

Prosthetic Devices for Children with Emphasis on Fitting Upper Extremity Amputees

A Report of the Area Amputee Program of the Michigan Crippled Children Commission, Carleton Dean, M.D., Director

As the director of the Michigan Crippled Children Commission, I have been administratively responsible for the Child Amputee Program, and have the opportunity to observe the case histories of child amputees, in which are recorded the services and prosthetic devices that are being provided and prescribed by the medical directors of the Amputee Program; namely, C. H. Frantz, M.D., and G. T. Aitken, M.D. In line with the objectives of our program, certain information has been compiled that is of value to anyone contemplating such a project. Having conducted a Child Amputee Program for over eleven years in a population now approaching seven-and-a-half million, the statistical records furnish sufficient information to be significant. We will, in this paper, list the frequency distribution of types of child arm amputees in a given population. We will further describe and illustrate, by exploded diagrams and pictures, prosthetic devices for child amputees. In addition, the medical and prosthetic services will be tabulated by presentation of forty observations selected to emphasize the requirements of child amputees in regard to frequency of repairs, changes and replacement of prostheses.

Before we started our original project, a survey of Michigan child arm amputees showed that seven out of eight were not wearing their prostheses. This was partly due to the lack of proper fitting, but basically was due to the lack of a suitable and adequately functional prosthesis for the various types of amputation. In addition, there were no existing facilities or established procedures to establish whether the child was physically conditioned to accept a prosthesis or to provide him with instruction and training in its use, and no orderly sequence of follow-up care for adjustment, repair or replacement.

As a result of these findings, a program devoted entirely to child amputees was originated by the Michigan Crippled Children Commission and initiated in 1946.

The program was selected by the Advisory Committee on Artificial Limbs of the National Research Council, National Academy of Sciences, of which General Strong is Chairman, as a state crippled children agency in the United States having a program that would readily lend itself to a research project in the formation of an armamentarium in the prosthetic devices for children.

The physical aspects of the treatment are under the direction of George T. Aitken, M.D., and Charles Frantz, M.D., who are members of the Children's Prosthetic Committee of the Prosthetics Research Board of the National Research Council, as well as members of the American Board of Orthopedic Surgery. To the chairman and members of this Committee, we owe a debt of gratitude for their support, cooperation and interest in the child amputee problem.

Until two years ago, the project was financed entirely by the Commission, its services being limited to Michigan children. The success of our endeavor prompted the Children's Bureau of the U. S. Department of Health, Education and Welfare to make a special grant to the Commission in order that services to child amputees of other States might be made available.

Our prime consideration in continuing, expanding, and further developing the program is given to providing for the fundamental needs of the child amputee which, we have found by experience, dictates the early fitting of a prosthesis.

As growth and development are dependent upon use and exercise, it is essential that a child amputee be fitted with a prosthesis and trained in its use as early as he will tolerate same. Whether a congenital or traumatic amputee, this is important in order that his greatest potential of purposeful movements and motor patterns be obtained within the limitations of the prosthesis. The demands of daily activities develop his skill in the use of the appliance; thus he becomes more natural in using it and at maturity is better adapted physically and emotionally toward his condition. As a non-wearer, a child encounters the danger of greater disability due to the atrophy of disuse, contractures, ankylosis, or development of ancillary deformities. He may also develop hostile attitudes and faulty habit patterns that are difficult to change.

One must remember, "An ounce of prevention is worth a pound of cure." Early treatment is the criterion for the best functional results, thereby eliminating the serious difficulties previously mentioned.

Program Team

We are convinced by our experience that in order for such a program to be successful, it is essential to have an informed team composed of physicians, therapists, prosthetists, nurses, and social workers. They must have knowledge of what consists of a modern prosthesis and know the potentials and utility of the various new devices. This is important in order that the physician may know how to prescribe, the therapist how to train, and the prosthetist how to manufacture the prescribed prostheses. Further, a successful program must be coordinated in a physical setup which is convenient for, and will permit, close relationship of team services including clinical supervision, training, limb fitting, and follow-up services.

