R E P O R T

WORKSHOP ON KNEE-DISARTICULATION AND HIP-DISARTICULATION PROSTHESES

SUBCOMMITTEE ON DESIGN AND DEVELOPMENT

March 31, 1969

San Francisco, Calif.

COMMITTEE ON PROSTHETICS RESEARCH AND DEVELOPMENT
DIVISION OF ENGINEERING - NATIONAL RESEARCH COUNCIL
NATIONAL ACADEMY OF SCIENCES--NATIONAL ACADEMY OF ENGINEERING

REPORT
WORKSHOP ON KNEE-DISARTICULATION
AND HIP-DISARTICULATION PROSTHESES
Subcommittee on Design and Development
Committee on Prosthetics Research and Development

The meeting of the Workshop on Knee-Disarticulation and Hip-Disarticulation Prostheses was held at the University of California Medical Center, San Francisco, Calif., on March 31, 1969. A list of the participants is appended to this report (Attachment 1).

The chairman opened the meeting by recalling that the Subcommittee on Design and Development had suggested that meetings be organized to review the status of developments of prostheses and systems for knee-disarticulation and hip-disarticulation cases. Professor Radcliffe noted that the Canadian-Type Hip-Disarticulation Prosthesis had become the standard of the world since its introduction in the early 50's. A few minor modifications have been introduced; these should be reviewed, and consideration should be given to what might be done in the future to improve further prostheses for patients who have been disarticulated at or about the hip.

In contrast to prostheses for the hip-disarticulation case, prostheses for the knee-disarticulation have never been adequate primarily because of the difficulty encountered in providing swing-phase control. Professor Radcliffe called attention to the fact that the UC Biomechanics Laboratory, DuPaCo, and the VA Prosthetics Center had worked or were currently working on the problem. These efforts would be reviewed and attention would be given to what might be done in the future in the development of prostheses that would make greater potential of the residual functions of knee-disarticulation and supracondylar stumps.

Dr. Murphy noted that the Workshop on Rehabilitation of Cancer Patients that was held at Princeton in 1967 stressed the desirability of fitting patients early, and Mr. Bennett Wilson recalled that state crippled children programs for the most part were also providing prostheses as early as possible to child patients who had had amputations for cancer. Some states had in the past required that the child survive a definite period after amputation before a limb would be supplied.

KNEE DISARTICULATION

A. VAPC

Mr. Henry Gardner presented two brief papers: the first (Attachment 2) outlines the present-day fabrication procedure for the through-knee or knee-disarticulation patient; the second (Attachment 3) outlines a method of fitting the supracondylar patient with the DuPaCo hydraulic knee control device in which the DuPaCo boring jig is used.

B. U. S. Manufacturing Company

Mr. Greene reported that the Area Child Amputee Center (Grand Rapids, Mich.) was using the UCB-designed stainless steel below-knee joints and Hydra-Knee units. After some discussion it was agreed that VAPC would check out the applicability of the stainless steel BK joints to the knee-disarticulation case.

C. Hosmer Corporation

Mr. Benton stated that the DuPaCo yoke is currently being revised to overcome problems that had been encountered in application and that in due course Hosmer will request an evaluation of the revised design.

D. Winnipeg

Mr. Foort reported that the present technique in Winnipeg includes a flexible socket with overlapping walls to permit adjustment in the antero-posterior plane. It is his feeling that the true knee disarticulation has much to offer. Not only is full weight-bearing possible but the presence of the femoral condyles provides excellent means of suspension. He then sketched a hinge he had designed to provide adjustability in the medio-lateral plane.

E. U. S. Navy

Mr. Porter said that the U.S. Naval Hospital (Oakland) had fitted 17 cases with the DuPaCo System but has had problems with alignment. To alleviate this problem, he has designed an alignment jig for the upper side-straps. He has also designed a new ball-bearing joint in an attempt to overcome new problems experienced with presently used designs. The prototype unit is scheduled for an early trial.

F. University of California--Berkeley

In commenting on the past efforts of the Biomechanics Laboratory in knee-disarticulation prostheses, Professor Radcliffe suggested that VAPC include in its pneumatic swing-phase unit evaluation a number of the setups that used a knee "block" with an inclined plane for the upper surface. It was agreed that UCB would prepare the units for trial by VAPC, the Navy, and Winnipeg.

