May 8, 1962 R. A. PROUD 3,032,824

METHOD OF FORMING SEAL RINGS AND THE LIKE FROM MATERIALS HAVING ELASTIC MEMORY

Filed July 28, 1958

Fig. 1

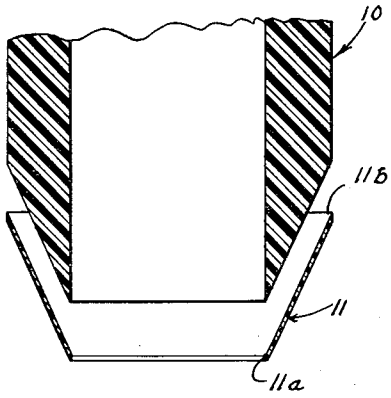


Fig. 2

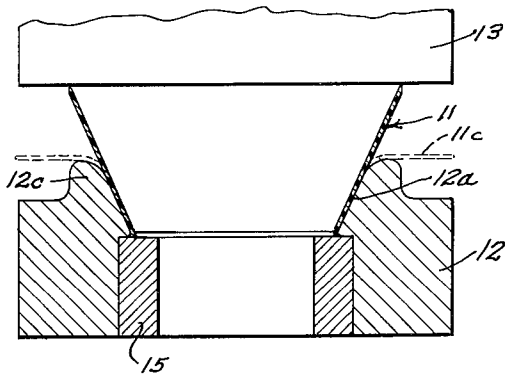


Fig. 3

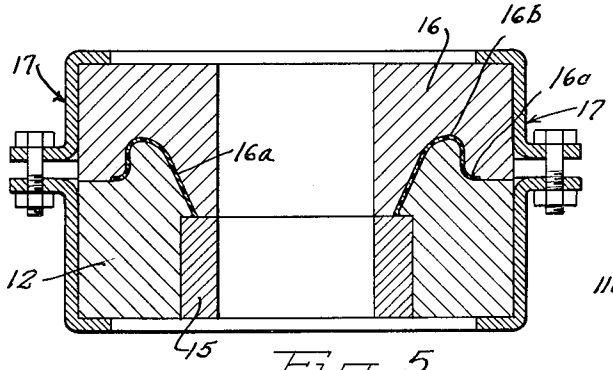


Fig. 4

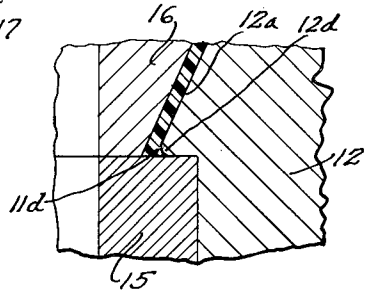


Fig. 5

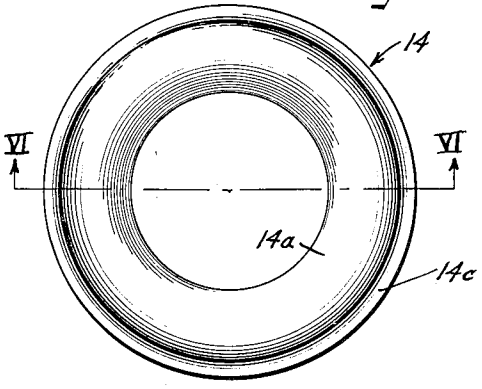
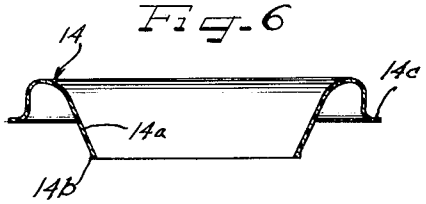


Fig. 6



Inventor
Ralph A. Proud

by Hill, Sherman, Meroni, Gross & Simpson Attys.

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METHOD OF FORMING SEAL RINGS AND THE LIKE FROM MATERIALS HAVING ELASTIC MEMORY

Ralph A. Proud, Willoughby Hills, Ohio, assignor to Thompson Ramo Wooldridge Inc., a corporation of Ohio

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6 Claims. (Cl. 18—56)

The present invention is directed to an improved method for shaping materials having the characteristic of elastic memory, that is, the property of reverting to a previous shape after being pressed in a cold die or the like.