Psychological Preparation for Acceptance of Prosthesis

Every child amputee realizes his physical loss because it restricts him in competing in many normal activities to a greater or lesser degree, but the psychological problem varies in children of different ages. Anxieties, present and future, must be allayed by sympathetic explanations of the advantages in using a proper and adequate prosthesis. All children are born with an inherent desire to compete in physical and/or mental activities and to be independent. A child amputee, during his initial visit to the Amputee Clinic, has an opportunity to see other amputee children with prostheses doing things he has wanted to do. This observation excites his curiosity and creates within him an eager desire, which heretofore may have been expressed or suppressed, to be able to do likewise. As a result he is more willing to accept a prosthesis and to cooperate in the training program that is directed towards dexterity in his use of it.

Past experience has shown the importance of parental influence. The attitude of the family toward the child and his prosthesis can determine whether or not the child will be a good user of his artificial limb. To enhance a positive psychological environment, parents are interviewed on their first visit to the clinic by the medical social consultant and the orthopedic nursing consultants. Opportunities are given on subsequent visits and whenever questions or problems arise, to confer with the clinic staff.

Selection, Manufacture and Fitting of Prosthesis

The true criteria of an adequate and efficient limb is its fit and utility. The amputee rehabilitation team works closely in evaluating the individual needs of the amputee in relation to his age, sex, and social background, and recommending the type of prosthesis that will assure the maximum efficiency and service.

Leg prostheses have already reached a high degree of perfection. New developments in artificial arms are rapidly changing the picture for arm amputees and more adequate and satisfactory functional arm prostheses are being manufactured. Careful selection of the prosthesis for the various types of amputations is of primary importance for maximum physical restoration.

To have a good prosthetic user it is essential that the prosthesis be in good working order, that worn components be replaced or repaired, and that it be altered or replaced concomitant with growth. Periodic checking and re-evaluation by the team for fit of socket and alignment and length of prosthesis is important. It is important, too, for the child amputee to be checked at intervals to determine need for further training in activities that later may be related to the individual's future vocational plans.

Training in the Functional Use of the Prosthesis

Teaching a child to efficiently use his prosthesis is a basic and vital step of the program, and yet in the past was so neglected. The training of a child is different from the adult as regards the use and acceptance of prosthetic devices. This is particularly true with the very young amputee. Each prosthesis presents a separate training problem, requiring skin and muscle adaptation and habit pattern. The age and the type of amputee determine the instructive training efforts to be employed. In the very young the training is directed towards activities adaptive to age. As the age of the amputee increases, so do the training efforts become more involved to perfect the motions required in activities such as eating, writing, buttoning clothes, tying shoes, opening and closing doors and other important activities of daily living that are normally done without thought of the action involved. Leg amputees must be impressed with the fact that merely learning to get around on an artificial limb is not enough. Maximum efficiency with the prosthesis is not attained until balance, muscular coordination and smoothness of walking rhythm, climbing and descending stairs and even roller skating has been accomplished.

The type and length of training required is dependent upon the needs of the individual, the age of the child, the site of the amputation, and the type of prosthesis provided. Although individual cases may vary, an established pattern of training is followed in that the child is started with the simplest of activities and graduated to the more complicated ones. The goal in every case is to encourage and train the child in the proper and efficient use of his artificial limb and restore, insofar as possible, his normal social and physical capacity, thereby preparing the child to ultimately attain his maximum economic and social independence.

Follow-up Services

It is our opinion that the continuing success of our program can be attributed to a large degree to regular follow-up supervision and developmental guidance. In our program, definite clinic appointments are made for the child's return visit on a month-to-month basis, every three months, etc. Postal cards are sent out ten days in advance of the appointment date to remind the parent when the child is to return. If the child fails to keep the appointment, arrangements are made for one of the Commission's orthopedic public health nursing consultants to make a home visit to determine the reason for the broken appointment. The parents are encouraged and/or urged to return immediately to the clinic if the appliance should be worn or broken or if it does not function properly. Attempts by parents to remedy or repair the prosthesis are not approved or condoned.

