July 22, 1947. P. W. KUNKEL 2,424,278

METHOD OF FORMING SOCKETS FOR ARTIFICIAL LIMBS

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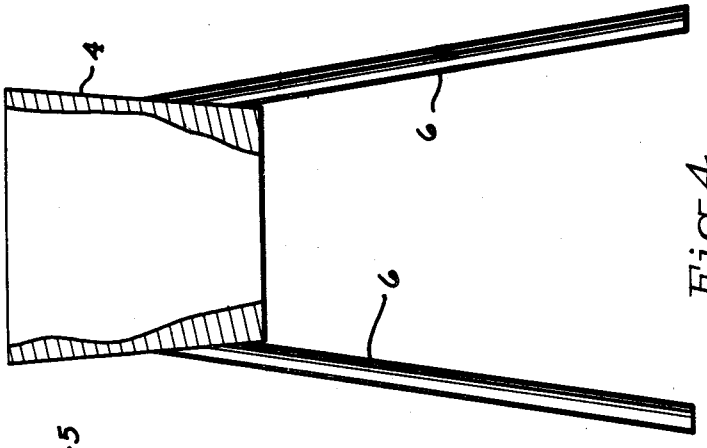


Fig. 4.

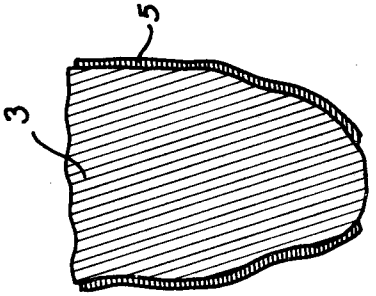


Fig. 3.

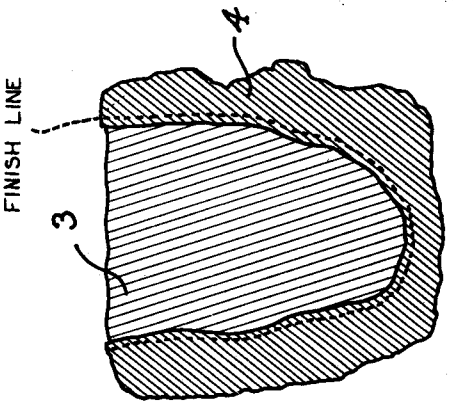


Fig. 2.

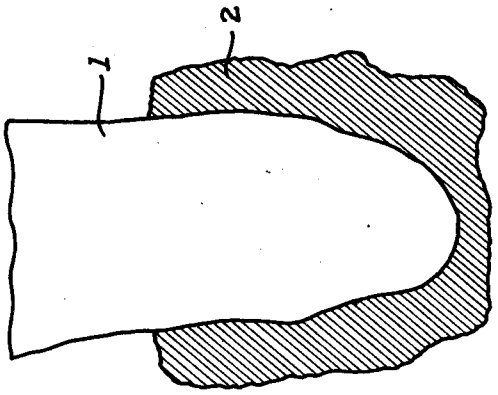


Fig. 1.

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METHOD OF FORMING SOCKETS FOR ARTIFICIAL LIMBS

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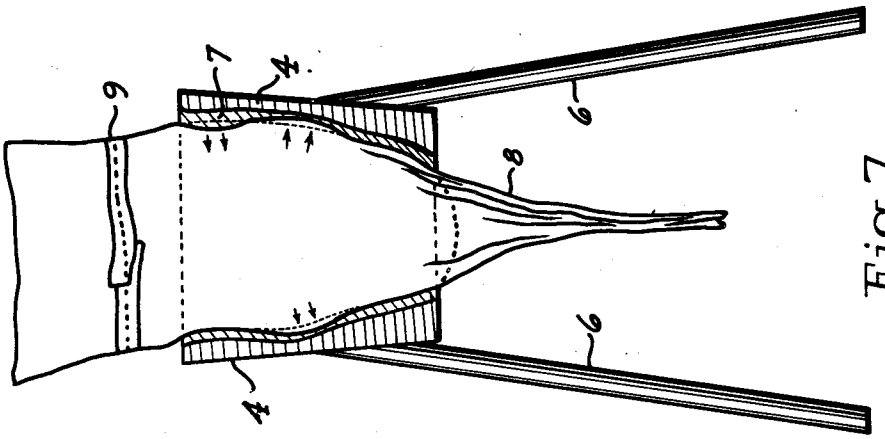


Fig. 7.

