

- [54] **BONE JOINT FUSION PROSTHESIS**
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- [52] U.S. Cl. .... **3/1, 128/92 C**
- [51] Int. Cl. .... **A61f 1/24**
- [58] Field of Search .... **3/1; 128/92 C, 92 CA, 92 R,**  
**128/92 B, 92 BA, 92 BC, 92 G**

- [56] **References Cited**
- UNITED STATES PATENTS**
- 2,518,019 8/1950 Kane ..... 128/92 BC
- 3,112,743 12/1963 Cochran et al. .... 128/92 C

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"Arthrodesis of the Ankle Joint by Springs" by G. Hauberg, *The International Abstracts of Surgery*, Vol. 95, No. 1, July 1952, pages 77 and 78.

The *Journal of Bone and Joint Surgery*, October 1956, Austenal, Inc. Advertisement, page 41, "Mid-Shaft for Humerus" Figure relied upon.

"Nailing of Pterochantheric Fractures by Round Nail" by Guido Meins, *International Abstracts of Surgery*, 1952, page 498 relied upon.

"Sintered Fiber Metal Composites as a Basis for Attachment of Implants to Bone" by J. Galante et al., *The Journal of Bones & Joint Surgery*, Vol. 53-A, No. 1, Jan. 1971, page 101 relied upon.

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[57] **ABSTRACT**

A prosthesis for use in fusion of a bone joint especially for managing the severely disabled rheumatoid wrist. The prosthesis serves as a bridge across the joint and is formed of an appropriate metal of hollow construction and is bifurcated at one end to provide projections which are received within the medullary canal of two metacarpals and has an extension on the other end for reception within the radius. Methylmethacrylate or other appropriate settable cement is packed within and about the prosthesis to provide, upon setting, a strong, rigid joint bridge.

**10 Claims, 7 Drawing Figures**

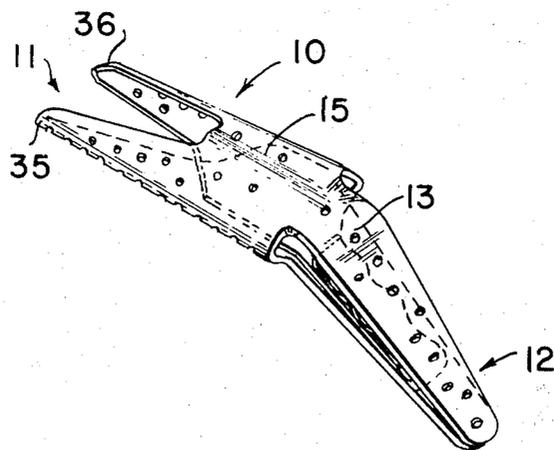


Fig. 1

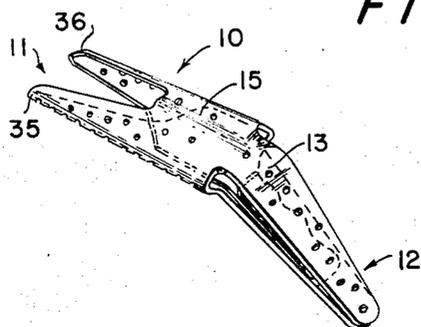


Fig. 2

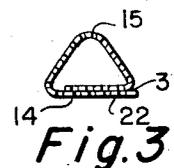
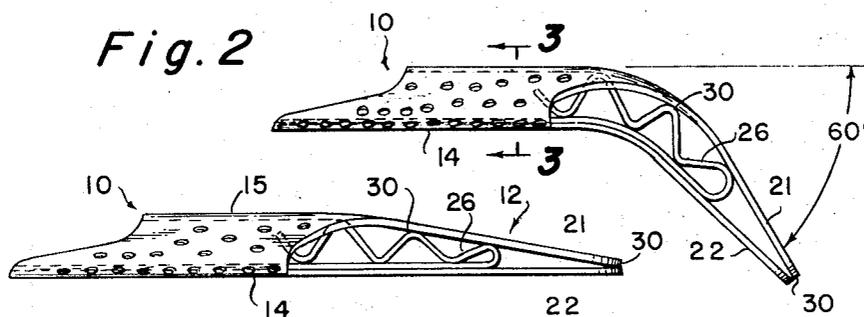


