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F. TOLKE
RESILIENT TUBULAR BODIES
Filed March 4, 1941

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2 Sheets-Sheet 1

Fig. 1

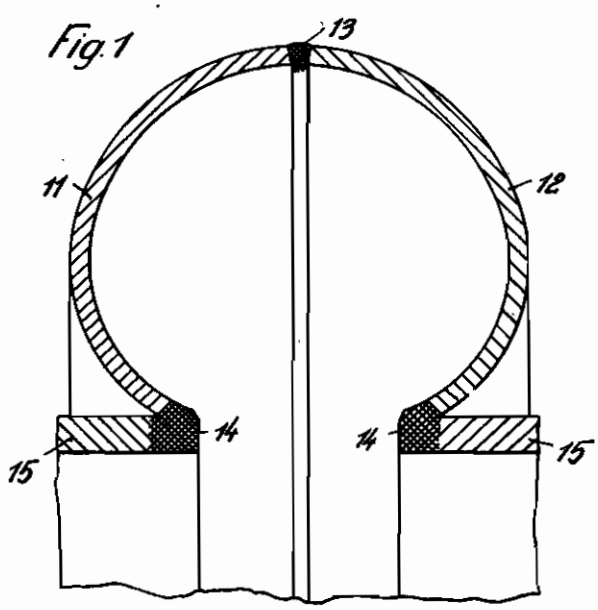

Fig. 2

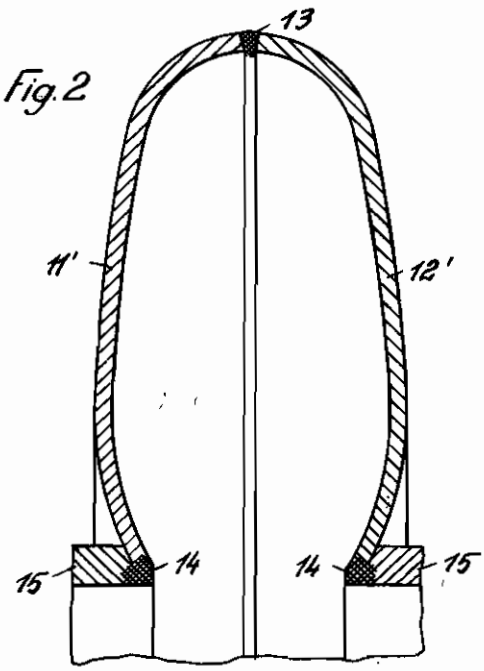

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Fig. 3

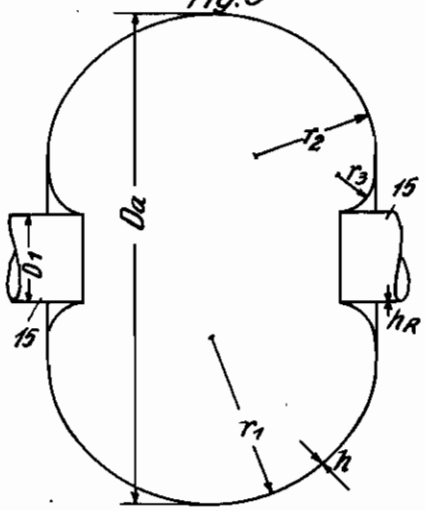


Fig. 4

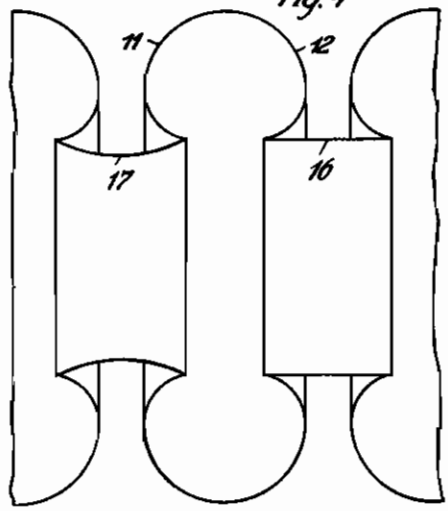
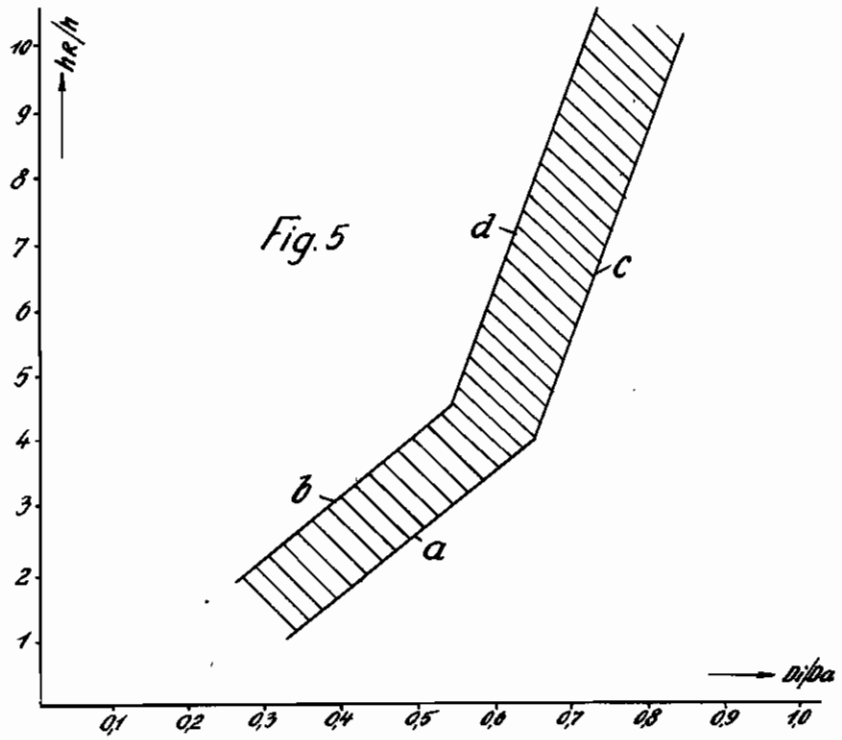


