ORTHOTICS

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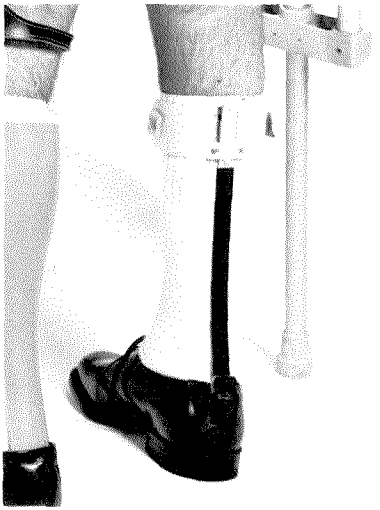
Prior to World War II orthotics was essentially a metal and leather craft which appeared to have reached the limits of its development with the materials and expertise employed. Following World War II the clinical engineer, the physiologist, and the rehabilitation specialist entered the field, and the bracemaker was metamorphosed into an orthotist. Their combined talents were directed at moving away from the static immobilization types of devices to the active, functional orthoses that all centers are now concentrating upon developing. The introduction of plastics and external power was an important landmark in this revolutionary trend, a trend guided by the highly trained specialists newly involved in orthotics. In 1956, Thorndike, Murphy, and Staros (1) proposed suggestions for the application of engineering principles to the future design of orthoses, and recommended such improvements as the prefabrication of orthotic components and higher orders of quality control by manufacturers.

It is understandable that the simpler problems would be approached first. The most varied and greatest efforts have been concentrated on ankle-foot orthoses, an area where the need for sophistication contrasts with the requirements for functional hand orthoses.

Ankle/Foot Orthoses (AFO) research has resulted in the production of the Teufel (2) polyethylene and the polypropylene AFO's (Fig. 1), as well as the commercially available TIRR and Snelson Orthoses, the VA Prosthetics Center Shoe-Clasp Orthosis developed by McIlmurray and Greenbaum (Fig. 2) (3), the Lehneis Spiral Orthosis (4) (Fig. 3), and the Ljubljana functional electrical stimulator (FES) (Fig. 4). Liberson (5), who stimulated the research on FES by his original work, continues to retain his interest in this area and is at present working to perfect an equino-varus control orthosis which will combine muscle and nerve stimulation in a balanced manner to more accurately achieve neutral foot dorsiflexion for the hemiplegic. New York University (6) has advo-

cated anatomically aligned ankle joints for the double-bar orthosis and has improved the cosmesis of their orthosis by employing a polypropylene shoe insert attached to metal uprights.

FIGURE 1



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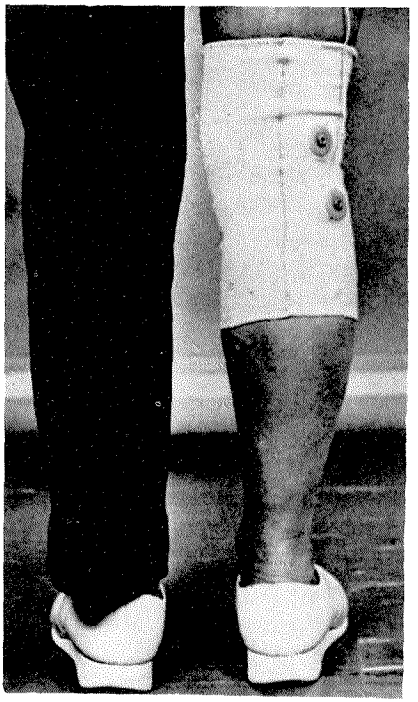


FIGURE 4

The lightness and cosmesis of polypropylene logically led to the fabrication of Knee/Ankle/Foot Orthoses (KAFO's), from this material by the addition of a thigh cuff and polypropylene joints to the AFO (Fig. 5).

