A Fluid Resin Technique for the Fabrication of Check Sockets

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INTRODUCTION

During walking, a below-knee amputee fitted with a patellar tendon bearing socket will experience a continually changing set of stump socket forces both of an anterioposterior and medial-lateral nature. For successful fitting, therefore, it is necessary to resolve the stump socket forces in such a way as to provide for both comfortable support and adequate stabilization throughout the walking cycle (1).

Many attempts have been made to measure the distribution of stump socket forces both statically and dynamically but no satisfactory practical limb shop method has evolved. Because of the lack of an accurate method for measuring these forces and the difficulty of achieving a precise fit, prosthetists have had to resort to the use of soft liners to relieve excessive unit pressure, at some sacrifice in stability, or the prosthetist relies upon circumferential measurements of the stump and socket as well as upon the subjective evaluation of the patient to judge adequacy of fit and comfort.

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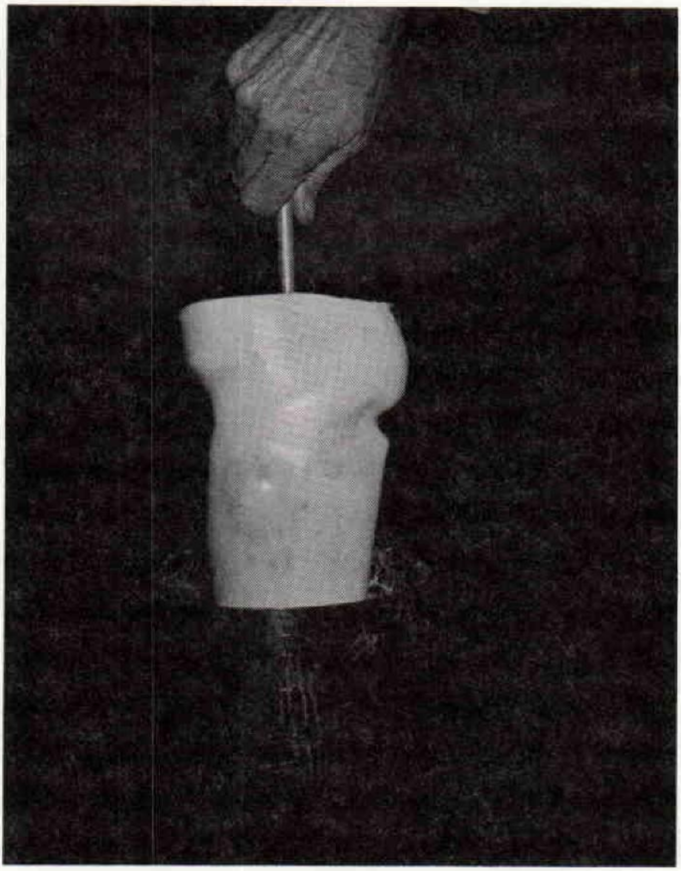

FIGURE 1.—Preparation of wax check socket.

One possible method which may be of help in visualizing the relative distribution of forces in a socket would be through the development of a clear transparent socket. In such a socket, pressure points should be readily observable by soft tissue blanching, thus the effect of various factors which influence stump socket pressures, such as socket fit and alignment of the prosthesis, i.e., location of the foot with respect to the socket, effect of thigh corsets, cuff suspension and side bars may be observed and studied.

In this paper, we report on a method for the fabrication of a transparent below-knee socket.

MATERIALS AND METHODS

After the cast of the amputee's stump is taken and a plaster of Paris positive is poured, a wax check socket consisting of eight layers of stockinet is prepared on the cast by dipping in wax in the usual manner (Fig. 1). The check socket has a thickness of approximately 0.25 inches (Fig. 2).

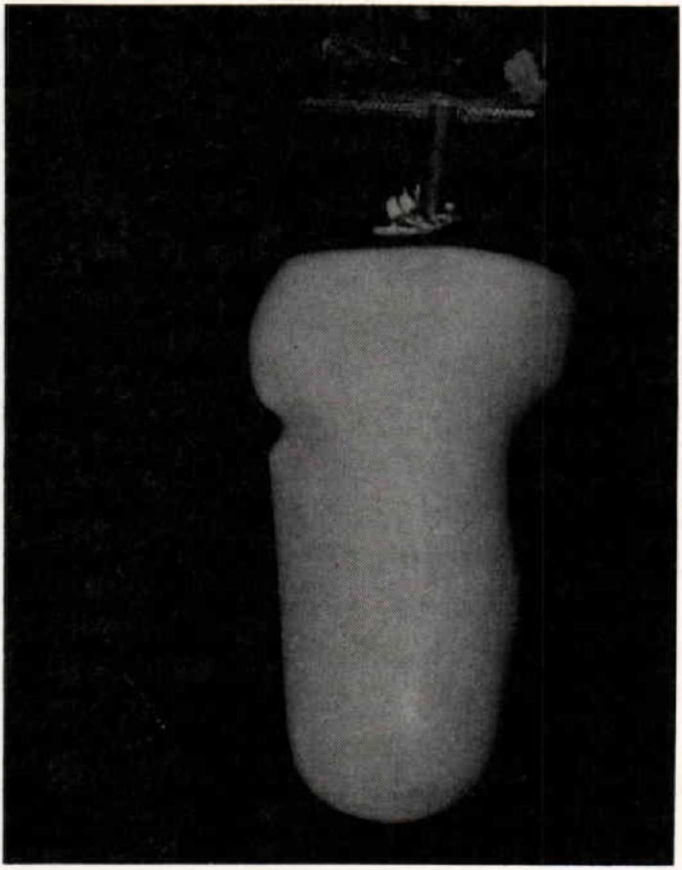

FIGURE 2.—Completed wax check socket.