Prostheses for Short Below Elbow Amputees

It would be impossible, in the time allotted, to cover the entire field of prosthetic devices for child amputees. In this paper we will discuss chiefly the most frequent type of congenital arm amputee, the short below elbow, covering the period of life from birth to twenty-one years of age. In this group we will discuss type of prosthesis for different ages, considering growth requirements, with its frequency of change, frequency and type of repairs, as well as cost of same.

For the past year-and-a-half, we have been fitting children with short below elbow prostheses at five months to thirty months of age with a Figure 8 harness, triceps pad, double wall socket, usually a flexible elbow hinge, modified friction wrist unit, and APRL plastic mitt. The "Mitten" is a passive device, having no moving parts, and was developed by Colonel Maurice Fletcher, Director of the APRL Research Laboratories.

The first prosthesis, with a pink plastic mitt, is usually very acceptable to the mother. It is clean looking, cosmetically appealing, and at a short distance resembles the normal hand. The mitt has a certain amount of flexibility which gives the child support without slipping when creeping and when he pushes himself to a standing position. (Figure 1)

SHORT BELOW ELBOW PROSTHESIS

PASSIVE MITTEN TYPE
5 MONTHS TO 30 MONTHS

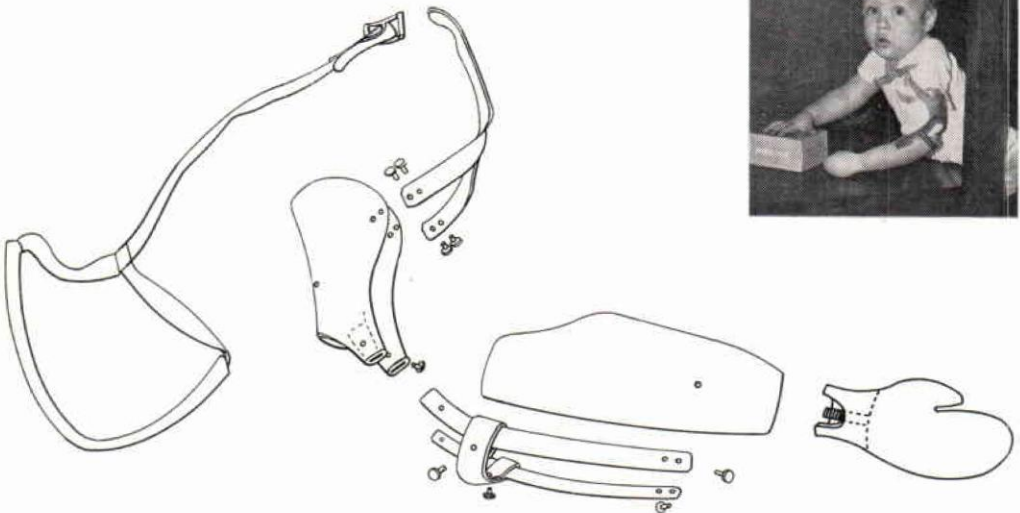


FIG. 1—Short below elbow prosthesis, passive mitten type, 5 months to 30 months: Figure "8" harness, triceps pad, flexible elbow hinge, double wall socket, modified friction wrist unit, APRL plastic unit. Services: 16 days rehabilitation training, 11 out-patient clinic visits, 20 physician services, 12 parts, 13 hours of labor for repairs, including two new forearms.

Fitting a child at an early age gives him "two arms" of equal length and allows him to function in a more normal pattern. At six or seven months, he will use the prosthesis to balance himself in a sitting position. One mother tells us her son (8½ months) "uses the mitt to bat balls and balloons, to spin figures on the side of the playpen, and to squeak his toy kitten". At about fourteen months, the child attempts to pack mud, sand, clay, etc., into the palm of the mitt.

By about twenty-one months he uses the mitt to assist him in eating, by pushing the food onto the spoon and holding his cup. He wears the prosthesis all of his waking hours, seems aware of its function, and is unhappy when for any reason he is not wearing it.

In-service care for fitting and training of children at this early age averages sixteen days. At the time of discharge, the child has built up a tolerance for the appliance. He demonstrates his acceptance by the offering of his stump when the therapist or attendant starts to put the prosthesis on him. The appliance is checked carefully by the team to see that the harness is correct and comfortable, and that the socket fits perfectly on the stump.