Mr. Lamoreux, after describing Mr. George Fulford's method of treating the knee disarticulation and his reasons therefor, described the evolution of a design he has been developing which consists of a four-bar linkage completely below and behind the socket, thereby eliminating the need for side joints. UCB was encouraged to fabricate prototypes.

G. Summary

The chairman summarized as follows:

1. There are three distinct categories of amputation about the knee.

   a. True knee disarticulation.

   b. Modified knee disarticulation, in which condyles are trimmed but length retained.

   c. Supracondylar, in which the femur has been shortened.

2. If a satisfactory prosthesis can be devised for the knee-disarticulation case, the others will automatically be satisfied.

3. DuPaCo is developing a detailed manual on application of the "yoke" and DuPaCo Unit and will check on quality control of the yoke. It was suggested that VAPC check out draft of the manual.

4. J. Foort, Leigh Wilson, and G. Porter will prepare manual on fabrication of plastic socket. Bennett Wilson will coordinate.

5. Leather sockets are not recommended for use with DuPaCo yoke.

6. UCB will prepare setups with inclined plane knee block for trial by VAPC, the Navy, and Winnipeg.

7. UCB will fabricate prototypes of the knee joints designed by Lamoreux.

HIP DISARTICULATION

Mr. Greene reported that U. S. Manufacturing Co. is presently supplying the original hip joint designed at Northwestern University and that a number of hip-disarticulation patients are being fitted with Hydra-cadence legs.

Mr. Benton reported that Hosmer Corporation intends to make available a hip joint originally developed by Mr. John Kolman of Whittier, Calif., which uses a #2 Morse taper connection for adjustability. The group agreed that this design represents an improvement over existing joints.

Mr. Wooldridge stated that no work on the hip-disarticulation problem was currently under way at OCCC but that the group there hoped to commence soon. They would like to incorporate an adult version of the stable polycentric knee now being tried on children and provide smoother transition between stance phase and swing phase and to provide greater ground clearance.

Further discussion led to a description by Prof. Radcliffe of a system shown him on a patient by Dr. G. G. Kuhn (Muenster) several years ago which seemed to combine the best features of the Canadian and Modl systems. He hopes to have available this summer a student who will be able to work on problems of the hip-disarticulation prosthesis.

The chairman summarized this section of the meeting as follows:

1. Manufacturers are encouraged to work closely with research and development groups. The Kolman device represents an excellent start.

2. The "tinker toy" or modular approach should be explored thoroughly.

3. The "pogo-stick"-type of extensor unit should be tried.

4. An attempt to combine the best features of the Canadian and Modl designs should be made.

5. Consideration should be given to the design of components, especially for immediate postsurgical and early fitting.

July 1, 1969

PARTICIPANTS

WORKSHOP ON KNEE-DISARTICULATION AND HIP-DISARTICULATION PROSTHESES

March 31, 1969

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BASIC STEPS IN THE FABRICATION OF THE THRU-KNEE SOCKET

Henry Gardner, C.P.O.*

I. Recording Prosthetic Information

A careful examination is made of the stump, noting all dimensions, characteristics, and conditions to be considered in the fabrication of the socket and prosthesis. The prosthetic information forms currently in use for above-knee prostheses are adequate for this purpose.

II. Stump Casting

Plaster-of-Paris bandage is wrapped spirally up the stump to form a total-contact quadrilateral-type socket. Casting stands and other mechanical aids expedite the process. Stump elongation in casting the thru-knee stump is minimal.

III. Cast Modifications

The cast must be modified so that:

1. Distal weight-bearing will not be constrictive circumferentially.

2. The lateral wall will conform accurately to the curvature of the femur on the lateral side and to the lateral condyle.

Anterior-posterior (A-P) dimensions in the proximal region are not critical if good end weight-bearing is available. In Table 1 the approximate A-P and M-L dimensions based upon stump circumferences at ischial level are given.

IV. Lay-up of Socket Liner

The socket liner is formed by molding over the modified cast a single piece of 4 oz. leather. The seam is placed on the anterior side. If a plastic socket is desired, three layers of nylon stockinet are used with a 70-30 proportion of resin to give a semiflexible laminate. The method of securing the socket liner over the cast is shown in Figure 1.

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* Technical Assistant to Director, VA Prosthetics Center, 252 Seventh Avenue, New York, N. Y. 10001.

Table 1

Approximate A-P and M-L dimensions computed from the proximal stump circumferential measurements.

