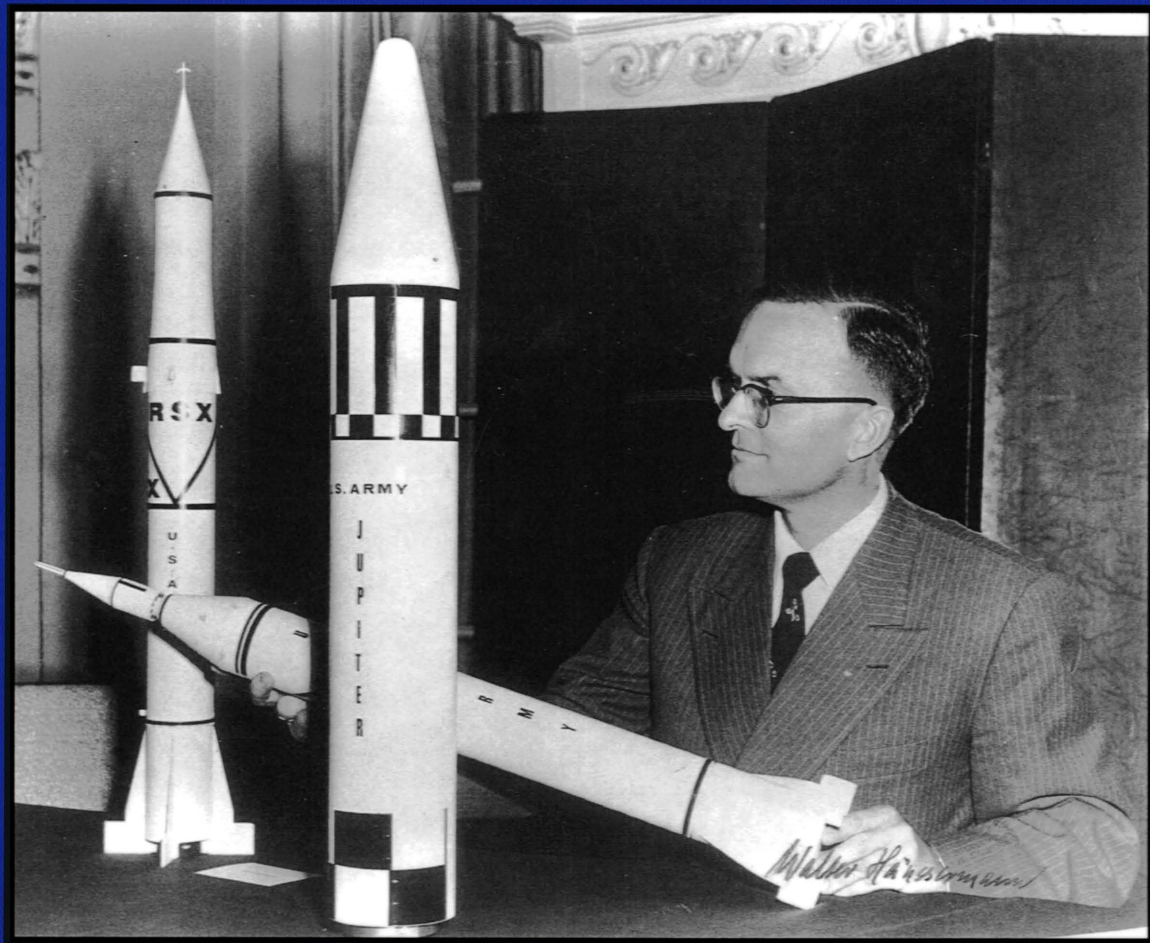


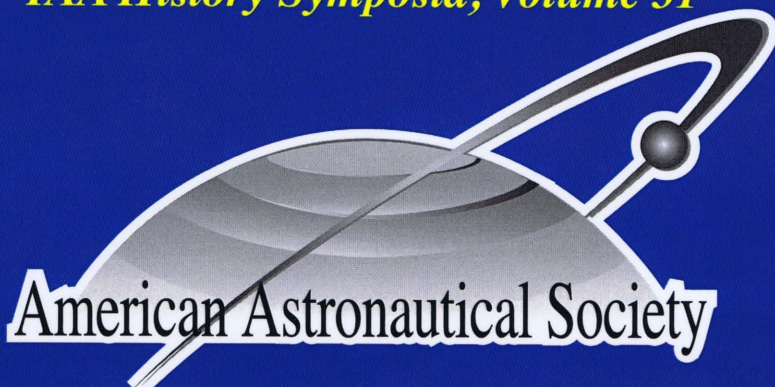
History of Rocketry and Astronautics

Otfrid G. Liepack, Editor



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Front Cover Illustration:

German-American aerospace engineer Walter Häussermann (2 March 1914 – 8 December 2010) holding a model of the Juno Rocket in Huntsville, Alabama, U.S.A. Häussermann's contributions to the advancement of guidance and control systems played a major role in the success of the Saturn rockets, the Apollo program, and Skylab. Häussermann immigrated to the United States from Germany following World War II as a member of Wernher von Braun's team of scientists and engineers. After the space race, Häussermann continued to live in Huntsville and support the space program until his death in December 2010. See Chapter 6 in this volume. Credit: NASA (Courtesy of Stefan Kraut, Künzelsau, Germany).

History of Rocketry and Astronautics

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the International Academy of Astronautics**

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Chapter 6

The Contributions of Walter Häussermann to Rocket Development^{*}

John B. Alcorn[†]

Abstract

For the year 2011, it is suitable to commemorate the life and work of Dr. Walter Häussermann, a German aerospace engineer, mathematician, and member of the original “Wernher von Braun Rocket Group” who died 8 December 2010, at age 96. Dr. Häussermann made many contributions to the development of complex guidance and control methods as well as research of how Hall electric devices effect electric motor efficiency. His excellence in understanding of rocket control caused him to be drafted into the German Army in 1939, and he was taken to the Rocket Development Center at Peenemünde, where he later became Director of Guidance and Control. After World War II, Häussermann joined Wernher von Braun’s rocket team in the United States, first at Fort Bliss, Texas, and later at Huntsville, Alabama, where he became Director of Guidance and Control of the Saturn rockets at Marshall Space Flight Center. In 1954, Häussermann became a U.S. citizen. When NASA was formed in 1958, he began to research and develop analog computer systems for rocket guidance and control. In 1959, Häussermann was recognized with the Decoration for Exceptional Civilian Service for his work on the Saturn rockets. In his later years he contin-

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ued to eagerly support the U.S. Space Program. The tragedy of his death prompts an exploration of the profound impact Dr. Häussermann has made on the scientific community through his involvement in the U.S. rocket program, specifically his contribution to guidance and control of missiles and rockets, and how his legacy of rocket control design has influenced modern aeronautics.

Biography

Early Years, 1914–1928

Walter Häussermann* was born on 2 March 1914, in the small town of Künzelsau, Baden-Württemberg, in south central Germany. He was the son of Otto Häussermann, whose profession was ironworking. Walter Häussermann became interested in rocketry at a very early age, due possibly to his father's willingness to craft inventive toys out of scrap iron. Like his contemporaries Wernher von Braun, Hermann Oberth, and Robert Goddard, his first experiences with rocketry included an attempt to build his own homemade rocket. Häussermann managed to build his own rockets and put them to practical use. He attached his homemade rocket to a cart he had built. Young Häussermann's goal was to use the rocket and cart as a ride, but the thrust was not strong enough. This prompted Häussermann to resort to books to learn more about rocketry.

Secondary Schooling and University Studies 1928–1939

In November 1928, Häussermann moved to Schwäbisch Hall,¹ the district capital of Baden-Württemberg, to begin his secondary education. Häussermann attended the Realgymnasium und Oberrealschule Schwäbisch Hall, which is known today as the Gymnasium bei St. Michaels. Records indicate that Häussermann lived about 1 kilometer away from the school. Häussermann recalls that his teachers encouraged him to pursue his interests in Physics, Astronomy, and Mathematics. He has good memories of his teachers and studies, which he would prepare for days in advance. Completing his studies at Schwäbisch Hall, Häussermann moved to the Technische Hochschule Stuttgart in March 1932. There he began his undergraduate work in electrical engineering. Furthermore, as part of his curriculum, Häussermann was required to take on an internship within the scope of his field for a minimum of six months. According to his transcript, Häussermann stayed at Stuttgart for four semesters. He graduated “with distinc-

* The author will use the German spelling of Häussermann's name. The English version is spelled Haeussermann.

