) engines. The increasing suburbanization of New Jersey meant that even their remote Lake Denmark test site caused rattling windowpanes in nearby communities. In 1962, lawsuits were filed against Thiokol for broken windows and cracked walls, ceilings, chimneys, and foundations in nearby towns. It was alleged that the testing of the 59,000 lb. thrust engines for the X-15 (as many as a dozen tests

"[RMD had to] carry its weight and produce a profit for Thiokol."

–Thiokol Management

per day) had caused the damage. An apocryphal story tells that local realtors showing homes to prospective buyers kept carefully apprised of RMD's engine testing schedule, and were careful never to show a house when a test might occur–the noise was an almost-certain deal killer.

The New Jersey Supreme Court ultimately held Thiokol liable for such damages, and over $1 million was paid out.[70] Such complaints and liability effectively limited the size of engines they could test. As RMD had felt that expanding into the field of larger engines was a key to future viability, this was a critical problem.

RMD was likewise interested in developing not only larger engines, but further exploring solid-fuel motors. Both acts would have encroached on territory traditionally claimed by Thiokol, and were thus rejected by Thiokol management.

A proposal to Thiokol management to relocate RMD to a western location better suited to testing larger engines was likewise rejected on the basis of cost. The harsh fact was that over the years, a host of firms (Pratt & Whitney, Rocketdyne, Bell, Marquardt, TRW, Aerojet) had emerged to compete with RMI for aerospace contracts, and most did so with considerable success. Thiokol management simply did not see much of a future in larger engines for RMD. A final blow came in the late 1960s. U.S. Navy contracts had long been RMD's bread-and-butter, but with the Vietnam War under way, the Pentagon was under pressure to review spending and contracting procedures and make necessary cost cuts. Liquid-fueled rocket research took among the hardest cuts.[71]

REACTION MOTORS' END, 1972

The figures are shocking: RMD's sales in 1963 were $35.7 million. By 1969, that figure had plummeted to $7 million. Old contracts such as the Navy Bullpup missile were completed, and new ones to fill the gap did not materialize.[72] RMD did find some work, notably producing vernier rockets (auxiliary engines for fine adjustment) for the NASA Surveyor lunar lander.

Other work was less impressive: one Navy contract had RMD actually supply parts to Aerojet, one of their oldest competitors. In 1968, RMD took perhaps the most mundane contract of its existence: machining eight-inch artillery shells under subcontract. With prospects thus gloomy, and the market for small liquid propellant rocket engines essentially saturated, in 1970 Thiokol Chemical began the gradual phaseout of RMD operations. Employee contracts were bought out, RMD facilities leased or sold.[73] The Reaction Motors Division of Thiokol Chemical ceased to exist in June 1972.[74]

The RMI ROCKET

Reaction Motors Celebrates 10th Anniversary

1951
1950

The Reaction Motors, Inc., newsletter, "The RMI Rocket," 10th Anniversary edition (December 1951). (author's collection)

Thus ended the career of the first commercial rocket company in the United States. Reaction Motors, "America's first family of liquid rocketry," was gone–"but," as Frank Winter, Curator of Rocketry at the National Air and Space Museum in Washington, D.C., wrote, it was "not for lack of talent, boldness, and vision."[75]

Thiokol Chemical merged with Morton Norwich in 1981 to become Morton-Thiokol, Inc., the company that manufactured the solid rocket boosters for the NASA Space Shuttle. In 1989, the firm was split up, with Thiokol Propulsion again becoming a separate unit retaining its traditional defense, aerospace, and NASA business. Thiokol Propulsion, later a division of Cordant Technologies, became one of the world's largest producers of high-technology solid rocket motors for space, defense, and commercial launch applications.[76] In 2001, Thiokol was sold to Alliant Techsystems (ATK) Inc., formerly a division of Honeywell. ATK today supplies all rocket engines used by NASA, and numerous propulsion systems used by the United States Military.

