June 2, 1942. L. J. SIVIAN ET AL 2,284,773

METHOD OF FORMING THIN ARTICLES

Filed April 16, 1940

FIG. 1

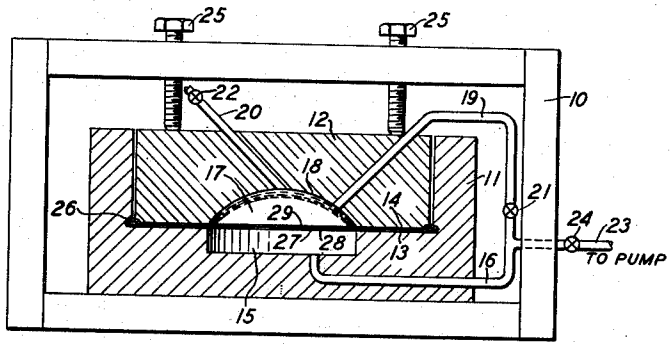


FIG. 2

FIG. 3

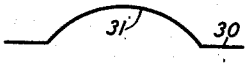


FIG. 4

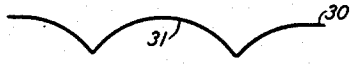
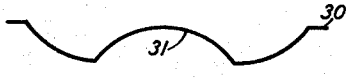


FIG. 5



INVENTORS: L.J. SIVIAN
E.C. WENTE
BY
Walter C. Kiesel
ATTORNEY

Patented June 2, 1942

2,284,773

UNITED STATES PATENT OFFICE

2,284,773

METHOD OF FORMING THIN ARTICLES

Leon J. Sivian, East Orange, N. J., and Edward C. Wente, New York, N. Y., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application April 16, 1940, Serial No. 329,842

2 Claims. (Cl. 113—51)

This invention relates to methods of forming thin articles of non-planar contour and more particularly to methods of forming acoustic diaphragms having one or more dished or arched portions.

Acoustic diaphragms, such as are employed for example in telephone receivers, transmitters and loud-speakers, frequently are formed from sheets or blanks of a very thin material, for example metal, in order that they may have a very small mass, and are provided with one or more dished or arched portions to increase the rigidity thereof so that the diaphragm or a particular area thereof may vibrate bodily analogous to a piston. In forming such diaphragms, severe limitations are placed upon the degree of deformation which may be obtained due to the fact that sheets or blanks of diaphragm material almost invariably contain minute holes and spots or portions of less tensile strength than the major part of the sheet or blank. When the material is stressed during the forming operations, the weaker portions of the sheet or blank yield disproportionately, with the result that they may give way and pores or ruptures appear in the diaphragm. Even if these portions do not give way entirely, the diaphragm produced is not of uniform thickness, strength and elasticity throughout the local vibrations or other than the desired bodily movement thereof during use results. These effects may be circumvented to some extent by repeated annealing of the material during the forming process. Such treatment, however, greatly complicates the manufacture of diaphragms and increases the manufacturing cost thereof.

One object of this invention is to expedite the forming of thin articles of non-planar form.

Another object of this invention is to assure substantially uniform stressing of all elements of the material of an acoustic diaphragm during the forming thereof.

A further object of this invention is to prevent excessive yielding or rupturing of the diaphragm material during the forming of a dished acoustic diaphragm.

In one method illustrative of this invention, a blank or sheet of the material from which the article, for example diaphragm, is formed is securely clamped at its periphery or other portion thereof in a mold having a surface opposite the blank or sheet of the contour desired for the formed article. The sheet or blank is then stretched out of its plane, as by the creation of a pressure difference between opposite faces thereof, until it abuts the contoured surface of the mold.

In accordance with one feature of this invention, during the forming process the blank or sheet is sandwiched between two backing sheets of an impervious material of greater strength than the material of which the article is formed, whereby all elements of the article are stressed proportionately.

In accordance with another feature of this invention, the composite element including the backing sheets and the blank or sheet from which the article is to be formed is clamped in a mold and equal hydraulic or pneumatic pressures greater than, for example 5 to 10 times as great as, that necessary for the forming of the composite element are applied to opposite surfaces of the composite element whereby the blank or sheet is frictionally clamped between the backing sheets, the pressure on one surface of the composite element is then reduced and the pressure difference thus established between the two faces of the composite element forms the element into the desired shape.

The invention and the foregoing and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing in which:

Fig. 1 is a view mainly in section of apparatus employed in forming thin articles in accordance with this invention;

Fig. 2 is an enlarged fragmentary view in section illustrating the construction of the composite element; and

Figs. 3, 4 and 5 are outline views illustrating various contours of articles which may be formed in accordance with this invention.

