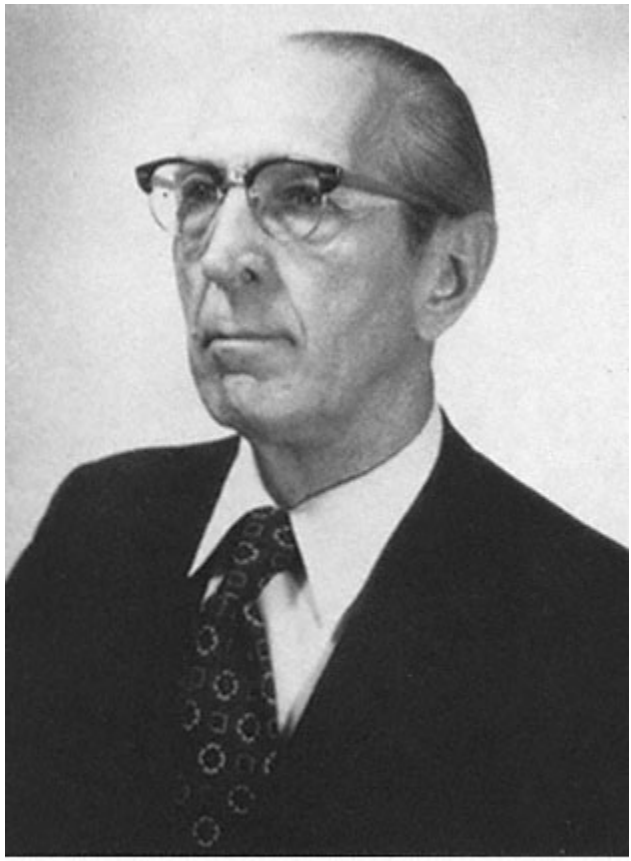

Hans A. Mauch.

Hans Adolph Mauch

1906–1984

By Eugene Murphy

A major contributor To rehabilitation engineering, a distinguished engineer in several other areas, and a strong personality, Hans Adolph Mauch repeatedly predicted he would live to be a hundred years old. Tall, tough, and an advocate of vigorous exercise, at age seventy-seven he worked long hours. Instead of quiet relaxation, he and his wife undertook such major adventures as a trip around the world, including some days and nights on the Trans-Siberian Express in 1983.

He seemed in excellent health when he went to his laboratory as usual the morning of January 13, 1984. Yet, suddenly, he collapsed from a massive stroke. After lingering a week in intensive care, he died on January 20, 1984.

Fortunately, the S-N-S, his well-known hydraulic artificial knee designed to control both swing and stance phases of walking for above-knee amputees, was a well-established product here and abroad (more than 12,000 had been sold). Voluntarily, Mauch had progressively lengthened the warranty period to two years on this ingenious, complex, yet dependable mechanism.

He had also made plans for three of his associates to attend regional meetings of the American Orthotic and Prosthetic Association in April 1984 to introduce new variants of the knee that might broaden the possibilities for prescription and especially to announce the availability of the long-

awaited Mauch multifunction hydraulic ankle joint. He had deliberately planned that the presentations by these younger men would emphasize the point that the future of Mauch Laboratories did not depend solely on his own health. Indeed, Mrs. Mauch (long a director of the company) has since taken over the presidency, employees have been purchasing stock, and the recently expanded plant building has been equipped with modern machinery that includes three computer-controlled machine tools.

Hans Mauch was born in Stuttgart-Bad Cannstatt, Germany, on March 6, 1906. He was educated in mechanical, electrical, and electronic engineering at the technical universities of Stuttgart and Berlin. He received the advanced degree of Diplom Ingenieur at Berlin in 1929, where he was in the top two percent of his class.

One of his professors was Georg Schlesinger, who had contributed so much to German work in prosthetics during World War I, work that included writing a third of the classic German text *Erstazglieder und Arbeitshilfen*. Yet the contact appeared to have no immediate influence on Mauch's interests. He began his studies for the doctorate in engineering, but dropped them when he found that his choice of a thesis subject had been preempted by another dissertation at a different university.

He took a position with E. Zwietusch & Company in Berlin in 1930 and worked until 1935 on methods for the control of pneumatic conveyors, which were then widely used not only in department stores and hospitals but also to carry mail in large cylinders from one post office to another in many cities. He was in charge of research and development efforts involving automatic conveyors and sorters; these efforts included the development of a method by which each cylinder would carry an easily changed, predetermined code that, despite unpredictable rotation and high velocity, could be read automatically and signaled ahead to set switches that would divert the capsule to its correct destination.

Mauch was employed as a civilian engineer in the German

Air Ministry from 1935 to 1939. He left to establish his own consulting engineering office in Berlin, which he headed until the end of World War II. He developed testing equipment and aviation and automotive engines and accessories; he also acted as a consultant to the German Air Ministry, where he was later placed in charge of the terminal development of the V-1 buzz bomb, the first guided missile. He knew, and sometimes differed with, many of the top German engineers of the period, including Wernher von Braun.

Mauch's third major consulting activity was original research and development in the fields of aviation medicine and prosthetic devices. In this bioengineering sector, Hans Mauch cooperated closely with Ulrich K. Henschke, a radiologist with a Ph.D. in physics. Head of the Aeromedical Institute in Munich, Dr. Henschke worked on a variety of physiological problems.