EPILOGUE

As early as 1969, when RMI was nearing the end of its existence, some people felt the firm's significance in early rocketry was being overlooked, and merited recognition. Dr. Elman B. Myers of Oakland, a former RMI employee, argued that the Franklin Lakes test site was the "birthplace" for the whole UNITED STATES space program. This, said Myers, "was the very beginning, the foundation for our whole space program, laid by local men and given its first thrust toward infinity from that concrete slab in Franklin Lakes. This is the Rosetta stone for all our earth-space missions."[77]

While certainly exhibiting a degree of hyperbole understandable coming from a former employee, many would nevertheless come to agree that Myers had a good point. Reaction Motors, Inc., "played a most significant role in the development of American aerospace technology," according to Frank Winter, of the National Air and Space Museum.[78] Many RMI engines and associated artifacts can be found on display in museums and air bases across the country, including the National Air and Space Museum of the Smithsonian Institution in Washington, D.C., the Aviation Hall of Fame and Museum of New Jersey, Teterboro, N.J. (which has a restored 6000C-4), and the NASA Hugh L. Dryden Flight Research Center in Edwards, California.

In addition to the ARS Rocket Test Stand #2, the National Air and Space Museum has on display Wyld's Serial #1 and Serial #2 rocket motors, the Viking N0.12 rocket with its RMI engine, as well as the X-15 hypersonic plane with its RMD-produced XLR99

Image of Wyld crater on the Earth's Moon taken by Lunar Orbiter 1

engine. Also on display is the 6000C-4 (Air Force designation XLR-11), the famed "Black Betsy," designed in Pompton Plains. A *Surveyor* vernier engine and M17G and M19G JATO engines (c.1942 and c.1943) are likewise on display.[79]

Lovell Lawrence, Jr. left RMI in 1951. Though a founder of the company, he found his role diminished as Rockefeller, and later Olin-Mathieson, became part owners of the company. He went on to be a key figure in the Army Redstone ballistic missile project, which played an important role in NASA satellite and manned launches in the late 1950s and early 1960s.[80] Among these launches were the suborbital flights of Alan B. Shepard Jr. and Virgil I. Grissom.[81] In 1950 Lawrence was awarded the Goddard Memorial Lecture Award for outstanding work in the development of rocket engines and propellants.[82] Lawrence joined the Chrysler Corporation (a major army contractor) in 1953, where he was a chief research engineer.[83] At Chrysler, he was manager of power plant design in their missile division, and was involved with work on a lunar rover.[84] He died in 1971.

James Hart Wyld died in 1953 at the age of forty-one. The primary technical genius at RMI, his picture today hangs in the National Air and Space Museum of the Smithsonian Institution.[85] The American Institute of Aeronautics and Astronautics (AIAA, formerly the American Rocket Society) annually gives the Wyld Propulsion Award in his honor, recognizing unique contributions to the field of rocket propulsion.[86] In addition, Wyld was inducted into the New Jersey Aviation Hall of Fame in 1997, and was further honored by having a crater on the Moon named after him.[87]

Hugh Franklin Pierce is said to have lost interest in rocketry, and left RMI in 1947. He reportedly purchased a citrus farm in California, which failed; he later worked for the Douglas Aircraft Company.

Only John Shesta lived to see RMI's role in early rocketry fully recognized. In 1948, he received the American Rocket Society's Goddard Memorial Award for his contributions to aerospace research. He left Reaction Motors in 1952. In 1978, the sole surviving founder of the firm, he delivered a paper, "Reaction Motors, Incorporated–First Large Scale American Rocket Company: A Memoir," at the 29th Congress of the International Astronautical Society in Yugoslavia.

RMI's Pompton Plains headquarters, the Silver Factory, was demolished in later years to accommodate the widening of State Route 23. Nothing presently marks the site, though plans are being made to erect a commemorative sign.

The Navy property at Lake Denmark was returned to the Army in the 1960s, becoming part of Picatinny Arsenal. Testing of rocket

This humble reminder that our 20th century aerospace age had some of its roots here in northern New Jersey did not, alas, survive long into the 21st century.

engines at Picatinny Arsenal ended in the early 1970s.[88] Much of RMI's test facilities at Lake Denmark have been demolished. Among those that remain is the massive, steel-and-concrete Test Stand R-2, a huge, silent, crumbling sentinel of the history made here.