tion” towards his degree in electrical engineering on 2 December 1935. His cumulative GPA was 6.7. Häussermann soon began his graduate studies at the Technical University of Darmstadt,² where Kurt Debus had previously studied. Debus would later become the first director of NASA’s Kennedy Space Center in Cape Canaveral, Florida. Furthermore, Ernst Steinhoff had studied Aeronautics and Meteorology at Darmstadt approximately the same time. Steinhoff would later become a close associate of Häussermann, as both of them worked on gyroscopic control systems at Peenemünde. By 1938, Häussermann had earned a Master’s Degree in Electrical Engineering from Darmstadt, but he was unable to pursue a doctorate as he had hoped. Germany invaded Poland on 1 September 1939, and Häussermann was drafted into the Germany Army. In 2008 Häussermann recalls that he had been drafted in October 1939 and was on his way to Poland when an officer ordered him to step off the train.³ Häussermann was to be sent to the Heeresversuchsanstalt Peenemünde, the Army Research Center at Peenemünde. His knowledge of physics and aeronautics had caused him to stand out from the other soldiers.

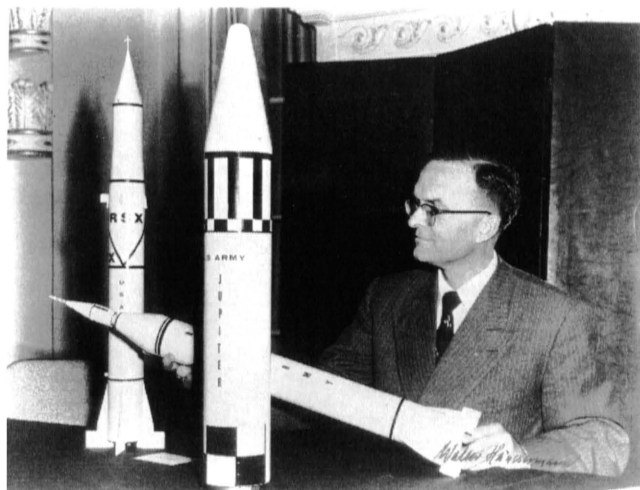


Figure 6-1: Walter Häussermann holding a model of the Juno Rocket.
Credit: NASA (Courtesy of Stefan Kraut, Künzelsau, Germany).

Peenemünde and Research at Darmstadt, 1939–1945

Häussermann arrived at Peenemünde on 2 December 1939. The Department of Air Ministry had recently purchased the peninsula in 1936. When Häussermann arrived, there was already a wind tunnel and a guidance and control laboratory led by Ernst Steinhoff. Steinhoff would later play a major role in the development of the Saturn V rocket. Häussermann reportedly met Wernher von Braun and Walter

Dornberger the second day he was there.⁴ Von Braun was, of course, the Director of Research and Development at Peenemünde.* Häussermann recalls that he was also shown a rocket test within the first few days of his arrival. Because of the secrecy of the rocket development at Peenemünde, he had not known of the existence of any of it until then. According to a 2008 interview of Häussermann, “In Peenemünde I was flabbergasted. On the first day I saw a rocket testing... I was astonished that something like this already existed.” Von Braun assigned Häussermann to the Department of Guidance and Control, which he had previous experience in from Darmstadt. For the next few years, he worked on various gyroscopic control methods for rockets, as well as accelerometers, simulators, and analog computers for testing purposes. Häussermann continued to work with guidance and control systems at Peenemünde until 1942. When Germany invaded the Soviet Union in June 1941, Häussermann realized that it was a fatal move for the German army. “I knew that the war with Russia could not end well. Hitler had stated himself that the mistake in the First World War was that there were two fronts to fight.” Häussermann approached Steinhoff and told him that if there were an opportunity for him to return to Darmstadt and conduct research, he would like to go. Steinhoff approved of the transfer, so Häussermann went back to Darmstadt to gain experience with attitude control mechanisms and analog computers. He remained there for the remainder of the war.



Figure 6-2: Walter Häussermann in Künzelsau, Germany. Credit: NASA.

* It is interesting to note that it was von Braun's mother, Emmy von Braun, that suggested Peenemünde as a research-and-development site.