Fig. 5



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ALIEN PROPERTY CUSTODIAN

RESILIENT TUBULAR BODIES

Friedrich Tölke, Berlin-Charlottenburg, Germany; vested in the Alien Property Custodian

Application filed March 4, 1941

This invention relates to resilient tubular bodies or bellows of the type used in expansion pipes, compensators, spring bodies, elastic pressure cushions, stuffing boxes for shafts, pressure regulators, pressure reducers and the like.

It is an important object of the present invention to provide annular bellow elements of a shape withstanding high pressure of the medium within the bellow, with relatively small wall thickness of the ring elements.

With this and further objects in view, as may become apparent from the within disclosures, the invention consists not only in the structures herein pointed out and illustrated by the drawings, but includes further structures coming within the scope of what hereinafter may be claimed.

The character of the invention, however, may be best understood by reference to certain of its structural forms, as illustrated by the accompanying drawings in which:

Figs. 1 and 2 are fragmentary sections of two types of bellows having the invention applied thereto.

Fig. 3 is a diagrammatic section indicating the manner in which the shape of the bellow elements may be ascertained by computation.

Fig. 4 is a diagrammatic fragmentary section indicating two possible forms of tubular connecting members between the bulbous bellow elements, and

Fig. 5 is a diagram illustrating the optimum ratio of wall thickness of the pipe to thickness of the ring elements in dependence of the ratio of pipe diameter to ring diameter.

Similar characters of reference denote similar parts in the different figures.

Broadly speaking, the present invention contemplates the provision of bulbous collars for the expansion elements of the bellow which are so shaped that the strain therein owing to the interior pressure is substantially the same on all points and in any section of the collar.

Referring now to the drawings in greater detail, and first to Figs. 1 and 2, it will be noted that the resilient collar portions of the elastic tubular body consists of two shell members or annular disks 11, 12, or 11', 12', resp., which are welded together at 13, and moreover are welded to the pipe ends 15 at 14. The shell portions are so shaped that in case of inner pressure acting within the pipe the stresses set up in the shells are pure longitudinal stresses (i. e. no transverse stresses), and normally tension stresses only, while pressure stresses which might cause bending or bumps cannot occur. Thus, the duration of life of the resilient body which is greatly reduced in the known forms of resilient tubular bodies by bending and bumping phenomenons, especially at high pressure, is considerably increased.

Fundamentally, the shell portions to this end are shaped in such a manner that their interior curvature is concave throughout, without any portions having a convex inner curvature or a non-curved, straight form over a finite length. Preferably, I use a shape defined by a so-called nodoid surface (refer, e. g., Auerbach-Hort, Handbuch der Physikalischen und Technischen Mechanik, vol. VII, pp. 46–48) which depending on its use may be applied in its original shape, as shown in Fig. 1, or in a shape which is distorted by affinity or otherwise, as shown in Fig. 2. A special advantage of the nodoid surface consists in the fact that the radii of curvature of its generating or cross sectional curve are decreasing continuously from its outer part towards its inner part, i. e., as shown in Fig. 3, $r_1 > r_2 > r_3$, whereby a shell of uniform strength is produced. Where a distorted nodoid surface is used, as per Fig. 2, its generating curve may be shaped so that at least a negative or concave curvature is ensured on all points. In other words, the generating curve or cross sectional line of the shells should be curved in only one direction throughout, avoiding any points of inflection or straight portions.

In order to avoid tensions or strains due to different elongations of the tubular portions 15 and the shell portions at the welds 14, I have computed the optimum proportions of pipe thickness to shell thickness in dependence of the ratio of pipe diameter to shell diameter. The straight lines shown in Fig. 5 define the region of dependence which is formed by the four straight lines *a*, *b*, *c*, *d*, whose formulae are put hereunder, viz:

$$\left.\begin{array}{ll} (a) & \frac{h_R}{h}=9{,}5\,\frac{D_i}{D_a}-2{,}2 \\ (b) & \frac{h_R}{h}=9{,}5\,\frac{D_i}{D_a}-0{,}6 \end{array}\right\} \text{up to } \frac{D_i}{D_a}=\text{about } 0{,}6$$

in which

$$\left.\begin{array}{ll} (c) & \frac{h_R}{h}=32\,\frac{D_i}{D_a}-17 \\ (d) & \frac{h_R}{h}=32\,\frac{D_i}{D_a}-13 \end{array}\right\} \text{upwards of } \frac{D_i}{D_a}=\text{about } 0{,}6;$$

in which

h_R=wall thickness of tube
h=wall thickness of shells
D_I=tube diameter
D_a=diameter of shells,

as shown in Fig. 3.

The above mentioned definition gives a very reliable welded connection between tube 15 and shells 11, 12, or 11', 12', preventing the welds 14 (Figs. 1 and 2) from tearing. The tubular connecting member 15 between the adjacent shells may be formed in any desired manner, for ex-

ample, cylindrically, as indicated at 16 in Fig. 4, or with an inward curvature, as indicated at 17 in Fig. 4.

The method and apparatus of the present invention have been described in detail with reference to specific embodiments. It is to be understood, however, that the invention is not limited by such specific reference but is broader in scope and capable of other embodiments than those specifically described and illustrated in the drawings.

FRIEDRICH TÖLKE.