Fig. 2A

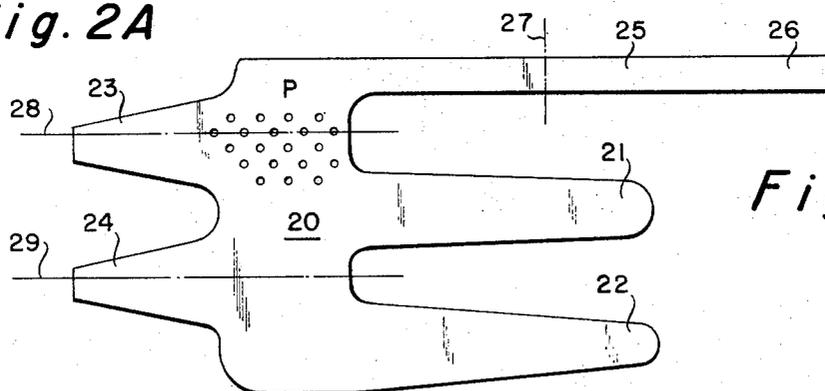


Fig. 4

Fig. 5

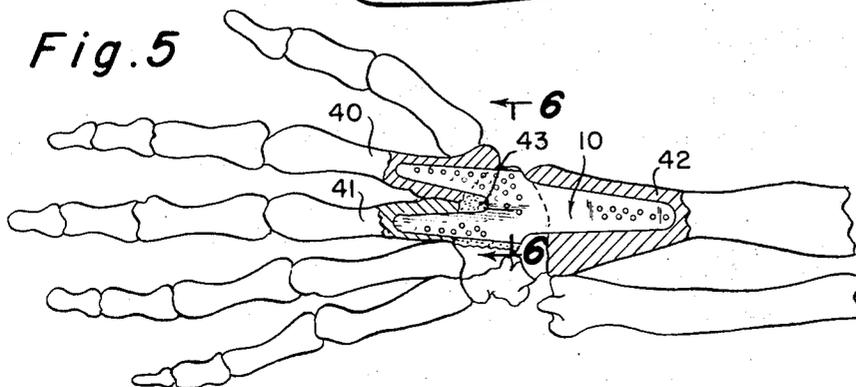


Fig. 6



## BONE JOINT FUSION PROSTHESIS

This invention relates broadly to the surgical management of severely disabled rheumatoid joints and more particularly to a joint fusion prosthesis which may be emplaced spanning a human or animal joint as a substitute for conventional arthrodesis, or fusion of the joint.

While the present invention is applicable for use in most body joints, especially the wrist, shoulder, and finger, it will be described herein for purposes of example only specifically as adapted for use in the human wrist.

Severe rheumatoid arthritis is prevalent today in many elderly patients and is characterized by the inflammation of the joints, frequently accompanied by marked deformities and associated pain. In an increasing number of such rheumatoid patients, the limiting factor in their rehabilitation, self-care, and maintenance of useful daily functions appears to be the severe involvement of the wrist, along with disorganization of the joint, instability, dislocation, and chronic pain. In prior methods of management, external splinting has been employed with very limited success. Such splinting, however, is only a staying device over the long term since gradual wrist destruction frequently ensues and thereafter the malady may only be successfully rehabilitated by arthrodesis or wrist fusion.