Häussermann managed to complete his doctorate in 1944 in physics. He also taught classes in electrical engineering and physics during his time there. His research included testing gyroscopes and developing testing platforms for them, a project that he collaborated with Siemens on. In one technical paper from 1943, Häussermann states that “vibrating tables” were used to simulate the effect of a rocket launch on the gyroscope. However, he also states that the university lacked funding for a more advanced testing platform.⁵

Operation Paperclip, 1945–1950

In the spring of 1945, the Soviet Army had advanced to within about 150 kilometers from Peenemünde. Wernher von Braun had received orders from the German Army to cease his work on rocketry and fight the Soviets. However, he and his team fled to Bavaria, where they surrendered to American soldiers on 2 May 1945. Von Braun and his team were eventually given the opportunity to work for the United States Army developing rockets.



Figure 6–3: The naturalization ceremony for the Operation Paperclip scientists, Birmingham, Alabama, 1954. Walter Häussermann is fourth from left. Credit: NASA-MSFC.

This was codenamed Operation Paperclip. The team of scientists was ultimately sent to Fort Bliss, Texas, just north of El Paso. Häussermann, however, was not with the group when they surrendered. Even though he was contacted by von Braun and given the opportunity to go to the United States, he declined because his wife, Ruth, was ill, due largely to malnourishment. At a doctor’s rec-

ommendation, Häussermann stayed with his wife in Darmstadt for the next few years. In 1947, von Braun returned to Germany to marry his cousin, Maria Luise von Quistorp. While he was in Germany, von Braun contacted many of the original Peenemünde rocket team and gave them a second chance to come work at Fort Bliss. However, it was actually Helmut Hölzer and Ernst Steinhoff who contacted Häussermann. With his wife in better condition, Häussermann decided to take the offer.



Figure 6-4: The leading Operation Paperclip engineers pose for a photo. Walter Häussermann is sixth from left, and to the right is von Braun, who is speaking to Häussermann. Ernst Stuhlinger is at the far left, and Kurt Debus is at the far right. Credit: NASA-MSFC.

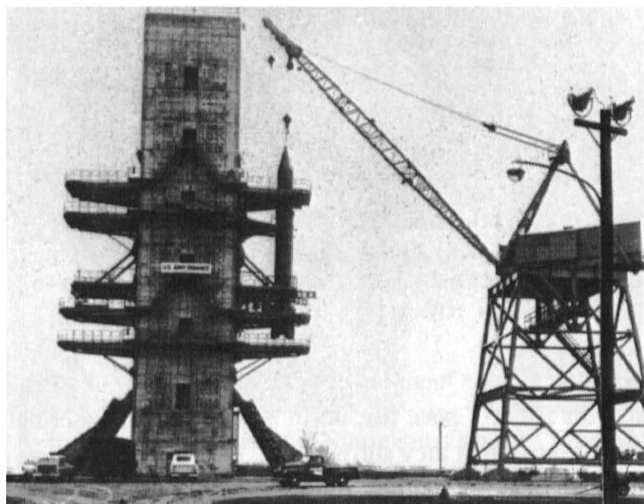


Figure 6-5: A static test firing of an early Jupiter ballistic missile. Redstone Arsenal, August 1954. Credit: NASA.

In late 1947, Häussermann arrived with his wife in Fort Bliss. The Operation Paperclip Germans spent the next few years at Fort Bliss. Their tasks included educating army, industry, and university officials on rocket intelligence. On 16 April 1946, (prior to Häussermann's arrival) they launched the first V-2 captured by the U.S. Army at White Sands Proving Ground. The launch proved to be only partially successful, as its radio malfunctioned shortly after launch.

Many more V-2 firings occurred in following years. After the Korean War began in 1950, the group moved to Redstone Arsenal in Huntsville, Alabama.