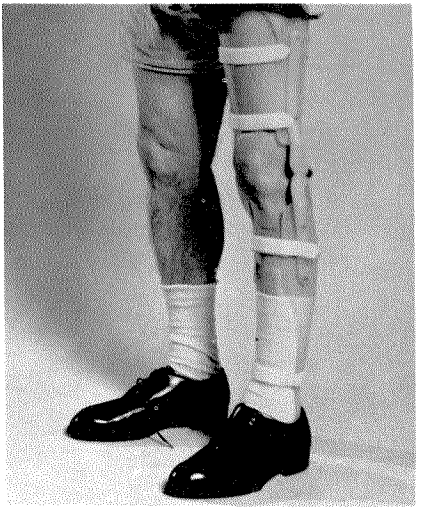


FIGURE 5

Similarly, the need for a lightweight lower-limb orthosis produced the Ortazur, a French product, and an American version called the Ortho-Walk (Fig. 6). The Ortazur was highly successful in the treatment of children with congenitally fragile bones (osteogenesis imperfecta). It is also being experimentally tested for paraplegics. These Knee/Ankle/Foot Orthoses (KAFO's), Ortazur A and Ortho-Walk (Fig. 7), would appear to have limited usefulness. The Hip/Knee/Ankle/Foot Orthosis (HKAFO) (Ortazur B) may have a wider application enabling midthoracic level paraplegics to stand and exercise. There are still some problems: the patient cannot sit comfortably without unzipping the device (Fig. 7); the patient must deflate each time he wishes to sit and inflate whenever he wishes to stand; and perspiration within the orthosis is still a factor with some patients. The area of application for the Ortazur or Ortho-Walk will be more clearly defined with further experience.

Polypropylene KO's have been developed by Dixon and Palumbo (7), employing a suprapatellar suspension strap modeled after the PTB strap.

The UC-BL foot orthosis (8) for flexible pes valgoplanus has also been fabricated of the versatile polypropylene. The foot deformity is corrected during casting, and it is the purpose of this orthosis to attempt to maintain the corrected position on weight-bearing (Fig. 8).

The PTB orthosis for below-knee instability or weight-bearing pain has been secure in its acceptance for many years (Fig. 9). This was the

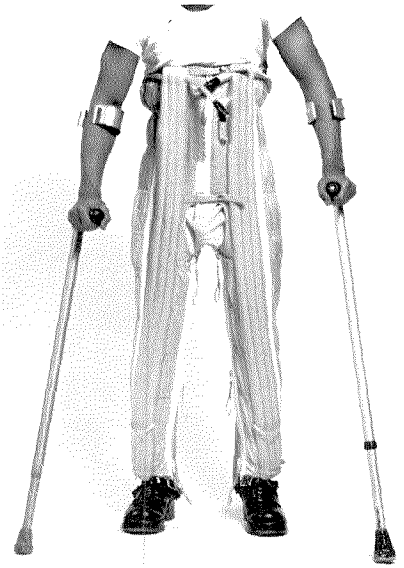


FIGURE 6

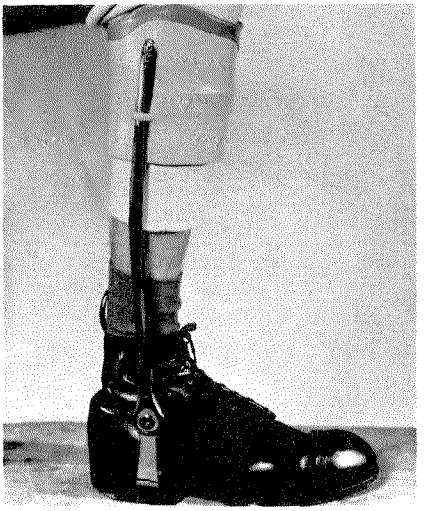
FIGURE 7

FIGURE 8

first significant application of prosthetic principles to orthotics. Another important application of these principles was that of Murphy (1) who demonstrated the usefulness of the SACH heel and rocker bar when employed with a solid ankle orthosis. The quadrilateral socket orthosis (Fig. 10) provides partial unweighting of the hip and more distal structures. Both this approach and that of its forerunner, the PTB orthosis, were the antecedents of fracture bracing techniques. The development of orthoses for the upper limb has been slower and more difficult than the development of those for the lower limb. The problems of positioning the jointed upper limb in space, targeting the paralytic hand, and then providing that hand with useful function are extremely complex and require multiple controls. The orthosis developed at Rancho Los Amigos Hospital (9) for the quadriplegic illustrates an heroic attempt to provide some function for this type of total disability. The Rancho orthosis is a tongue-switch controlled remote manipulator (Fig. 11). Schmeisser and Seamone,[a] at Johns Hopkins, are experimentally approaching this same problem by attaching a remote manipulator to a

[a] See "Status of the Johns Hopkins Research Program on upper-limb Prosthesis-Orthosis Power and Control Systems," by Seamone and Schmeisser, Jr., appearing elsewhere in this issue of the Bulletin.

wheelchair arm and using other control systems such as an accelerometer, temporal muscle myoelectric control, and vibratory controls. They have also been testing a cable device to accomplish elbow flexion. Current, and promising, research is directed at the production of clinically useful voice control devices.