When the child is between twenty-four and thirty months of age, the passive mitt is changed to a grasping device which is a voluntary-opening hook, operated by a single control cable system. Now, for the first time, the child has a means of grasping an object. In order to utilize this new device, a second period of in-patient training is necessary. It is interesting to note that during the first few days the child will use his new appliance in the same manner as he did the passive device; i.e., pushing, pulling and hugging larger objects to him. In a short time, with the training provided by experienced therapists, he learns to open the hook, grasp objects and release them. Taking the paper off a lollipop is one of the activities he does best in the earliest period of his training. The length of in-patient training, of necessity, averages more for this age group than the younger age group. Our records show that fifteen to twenty-one days of training are required for children of twenty-four to forty-eight months.

At the age of four years, the child with the short below elbow amputation (stump length two to three inches) is ordinarily changed to a split socket type appliance, which allows him to increase his activities greatly. The new prosthesis has a Figure 8 harness and half-cuff; the elbow hinge is a rigid step-up hinge. The plastic part of the arm is made up of a socket and forearm piece. The socket must fit the child's arm perfectly. The step-up elbow hinge allows the child to get his hook to his mouth without the short stump slipping out of the socket. When he flexes his elbow one degree, the forearm piece flexes two degrees.

As the arm amputee becomes older, the type and number of his activities, as well as skill also increases. The prosthesis becomes more a part of him. He dresses and undresses himself with greater ease and is more adept at handling a knife, fork and spoon. Outdoors, he rides his bike, hangs and swings on monkey-bars, and plays ball (interchangeable hook and baseball mitt). One "mother's little helper", at three years, assists with the dishes by scraping them with her hook.

From four years to ten or twelve years, there are no major changes in the type of mechanical components which make up the prosthesis. Maintenance will include reconditioning and replacing the hook, replacing cables, lengthening the forearm and reconditioning the socket. Two or three complete new arms may be required during the six to eight-year period.

At this writing, there are no functional child-size hands commercially available which are practical. The APRL hand and cosmetic glove is now

available only in adult sizes. However, functional child-size hands with cosmetic glove that are practical have been designed by Colonel Fletcher. The manufacturer has now delivered the first models which will be used for testing purposes. Later they will be made commercially available.

At thirteen or fourteen years of age, both boys and girls are given a hand in addition to their hook. Instructions for operating the hand are given at the Amputee Center; a child occasionally is admitted to the hospital for one week of training in its operation.

From fourteen years on, adjustments for growth are not so great. Added now to the maintenance problem is that of the replacement of the cosmetic glove. The child who wears the hand at school and for all occasions will require a new glove every three to five months. The wearer who puts it on only for social occasions will get along with fewer during a year. A glove tends to darken and stain easily. Therefore, a good user requires replacement more frequently.

For the purpose of gaining an estimate of the number of prostheses required, we will take a hypothetical child and fit him at the various age levels.

Age 5 months to 30 months (Passive Pylon Type—Figure 1):

- Figure "8" Harness
- Triceps pad
- Flexible elbow hinge
- Double wall socket
- Modified friction wrist unit
- APRL plastic unit