The use of endoprosthetic joints and especially an endoprosthesis for ginglymus joints is well documented. Such hinge type devices are in common use today. A typical ball and socket joint of this type is disclosed in the patent to Steffee, U.S. Pat. No. 3,506,982. A silastic joint prosthesis specifically designed for reconstruction of metacarpophalangeal and interphalangeal joints is shown in the patent to Niebauer, U.S. Pat. No. 3,593,342. Also note in the literature Swanson, "Silicone Rubber Implants for Replacement of Arthritic or Destroyed Joints in the Hand" appearing in *Surgical Clinics of North America*, Vol. 48, No. 5, October 1968, pp. 113-27. The use of such prosthetic appliances is, however, not feasible in all cases and in severe cases fusion is the only available alternative.

The use of fusion or arthrodesis is sometimes advantageous in some body joints as opposed to replacement arthroplasty in that the fusion is permanent in its effect and does not break down, it is not subject to the wear problems of motion, and it allows achievement of very satisfactory function and complete pain relief over the long term. Since wrist rotation takes place diffusely between the radius and the ulna, pivoting at the elbow, the wrist can maintain full pronation and supination even though fused. Generally satisfactory pain-free function is achieved with fusion and there is generally adequate finger function.

There are however certain well known disadvantages to fusion of the wrist in the rheumatoid, and these are (1) the lengthy recovery time for the patient to heal from the surgery involved and the associated morbidity and disability; (2) the requirement for a long arm cast to be worn about three months; (3) the high experience of failure of fusion in the rheumatoid due to the poor quality of bone and soft tissue and the regrowth of rheumatoid synovium into the fusion area; and (4) the appearance of the necessarily foreshortened arm and associated weakened grip due to the foreshortening of the muscle-tendon unit about the joint.

The combination of these disadvantages results in the use today of wrist stabilization as the common management method especially since many patients who would benefit from fusion have joint disabilities too severe to tolerate the long term immobilization produced by having their arm in a cast.

## OBJECTS OF THE INVENTION

A principal object of the present invention is to provide an implant, compatible with body tissues, for use in clinical rheumatoid fusion.

Another object of the invention is to provide a methylmethacrylate reinforced implant for fusion of the wrist which will restore normal muscle-tendon length by restoring full length and normal joint configuration to the wrist in order to improve the patient's ability to use muscle forces and aid in restoration of normal power and grip.

Yet another object of the invention is the provision of a joint fusion implant of acrylic cement reinforced by means of a structural metal framework, the ends of which are inserted into the bones to be bridged by the fusion.

A further object of the invention is to provide a joint fusion implant which can be applied during a relatively short surgical procedure.

Yet another object of the invention is to provide a reinforced fusion implant which is simple in construction, relatively inexpensive to manufacture, and which is safe, efficient and reliable in use.

A further object of the invention is to provide a joint fusion implant which can be bent and straightened without buckling or collapsing during insertion, to facilitate insertion and maintain maximum strength.

Another object is to provide a joint fusion implant which can be bent during insertion to allow fusion in any desired position.

Other objects and advantages will become apparent from the following description of an exemplary form of the invention illustrated in the accompanying drawings.

## DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the fusion prosthesis prior to application;

FIG. 2 is a side elevation of the prosthesis prior to application;

FIG. 2a is a side elevation of the prosthesis of FIG. 2 showing the device after being bent and as it would appear after implantation.

FIG. 3 is a cross sectional view taken along the lines 3-3 of FIG. 2;

FIG. 4 is a plan view of the metal blank from which the prosthesis is formed;

FIG. 5 is a plan view of the bones of the human left hand showing the prosthesis in place; and

FIG. 6 is a sectional view taken along the lines 6-6 of FIG. 5.

Referring to the drawings in greater detail wherein like parts are represented by like reference characters, the joint fusion prosthesis of the present invention is shown generally at 10. The prosthesis is of generally triangular cross section throughout its center portion as shown in FIG. 3 and has a bifurcated front end 11, a rear depending tapered blade portion 12 having an upper face 13, and a generally flat lower face 14. The prosthesis is preferably of unitary one-piece construc-

tion and provides a relatively strong, substantially rigid, beam structure. The triangular configuration provides the necessary strength of the beam and the apex 15 serves as a top ridge as shown in FIG. 1.