Next, a negative mold or impression of the wax-coated cast is made using agar-agar duplicating compound. Agar-agar, a hydrophilic colloid extracted from certain types of seaweed, is changed from a gel (solid) to a sol (liquid) with heat.* The gelation or hardening temperature of the agar-agar varies between 86°F and 122°F. The temperature at which the gel changes to the sol ranges between 160°F and 212°F. The agar-agar supplied in one-gallon containers is cut into small pieces and heated to 212°F. The liquid agar-agar, so formed, is cooled to a temperature of 115°F before being poured. After the agar-agar has been prepared, the wax-coated model is then placed in a container and positioned in the center of the container (Fig. 3). The aligning rods (Fig. 4A) are scored and used as reference marks to insure that the model is centered in the same position as it is removed and replaced into the container throughout the procedure. For the purposes of illus-

* Nobiloid Duplicating Material, Mobilium Products, Inc., 125 No. Wabash Avenue, Chicago, Illinois 60602

tration the cross bars (Fig. 4B) have been either removed or replaced by ring stand clamps to allow unobstructed photographs. The liquid agar-agar which has previously been cooled to a temperature of 115°F is now poured into the container holding the wax covered cast (Fig. 5). After gelation of the agar-agar, the wax covered cast is removed from the agar-agar and the wax is cut to a distance of 7 to 8 inches from the distal end of the cast (Fig. 6). The wax is sufficiently elastic to allow removal without fracturing (Fig. 7). The cut ends are then approximated and sealed with a warm wax spatula (Fig. 8). The wax model is then gently replaced into the agar-agar mold from which it had previously been removed (Fig. 9). Next a rod, containing a series of circular discs (Fig. 10) is placed inside the wax model and positioned by using the reference lines used earlier to align the plaster cast. More agar-agar is then poured inside the wax check socket (Fig. 11) and after gelation, is removed (Fig. 12). The circular discs are necessary to prevent the rod from pulling cleanly out of the agar-agar. The wax usually adheres to the agar-agar stump model and is removed by again cutting with a knife. (Fig. 13). The wax at this point is discarded and can be remelted for use in the fabrication of future check sockets as needed. The agar-agar model of the patient's plaster cast is then placed back into the negative agar-agar mold and again positioned using the reference lines on the aligning rods (Fig. 14).

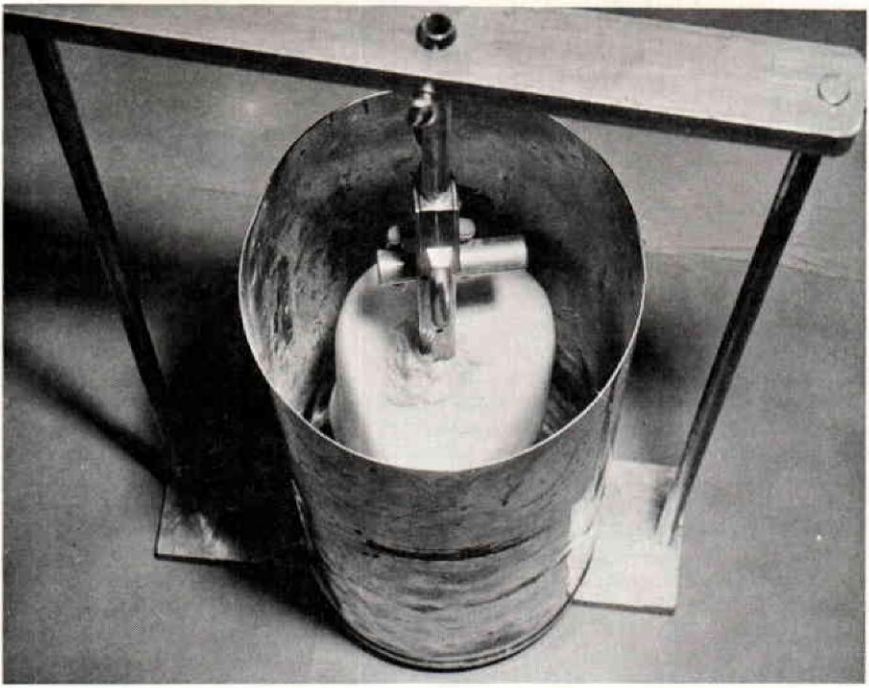

FIGURE 3.—Wax check socket centered in container.