SHORT BELOW ELBOW PROSTHESIS

RIGID HINGE TYPE
30 MONTHS TO 4 YEARS

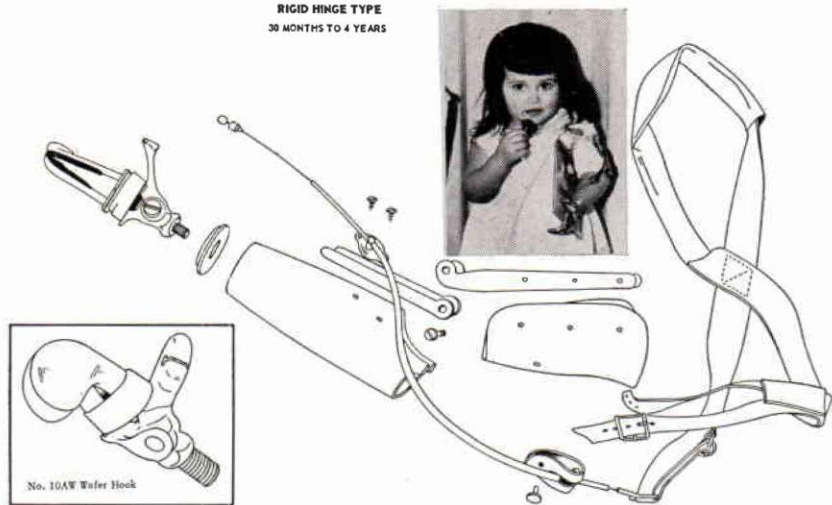


FIG. 3—Short Below Elbow Prosthesis, Rigid Hinge Type, 30 months to 4 years: Figure '8' harness, Single control cable system, Half cuff, Single or double pivot hinge, Double wall socket, Child size friction wrist unit, No. 10X Dorrance Terminal Device or No. 10AW wafer hook. Services: 21 days rehabilitation training, 8 out-patient clinic visits, 14 physician services, 12 parts (cables, joints, cuffs, harness, fabricated parts, etc.) 5 hours labor for repairs including one new forearm.

Between the ages of 6 months and 30 months, a child may require the following services:

- 16 days rehabilitation training
- 11 out-patient clinic visits
- 20 physician services
- 12 parts
- 13 hours of labor for repairs, including two new forearms

Age 30 months to four years: (Rigid Hinge Type—Figure 3)

- Figure "8" Harness
- Single control cable system
- Half cuff
- Single or double pivot hinge
- Double wall socket
- Childsize friction wrist unit
- No. 10X Dorrance Terminal Device, or
- No. 10AW Wafer Hook

