The "Dundee" Socket—A Total Contact Socket for the Below-Knee Amputation*

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The patient with a below-knee amputation was, until 1959, fitted with a prosthesis, incorporating a corset and side-steels and employing a socket made of leather or wood. The socket was so shaped that areas such as the head of fibula, the front of the shin and the end of the stump were relieved of pressure. Weight bearing loads were borne partly by the flare of the tibial condyles and partly by the thigh corset and side-steels. In the same way inadvertent errors of alignment built into the prosthesis during fitting and construction were disguised and angular forces absorbed by these same side-steels and encircling corset. Finally the artificial knee joints, whether uni-axial or polycentric, aided or otherwise by devices such as slip sockets, failed to simulate the movement of the natural knee.

The work of a team under the chairmanship of Professor Charles Radcliffe at the University of California has resulted in the development of the Patellar Tendon Bearing Cuff Suspension Limb. This prosthesis eliminates artificial knee joints, side-steels and corset, employs a plastic socket of more sophisticated design and ensures accurate alignment by the use of an adjustable jig at the fitting stage. The socket is fabricated on a male cast of the stump rectified to exaggerate the features of the respective pressure resistant and pressure sensitive areas. In particular the socket is so shaped that a high proportion of the load is absorbed by the patellar tendon.

The higher demands for accuracy of fit and alignment of this prosthesis have served to highlight certain deficiencies in the limb-fitting service and in particular in the method of cast-taking. It has become increasingly clear that moulding of the female plaster cast of the stump by the limb fitter's hands and subsequent arbitrary rectification of the male cast both involve the introduction of human error. In an effort to eliminate sources of error the concept of total contact was examined. In this socket all parts of the stump, both fleshy and bony, bear a proportionate share of the loads of dynamic bearing. Various attempts have been made to satisfy the demands of this theory of total contact in socket construction. Wrap-casting, however carefully done, does not produce a cast which truly represents the shape of the stump under load and in movement. Furthermore there are inevitably some areas of the cast deformed by the edges of the bandage even when elastic plaster of Paris bandages are employed.

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Canty, United States Navy, a pioneer in this field, used a method which went some way towards the ideal. In this procedure the cast of the stump was produced in free-flowing plaster of Paris and the patient's weight was gradually allowed to bear on the stump as the plaster set. It appears that comfortable sockets were produced following this method of cast taking and it may be that total contact was achieved. Nevertheless the method has not been widely adopted and it is likely that insufficient loads were borne by the soft parts of the stump because too little pressure was brought to bear on the stump during its immersion in free-flowing plaster.

Since the inception of the Prosthetics Research Department in Dundee in July, 1963, one of the projects has been the development of a total contact socket for the below-knee amputation. Clearly success depends on the method of cast-taking employed and many techniques were tried before the final procedure was adopted. In order to expose the method to the rigorous test of patient comfort it was decided to use a hard socket without soft liner in a prosthesis with the same basic construction as the Radcliffe limb.

It was also our hope that the system of cast-taking, fitting and production of the final socket could be so arranged that the factory work on the prosthesis would be confined to removal of the alignment device, completion in the transfer jig and finally, lamination and finishing. In this way we could reduce to a minimum errors introduced at the factory mainly in rectification of the male cast.

The method of cast-taking finally evolved is to employ hydrostatic pressure to shape the female cast.

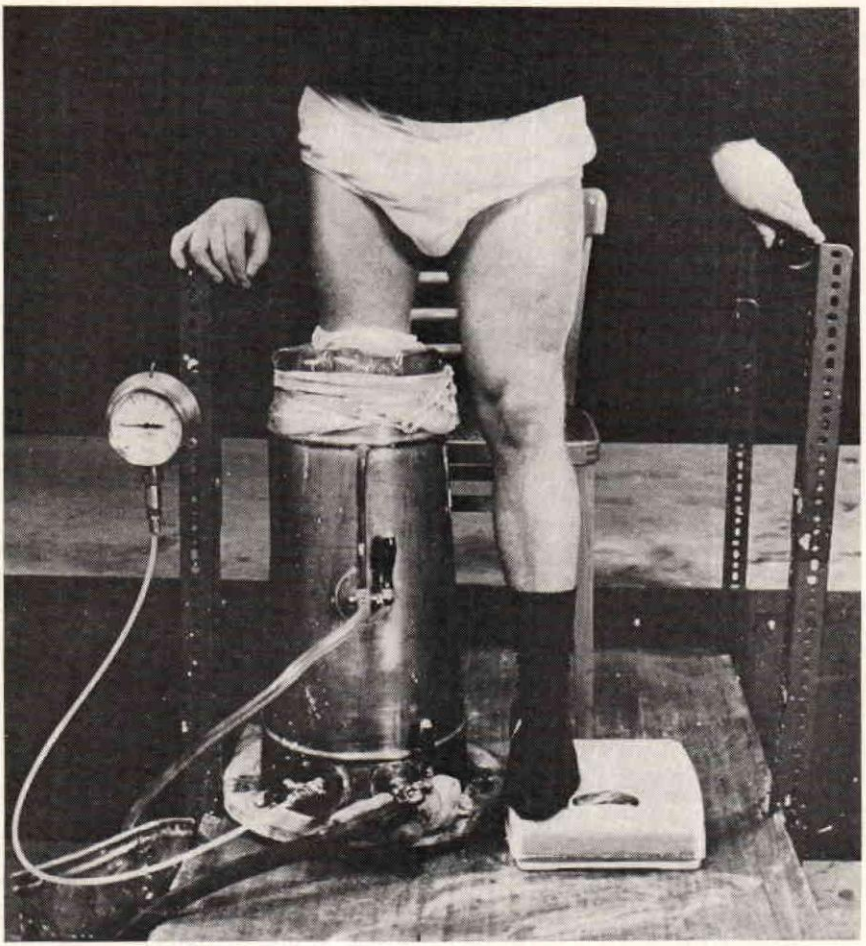
Plaster impregnated nylon stockinette is pulled over the stump which is protected by a 'sock' of nylon sheeting. The stump is then placed in a water tank and the nylon sheeting sealed around the rim with an elastic band. The patient then 'stands' with the stump in the tank with his weight supported by the water and maintains his balance with his hands on side-rails. The tank is so constructed that further water can be forced in or excess water drained off. Similarly allowance is made for the escape of air, from the 'collar' of nylon sheeting formed around the region of the knee. The water in this way moulds the plaster of Paris to the exact shape of the stump under load, compressing hard and soft parts proportionately.