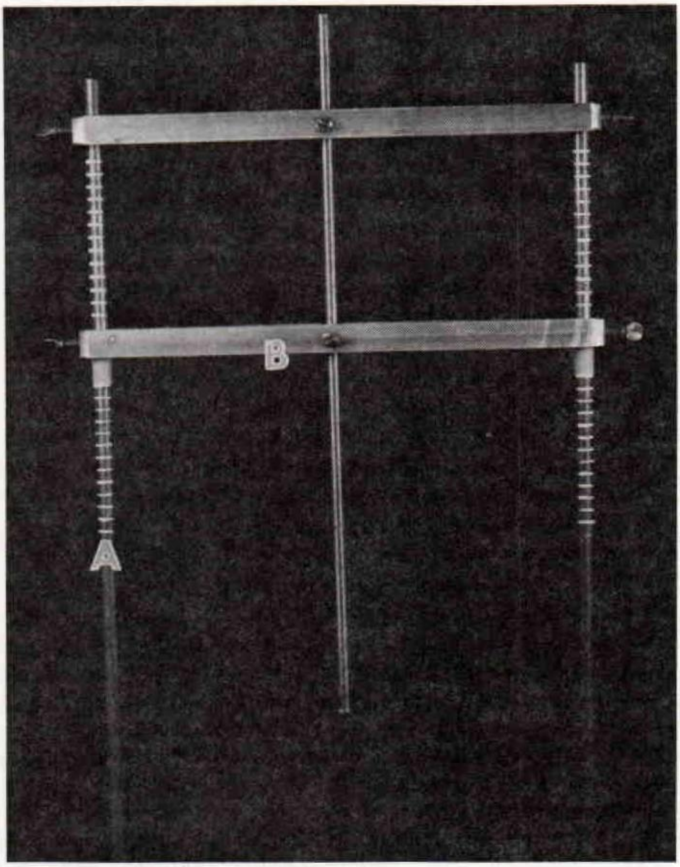

FIGURE 4A.—Scored aligning rods; B—Cross bars.

The transparent socket is fabricated using a poly (methyl methacrylate) syrup† which polymerizes at room temperature by means of chemical initiators and promotors to form poly (methyl methacrylate), a hard synthetic resin which is transparent and of high clarity. The poly (methyl methacrylate) syrup is poured into a beaker to which a white powder, supplied by the manufacturer, presumably benzoyl peroxide, is added and the mixture stirred (Fig. 15). A sheet of Saran wrap is placed over the beaker and the mixture is allowed to stand for 10 minutes. The resin syrup is then poured into the space B, between the agar-agar model of the patient's plaster cast A and the agar-agar matrix C (Fig. 16). The length of time necessary for the check socket to completely polymerize varies according to its size and thickness but an hour is usually sufficient. The agar-agar stump and poly (methyl methacrylate) check socket are removed together from

† Klearmount w/Catalyst, Vernon-Benshoff Co., Inc., 413 No. Pearl St., Albany, N. Y. 12207

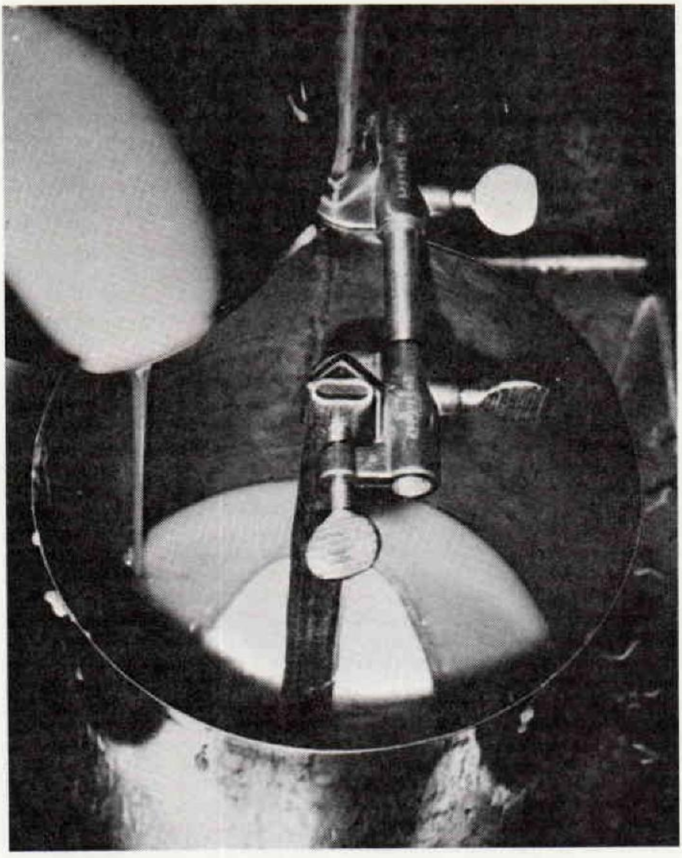

FIGURE 5.—Liquid agar-agar is poured around wax covered cast.