SHORT BELOW ELBOW PROSTHESIS

SPLIT SOCKET TYPE
4 YEARS TO 14 YEARS

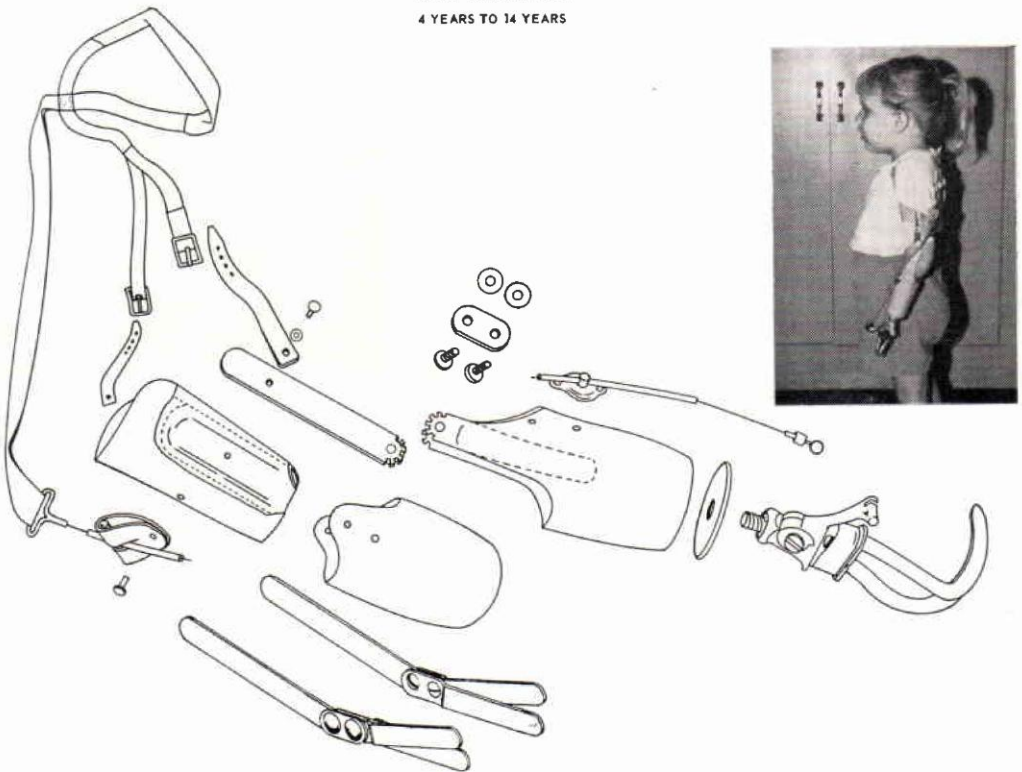


FIG. 4—Short below elbow prosthesis, split socket type, 4 years to 14 years: Figure "8" harness, single control cable system, half cuff, step-up hinges, split socket, child size friction wrist unit, No. 10X or 88X Dorrance Hook. Services: 18 out-patient clinic visits, 15 physician services, 22 parts, 16 hours labor for repairs, including one new socket.

Between the ages of two years and four years, a child may require the following services:

- 21 days rehabilitation training
- 8 out-patient clinic visits
- 14 physician services
- 12 parts (cables, joints, cuffs, harness, fabricated parts, etc.)
- 5 hours labor for repairs, including one new forearm

Age 4 years: (Split socket type—Fig. 4.)

- Figure "8" Harness
- Single control cable system
- Half cuff
- Step-up hinges
- Split socket
- Child-size friction wrist unit
- No. 88X Dorrance Hook

Age 5 years:

- B. E. split socket prosthesis without terminal device

SHORT BELOW ELBOW PROSTHESIS

SPLIT SOCKET TYPE

14 YEARS TO ADULT

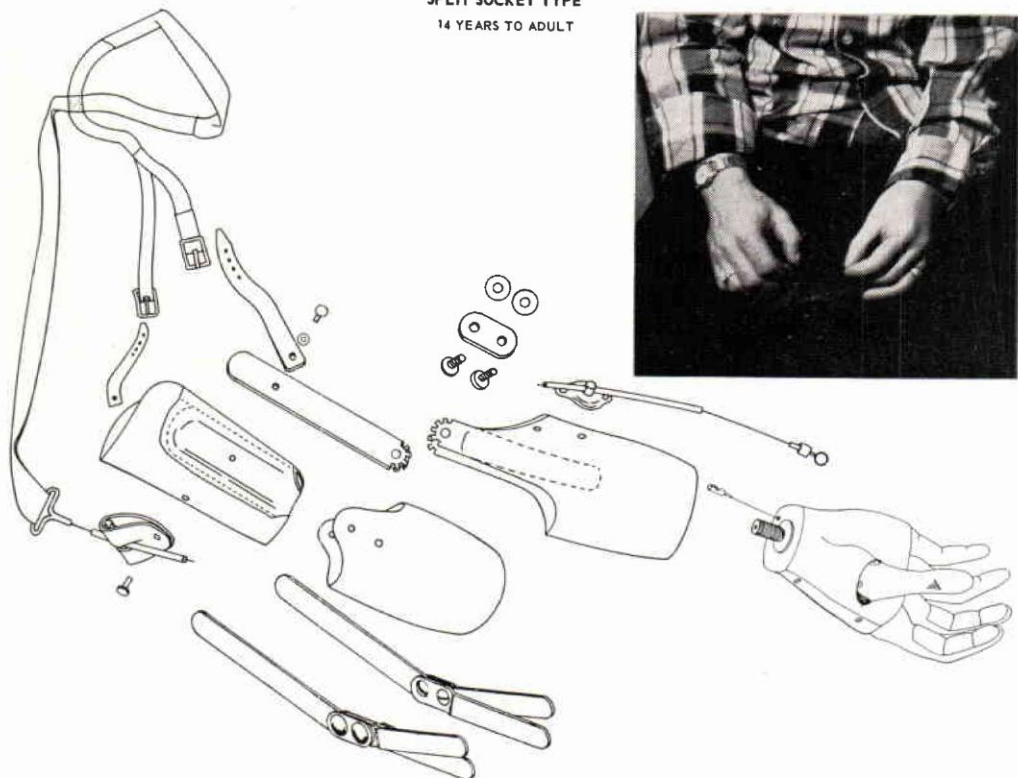


FIG. 2—Short below elbow prosthesis, split socket type, 14 years to adult: Figure "8" vinyon harness, single control cable system, half cuff, step-up elbow hinges, split socket—plastic, standard forearm sizing, FM wrist disconnect unit, APRL hand and glove. Services: 3 out-patient clinic visits, 3 physician services, 6 parts, 6 hours labor for repairs, including 2 new gloves.