Referring now to the drawing, the apparatus shown in Fig. 1 comprises a foundation member or frame 10 in which there is mounted a mold having a dished outer member 11 and an inner member 12 telescopically fitted in the outer member 11, the members 11 and 12 having juxtaposed, for example annular, clamping surfaces 13 and 14 respectively. The outer member 11 is provided with a central recess 15 which communicates with a pipe or conduit 16; the inner member 12 is provided with a recess 17 opposite the recess 15, the defining surface 18 of the recess 17 being of the contour desired for the article to be formed. For example, in the specific form shown in Fig. 1 the surface 18 is a portion of a spherical surface. Communicating with the recess 17 is an inlet pipe or conduit 19 and an

outlet pipe or conduit 20, the pipes or conduits 19 and 20 being provided with valves 21 and 22 respectively. As shown in Fig. 1, the inlet pipes or conduits 16 and 19 are connected to a common header 23 leading to a hydraulic or pneumatic pump, not shown, the header 23 being provided with a valve 24.

The two members 11 and 12 of the mold may be securely clamped together by a plurality of bolts 25 threaded through the frame or foundation member 10 and bearing against the member 12. In order to prevent leakage between the members 11 and 12 a sealing gasket 26 is provided adjacent the outer edges of the surfaces 13 and 14.

In the forming of the article, a blank or sheet 27 of the article material is sandwiched between impervious backing sheets 28 and 29, as shown more clearly in Fig. 2, and the composite element thus formed is securely clamped between the clamping surfaces 13 and 14. The backing sheets 28 and 29 preferably are of considerably greater strength than the sheet or blank. For example, if the blank or sheet 27 is of duralumin 0.0005 inch thick, the backing sheets 28 and 29 may be nickel-silver sheets 0.002 inch thick or copper sheets 0.003 inch thick. Other impervious and pliable backing sheets, for example of lead, may be employed.

When the composite element is clamped between the surfaces 13 and 14, equal hydraulic or pneumatic pressures are established in the chambers 15 and 17 by means of the pump connected to the header 23, the valves 21 and 24 being open and the valve 22 being closed. These pressures are greater than that required to form the composite element into the desired shape so that the sheet or blank 27 is securely clamped frictionally along its entire surfaces to both the sheets 28 and 29. The valve 21 is then closed and the valve 22 is opened slightly whereby a pressure difference between opposite surfaces of the composite element is created sufficient to stress and form the composite element so that it bears against the surface 18 as indicated by the dotted lines in Fig. 1. The valve 23 is then closed, the mold opened, and the sheet 27, now of the desired form, is removed from between the backing members 28 and 29.

During the forming operation, it will be noted that every elementary area of the central portion of the blank or sheet 27 is in effect clamped to the corresponding areas of the backing sheets 28 and 29 by a force proportional to the product of the coefficient of friction between the blank 27 and sheets 28 and 29 and the pressure applied to the composite element. Hence, the weak spots in the blank 27 are constrained against excessive stressing thereof and substantially uniform stretching of the blank 27 obtains. The sheet 29, which is noted heretofore is impervious, effectively seals any minute pores or pinholes which may be in the blank 27 or appear therein during the forming process so that the blank 27 is maintained in intimate contact with the backing sheet 28 throughout the forming process. The high pressures in the chambers 15 and 17, of course, further assure intimate and high frictional engagement between the blank or sheet 27 and both of the backing sheets 28 and 29.

A diaphragm formed in a mold of the construction shown in Fig. 1 is illustrated in Fig. 3 and comprises a flat peripheral portion 30 and a central, relatively rigid, dished portion 31. Other illustrative forms are shown in Figs. 4 and 5, the particular form being determined, of course, by the contour of the surface 18 of the mold.

Although specific embodiments of this invention have been shown and described, it will be understood, of course, that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. The method of forming a non-planar article from a blank of material which comprises mounting the blank of material between and in direct, intimate face-to-face engagement with a pair of impervious pliant members, fixedly mounting the composite element thus formed with one surface in opposition to a rigid surface of the contour desired for the article, applying equal uniformly distributed pressures greater than that necessary to distort said element to opposite surfaces of said element, and relatively decreasing the pressure upon said one surface, while maintaining said uniformly distributed pressures at magnitudes greater than that necessary to distort said element, sufficiently to allow deformation of said element until limited by said rigid surface.

2. The method of forming a thin metallic diaphragm having a dished central portion, which comprises mounting a blank of the diaphragm material between a pair of impervious sheets of greater strength than said blank, clamping the composite element thus formed at an area surrounding the central part thereof, applying equal uniformly distributed pressures several times as great as that required to distort said element to opposite faces of said element, creating a difference between the pressures on said faces, while maintaining the pressure on each of said faces several times as great as that required to distort said element, whereby the central portion of said element is deformed, and limiting the deformation to produce the form desired for the dished central portion of the diaphragm.

LEON J. SIVIAN.
EDWARD C. WENTE.