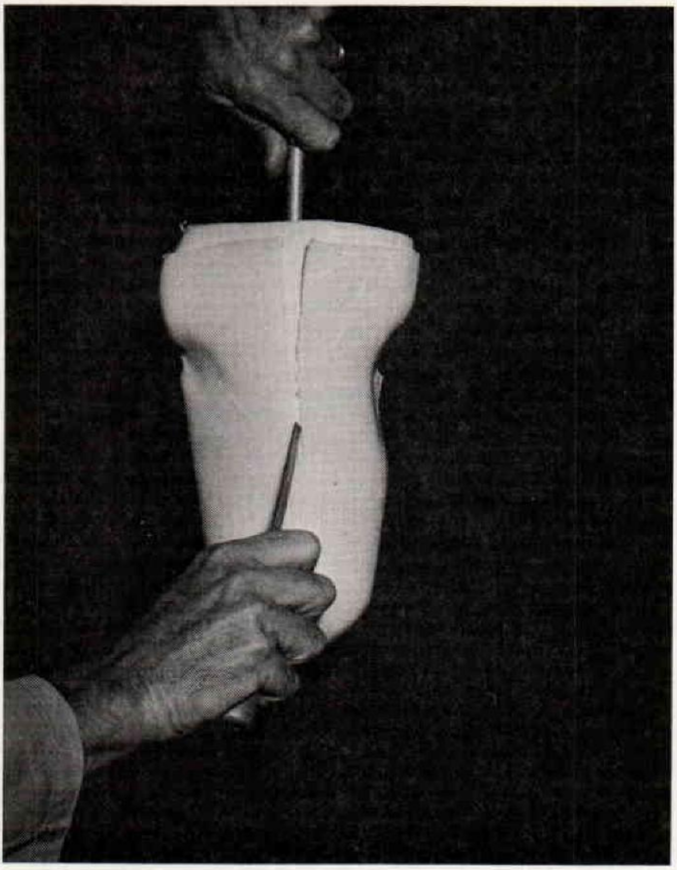

FIGURE 6.—Cutting wax check socket to facilitate removal.

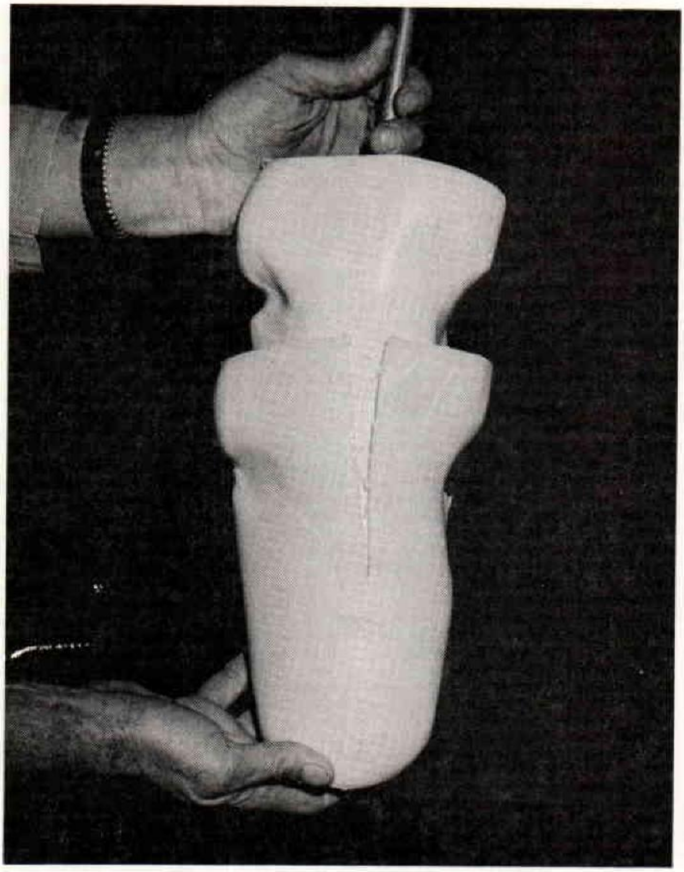

FIGURE 7.—Removal of cut wax check socket.

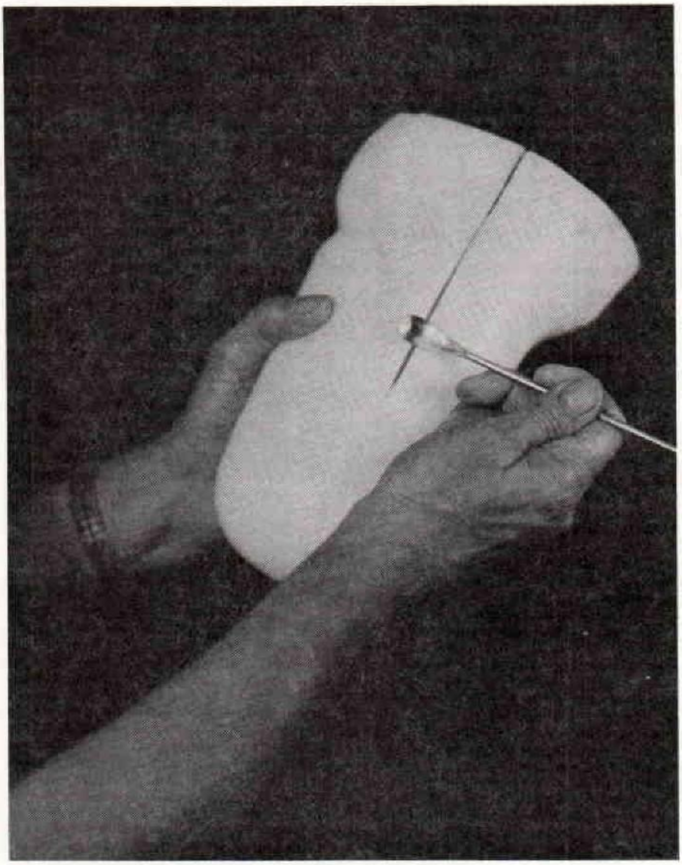

FIGURE 8.—Cut wax check socket is sealed with warm spatula.