Age 7 years:

B. E. split socket prosthesis with hook and child's small size
APRL hand

Age 9 years:

B. E. split socket with hook (Child's APRL hand, when available)

Between the ages of four years and nine years a child may require the following services:

18 out-patient clinic visits

15 physician services

22 parts

16 hours labor for repairs, including one new socket

Age 9 years through 15 years, the child may require the following:

17 out-patient clinic visits

17 physician services ----

29 parts

9 hours labor for repairs, including a new No. 3 Dorrance Hook

Age 15 years: (Split Socket Type—Fig. 2)

Figure "8" Vinyon Harness

Single control cable system

Half cuff

Step-up elbow hinge

Split socket—plastic

Standard forearm sizing

FM wrist disconnect unit

APRL hand and glove

Between the ages of fifteen years and sixteen years the child may require the following services:

3 out-patient clinic visits

3 physician services

6 parts

6 hours labor for repairs, including 2 new gloves

Age 18 years:

B. E. split socket, as listed above at 15 year period,
without terminal devices

Between the ages of sixteen years and nineteen years the child may require the following services:

9 out-patient clinic visits

9 physician services

22 parts

13 hours labor for repairs

Age 20-21 years:

Figure "8" Harness

Single control cable system

Half cuff

Variable ratio elbow joint

Split socket

Hosmer friction wrist unit

Two load hook

Between the ages of nineteen years and twenty-one years the child may require the following services:

8 clinic visits

8 physician repairs

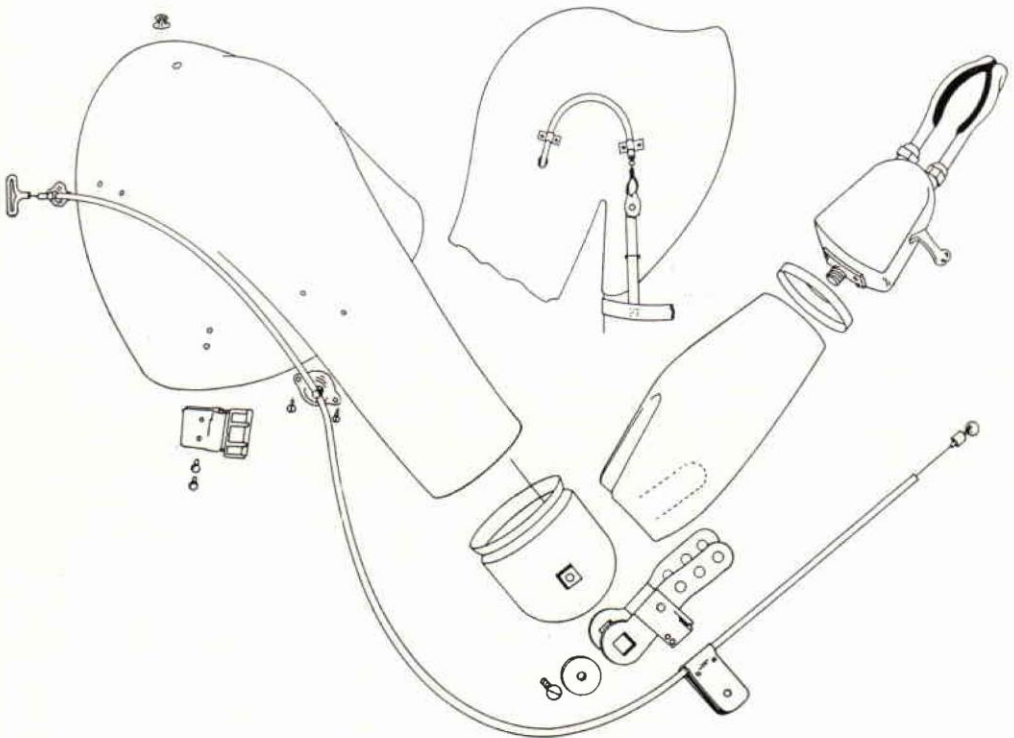
12 parts

5 hours labor for repairs

Nine new limbs are required for the first 20½ year period of life for the short below-elbow congenital amputee.

