July 11, 1961 J. A. BROPHY, JR 2,991,509

CORRUGATED DIAPHRAGM MANUFACTURE

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Fig. 1

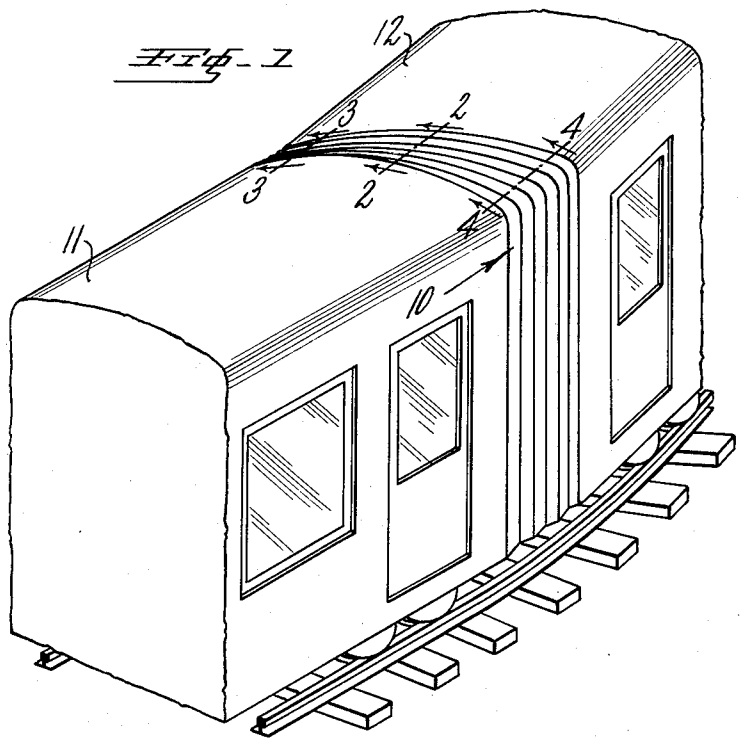



Fig. 5

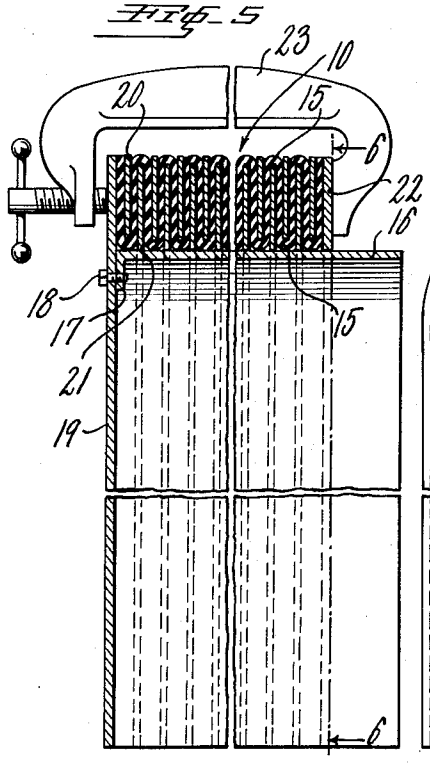
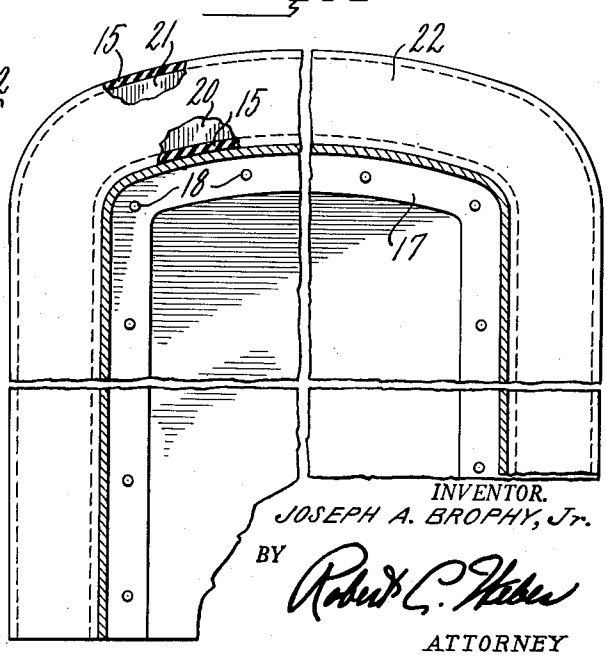