Most Proximal Peripheral Stump Measurement	15	16	17	18	19	20
A - P =	3	3-1/2	3-3/8	3-1/2	3-3/4	4
M - L =	5	5-3/8	5-5/8	6	6-3/8	6-5/8
Most Proximal Peripheral Stump Measurement	21	22	23	24	25	26
A - P =	4-1/4	4-3/8	4-1/2	4-3/4	5	5-1/4
M - L =	7	7-3/8	7-5/8	8	8-3/8	8-5/8

V. Attaching the Knee-Extension Block

A recess is formed in a 4" x 4" x 4" block of willow to fit over the end of the cast and socket liner. A depth of 1" is usually adequate to permit good attachment. The block is then permanently bonded to the leather or plastic liner. The knee block attached to the socket is shown in Figure 1.

VI. Location of Knee Axis and Knee Shaping

The level of the knee center is determined from measurement of the sound side and located on the wood block. The A-P position of the knee axis is determined as follows: (see Figure 2)

1. Knees 4 inches wide require a radius of 2-3/4 inches A-P.
2. Knees 3-1/2 inches wide require a radius of 2-1/2 inches A-P.
3. Knees 3 inches wide require a radius of 2-1/4 inches A-P.

The template used for "swinging" (contouring) knee blocks is shown in Figure 2.

Fig. 1. Inner liner of leather placed over a modified plaster-of-Paris model in the fabrication of a leather socket for thru-knee stump. Here the assembly has been bonded to a willow block that has been rounded in the M-L plane as the first step in shaping it into a spherical knee block. See Figure 2.

Fig. 2. Using a template to "swing" or contour a wooden knee.

VII. Building Posterior Distal Socket Wall

The posterior half of the leather socket is reinforced by using sections of Silastic. Dacron felt and fiberglass are used for plastic sockets. The reinforcement at the top of the socket extends anteriorly on the lateral side past the point of attachment for the pelvic belt. The distal area is built up to fair into the posterior contour of the wooden knee block. If a hydraulic knee-control unit is to be used, the posterior distal wall must be thick enough to contain the piston-rod pin as shown in Figure 3.

VIII. Forming the Socket Shell

Leather sockets are molded by using a single piece of 8 oz. molding leather. The seam is located along the anterior of the socket, and is largely removed with the cut-out for an opening that comes to a point about 3 inches above the stump end. Knee-disarticulation stumps require a lower opening, depending upon the size of the knee condyles. Plastic sockets are laminated using approximately 6 layers of nylon stockinet. A typical leather socket with anterior opening is shown in Figure 4.