Michigan's Child Amputee Program has not been operating long enough to predict what the very young group of children wearing prostheses will be doing vocationally at twenty-one years of age. We can say, however, that those children treated early in our program are now working successfully as school teachers, farmers, and homemakers. Others are in the industry and business offices. From a monetary standpoint, the cost of rehabilitating the person with an amputation is very small compared to the compensation gained socially, emotionally and economically.

We are convinced that there is much yet to be accomplished for the child amputee in the fields of education and prosthetic appliances, and in the environmental situation. Progress in this field of human endeavor and adjustment is rapidly gaining ground. We look forward with enthusiasm and optimism.



The Area Amputee Program
MICHIGAN CRIPPLED CHILDREN COMMISSION

FIG. 5—Shoulder disarticulation type prosthesis, APRL terminal device voluntary closing: Chest strap harness, dual control system—1st, cables control terminal device, forearm lift; 2nd, cable attached to abdominal belt, to brassiere or to a nudge control; controls elbow lock—shoulder cap and humeral section one solid piece, Hosmer elbow, standard forearm shell, FM wrist disconnect, APRL Hook.

TABLE A. UPPER EXTREMITY CHILD AMPUTEES
CONGENITAL AND ACQUIRED

CHARACTERISTICS OF 226 CHILD AMPUTEES RECORDED ON THE STATE REGISTER OF MICHIGAN CRIPPLED CHILDREN WITH
UPPER EXTREMITY AMPUTATIONS AS OF JUNE 30, 1956.

AMPUTATION TYPE	TABLE A-1. TYPES OF AMPUTATION, BY CONGENITAL AND ACQUIRED, BY SEX							TABLE A-2. TYPES OF AMPUTATIONS BY CONGENITAL AND ACQUIRED, BY LOCUS OF AMPUTATION, RIGHT, LEFT OR BILATERAL								
	TOTAL	CONGENITAL			ACQUIRED			TOTAL	CONGENITAL				ACQUIRED			
		Total	Male	Female	Total	Male	Female		Total	Right	Left	Bilat.	Total	Right	Left	Bilat.
TOTAL	226	163	83	80	63	48	15	226	163	50	102	9	63	30	30	1
ABOVE ELBOW Total	53	21	14	7	32	25	7	(2) 53	21	5	12	4	(2) 32	13	16	1
TYPE NOT ESTABLISHED	1	0	0	0	1	1	0	(1) 1	0	0	0	0	(1) 0	0	0	0
SHOULDER DISARTICULATION	6	3	2	1	3	2	1	6	3	0	0	3	3	1	2	0
SHORT ABOVE ELBOW	10	6	1	5	4	4	0	10	6	2	3	1	4	1	3	0
STANDARD ABOVE ELBOW	23	6	6	0	17	13	4	23	6	1	5	0	17	8	8	1
ELBOW, DISARTICULATION	13	6	5	1	7	5	2	(1) 13	6	2	4	0	(1) 7	3	3	0
BELOW ELBOW Total	173	142	69	73	31	23	8	173	(2) 142	45	90	5	31	17	14	0
VERY SHORT BELOW ELBOW	37	32	13	19	5	4	1	37	32	14	17	1	5	3	2	0
SHORT BELOW ELBOW	45	41	22	19	4	4	0	45	41	15	25	1	4	1	3	0
LONG-MEDIUM BELOW ELBOW	33	23	12	11	10	7	3	33	23	5	17	1	10	8	2	0
WRIST DISARTICULATION	34	26	13	13	8	7	1	34	(2) 26	7	17	0	8	3	5	0
PART OF HAND (1/)	24	20	9	11	4	1	3	24	20	4	14	2	4	2	2	0

1/ When Prosthesis Can Be Utilized

Figure in Parenthesis: () Locus Not Reported, Included in Totals