Redstone Arsenal, 1950–1958

Redstone Arsenal was established in 1941 as a manufacturing facility of chemical weapons for use in World War II, mainly on the Pacific front. The U.S. Army formed a land-use agreement with the Tennessee Valley Authority, and about 5 square kilometers were cleared along the river, just south of what is now Huntsville. The name Redstone comes from the reddish color of the soil and rock, which still exists today. As it turns out, the name carried over as the denotation of the first U.S. nuclear ballistic missile, the Redstone Rocket. Häussermann worked under von Braun's authority on the guidance and control systems of the rocket. Most of the Operation Paperclip Germans became naturalized U.S. citizens in 1954. At this point the U.S. Army had little interest in usefulness of rockets in space, much to the Operation Paperclip Scientists disappointment. However, this was soon to change. On 4 October 1957, the Soviet Union announced that it had successfully launched the world's first artificial satellite, Sputnik 1. As scientists and engineers around the world listened in to faint beeping of the mysterious Sputnik, it was soon clear to everyone that the space race had begun. The following January, the West launched its first successful satellite, Explorer 1, by means of the Juno-1, a modified Redstone rocket. The American government soon realized that it would need a powerful organization to handle the space program, and as a result NASA was founded in July 1958, replacing its predecessor, the National Advisory Committee for Aeronautics (NACA).



Figure 6-6: A full-scale model of Explorer 1. Häussermann is standing third from left. Von Braun and Stuhlinger are at right. Credit: NASA-MSFC.

NASA and the Saturn Rockets, 1958–1978

Walter Häussermann was on the original personnel register for NASA, as well as all of the original Operation Paperclip Germans. The Marshall Space Flight Center in Huntsville was dedicated by President Eisenhower on 8 September 1960, in honor of World War II general and Nobel Peace Prize winner George C. Marshall. Häussermann was given the title of Director of Guidance and Control at the Astrionics Laboratory at Marshall, and had dozens of engineers that answered to him.



Figure 6-7: A meeting of the directors of the Saturn V rocket development. Häussermann is second from left. The man speaking is Dieter Grau. Credit: NASA-MSFC.

After Sputnik shocked the world, the West realized that it was behind in the space race. Even after the first launch of Explorer via Juno-1, it was apparent that a much more powerful rocket was needed. The name for this vehicle, Saturn, became official in 1959. Beginning as a variation of the Jupiter rocket, its name came about as “the next planet after Jupiter.” As Häussermann recalled in 2008, the goal of putting man on the moon was nothing new. When asked if he had anticipated the Apollo Project, Häussermann responded that they, the Operation Paperclip engineers, had imagined man on the moon long before coming to America. On the other hand, when asked if he had hoped to go to the Moon himself, Häussermann replied, “No, I’m just an engineer” in an interview in German.⁶ As the Apollo Program gained momentum, the need for a faultless control system became more and more imperative. One of the last components of the Saturn V and Saturn IB to be finalized, variations of the gyroscopic guidance and control system that Häussermann and his team developed are still in use today. When Apollo 11 landed safely on the Moon in July 1969, Häussermann was at Cape Canaveral, Florida, with Wernher von Braun.



Figure 6-8: Häussermann with friends. Left to Right, Pastor Derrick; Heidi Weber, the daughter of Fritz Weber; Dr. Häussermann; and Dr. Häussermann’s wife, Ruth. Credit: Heidi Collier.

He refused any congratulations for his team’s accomplishments on the guidance system for the Saturn V until the astronauts had returned to Earth. Häussermann was also essential in the design of the analog computer that was to control the Saturn V. Said Häussermann in a 2004 interview, “The instrument unit marked the first time we had a unit to manage all three propulsion stages. It

would perform the vital checkout tests before launch, and would guide the Saturn during launch. We needed a unit that was reliable and one that could be used on a launch vehicle.”⁷ The first units were built on-site by Marshall employees, whom Häussermann had influence over. By 1964, IBM had built a facility in Huntsville, very near to the University of Alabama in Huntsville, and the task of building the computer for the actual flight was contracted to them. The analog computer included a unit for the guidance and control feature of the Saturn V. The instrument would also be used at a later date in Skylab. Häussermann was recognized with many distinguished awards for his work with NASA. In October 1963 he was awarded the NASA Medal for Outstanding Leadership. Furthermore, after the success of Apollo 11 in July 1969, Häussermann’s efforts were recognized with the NASA Exceptional Service Medal.



Figure 6–9: Häussermann and von Braun inspect a part of the guidance-and-control system at the IBM facility in Huntsville. The man at left is Clinton Grace of IBM. Credit: NASA.

After the success of Apollo 11, Häussermann took up a new position at Marshall Space Flight Center. He became Director of Central Systems Engineering. Beginning in 1972, Häussermann gained an even higher position.

He held the position of Director of NASA’s Space Sciences Laboratory, which allowed him to continue his work as a systems engineer until he retired in 1978. Dr. Charles Lundquist, a close associate of Häussermann throughout his entire career with NASA, succeeded him as director of the Space Sciences Laboratory 1978.