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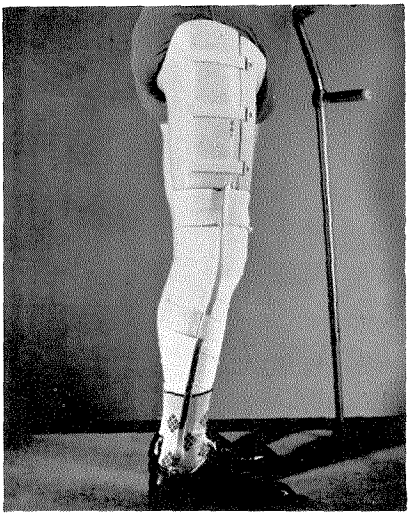


FIGURE 10

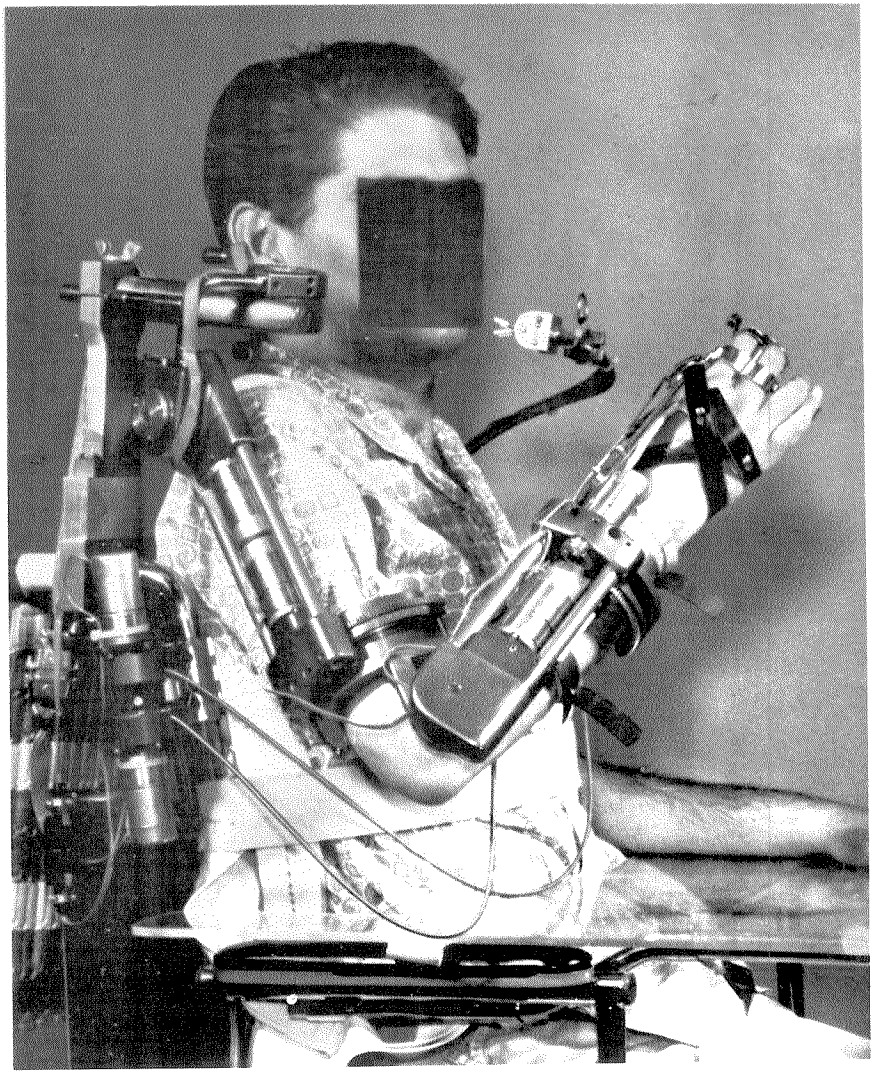
The VA Prosthetics Center is experimentally fitting an electrically operated orthotic elbow and hand system to a patient with a flail upper limb secondary to total brachial plexus avulsion (Fig. 12).

The Engen wrist driven splint (10) and, in the absence of voluntary control, the use of the McKibben muscle or myoelectric control are familiar approaches to provision of function to the paralyzed hand (Fig. 13, 14 and 15).