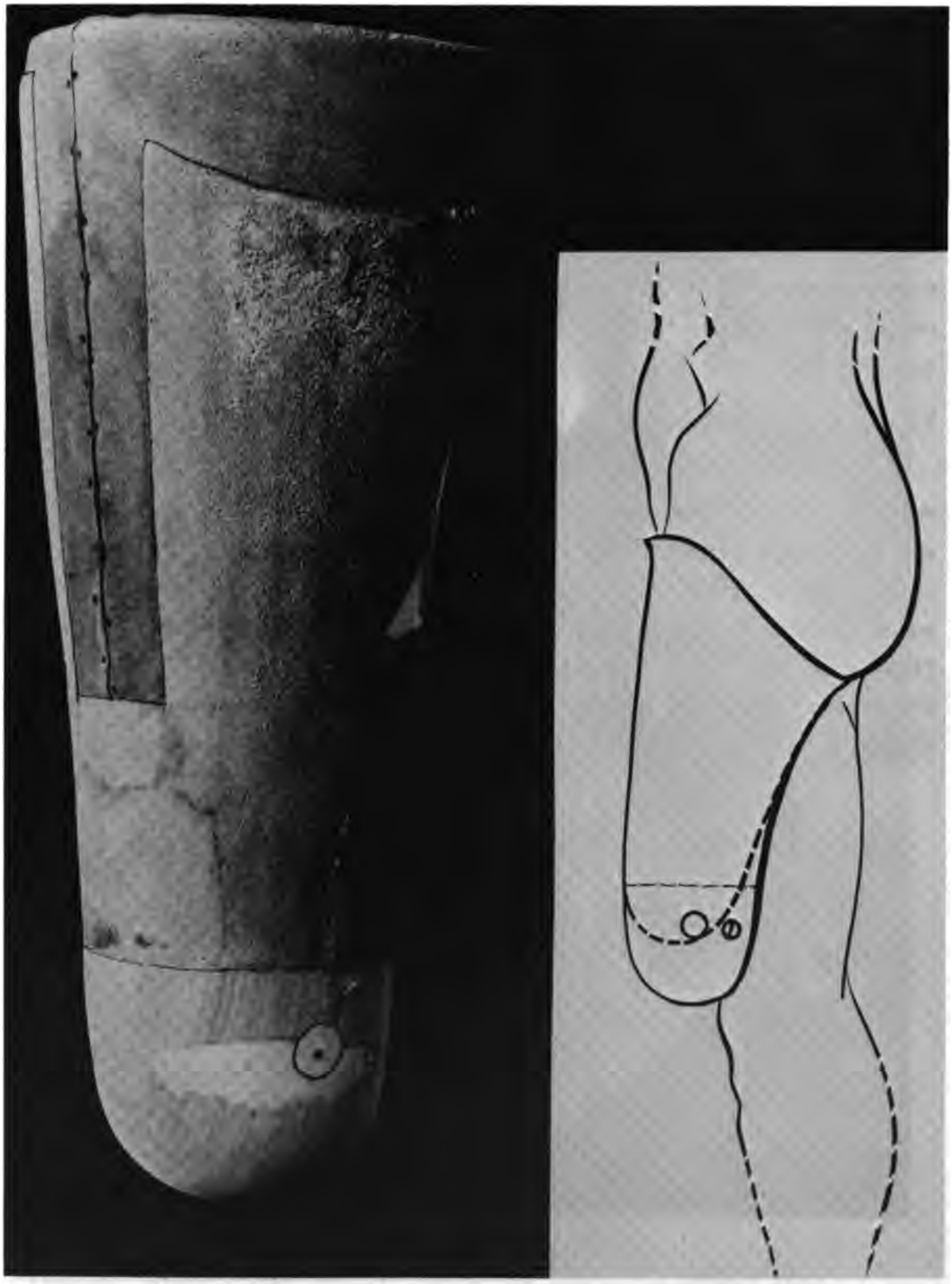

Fig. 3. Location of knee center, and upper bushing for piston-type hydraulic unit if used. Also shown is filler used in posterior aspect to provide reinforcement and cosmesis.