RMI's Rockaway headquarters and its expansive Denville plant survive, and were converted to other uses. The Denville plant, at 100 Ford Road, is now part of a large industrial park. In 1997, Wharton, N.J., resident Augustine E. Magistro organized a successful effort to have plaques commemorating RMI placed at the site of their former Denville headquarters, and at Picatinny Arsenal.[89] The Denville plaque was sponsored by the Denville Historical Society, which in 1997 organized an exhibit entitled "A Gateway to Space,' commemorating RMI's role in aerospace history on the fiftieth anniversary of the breaking of the sound barrier.[90] On September 25, 2005, the American Institute of Aeronautics and Astronautics (formed when the original American Rocket Society merged with the Institute of Aerospace Science in 1963) designated the Denville plant as a "Historic Aerospace Site."

After RMI's Franklin Lakes testing facility was vacated, the masonry blockhouse ultimately became a garden shed for a house constructed at 936 Dogwood Trail, near the intersection of Lake Drive and Kent Place, part of the sea of suburban housing which enveloped the former airport area. The structure was threatened in the 1970s. While the owner of the structure, Mr. Fred Grimaldi, liked the structure and its history, neighbors thought the blockhouse unsightly and pressed him to demolish it.[91]

These threats led archaeologist Edward J. Lenik, director of the Wayne Archaeological Research Lab, to research the history of the structure, document it in photographs and drawings, and nominate it to the State and National Registers of Historic Places in 1977.[92] The Franklin Lakes "Rocket Test Site" of Reaction Motors, Inc. was listed on the State Register of Historic Places on November 27, 1978, and on the National Register of Historic Places on June 6, 1979.

It is worth noting that sites applying to the State and National Registers must normally be at least fifty years old to be considered. If not, they must be deemed to be of "exceptional significance," which the thirty-six year old RMI test site was determined to be. Few who passed this prosaic-looking structure would have guessed that it was one of the last remaining elements of early rocket testing technology in the United States.[93] This humble reminder that our 20th century aerospace age had some of its roots here in northern New Jersey did not, alas, survive long into the 21st century.

Listing on the State and National Register of Historic Places

"There was power and beauty in that."

–Benjamin Misajet

does not, contrary to widespread belief, protect a site from alteration or destruction by a private owner. Franklin Lakes had no historic preservation ordinance to protect the Reaction Motors blockhouse. The property owner, preparing his home for sale, ultimately yielded to arguments that the structure was unsightly, and the aerospace landmark was unceremoniously demolished in early 2005. It was a tragic loss for New Jersey, and United States, aerospace history.

THE ROCKETEERS CLUB

Happily, there is another legacy of Reaction Motors that does survive: its people. Today, over sixty years after RMI was founded and more than thirty years after it disappeared, a dedicated group of former RMI employees continues to hold reunions to celebrate their days at the old firm. Calling themselves "The Rocketeers Club," the employees have gathered together every other year to recall their youth, swap old stories, eat, and laugh.

Their memories of days at RMI have a poignancy lost in facts and figures. Recalling a time when tight schedules demanded testing engines well into the night, former employee Benjamin Misajet noted "I'll always remember the blast of those rockets at night, how they reached out with all the colors of the rainbow. There was power and beauty in that. You couldn't walk away from such a sight and be unchanged the rest of your days."

Former RMI engineer Harry W. Burdett, Jr. perhaps best summarized the feelings of former employees: "We knew that we were involved in something wondrous, something monumental, and when man first landed on the moon, there was a little bit of each of us with him."[94]

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Ronald J. Dupont, Jr., received his B.A. from Columbia College, Columbia University, in 1985. He has authored two books and numerous articles and reports on local and regional history in northern New Jersey. This history originally appeared on the "The Vernon Stories of Jacobus Van Brug" (www.vernonstories.com) as "Rocketry! The Story of Reaction Motors, Inc."

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