The Score

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The past twenty years of the Artificial Limb Program comprise predominantly a series of wins, a few losses, and some ties awaiting replays. Participants, coaches, and managers in this prolonged struggle against nature and ignorance have enjoyed some spectacular seasons, but they also have endured grueling practice and frustrating defeats.

Wide interest in artificial limbs accompanies major wars. Ancient armorers made cleverly articulated limbs. The Napoleonic and Crimean Wars stimulated active development in Europe. The American Civil War led to numerous private inventions of prostheses. During World War I vigorous and systematic programs were conducted on both sides. These ended soon after the war, partly because of inflation and other disturbances, and partly because of confidence that limbs had been substantially improved. Everywhere there was a return to "normalcy," but the general impression that amputations are infrequent in peacetime is erroneous. Dr. Glattly's recent survey *(Artificial Limbs,* Spring 1963) corroborates the claim that for a variety of reasons very substantial numbers of civilians face this major operation in peacetime.

In World War II both the Army and the Navy of the United States set up large amputation centers to provide definitive surgery, artificial limbs, and other rehabilitation. Both Services introduced some new materials and mechanisms. To combat severe shortages they used prefabricated, standardized parts and division of labor for fitting and assembling instead of the slow, painstaking custom craftsmanship in very small shops typical of the American limb industry. Dramatic successes occurred. Nevertheless, Service Centers, amputees, commercial limb shops, and, increasingly, the general public were made conscious of the severe limitations of even the best prostheses.

The Surgeon General of the Army, therefore, called a conference in January 1945 which was supposed to agree upon the best available prosthetic components. The principal conclusion was that *none* of the available limbs was really adequate, so research was needed.

The Surgeon General then asked the National Research Council to set up a committee to conduct a research and development program. The resulting

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committee and its descendants have had a variety of designations, membership, organizational structures, and sponsors. Originally the work was supported by the wartime Office of Scientific Research and Development, then by the Army. The Veterans Administration, for many years the sole sponsor of contractual research in prosthetics, still continues important support, but in recent years various agencies within the Department of Health, Education, and Welfare have assumed major financial responsibility.

When the original Committee on Prosthetic Devices asked its surgeons to appraise the artificial limbs available in the summer of 1945, the two chief demands to its engineers were for development of a functional artificial hand that looked normal and for stance-phase stability for above-knee artificial legs, presumably from a lock released during swing phase. Patent files and technical literature were littered with descriptions of inadequate attempts by several generations of inventors.

The surgeons' demands reflected a primary conception of the Committee's role to concentrate on *devices,* susceptible to engineering design. In an era when many orthopaedists still were active in military amputation centers and physical medicine was only emerging, the surgeons were not yet concerned with development of new surgical techniques or with prosthetics education.

Neither were the surgeons primarily concerned with fitting, though its importance was realized. The second subcontract of the Committee, to develop further a saucer socket for the hip-disarticulation case, was with the Research Institute Foundation, a tiny laboratory which had been set up by the Artificial Limb Manufacturers Association. (This project incidentally initiated a number of ideas which later and independently were developed vigorously at larger laboratories.) Both Committee and limb industry a score of years ago considered the fitting of limbs to be a handicraft, often a sculpture-like art, learned by long experience but scarcely susceptible to systematic research.

German studies of alignment principles in World War I had relatively little immediate impact on American practices. Alignment of the above-knee prosthesis in 1945 typically placed the artificial foot far out under the head of the femur "so the amputee would not fall over to the amputated side" and made the axis of the socket bore vertical "so as not to give in to flexion contracture." Thus, while standing on the prosthesis, the amputee leaned against his pelvic band and mechanical hip joint, stressing them severely, in an effort to shift his center of gravity nearer to the foot. Likewise, after exhausting the possibilities of lordosis and unsymmetrical gait in an effort to control a free knee joint after maximum hyperextension of a slightly flexed stump in a straight socket, the recent amputee demanded a mechanical knee lock; a stiff heel bumper or a "long" prosthetic step (caused by inadequate knee friction) only increased instability at heel contact and made the demand for a knee lock more insistent.

The early years of the Artificial Limb Program were dramatic, in some senses wasteful, yet in others very fruitful. Some efforts were lost, but unquestionably

the whole field of upper-extremity prosthetics was changed for the better by fundamental studies, development, and improved management of the individual amputee. Some unilateral amputees found the APRL hand adequately functional, and careful testing proved its cosmetic glove passed unrecognized in a wide variety of social situations. Thus one complaint was at least marginally resolved.

Vigorous study of locomotion proceeded concurrently with numerous development projects. Reintroduction of the suction socket, almost a side activity, forced attention to principles of fitting and alignment, to fostering of cooperation among doctor, limb fitter, therapist, and amputee, and to prosthetics education. Improved alignment as well as added gait training reduced the clamor for knee locks for stance control, and attention shifted toward the swing phase. Several swing-phase mechanisms are now widely used. The Henschke-Mauch Model "A" hydraulic stance-plus-swing-control mechanism has finally been recommended after prolonged development and evaluation. If clinical application studies of the Henschke-Mauch Model "A," including application to recent amputees, prove as encouraging as now seems likely, this device will answer at last the second complaint of the surgeons back in 1945.

But many problems remain. The Program has gradually spread its field of vision beyond the mere development of mechanical components. Fundamental research has provided data on locomotion, biomechanics, muscle action, pain, and other problems. Clinical studies have been made of amputation surgery, cineplasty, myoplasty, and early postsurgical fitting, though further studies of surgery and wound healing are needed. Fitting and alignment now can profit from better anatomical and biomechanical principles, new shop tools, improved materials, clearer analysis of defects, and greater insight into causes. The necessary skill and artistry of the increasingly professional prosthetist can be used more effectively. The team principle has become widely practiced, to the reassurance of all concerned.

Continuing soul-searching has steadily spurred the participants in this battle against ignorance. The best artificial limbs are still crude. Very little has yet been done about orthotics, deliberately kept in abeyance because braces are worn for such a wide variety of conditions that analysis is difficult. The Subcommittee on Sensory Aids, resuming the tasks of the wartime Committee on Sensory Devices, is only beginning its task of reviewing the present VA projects on aids for the blind. CPRD is studying its possibilities and responsibilities in the broad field of bioengineering.

The past score of years has given the Committee an intensive series of encounters, sometimes bruising—but often exhilarating—with problems of mechanisms, their human users, the man-machine interfaces, and the idiosyncracies of the professions concerned.