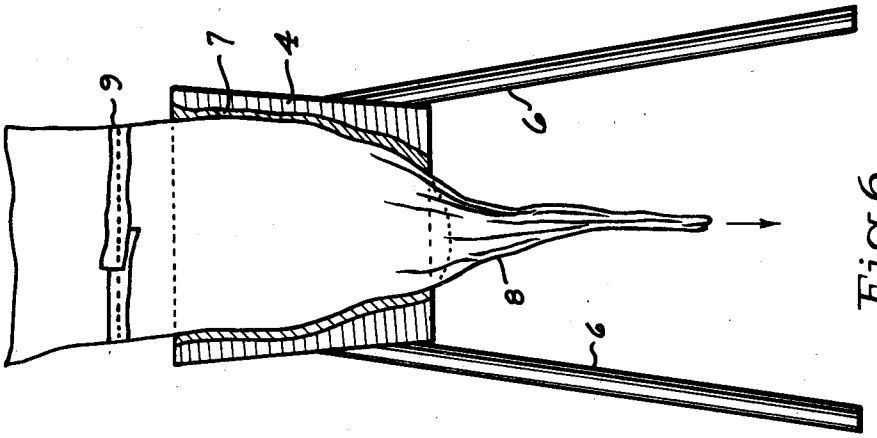


Fig. 6.

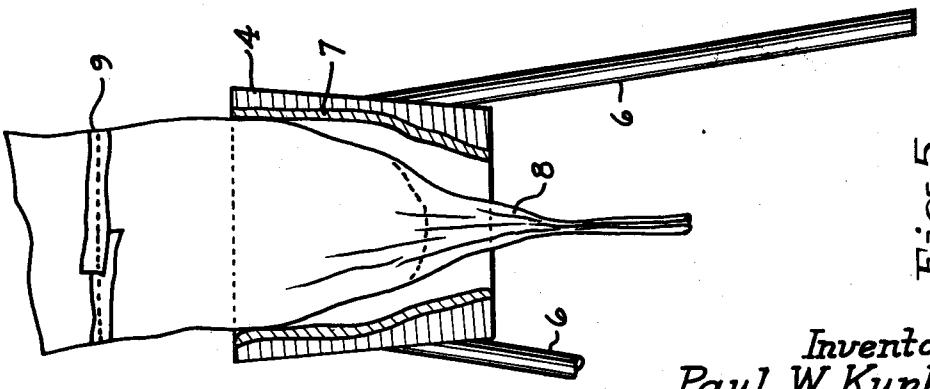


Fig. 5.

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METHOD OF FORMING SOCKETS FOR ARTIFICIAL LIMBS

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6 Claims. (Cl. 3—3)

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My invention relates to the formation of sockets for artificial limbs. It is a relatively simple matter to reproduce the external contour of the terminal portion of a limb. This, however, is not satisfactory because it does not take into consideration the sensitivity of the area and the proximity of the bone and other hard tissue. That is, a socket to be comfortable should sustain equal portions of the weight and operating stresses independent of whether it is soft tissue or bony structure. A socket must be an annular member and must surround the terminal portion of a limb so that it will sustain the weight of the individual and must function efficiently and comfortably. In the past it has been common practice to cast a socket to conform to the shape of a limb when at rest and then to carve away the portions which tend to bind or bear too heavily upon sensitive areas. This at best is a tedious cut-and-try method and seldom, if ever, provides adequate comfort for a person wearing an artificial limb.

I have discovered that such a socket may be formed of an encompassing molding band coated with a material which may be plasticized at a temperature which the skin can tolerate and which will yield to operating stresses to form a comfortable socket which does sustain a person's weight and does resist operating strains proportionate to the area so as to be comfortable. A mold thus made may then be reproduced in some material such as a plastic or other material compatible to tissue and may either be a metal casting or may be made of plastic such, for example, as one of the synthetic resins.