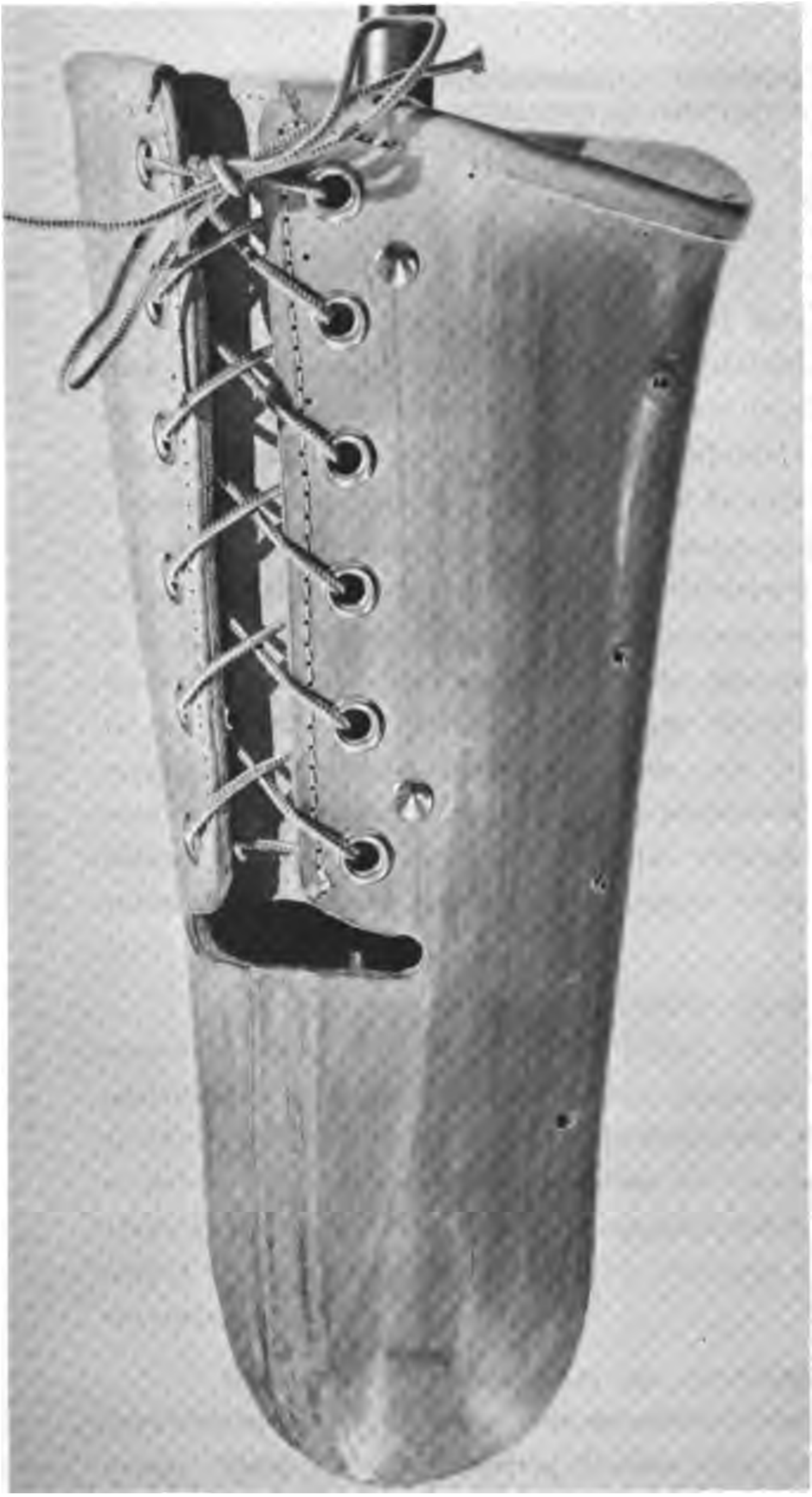

Fig. 4. Finished leather socket.

HYDRAULIC KNEE CONTROLS OF PROSTHESES FOR THRU-KNEE AND SUPRACONDYLAR AMPUTATION LEVELS

Joseph Cortolino, C.P.
and
Henry Gardner, C.P.O.

In view of the increasing number of geriatric amputees and their most common cause of amputation (arteriosclerosis with or without diabetes), serious consideration must be given to acceptance of the supracondylar amputation as the preferred level for those patients in this group whose knees cannot be saved. This level of amputation is high enough to obtain good healing and low enough to secure the important advantages that myoplastic surgical procedures offer. Such critical objectives as marked reduction in muscle weakness, reduction of gait disturbance due to loss of stability and balance, and a marked reduction in the formation of hip contractures may all be achieved with the long myoplastic above-knee stump. The stump thus formed equips the patient with the best potential for increased proprioception, weight-bearing and control. Other patients not classified in this particular group may acquire the same benefits from supracondylar as well as thru-knee amputations.

Thru-knee and supracondylar levels of amputation have not been popularly accepted in the past due in part to a lack of adequate knee controls for this type of prosthesis. Recently, a method was developed to incorporate fluid-control knee systems into the conventional plastic or molded leather sockets of thru-knee and supracondylar-type prostheses (Fig. 1). This relatively simple approach makes available the urgently needed fluid-control knee devices in this most vital area of lower-extremity prosthetics.

The procedure provides for the installation of a fluid-control knee system directly through the prosthetic knee posterior to the distal stump. Using the DuPaCo Boring Fixture (Fig. 2) which was designed for the installation of the DuPaCo Hydraulic Unit in a conventional wooden limb, thru-knee and supracondylar prostheses may be bored to receive

Fig. 1. Two views of prosthesis for supracondylar amputation stump. The socket is conventional but the knee block is made and located so that a piston-type hydraulic or pneumatic knee unit may be used.