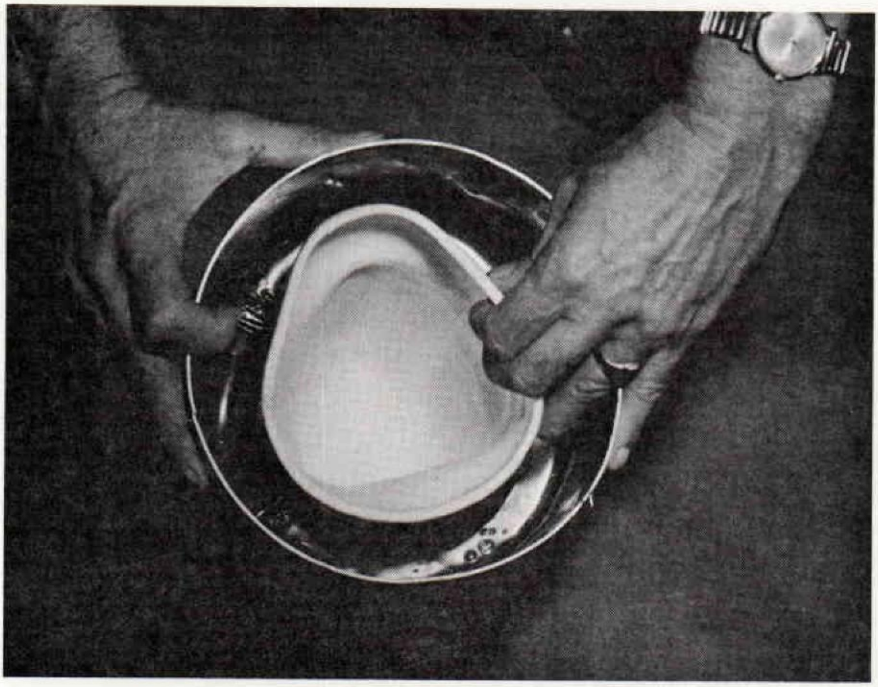

FIGURE 9.—Replacing wax check socket into agar-agar mold.

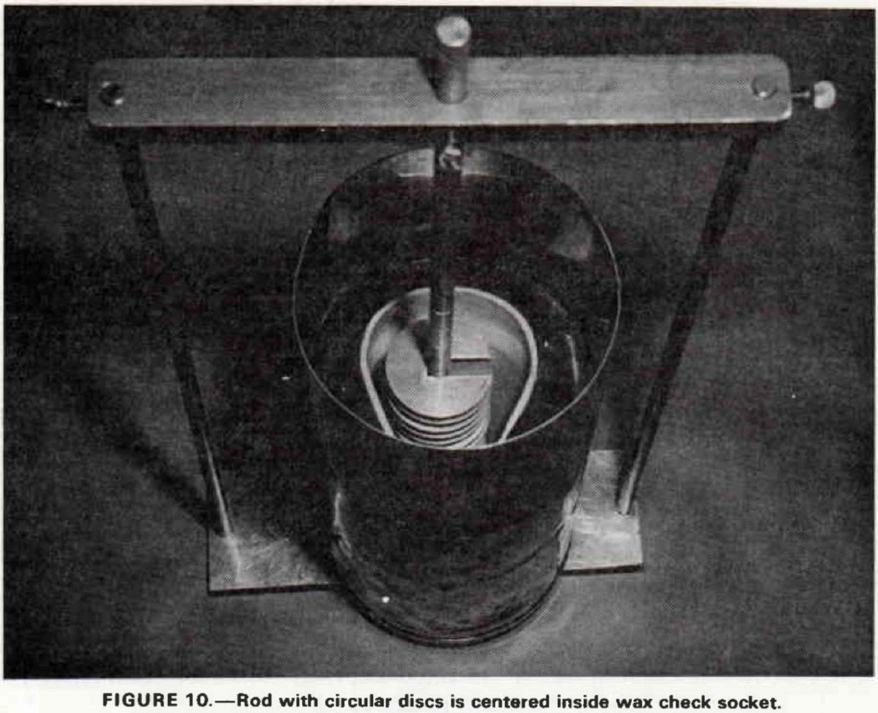

FIGURE 10.—Rod with circular discs is centered inside wax check socket.

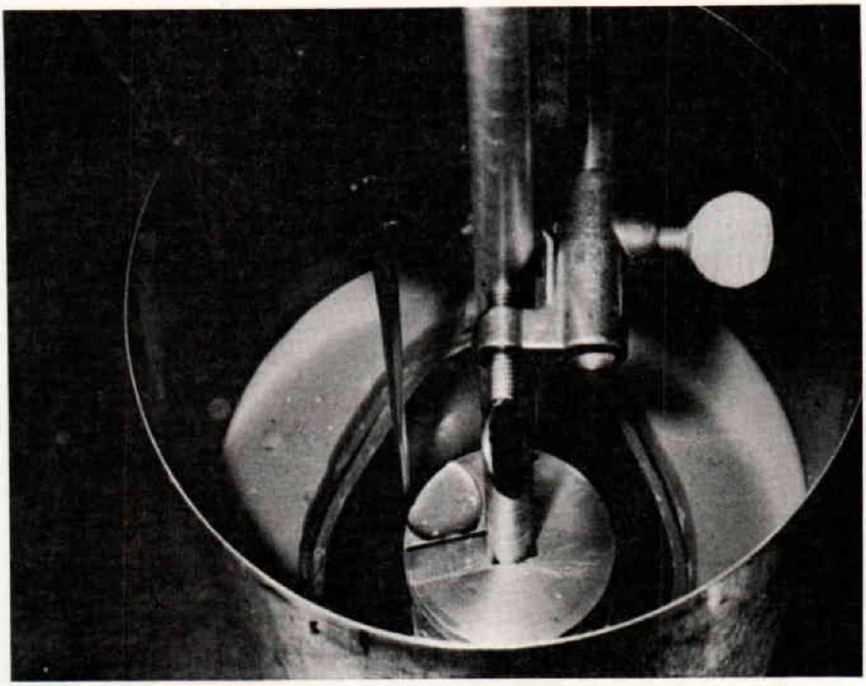

FIGURE 11.—Pouring agar-agar into wax check socket.