The details of my invention are hereinafter described with reference to the accompanying drawings, in which:

Fig. 1 is a diagrammatical view of the step by which a mold may be made in intaglio of the stump or terminal portion of a limb to be fitted with a socket;

Fig. 2 illustrates the manner in which said limb may be reproduced in molding material;

Fig. 3 illustrates the manner in which a predetermined thickness of material may be applied to such mold to accommodate a thermo-plastic coating material;

Fig. 4 illustrates a mold formed from the model produced in Fig. 3;

Fig. 5 illustrates the manner in which a stump may be placed in said coated mold;

Fig. 6 illustrates the manner in which pressure may be applied to force said coating in to proper conformation while the person rests his weight upon said stump; and

Fig. 7 illustrates how said coating may be further relieved and formed to shape said coating by the pressure and articulation of said stump, simulating the actual use thereof and the stresses generated thereby.

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My invention is illustrated in connection with the making of a socket for an artificial limb attached to the terminal portion of a leg. It is to be understood, however, that this is merely for the purpose of illustration and the same factors would be met with in providing any other artificial limb.

As has been pointed out, such socket cannot be a cup or recess capable of sustaining a person's weight because the terminal portion of the limb to be accommodated usually is extremely sensitive. Thus the bounding member or socket must be an annulus. Such annulus must also be sufficiently firm and formed to support the weight and to resist the stresses incident to walking and the like. If a socket were used which was an exact inverse replica of the terminal portion of the limb at rest then the major portion of the weight would be sustained underneath the bone and other hard tissue. The soft tissue would not support its proportionate part of the weight nor would it resist the operating stresses and this would produce more or less spaced point contacts in effect rather than contact uniformly over the entire area. The socket thus must initially bear more tightly over the soft tissue when the limb is at rest than it does over bony structures. A socket must not only be perfectly fitted and be comfortable but it also must not cause the stump to chafe nor sweat and the body heat should be conducted away instead of being confined or restricted. Of course the contacting space of the socket must be highly polished so as to be smooth to prevent chafing or adhesion to the tissues.

After an amputation has healed completely a preliminary impression is taken of the severed member. Said impression may be taken with the use of plaster of Paris or similar molding material. This should accurately reproduce all of the tissue to be involved in the socket. In Fig. 1 the terminal portion, or stump, of a limb 1 is shown in an inverse mold 2 of plaster of Paris or the like. After the mold or impression has been removed, it should be painted inside with a suitable separating medium and the recess filled with so-called artificial stone which is sold under a number of different trade names such as Cocal, Modocal, Castone, and other trade names.

The model 3 thus produced should be a fairly accurate facsimile of the stump of the amputated limb. Inasmuch as the said stump is not cylindrical and frequently has a terminal end larger in diameter than adjacent portions it probably will be necessary to remove the mold 2 in sections. After said mold has been divided into sections, it must be reassembled accurately to its original form. Said model 3 thus produced may then be used as a guide to form a socket 4. Said socket may be made out of wood or heavy sheet metal and should generally conform to the con-

tour of said model. The bore of said socket 4 however should be enlarged by a predetermined amount in over-all dimensions, as indicated in dotted outline in Fig. 4 and identified as "finish line" so as to leave between a quarter and a half inch space between the model and the socket. Another way in which this could be done is to coat the model with a temporary coating 5 from one-quarter inch thick to one-half inch thick and of uniform depth so as to produce the predetermined enlargement of the bore 4a of the socket. The necessity for such enlargement in over-all dimensions is to accommodate a coating of plastic material, which will hereinafter be described in greater detail. When the amputated member is a leg, the socket 4 is then mounted on a tripod 6 fixed to the correct height and angle to permit the patient to stand in it, in a natural position. Care should be exercised in determining such correct height and angle. Of course, it is unimportant exactly how said socket is supported, but I deem a tripod arrangement, such as this, the most expedient.

The socket 4 is then lined with a coating of a thermo-plastic material such for instance as modeling compound used in dentistry. Such material should have the characteristic of being solid at room temperatures and plastic at temperatures which may be tolerated by the sensitive area. Such temperatures might range from 125° F. to 150° F. Some types of modeling compound used have been Kerr's, Dresche's, S. S. White's or similar materials. Such plastic coating material is formed in a more or less uniform layer of the depth of from one-quarter inch to one-half inch. It is preferable to approach the greater dimension when there is any substantial deformity.