The invention has particular applicability to the manufacture of shaft seals composed of polytetrafluoroethylene ("Teflon"). Heretofore, such seals were made by shaping a flat annular blank with a punch or the like into the configuration desired in the finished seal ring. In many instances, however, the use of the flat blank did not result in the production of a suitable product. The use of the annular flat blank made it necessary to achieve substantial flow of the material of the blank during the shaping operation, with the result that working strains were left in the material after its removal from the shaping assembly. Eventually, the strains brought about a tendency for the material to revert back into the original flat annular form. The seal thereupon shrank and frequently exhibited wrinkling at the outer diameter of the seal and leakage at the inner diameter. In addition, methods of shaping employed in the past have resulted in unequal distribution of material throughout the body of the seal, with the result that the seal was thinner in those portions which required greater mechanical rigidity.

In a co-pending but now abandoned application, Serial No. 713,261 filed February 4, 1958, and entitled "Method of Shaping Materials With Elastic Memory," I have described a method for shaping seals and the like from materials having elastic memory which eliminate the disadvantages noted above. The present application, which is a continuation-in-part of the aforementioned now abandoned pending application Serial No. 713,261 includes the initial shaping step of said application plus a further improvement which results in the production of an article having increased flexibility, a practical absence of cold flow, and improved wear resistance.

In the method of the present invention as in the method of the aforesaid abandoned application I employ a conical blank of tetrafluoroethylene and bend it to a generally U-shape. However, I then confine the U-shaped blank under pressure within shaping dies to provide no open flow path for the blank within the dies. This is followed by heating the dies and the blank above the gel temperature of the polytetrafluoroethylene and thereafter quenching the dies while the blank is contained therein. This treatment has been found to provide a polytetrafluoroethylene article with increased flexibility, practically no cold flow characteristics, a thinner and more transparent structure, increased elasticity, and other structural advantages.

With the process described, the shaping of the material in the dies puts the outer periphery of the seal in tension during the forming operation and therefore eliminates wrinkling of the outer flange and the outer curved form. The conical shape of the blank also minimizes the stressing and possibility of tearing the blank during formation. The high temperatures employed when the material is confined within the dies provides very low stresses and, accordingly, less tendency for the material to be affected by elastic or plastic memory. Consequently, the maximum temperature at which the seal can be employed can be near the gel temperature of the "Teflon."

Accordingly, an object of the present invention is to provide an improved method for minimizing the tendency of materials with elastic memory to revert to their original form.

Another object of the invention is to provide a method for shaping a seal ring or the like in which the outer peripheral portions are kept in tension during the forming operation.

Still another object of the invention is to provide a method for the shaping of seals or the like from materials having the property of elastic memory so as to permit such members to be employed at temperatures higher than that could be previously employed without danger of shrinkage.

A further description of the present invention will be made in conjunction with the attached sheet of drawings in which:

FIGURE 1 is a fragmentary view in cross-section illustrating the manner in which frusto-conical blank of the material is skived from a tube;

FIGURE 2 is a cross-sectional view with parts in elevation, illustrating the manner in which the blank is initially shaped in the die cavity;

FIGURE 3 is a view of the shaping assembly as it is introduced into the heat treating furnace;

FIGURE 4 is an enlarged fragmentary view of the shaping dies illustrating the manner in which a partial bead is formed;

FIGURE 5 is a plan view of the finished seal ring; and

FIGURE 6 is a cross-sectional view taken substantially along the line VI—VI of FIGURE 5.

As shown in the drawings:

In FIGURE 1, reference numeral **10** indicates generally a tube of material having the property of elastic memory, such as polytetrafluoroethylene. This type of resin exists in a semi-crystalline form below temperatures of about 620° F. Above about 620° F., the material becomes a gel.

In the manufacture of the tube **10**, the polyetetrafluoroethylene powder is compacted into the shape of the tube, and heated above the gel temperature, normally to a temperature of about 730° F. The tube is held at this temperature until complete transformation of the material into its gel form occurs. The time involved may be several hours.

After cooling, the thus sintered, tube is skived with a suitable knife or the like to cut off a thin frusto-conical blank generally indicated at numeral **11** is the drawings. The inner diameter **11***a* of the blank **11** and the outer diameter **11***b* of the blank can be made substantially the same as the inner and outer diameters required in the seal. In normal practice, I prefer to employ a blank **11** which has an inner diameter and an outer diameter only slightly smaller than the corresponding dimensions in the finished article.

With the new method of forming such blanks, the thickness of the blank may be less than that previously employed for similar seal rings. For example I prefer to employ a thickness of blank ranging from about 0.0100 to 0.0150 inch.