In the area of spinal orthotics, the newer developments have been limited. The Sterno-Occipital-Mandibular-Immobilizer cervical orthosis of Nitschke (11) is simply applied without moving the patient (Fig. 16). The prefabricated VA Prosthetics Center lumbosacral orthosis designed by Rubin and Greenbaum (12, 13) adds a "Milwaukee brace" type of stimulus to withdrawal to a contoured plastic orthosis and provides the patient with a socket into which to rest the portion of the trunk super-incumbent to the lumbar spine (Fig. 17). Morris' (14) UC-BL lumbosacral orthosis is a plastic laminate flexion jacket with a pneumatic abdominal pressure pad. John Hall[b] is involved with the development of a modular Milwaukee brace, and Staros has proposed that the VA

[b] John Hall, M.D., Professor of Orthopaedic Surgery, Harvard Medical School, Chief of Clinical Services, Childrens Hospital, Boston, Mass.

Prosthetics Center explore the possibility of fabricating a bilevel scoliosis orthosis based on a modular Milwaukee plus the VA Prosthetics Center lumbosacral orthosis.



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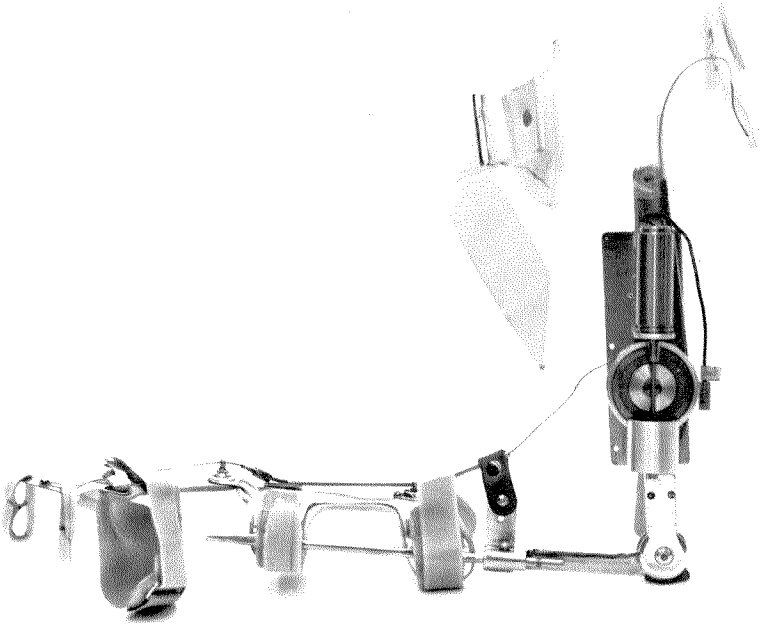

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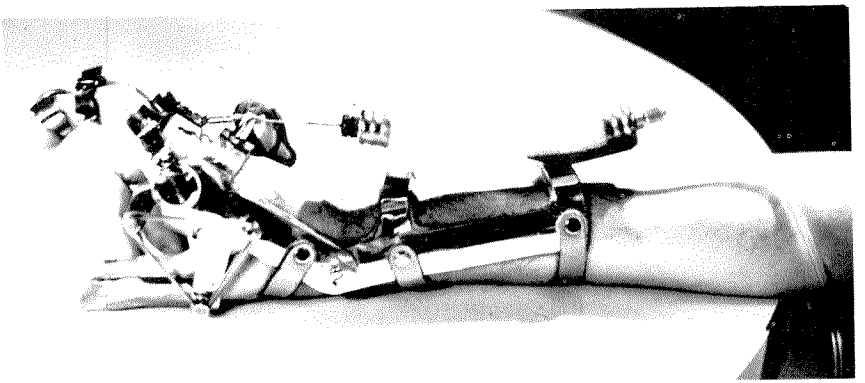

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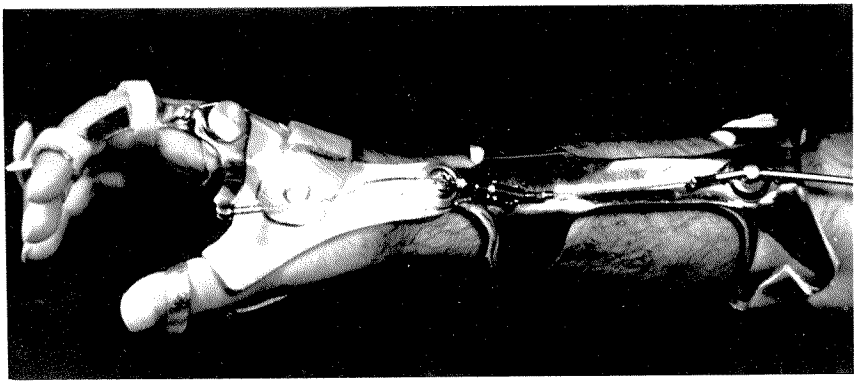