The plastic coating is then heated by heat applied to the surface thereof. Of course, said material is not a good conductor of heat and thus the surface is hotter than the underlying layers and thus it is more plastic. The stump or terminal portion of the limb is then encased in a rubberized stocking 8 which covers the entire terminal portion of the limb to which the socket is to be formed. Said stocking preferably is fastened securely to said terminal portion of the limb by strips of adhesive tape 9 or the like, preferably immediately above the area over which the socket will be fitted, as is shown in Figures 5 to 7, inclusive. The stocking is then coated with Vaseline or some other suitable material to prevent it adhering to the plastic coating.

When the plastic coating, and particularly the surface thereof, is in a semi-plastic state, the stump is drawn into the socket by grasping the end of the rubberized stocking and pulling it through the socket and at the same time having the patient bear his weight in the socket to cause the plastic coating to accommodate itself to the pressure of the areas with which it is in contact. This must be done fairly rapidly while said plastic covering is heated and thus rendered semi-plastic. The plastic coating is then chilled and the stump withdrawn. An inspection will reveal that there are some imperfections and some portions will require displacement to a greater degree than others. The plastic coating is then reheated to the optimum temperature and the process is repeated. After several repetitions of this operation, the areas should be displaced and formed to the area of the stump so that each unit area will sustain its proportionate

part of the patient's weight and will resist equal portions of the other stresses imposed upon said socket when use of said limb is simulated.

It may be that some areas, because they are sensitive or because of circulatory restriction, will be required to be relieved to sustain less than their proportionate part of said stress. This is accomplished either by carving out said areas or by exaggerating the manipulation of the stump while the compound is in a plastic or semi-plastic state. It is important that any area which might impinge upon important blood vessels should have special attention in relieving the impression.

The manner in which said manipulation of the stump is practiced to cause the plastic coating to conform to the stump of the limb under working stress is illustrated diagrammatically in Figure 7.

The temporary mold is then completed and this may be reproduced in metal or plastic. This preferably is done by pouring up the bore or cavity in said mold with one of the artificial stones, such as has heretofore been described. It is essential that a material be used which does not undergo too much volumetric change in setting so that the resulting model of the stump is a perfect inverse replica of the socket thus formed.

From the model thus formed, a socket is made which is a finished product. It is desirable that the material used for making such socket should be one compatible to the tissue. Some such materials are one of the so-called chrome-cobalt-nickel alloys which are sold under trade names Ticonium, Durallium and Vitalium. Said materials take a high polish and are not affected by any of the secretions from the body, are wholly compatible to body tissue, and are good conductors of heat. A much less costly socket could be constructed of a plastic such as, for example, one of the synthetic resins. Acrylic resins lend themselves admirably to this purpose. Said plastics possess many of the virtues of the metal alloys previously described and may be made with less expense with molds commonly used for this purpose. It is understood that the sockets thus formed may be attached to any type of artificial limb.

I claim:

1. The method of forming sockets for artificial limbs comprising forming an encompassing molding band of more or less unyieldable material, the bore thereof conforming generally to the contour of the terminal portion of a limb to be accommodated therein and to which an artificial limb is to be secured, applying a coating of plastic material to the bore of said band to make it conform more or less exactly to the contour of said limb at rest, plasticizing the external face of said coating, applying pressure to the terminal portion of said limb to simulate operating stresses upon said coating and thus to form an impression in said coating, and casting a permanent socket which reproduces said molding band with the coating thus impressed, whereby a socket is formed which, in place on the terminal portion of a limb to which an artificial limb is to be secured, applies more or less uniform pressure to the entire contacted area of said terminal portion of said limb under operating stresses, which contour thus formed is independent of the contour of said terminal limb portion when it is at rest.