Fig. 6




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Fig. 3

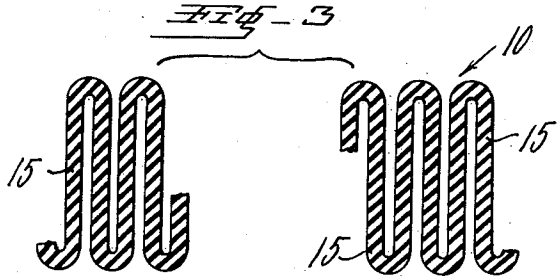



Fig. 2

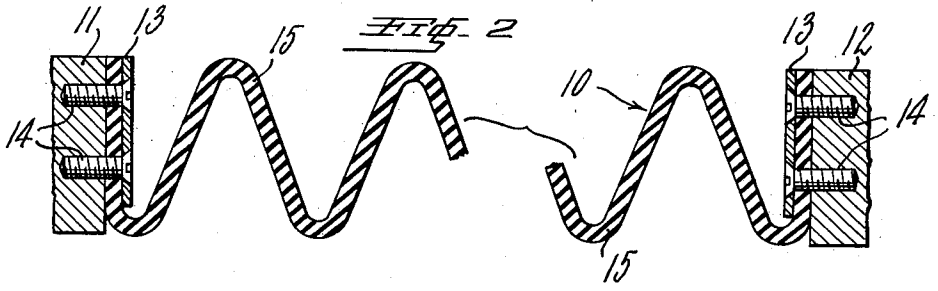



Fig. 4

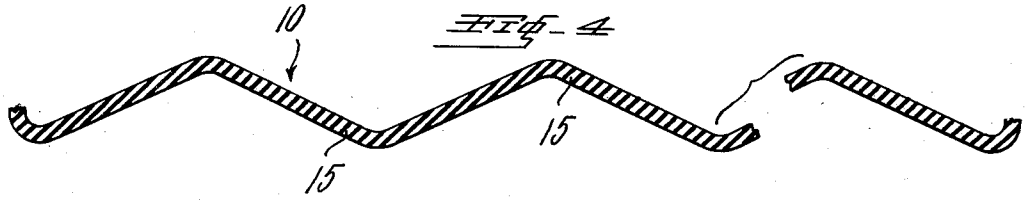
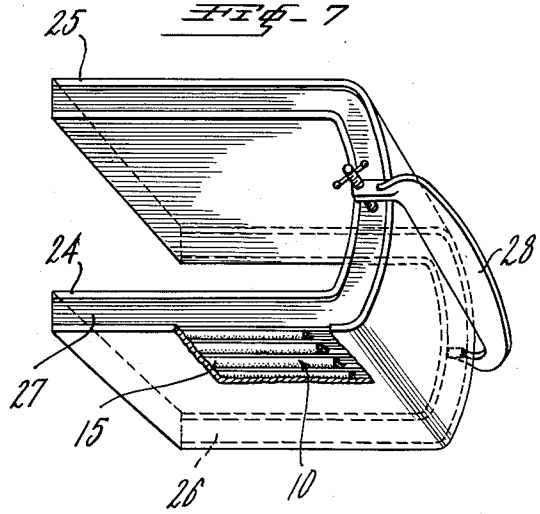



Fig. 7




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# CORRUGATED DIAPHRAGM MANUFACTURE

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This invention relates to corrugated diaphragm manufacture and more particularly to an improved flexible, corrugated diaphragm for connecting two articulated members such as train members, and an improved method of making said diaphragm.