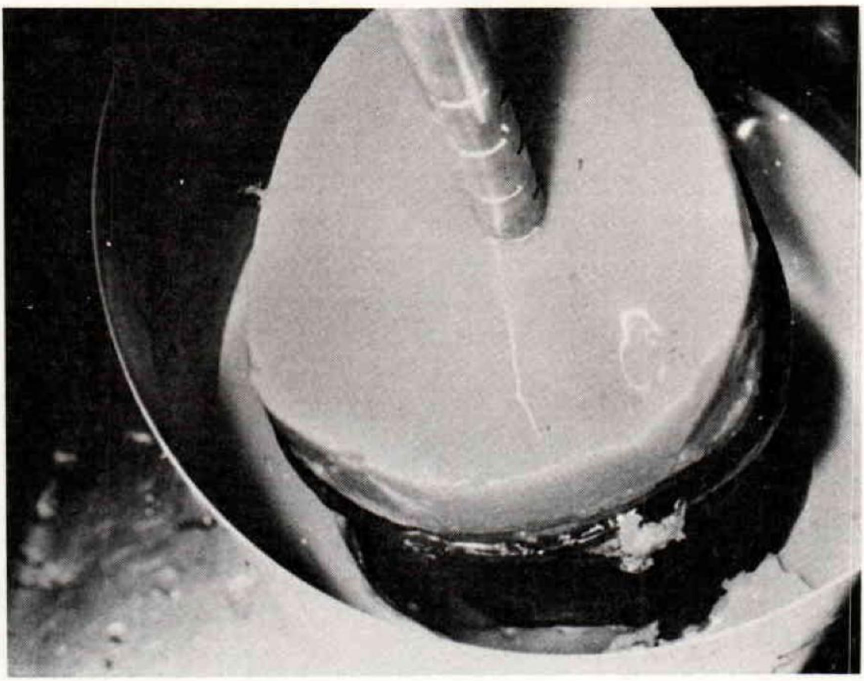

FIGURE 12.—Removal of agar-agar stump model after removal of wax check socket.

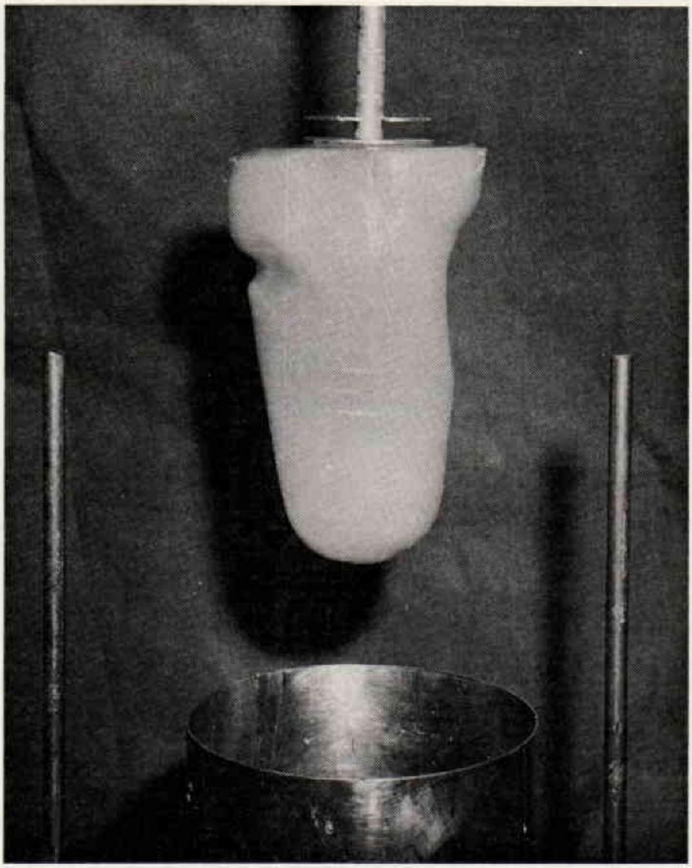

FIGURE 13.—Agar-agar stump model after removal of wax check socket.