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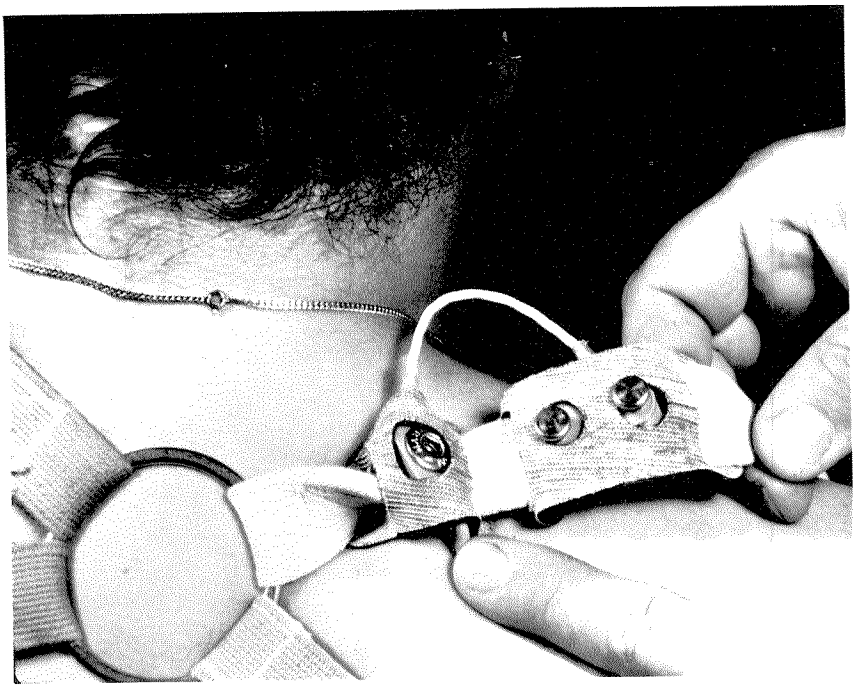

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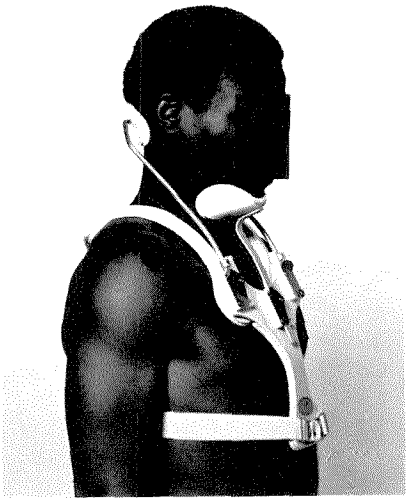

FIGURE 16

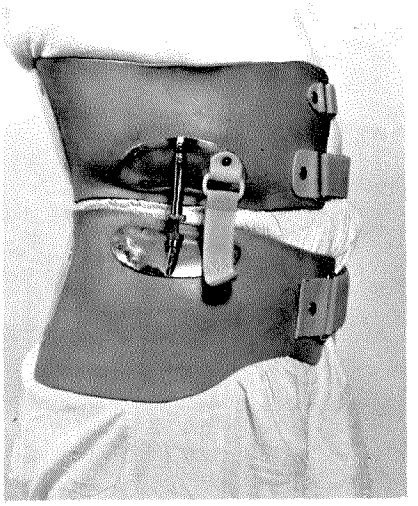

FIGURE 17

The needs for future development are most apparent in the upper-limb area, and, most particularly, for the quadriplegic, the hemiplegic, and the patients with peripheral nerve upper-limb problems. Experimental work is being done in the area of sensory feedback for the amputee where peripheral nerves are present in the stump; but the need is just as great in the case of the paralytic with sensory impairment, and an effort should be made to reach a practical solution to this problem. There is need for a simple, functional, inexpensive orthosis for the quadriplegic upperlimb—one that will not make the patient feel robotized. Perhaps the solution will be in the experimental efforts being made by Liberson and Dixon to utilize FES in this respect.

The spastic upperlimb of the hemiplegic is a constant reminder of an almost neglected area of research. Conventional orthoses are of little help. Perhaps the FES approach may help to improve this difficult situation. Certainly, more should be done for these patients than is being done.

Although the area of need is greatest in the upperlimb, this is not to suggest that all lower-limb and spinal problems have been solved; for example, adequate orthoses are not available in many areas. For the mid-thoracic paraplegic who does not have pelvic control, there is no truly adequate orthosis for immobilization of the dorsal spine, or one for providing the patient with hip stability in the presence of paralyzed hip-control musculature.

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