After World War II, the U.S. Air Force assembled many top German scientists and engineers at Heidelberg. There, Henschke and Mauch collaborated on an important chapter, "How Man Controls," of a two-volume work, *German Aviation Medicine—World War II*. This chapter was a pioneering effort in what later became known as the fields of cybernetics and human factors engineering. Henschke and Mauch also assembled an extensive bibliography of German work on artificial limbs, designed a metal artificial leg that was intended for mass production of components and easy assembly to an individually fitted socket, and constructed a series of models illustrating various concepts for stabilizing the knee joint of an above-knee prosthesis.

In March 1946 the U.S. Army surgeon general sent a team to Europe to survey artificial limbs. In addition to important information on various devices and procedures including the suction socket leg and cineplastic surgery to control arms, the team brought back the Henschke-Mauch bibliography and the concepts they developed involving knee control. Subsequently, Henschke and Mauch went to Dayton, Ohio, late in 1946, to work as civilian employees at the Aeromedical Laboratory

of the Wright Air Force Development Center. Yet, they were able to devote only a small portion of their efforts to prosthetics. Later, Mauch and several others worked evenings and weekends in the basement of his small home with support by the Veterans Administration through its National Academy of Sciences' contract.

Hans Mauch became a naturalized U.S. citizen in June 1955. He left the Aeromedical Laboratory in 1957 to set up his own organization, which was incorporated in 1959 as Mauch Laboratories, Inc. The company engaged in research, development, and manufacturing in the biomedical engineering field.

Except for a classified project to develop a novel space suit for the Air Force and NASA, which the company performed from 1959 to 1964, all of Mauch's work until the mid-1970s was devoted to rehabilitation projects sponsored by the Veterans Administration in coordination, through various National Research Council committees, with projects of other agencies. In recent years, after termination of his VA contracts, further improvements in the company's devices were made by Mauch as proprietary developments.

After exhaustive development and evaluation efforts that culminated in a nationwide clinical trial, the original Henschke-Mauch Model A semivoluntary stance-and-swing hydraulic leg for above-knee amputees was shortened, refined, and renamed the S-N-S. A simpler Model B to control only the swing phase was produced briefly in 1963; it has been refined and is currently sold as Model S. Several other companies produced swing-phase units under the Mauch patent, which was assigned to the VA and licensed to others without royalties after training at Mauch Laboratories.

The Mauch swing control provides programmed resistance that automatically varies with knee angle and walking speed, plus the possibility of independent adjustment of resistances to flexion and extension. The stance phase control always allows extension, but automatically imposes a high (but adjustable) resistance to knee flexion *except* after a brief

application of a hyperextension moment, normally after the heel leaves the ground.

The rigid locking of the device is normally undesirable (the residual limb could be injured after stumbling), but it can be obtained voluntarily if desired—for example, for prolonged standing or for driving an automobile with flexed knee. Conversely, very low resistance to flexion can also be ensured for bicycling. These knee control features are superior to other brakes and locks that have been disclosed in literature and patent applications here and abroad for well over a century.

The S-N-S is the sole survivor of many years of effort by numerous capable engineers and interdisciplinary teams supported by substantial government projects. The genius, persistence, and vision of Hans Mauch are demonstrated by his eventual success with the S-N-S, the recent acceptance of the hydraulic ankle, and his yearning to attain a truly voluntary yet subconscious control of swing-and-stance phase movement.

Although this memoir focuses on Mauch's contributions to hydraulic lower limb prostheses, he made thoughtful, ingenious contributions in many fields, including aviation and aviation medicine, space suits, and the human factors aspects of displays and controls. Mauch was the inventor or coinventor of more than eighty patented inventions in nine countries and the author or coauthor of numerous papers and reports. Under VA contract, he developed several types of personal reading machines for the blind, another area he and Dr. Henschke had explored in Heidelberg. His audible-output Stereotoner direct-translation reading aid, which was smaller, lighter, and lower in price than the widely known tactile-output Optacon, reached limited commercial production.

Hans Mauch was elected to the National Academy of Engineering in 1973. He served on its General Engineering Peer Group from 1976 to 1978, and he consistently attended the academy's annual meetings. He also served for a quarter

of a century on many National Research Council committees and working groups in prosthetics. He was a consultant to the U.S. Air Force and to the U.S. Department of Health, Education, and Welfare.

In 1944 he received the Knight Cross to the Merit Cross from the German Air Ministry, the highest nonpolitical decoration for civilians. The U.S. Air Force awarded him the Outstanding Civil Service Commendation in 1956 and the Outstanding Inventor Award in 1960.

Hans Mauch married Austrian-born Tatjana Schmid in 1948. She also came to the United States to work for the U.S. Air Force. They had three daughters.

A brilliant, well-educated, cultured man, Mauch was a creative inventor and developer, a valuable member of committees and councils, and a delightful friend. Sometimes a naive suggestion to him would bring the rebuff, "We already thought of that in Heidelberg!" or he would produce an old notebook containing a similar sketch and the record of the notion's failure. Nevertheless, he would explore suggestions carefully and accept good ideas or data. Another able engineer once observed, "The trouble with Mauch is that he's a perfectionist!" Well, what's so bad about that, especially when his work was offered to the consumer at such a surprisingly reasonable cost?