The frusto-conical blank **11** is then inserted into a shaping assembly which may constitute a lower shaping member **12** and a flat punch member **13** as illustrated in FIGURE 2 of the drawings. The lower shaping member **12** includes a central cavity having inclined side walls **12***a* the same as the angle of the side wall of the frusto-conical blank **11**. This arrangement permits the blank **11** to be nested securely against a base of the cavity formed in the lower forming member **12**. A cylindrical

insert 15 provides the base for bottoming the blank 11 in the shaping die.

The lower forming member 12 also has an arcuate annular rib 12c for shaping the outer peripheral flange of the seal member.

In the initial forming operation, the flat punch member 13 curls the exposed surface of the blank 11 over the rib 12c, an intermediate step of which is indicated by the dashed lines in FIGURE 2, to form a flange 11c.

After the initial shaping of the blank to form curled flange, the blank 11 is then shaped by means of an upper forming member 16 having a frusto-conical portion 16a arranged to engage the sloping side walls of the blank 11 and an arcuately relieved portion 16b arranged to cooperate with the arcuate rib 12c in shaping the outer peripheral portions of the blank 11. A groove 16c is provided to accommodate the outer peripheral flange of the blank 11.

It will be noted from FIGS. 1 to 3 that the frusto-conical blank 11 shown in FIGS. 1 and 2 has a predetermined side height or cross-sectional length (extending at an angle to the vertical from the inner diameter 11a to the outer diameter 11b) which is substantially equal to the cross-sectional length of the formed piece in the mold of FIG. 3 extending from the inner end of the frusto-conical portion 16a to the outer extremity of the flange in the groove 16c. This cross-sectional length may be referred to as the final peripheral dimension of the formed blank in cross section. In this way the forming operation prior to heat treatment in the dies of FIG. 3 is a bending operation rather than an operation involving "moving" substantial masses of plastic so as to effect substantial alterations and variations in the cross-sectional thickness of the blank before and after forming.

When the upper forming member 16 and the lower forming member 12 abut together, as illustrated in FIGURE 3 of the drawings, the shaping assembly provides a completely closed system in which there are no open flow paths beyond the die cavity for the material of the blank 11 confined between the shaping members. The shaping members 12 and 16 are clamped or pressed together as by means of clamps 17 and are then inserted into a furnace for the subsequent heat treatment step. In order to avoid sticking of the material to the faces of shaping surfaces, it is desirable to construct the dies so that the heat transfer is uniform into both sides of the blank. "Teflon" is a very poor heat conductor and if heat input to one blank face is greater than into the opposite face the blank might stick to the hotter die. Metal dies, preferably chromium coated steel are desirable because they have good wear life, and will not distort when heated and quenched.

The clamped dies are heated until the blank 11 attains a temperature in the range from about 700 to 750° F., which is considerably above the gel temperature of the polytetrafluoroethylene. The heating of the blank in the dies apparently results in development of an expansive force which, due to the rigidity of the dies, must be compensated for by a compression of the polytetrafluoroethylene. With this heat treatment, the polytetrafluoroethylene takes on a somewhat translucent appearance substantially different from the normal milky-white opaque appearance of the blank.

As illustrated best in the enlarged view of FIGURE 4, the inclined side walls 12a of the forming member 12 are rounded as indicated at 12d to provide a peripheral recess which receives the expanding polytetrafluoroethylene and forms a partial bead on the inner diameter of the seal ring.

After the blank has reached the required temperature, the whole assembly is cooled quickly to a temperature where the ring can easily be removed from the dies without distortion preferably by rapidly quenching, as by immersion, in water, oil or the like, until the ring has reached room temperature. When the ring is removed from the dies it is ready for use.

The completed seal element is illustrated best in FIGURES 5 and 6 of the drawings. The ring 14 includes a frusto-conical wall portion 14a, a partial bead 14b for receiving a garter spring or the like, and an outer substantially flat peripheral flange portion 14c. Since the blank has been allowed to form at an elevated temperature, it can be employed at working temperatures closer to the seal forming temperature without deformation of form or size.

It will be evident that various modifications can be made to the described embodiments without departing from the scope of the present invention.