2. The method of forming sockets for artificial

limbs comprising forming an encompassing molding band of more or less unyieldable material, the bore thereof conforming generally to the contour of the terminal portion of a limb to be accommodated therein and to which an artificial limb is to be secured, applying a coating of thermo-plastic material to the bore of said band to make it conform more or less exactly to the contour of said limb at rest, applying heat to plasticize the external face of said coating, applying pressure by the terminal portion of said limb to simulate operating stresses upon said coating and thus to form an impression in said coating and casting a permanent socket which reproduces said molding band with the coating thus impressed, whereby a socket is formed which, in place on the terminal portion of a limb to which an artificial limb is to be secured, applies more or less uniform pressure to the entire contacted area of said terminal portion of said limb under operating stresses, which contour thus formed is independent of the contour of said terminal limb portion when it is at rest.

3. The method of forming sockets for artificial limbs comprising forming an encompassing molding band of more or less unyieldable material, the bore thereof conforming generally to the contour of the terminal portion of a limb to be accommodated therein and to which an artificial limb is to be secured, applying a coating of modelling compound having the characteristic of being solid at room temperatures and plastic at temperatures in the range of 125° F. to 150° F., to the bore of said band to make it conform more or less exactly to the contour of said limb at rest, applying heat to plasticize the external face of said coating, applying pressure by the terminal portion of said limb to simulate operating stresses upon said coating and thus to form an impression to said coating and casting a permanent socket which reproduces said molding band with the coating thus impressed, whereby a socket is formed which, in place on the terminal portion of a limb to which an artificial limb is to be secured, applies more or less uniform pressure to the entire contacted area of said terminal portion of said limb under operating stresses, which contour thus formed is independent of the contour of said terminal limb portion when it is at rest.

4. The method of forming sockets for artificial limbs comprising forming an encompassing molding band of more or less unyieldable material, the bore thereof conforming generally to the contour of the terminal portion of a limb to be accommodated therein and to which an artificial limb is to be secured, applying a coating of thermo-plastic material to the bore of said band to make it conform more or less exactly to the contour of said limb at rest, plasticizing the external face of said coating, applying pressure by the terminal portion of said limb through repeated applications and intermittent heating to simulate operating stresses upon said coating and thus to form an impression in said coating and casting a permanent socket which reproduces said molding band with the coating thus impressed, whereby a socket is formed, which in place on the terminal portion of a limb to which an artificial limb is to be secured, applies more or less uniform pressure to the entire contacted area of said terminal portion of said limb under operating stresses, which contour thus formed is independent of the contour of said terminal limb portion when it is at rest.

5. The method of forming sockets for artificial limbs comprising forming an encompassing molding band of more or less unyieldable material, the bore thereof conforming generally to the contour of the terminal portion of a limb to be accommodated therein and to which an artificial limb is to be secured, applying a coating of plastic material to the bore of said band to make it conform more or less exactly to the contour of said limb at rest, plasticizing the external face of said coating, applying pressure by the terminal portion of said limb to simulate operating stresses upon said coating and thus to form an impression in said coating, relieving said coating by carving over the bony and sensitive areas of said terminal portion of the limb and casting a permanent socket which reproduces said molding band with the coating thus impressed, whereby a socket is formed which, in place on the terminal portion of a limb to which an artificial limb is to be secured, applies more or less uniform pressure to the entire contacted area of said terminal portion of said limb under operating stresses, which contour thus formed is independent of the contour of said terminal limb portion when it is at rest.

6. The method of forming sockets for artificial limbs comprising forming an encompassing molding band of more or less unyieldable material, the bore thereof conforming generally to the contour of the terminal portion of a limb to be accommodated therein and to which an artificial limb is to be secured, but enlarged a predetermined amount in over-all dimensions, applying a coating of plastic material to the bore of said band to make it conform more or less exactly to the contour of said limb at rest, plasticizing the external face of said coating, applying pressure by the terminal portion of said limb to simulate operating stresses upon said coating and thus to form an impression in said coating and casting a permanent socket which reproduces said molding band with the coating thus impressed, whereby a socket is formed which, in place on the terminal portion of a limb to which an artificial limb is to be secured, applies more or less uniform pressure to the entire contacted area of said terminal portion of said limb under operating stresses, which contour thus formed is independent of the contour of said terminal limb portion when it is at rest.

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