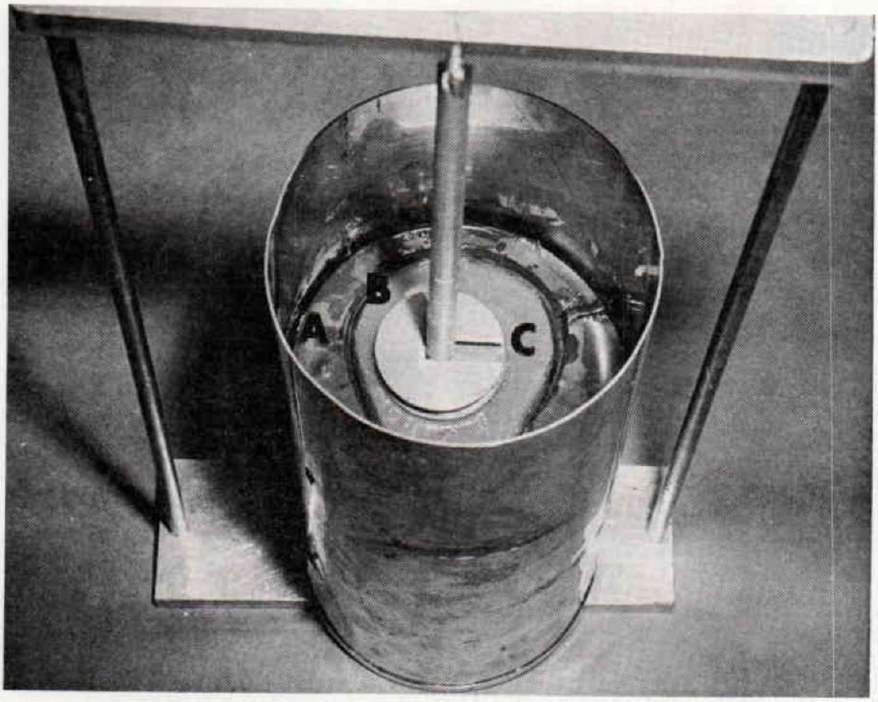

FIGURE 14A.—Outer layer of agar-agar; B.—Space formerly occupied by wax check socket; C.—Agar-agar stump model.

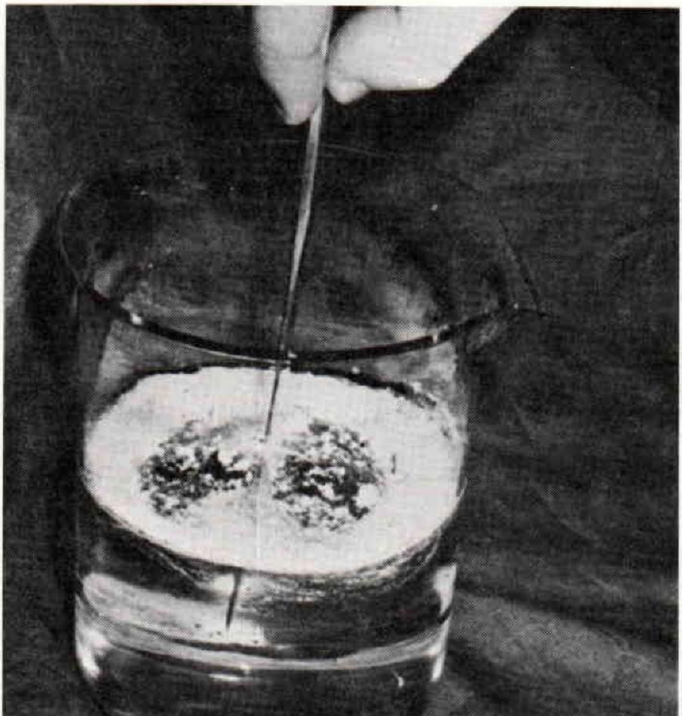

FIGURE 15.—Stirring of catalyst into methyl methacrylate.

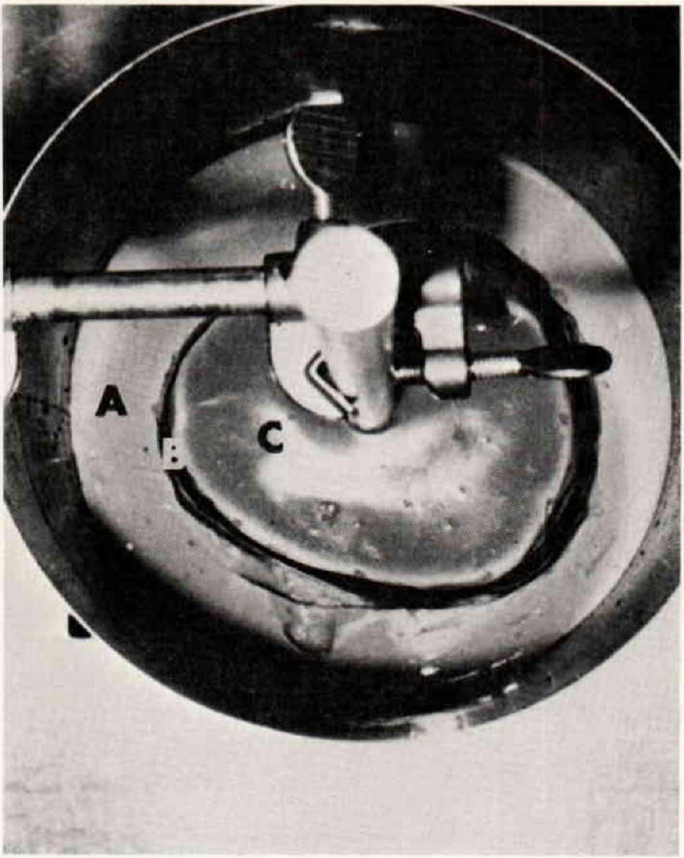

FIGURE 16A.—Outer layer of agar-agar; B.—Methyl methacrylate syrup; C.—Agar-agar stump model.

FIGURE 17.—Agar-agar stump model—A—inside of poly methyl methacrylate check socket—B.