The prosthesis is preferably formed from a sheet of biologically inert metal suitable for implantation in the human body. Stainless steel, tantalum, titanium, or a cobalt-chromium alloy commonly sold under the trademark Vitallium, have been used as implant materials in recent years and would be acceptable for the prosthesis. The use of titanium has been found to be ideal for this particular application. The implant is designed so that in use the titanium mesh will occupy the portion of the total structure which is subjected to the highest internal stresses. Titanium has a considerably higher elastic modulus than the methylmethacrylate which is used with the implant as later described. When the structure is subjected to strains, the titanium mesh will assume the greatest portion of the stress. It will be understood that the prosthesis 10 will be filled and encased in a matrix of methylmethacrylate during implantation. In such a composite system, it is desirable to obtain a limited degree of yielding in the total structure so that if failure should ever occur, it would occur by the production of a gradual deformation rather than sudden failure. Such properties can be accomplished by the proper proportioning of the reinforcing titanium mesh and the methylmethacrylate matrix.

The particular form of the invention exemplified herein was formed from a sheet of titanium approximately 1/32 inch in thickness and measuring 5 5/16 inches in length and 2 9/32 inches in width. The blank from which the prosthesis is formed is shown at 20 in FIG. 4. The entire blank is provided with perforations P preferably formed on centers spaced 3/32 inch apart. These perforations serve to permit the methylmethacrylate inserted within the prosthesis to be extruded somewhat to provide a tight locking engagement on solidification with the prosthesis. The methylmethacrylate extruded through the perforations will bond with external methylmethacrylate to bind with the prosthesis into one composite structure, achieving a strong shear bond and an extremely strong biphasic unitary implant structure providing immediate post-operative stabilization.

As will be seen in FIG. 4, the blank includes two rearwardly directed blade fingers 21 and 22 and two forwardly directed fingers 23 and 24. The former fingers are provided with rounded ends whereas the latter front fingers 23 and 24 have relatively flat end faces. Additionally, a rigidifying, elongated extension 25 is provided extending rearwardly and generally parallel to blade fingers 21 and 22 for a purpose described later herein. The free end 26 of the leg 25 is first corrugated to provide the necessary internal support and rigidification for the prosthesis and prevent buckling of the blade fingers 21 and 22 as they are bent straight during insertion of the prosthesis, as best shown in FIGS. 2 and 2a. Thereafter, the free end 26 of leg 25 is folded upwardly along the fold line 27 to overlie the forward portion of the leg 25. Subsequently, the top portion of the blank shown in FIG. 4 is folded downwardly along the longitudinal fold line 28 so as to underlie the central portion and the lower portion is folded downwardly along the longitudinal fold line 29 to a position below the folded upper portion. Side force applied to the central unfolded section will provide the top ridge 15 and

therefore the final triangular cross sectional configuration of the final prosthesis. The overlying blade fingers 21 and 22 are then bent downwardly to provide an angle of approximately 60° with the horizontal as shown in FIG. 2. Tack welding may be applied to the overlying portion of the lower member 22 to the upper member 21 as shown in FIG. 3 at 31. It should further be noted that the tip ends of the forwardly directed fingers 23 and 24 are brought together in the manner shown in FIG. 1 to provide a relatively pointed pair of bifurcated leg members 35 and 36 being hollow in the interior thereof.