Figure 6-10: Häussermann stands second from right at this pose from the dedication of the Saturn V replica at the U.S. Space and Rocket Center. Huntsville, July 1999. Credit: NASA-MSFC.



Figure 6-11: Häussermann and von Braun inspect an engineer's work at Cape Canaveral. Credit: NASA-MSFC.

Dr. Lundquist is now a researcher at the University of Alabama in Huntsville. After 1972, Häussermann continued to work on various projects within NASA, including examining control issues onboard the Space Shuttle. In the late 1970s, Häussermann contributed to the development of Spacelab, which was housed onboard the Space Shuttle for various experiments with microgravity. As Director of the Space Sciences Laboratory at Marshall, it was Häussermann's responsibility to attend scientific meetings in the Soviet Union, China, and Germany. Throughout his career, Häussermann frequently returned to Baden-Württemberg, where he would lecture at the Gymnasium in Künzelsau that his niece attended. He was known to encourage students to learn science and mathematics. He also urged the students to ask questions, which was uncommon at that time.

Retirement and Later Years, 1978–2010

Following his retirement in 1978, Häussermann became a consultant to the Bendix Corporation in the Guidance Systems Division. Since 1966, he had been a Professor of graduate level Electrical Engineering at Auburn University. Häussermann was a member of the American Astronautical Society (AAS), the American Institute of Aeronautics and Astronautics (AIAA), Sigma Xi, and the Explorers Club, of which Neil Armstrong was also a member. He was also a member of ION, the Institute for Navigation, from whom he received the Superior Achievement Award in July 1970. In the spirit of his accomplishments with guidance and control, Häussermann was awarded the Decoration for Exceptional Civilian Service in 1959, the highest Army award for a civilian.



Figure 6–12: A group of the original Operation Paperclip rocket scientists. Häussermann is third from right. Credit: NASA.

In 1985, Häussermann returned to Künzelsau to receive the Medal of Merit of the State of Baden-Württemberg. In 2009, the European Space Agency (ESA) declared that Alexander Gerst, a native of Künzelsau, would undergo training to be an astronaut for a flight in 2013. Gerst will be the first native of Künzelsau to go to space.⁸ Häussermann, when told this, remarked that he was very excited and happy for Gerst. Ernst Messerschmid, another astronaut for ESA, received the Medal of Merit of the state of Baden-Württemberg award the same year as Häussermann.



Figure 6–13: Walter Häussermann with friends at the dedication of the Davidson Center for Space Exploration. Huntsville, Alabama, January 2008. Credit: NASA.



Figure 6–14: A Saturn V launch. Walter Häussermann played a significant role in putting humans in space. Credit: NASA-MSFC.

Häussermann was in Künzelsau for the last time in 1998, and he lived in Huntsville for the rest of his life, in a house near Montesano Mountain, in downtown Huntsville. He was a regular worshipper at St. Mark's Evangelical Lutheran Church. The church was founded in 1950 by a group of the Operation Paperclip Germans. In 1999, several of the remaining von Braun Group attended the dedication of the Saturn V replica at Huntsville's U.S. Space and Rocket Center, near Redstone Arsenal. The group held another reunion in January 2008, this time for the dedication of the Davidson Center for Space Exploration. It houses the Saturn V dynamic test vehicle, which is recognized in the National Register of Historic Places, not least to Häussermann's credit.

Brooks Moore, who succeeded Häussermann as Director of NASA's Astrionics Laboratory at Marshall Space Flight Center, cared for Häussermann in his later years. Dr. Häussermann died on 8 December 2010, in Huntsville. He is buried in Maple Hill Cemetery, near his home. He will be remembered as a brilliant scientist, and a kind and loving person. He will be honored and respected for years to come as one of the most intelligent men of Operation Paperclip who were essential in putting humans in space. Many of Häussermann's designs for rocket control are still in use today. His legacy of guidance and control for spacecraft has influenced modern astronautics.