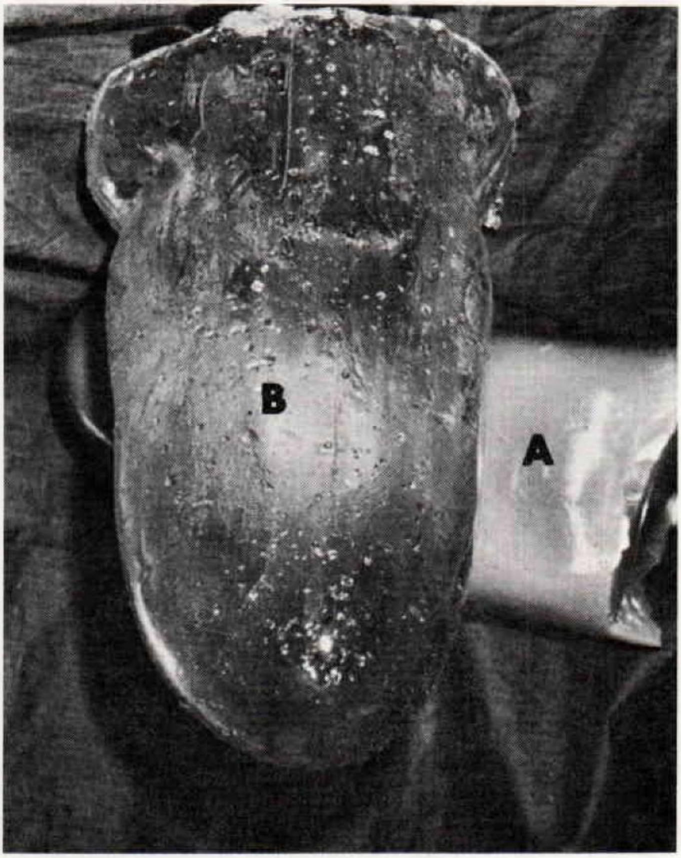

FIGURE 18.—Agar-agar stump model—A—removed from poly methyl methacrylate check socket—B.

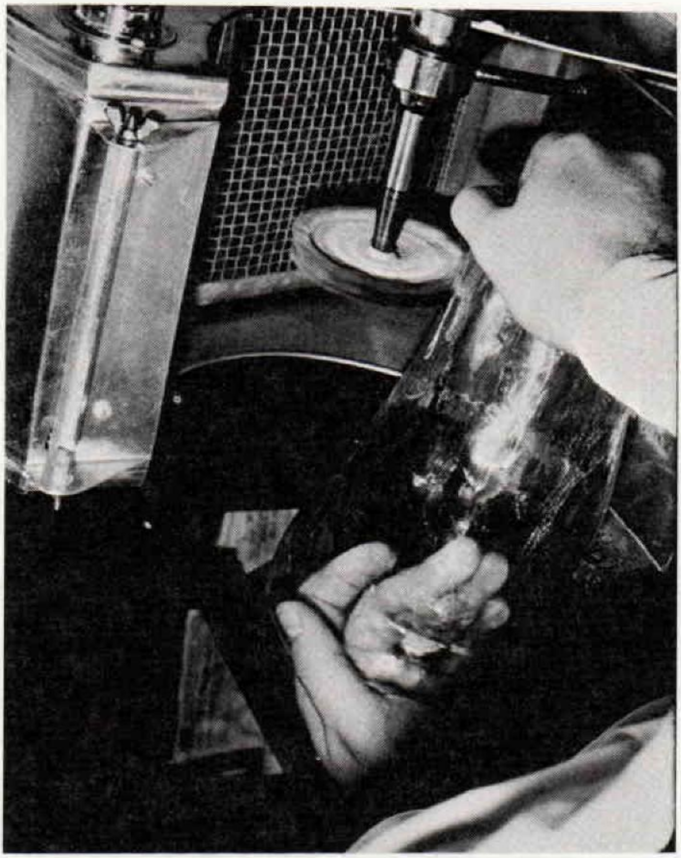

FIGURE 19.—Polishing of poly methyl methacrylate check socket.

FIGURE 20.—Finished transparent poly methyl methacrylate check socket.

the container (Fig. 17) and the agar-agar is then separated from the check socket (Fig. 18).

The proper relief in the margin of the socket is obtained by cutting the socket with various finishing stones on a lathe. The check socket is polished using a fine pumice and water slurry and a cloth wheel (Fig. 19). A high gloss is obtained by the use of a cloth wheel and polishing compound (Fig. 20).

Discussion

A review of the steps indicates that certain precautions should be taken; these are:

1. The agar-agar duplicating compounds lose moisture and shrink when exposed to air. It is advisable therefore to pour the resin as soon as possible in order to avoid dimensional changes in the finished check socket.

2. Under no circumstances should the agar-agar remain over night. Preferably the resin should be poured within 30 minutes after the gelation occurs.

3. Because heat transfer through the agar is slow the volume used should be kept to a minimum to permit rapid gelation. Gelation may be further hastened by placing the container in cold circulating water during cooling.

In our first attempts vents were placed in several areas around the open end of the socket but it was found that these were not necessary as the fluid resin has excellent flow properties thus eliminating the danger of an imperfect socket. The socket, prepared as described, was fitted to an amputee and pressure points were clearly visible.

SUMMARY

A simple technique for the fabrication of transparent sockets utilizing a fluid bench curing poly (methyl methacrylate) resin has been presented. The finished check socket possesses remarkable clarity and could prove useful in pressure studies on lower extremity amputees.

ACKNOWLEDGEMENT

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REFERENCE

1. Radcliff, C. W., **Artificial Limbs, 6,** No. 2, June 1962.