The resultant female cast is removed from the patient and, without rectification, is strengthened and placed in a Socket Block, and then fitted with an alignment jig, foot and ankle.

The patient then has a trial fitting to establish the precise position of the patellar tendon bar. This is achieved by cutting a slot in the plaster socket and fitting an adjustable bar. This has the advantage over the technique used in producing the tendon bar in the Radcliffe limb as the exact size, shape and position can be determined accurately.

The male cast is then made to the exact shape of the female cast using a special technique to ensure easy separation. No rectification is carried out on the hardened male cast and the hard polyester resin socket is constructed on this basis. A second fitting with adjustable jig in position then takes place to ensure accurate alignment and length. The prosthesis can then be finished in the customary fashion.

Results so far have encouraged us to continue producing the prostheses with hard sockets although clearly a soft liner can be easily introduced at the appropriate stage of construction if desired. Furthermore when the female plaster cast is tested at the first fitting stage, rectification in the form of pads, e.g. over the calf muscle or over the antero-lateral area of the stump can be introduced. If this is done it is recommended that the pads be made of hard rubber rather than additional plaster of Paris as there is in the



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latter method danger of deforming the basic shape of the female cast. In this way the size, shape and general efficacy of the rectification pads can be tested on the patient and changed or discarded as need be. The only rectification employed in the sockets of limbs so far supplied has been in the form of a patellar tendon bar. This has been incorporated to hold the end of the stump off the socket in activities such as running, going up and down stairs, and jumping. With stumps of the osteo-myo-plastic variety little or no patellar tendon bar is required.

Recordings made at the time of cast-taking in the subjects so far fitted suggest that pressures imposed on the stump are between 3 and 6 lbs. per square inch according to the surface area of the stump and the weight of the patient. We hope in the future to determine more accurately the loads borne by the various parts of the stump.

Over ten patients have been fitted with prostheses fitted with 'Dundee' sockets with surprising gains in comfort. The elimination of the soft liner has incidentally produced a neater and more natural appearance. Fitting of these sockets by the method described has so far been confined, with one

exception, to patients dissatisfied with the orthodox Patellar Tendon Bearing Cuff Suspension prosthesis. The exception has been a patient with a primary amputation of the osteo-myo-plastic variety where the coincident development of a painless 'phantom' limb has produced a situation where he is unaware of his stump and describes his prosthesis, without prompting, as 'part of himself'. Nevertheless for the present, the 'Dundee' socket would seem to be best suited to the mature stump although experiments continue to accommodate changing stump dimensions.

Whatever the final form of the prosthesis, whether it has a hard socket or in addition a soft liner, one of the main objects has been achieved, viz. to eliminate two of the main sources of error in socket construction and to give the limb fitter in the peripheral centre a greater measure of control in the production of the finished prosthesis. We hope soon to start an extensive field trial of the method of cast-taking, the system of preliminary fitting and of the 'Dundee' socket itself.

AOPA MEMBERS ON VRA ADVISORY PANEL

Alvin Muilenburg, C.P.O. and H. Blair Hanger, C.P., Members of the advisory group on Prosthetics and Orthotics of the U. S. Vocational Rehabilitation Administration, inspect an upper extremity prosthesis made by a student at the Institute for the Crippled and Disabled in New York City.

Shown above with Mr. Muilenburg and Mr. Hanger are Siegfried Paul, C.P.O., instructor in orthotics and prosthetics at ICD, and Robert Mitchell, C.P., Director of the center's prosthetic and orthotic laboratories.

The devices shown in the background of the picture were also made by students in the ICD training program, which is conducted under a VRA grant. Some 200 devices were made in the course of their training by the 1965 graduates. These appliances have been presented by ICD to the World Rehabilitation Fund for distribution to destitute disabled persons in foreign countries.

Dr. Howard A. Rusk, President of the World Rehabilitation Fund, accepted the appliances, which include prostheses, braces, surgical garments and other devices, and expressed his appreciation for the ICD's donation.