Contributions to Guidance and Control Systems

Attitude Control Mechanism

During the late 1950s Häussermann developed a mechanical system for the attitude control of satellites and small spacecraft.⁹ Attitude control is characterized by the guidance of a spacecraft along the three directional axes known as pitch, roll, and yaw. This is illustrated in Figure 6–15. Thus, an objective of any attitude control system is for the device to mount to the interior of a spacecraft and control all three of the attitude axes. This was usually done by incorporating flywheels, heavy rotatable disks, into the interior of the spacecraft, one for each directional axis. However, Häussermann realized flaws with this method. He pointed out that having a system of three independent flywheels caused a coupling effect between them that jeopardized the reliability of the system and presented an undesirable effect considering the power requirements.

An objective of Häussermann's invention was to provide the necessary attitude control without the coupling effect between the flywheels. He proposed that it should be done with only one rotary mass, not three. The single rotary

mass would effectively provide reactive force on the spacecraft for control of its pitch, roll, and yaw axes.

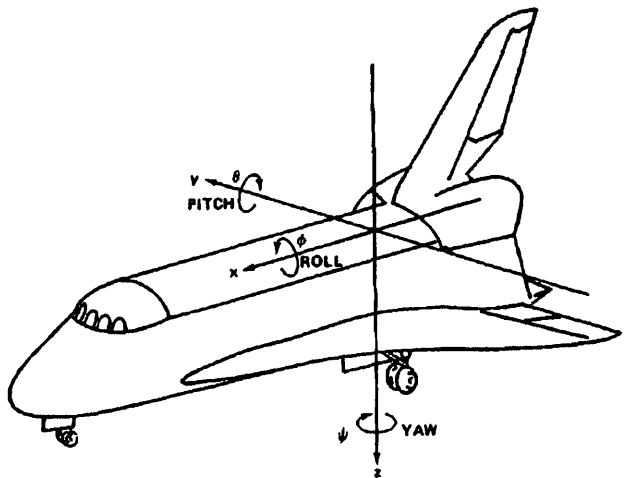


Figure 6-15: The pitch, roll, and yaw axes of an aircraft.
Credit: U.S. Patent No. 3,017,777.

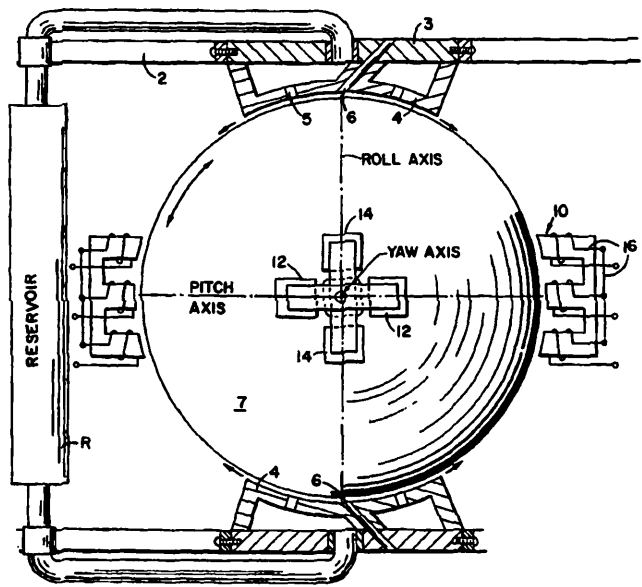


Figure 6-16: Häussermann's invention of a guidance system consisting of a single spherical flywheel. Credit: U.S. Patent No. 3,017,777.

In addition, the electric motor that controlled the motion of the rotary disk was to be supported on air bearings and magnetically supported. This guaranteed

that the rotary wheel was in a substantially frictionless state. The assembly as a whole would be attached to the hull of the spacecraft by arms and by air bearing supports. Surprisingly, the rotary mass was to be hollow. The outer shell would be composed of plastic, and coated with powdered ferrite, to produce a magnetic field. The spherical inner shell was to be composed of a non-magnetic material. To rotate the flywheel about the axes of the spacecraft, three electromagnetic torque-generating mechanisms were used. Running current through the electromagnetic torque generators would cause the mass to rotate, due to its magnetic ferrite coating. An additional advantage to this system was that it was not hard to reverse or stop the flywheel. To slow the mass or force it to come to a stop, the torque generators would simply be given a reversed phase of alternating current. This was not as easy with three individual flywheels. Häussermann noted that it would be of utmost importance to have the flywheel as spherically shaped as possible. The tendency of the massive flywheel to take preference of any axis because of a poorly distributed mass would cause an undesirable effect in terms of momentum, and, in the case of an even less spherical flywheel, would make it impossible to accurately control the vehicle. Häussermann's invention was patented in 1962.