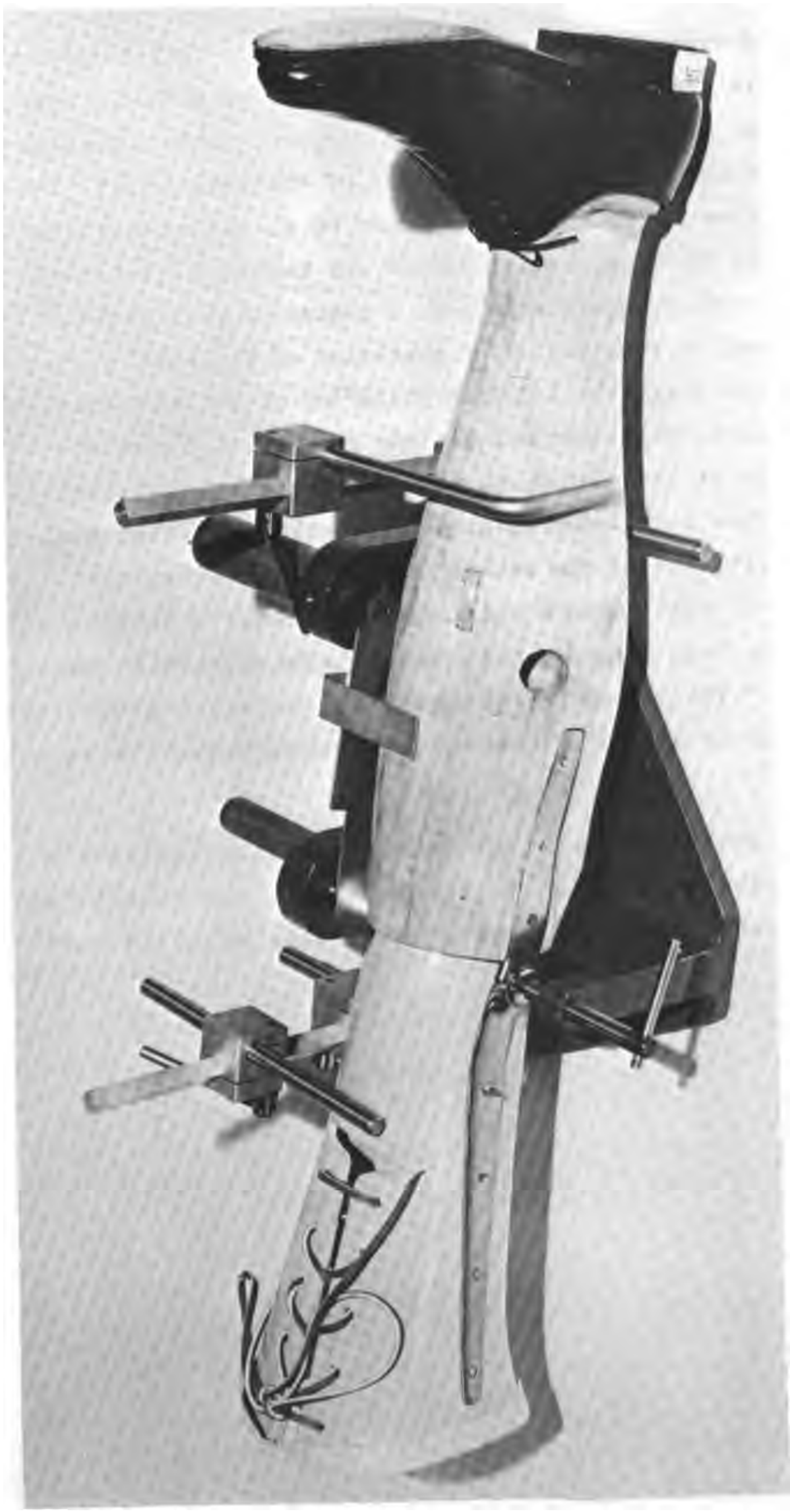

Fig. 2. The DuPaCo Boring Fixture.

DuPaCo or Hosmer fluid-control knee units. This procedure is possible only if adequate material is designed into the distal posterior socket (knee) area of the prostheses. The bushings for the piston-rod pin are located approximately 1-1/8 inches posterior to the axis of the knee joint. Knowing these facts, the side joints (knee axis) must be placed so as to center the piston pin position in the posterior socket and knee wall (refer to Attachment 2). To provide adequate strength, a posterior wall of 1-1/4 inches minimum thickness is required. The posterior of the inner socket wall should never extend more than 1/2 inch posterior of the knee axis and the outer posterior socket wall must not be less than 1-3/4 inches posterior of the knee axis or the piston-rod pin cannot be located properly. After the knee joints are positioned to properly locate the piston pin, they are temporarily attached to the socket, the entire prosthesis is assembled, fitted and aligned using a check lace for extension control. Once the prosthesis has been aligned, the prosthesis is clamped in the DuPaCo boring fixture.* The procedure for installing the fluid-control knee is followed as outlined in DuPaCo's "Prosthetic Products Manual" dated June 1965.

*The fixed knee center holder on the boring fixture is modified to receive wider knees. The shoulder of the fixed center is cut back 1 inch to permit moving the centers further apart. (See Figure 111-1A in the DuPaCo Manual.)

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DATE DUE	BORROWER'S NAME	ROOM NUMBER