In order to apply the prosthesis, the surgical team will, after resection of the diseased remnants of the wrist, ream longitudinal holes in the medullary canals of the metacarpals 40 and 41 shown in FIG. 5 and a somewhat larger hole in the radius 42. Methylmethacrylate cement is then applied to the hollow areas within the prosthesis and the prosthesis may be squeezed somewhat to force the cement through the perforations P therein. Additional cement may be placed with the hollow portions of the metacarpals and the radius and the bones may then be hyperflexed to an angle of about 60° so as to permit first the insertion of the fingers 35 and 36 within the hollowed metacarpal portions and then the blade portion 12 may be inserted in the larger bore drilled into the radius 42. If desired, additional methylmethacrylate may be applied as shown at 43 in FIG. 5 about the prosthesis. The wrist and prosthesis are then bent to a straight position or a position of choice in slight flexion or extension prior to settling of the cement mixture so that the prosthesis takes on the final straightened form shown in FIG. 2a.

The methylmethacrylate mixture will remain in a workable state for several minutes, however care must be taken to ensure that the prosthesis is properly fitted and the body of the same bent to the desired position before the material begins to set.

Preliminary tests have been completed utilizing a disarticulated dog knee and the wrist joint of a human cadaver. Additionally, tests on live subjects have been completed with success. With respect to the cadaver wrist joint and the dog knee, the mesh reinforced methylmethacrylate fusion was subjected to static mechanical testing to the point of initial failure. In each configuration, the initial failure occurred in the biological portion of the structure, i.e., in the human wrist joint, failure occurred in the first metacarpal as evidenced by a longitudinal crack; in the dog knee, failure occurred first in the posterior aspect of the femur rather than in the implant itself. The tests showed that the cadaver hand was able to withstand a simulated load of 103 pounds against the palmar surface before the initiation of the crack in the first metacarpal. Subsequent to the initial failure, an additional 100 pounds of load was applied and no further evidence of failure was observed. Even with the crack in the first metacarpal, the entire fused wrist was stable and sufficiently strong to support over 200 pounds of load.

While we have shown and described a preferred embodiment of the invention, it is to be understood that the drawings and detailed disclosure are to be construed in an illustrative rather than a limiting sense, since various modifications and substitutions of equivalents may be made by those skilled in the art within the spirit and scope of the invention.

We claim:

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1. A prosthesis for bone joint fusion comprising a hollow substantially rigid but malleable metal bridge member, said member having a bifurcated end to provide two hollow projections, each adapted for insertion within adjacent bones on one side of a joint, said member having substantially hollow projection means extending from the other end thereof and adapted for insertion axially into a bone on the other side of said joint so that the bridge member may span the joint, and means on the bridge member and the projections on each end thereof adapted to receive and lock with a settable cement to form a rigid unitary bridge implant.

2. A prosthesis as defined in claim 1, wherein the means to receive and lock with a settable cement comprises a plurality of perforations disposed in the surface of the bridge member and the projections.

3. A fusion prosthesis as defined in claim 1, wherein the projection means on the other end of the bridge member comprises a pair of similarly shaped fingers in overlying relationship.

4. A fusion prosthesis as defined in claim 3, wherein the ends of each of the fingers are connected and the remaining portion of the fingers are spaced apart.

5. A fusion prosthesis are defined in claim 4, and fur-

ther including a corrugated reinforcing member between the fingers.

6. A fusion prosthesis as defined in claim 1, wherein the projection means extends at an angle of about 60° from the remainder of the prosthesis for ease in insertion and said projection adapted to be bent into the plane of the bridge member.

7. A prosthesis as defined in claim 1 and further including a settable cement filling the bridge member.

8. A prosthesis as defined in claim 7 wherein said cement is methylmethacrylate.

9. A prosthesis for bone joint fusion comprising a hollow substantially rigid metal bridge member, said member being bifurcated at one end thereof to provide two hollow projections each adapted for insertion within adjacent bones on one side of a joint, a projection on the other end of the bridge member adapted for insertion in a bone on the other side of said joint, said last projection comprising a pair of similarly shaped fingers in overlying relationship, and a corrugated reinforcing member intermediate said fingers.

10. A prosthesis as defined in claim 9, wherein said bridge has a plurality of perforations throughout its surface.

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