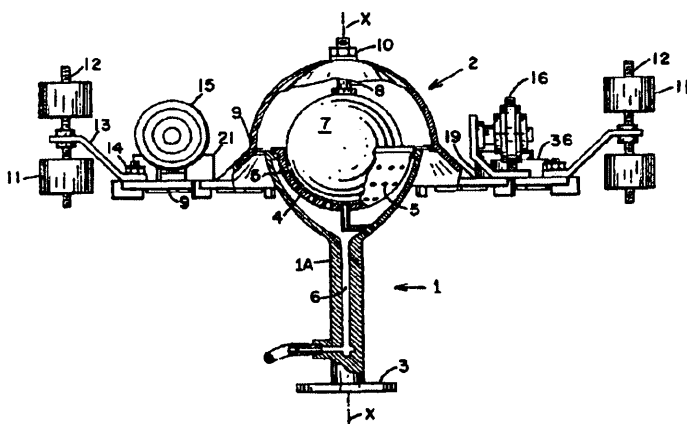


Figure 6-17: Häussermann's satellite motion simulator.

Credit: U.S. Patent No. 3,092,918.

The invention proved to be an appealing guidance and control device, and variations of it were used by NASA. The U.S. government had the right to manufacture Häussermann's invention from the time that it was patented. Häussermann also developed a testing platform for it and any other attitude control devices that were to be developed in the future. Out of all his inventions, he was probably the most proud of his design of a motion simulator for a satellite in or-

bit. This has been indicated in interviews of his associates. His direct intention of the device was for testing his guidance and control methods.

Work with Hall Effect Sensors

Velocity Measurement System

Of Häussermann's many areas of expertise, he is most well known for being the father of modern guidance-and-control systems for spacecraft. However, a proficiency of his that is often overlooked is the fact that he had an immense knowledge of electric motors and Hall effect sensing devices. Häussermann contributed many ideas and inventions to the space program that were based on his knowledge of Hall sensors.

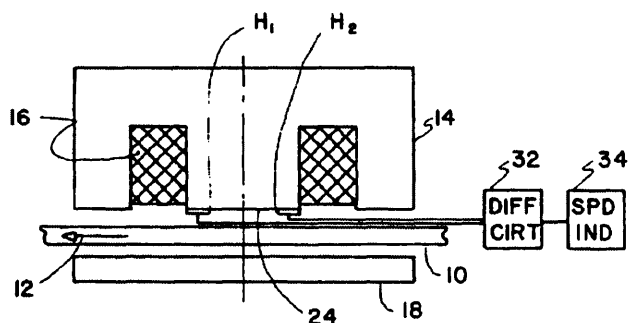


Figure 6-18: Häussermann's invention of a velocity measurement device.
Credit: U.S. Patent No. 4,093,917.

The one we will analyze here is his invention of a velocity measurement system, which was patented in 1978.¹⁰ At that time, the standard method of measuring velocity was to use the concept of the Eddy effect, which occurs when a magnetic field is run through a conductor. The magnetic field causes the conductor to produce an electric current. A disadvantage with this type of device is that their efficiency was poor at higher levels of Eddy effect current. The goal of Häussermann's invention was to avoid inaccuracy and to be able to operate correctly in the presence of external magnetic interference. The device was to be constructed of an E-shaped magnetic core with two Hall sensors, as shown in Figure 6-18. Their purpose was to measure magnetic field. The positioning of the Hall devices allows the measurement of the flux density of a conductive object in motion. The difference in the flux densities can be computed by comparing the measurements of the Hall devices, and the velocity can be determined. An important aspect of Häussermann's invention was that the device could operate in the

presence of an external magnetic field, specifically that of the conductive object whose velocity is to be measured.

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About the Author

John Alcorn is an undergraduate student at the University of Alabama in Huntsville. He is pursuing bachelor degrees in Aerospace Engineering and Mathematics. Mr. Alcorn plans to begin his graduate studies in 2013. His primary interest in aerospace technology is propulsion, which he hopes to study as a graduate student.

Mr. Alcorn is an active member of the UAH Space Hardware Club, where he is project manager for the Cansat project, and an aide to the mechanical division of a high altitude neutron detecting research platform.

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