I claim as my invention:

1. The method of die shaping a heat-gelable elastic memory plastic article free from flash and capable of retaining its shape at temperatures up to the temperature used in its formation which comprises placing an unheated sintered heat-gelable elastic memory plastic blank between rigid dies defining a closed die cavity conforming in shape with said blank and completely enveloping said blank with no open flow path for the blank beyond the die cavity, providing a recess in the die cavity adapted to receive expanding plastic blank material, holding the dies together in closed cavity defining condition, heating the assembly above the gel temperature of the blank to expand the plastic material into complete conformity with the die cavity, quickly cooling the assembly in said closed cavity defining condition to reduce the temperature of the plastic material substantially below its gel temperature to prevent subsequent distortion of the plastic article, thereafter opening the dies, and removing the article from the dies.

2. The method of die shaping a polytetrafluoroethylene article without flash thereon which comprises placing a thin bendable annular blank having inner and outer peripheries and composed of sintered polytetrafluoroethylene within a set of rigid shaping members having a blank receiving cavity conforming with the shape of said blank, entirely confining said blank between said members to provide no open flow path for the blank beyond said shaping cavity of the members, placing the outer peripheral portion of the blank in tension between said shaping members, applying clamping pressures to said shaping members, providing a recess in the shaping cavity of the clamped members to receive expanding blank material, heating said shaping members and blank above the gel temperature of the blank material with the blank so confined that the blank material on expanding causes internal pressures and flows to completely fill the shaping cavity and recess in minute detail, thereafter quenching the shaping members and blank confined therein while still under said clamping pressures to cool the blank substantially below the gel temperature of the polytetrafluoroethylene to thereby produce the shaped annular article free from flash, opening the shaping members, and removing the article.

3. The method of making an annular member of sintered polytetrafluoroethylene which retains in its free state the same shape created in its formation at temperatures up to the temperatures used in the method which comprises placing a sintered semi-crystalline polytetrafluoroethylene annulus between a set of rigid dies cooperating to define a completely closed die cavity of desired shape at least as large as the free volume of the annulus and conforming generally to the shape of the annulus, holding the dies in closed cavity forming condition with no open flow path beyond the cavity, heating the closed assembly at least to the gel temperature of the polytetrafluoroethylene, quickly cooling the closed assembly to reduce the temperature of the polytetrafluoroethylene substantially below said gel temperature, opening the dies, and removing a flash free shaped annular member from the dies.

4. The method of shaping a polytetrafluoroethylene article which comprises placing a room temperature sintered polytetrafluoroethylene blank within a set of rigid metal shaping dies, closing the dies to form a completely closed shaping cavity generally conforming to the shape of the blank and having no open flow path for the blank beyond the shaping die cavity and having a volume at least as large as the volume of the blank in its free state, heating the closed assembly to raise the temperature of the blank above 620° F. to develop an expansive force in the blank and to shape the blank into complete conformity with the die cavity filling the die cavity completely, quenching the assembly to reduce the polytetrafluoroethylene substantially below 620° F. while the shaped article is confined in the closed die cavity, opening the dies, and removing a flash free shaped article from the dies.

5. The method of making an annular seal member of a plastic material having an elastic memory which member in its free state retains the same shape created in its formation even at temperatures up to the temperatures used in the method which comprises skiving from a sintered elastic memory plastic tube a thin annulus with a base periphery, a converging side wall and an apex periphery smaller than said base periphery, placing said annulus between a set of rigid dies cooperating to define a completely closed die cavity of desired seal shape at least as large in volume as the free state volume of the annulus, holding the dies in closed cavity forming condition with no open flow path for the annulus beyond the die cavity, providing a recess in the die cavity adapted to receive expanding material from the annulus, heating the closed assembly to raise the temperature of the annulus at least to the gel temperature of the plastic material to expand the plastic material into complete conformity with the die cavity and recess, quenching the assembly to reduce the temperature of the plastic material substantially below said gel temperature while the plastic material is still confined in the closed die cavity, opening the dies, and removing the flash free annular seal member from the dies.

6. The method of making an annular polytetrafluoroethylene seal member from a thin conical blank of sintered polytetrafluoroethylene which comprises seating the small diameter end of the sintered conical blank in a rigid shaping die with the large diameter end of the blank projecting beyond the die, curling the large diameter end of the conical blank over the die to form a flange on the blank, covering the flanged blank in said die with a second rigid die cooperating with the first die to form a completely closed die cavity with no open flow path from the cavity, clamping the first and second die members together, heating the assembly to raise the temperature of the polytetrafluoroethylene above its gel temperature, quenching the clamped assembly to reduce the temperature of the polytetrafluoroethylene substantially below its gel temperature, opening the dies, and removing the seal member free of flash.

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