Diaphragms now in use are usually of the following types. The first type consists of sheets of fibrous material which are folded to form pleats or corrugations, the latter being sewn along their edges to prevent the sheets from flattening out. As a rule, this type of diaphragm is not pre-formed to the cross-sectional contour of the articulated train members, depends solely on the length of the material to compensate for expansion or contraction as the train rounds a curve, and is prone to sag between the members, which decreases its abrasion resistance. Moreover, being made entirely of fabric, such diaphragms have low flame resistance.

The second type consists of sheets of elastic material such as rubber, which may or may not be corrugated and which are usually molded in a press. Like the first type, the conventional elastic diaphragm is initially expensive to manufacture and is usually not pre-formed to the cross-sectional contour of the train members. Moreover, most of these elastic diaphragms depend solely upon the stretchability of the material to compensate for expansion and contraction as the train members move into and out of longitudinal alignment. As a consequence, the elastic material is continuously under stress during such movement, especially at points of attachment to the train members, thereby substantially reducing the service life of such diaphragms.

Accordingly, an object of the invention is to provide an improved method of making a diaphragm wherein a continuous sheet of elastic material, prior to being cured, is pre-formed over a mandrel to the cross-sectional contour of the articulated train members and folded between a plurality of spacer plates positioned alternately over and under the sheet to form a plurality of corrugations therein, which corrugations extend continuously transversely of the members throughout the extent of the diaphragm to permit relative movement between the members.

Another object of the invention is to provide an improved corrugated diaphragm which is connected to the articulated train members in partially extended condition so that the corrugations therein can simultaneously expand and contract as the members move relatively into and out of longitudinal alignment, as when the train rounds a curve, without depending solely upon the length or stretchability of the elastic diaphragm material but rather upon its resiliency, thereby prolonging its service life.

Another object of the invention is to provide an improved method of making such diaphragms, which method has the advantages of low cost fabricating equipment, ease of fabrication, and produces a diaphragm whose finished appearance closely approximates that of a more costly molded item.

Still another object of the invention is to provide a diaphragm which acts as a protective cover for passengers when passing from one train member to the other, which in connecting the members will present the train as one continuous unit, which has improved resistance to tearing, flame, abrasion and weather, which is adapted to



connect various types of train members and effectively seal the same against weather, smoke and dust, and which, while being flexible, substantially maintains its cross-sectional contour when connected between the members, under all conditions of stress or compression.

Other objects and advantages of this invention will become apparent upon consideration of the following specification and claims when read in conjunction with the accompanying drawings wherein:

FIG. 1 is a partial perspective view illustrating a diaphragm embodying the invention and serving to connect two articulated train members as they round a curve;

FIG. 2 is a partial sectional view taken on line 2—2 of FIG. 1;

FIG. 3 is a partial sectional view taken on line 3—3 of FIG. 1;

FIG. 4 is a partial sectional view taken on line 4—4 of FIG. 1;

FIG. 5 is an elevational sectional view of the apparatus or form used in one method of practicing the invention;

FIG. 6 is a sectional view taken on line 6—6 of FIG. 5, with portions of the apparatus or form being broken away, and

FIG. 7 is a perspective view partially in section, illustrating the apparatus or form used in a modification of the aforesaid method of practicing the invention.

Referring to FIG. 1, the flexible, corrugated diaphragm **10** is shown connecting the two articulated train members **11, 12**. As will be apparent, the diaphragm **10** is formed to coincide with the cross-sectional contour of the members **11, 12**, which in this instance, is substantially U-shaped. Referring to FIG. 2, the diaphragm **10** is attached to members **11, 12** by means of plates **13** and screws **14**, and as will be seen from both FIGS. 1 and 2, diaphragm **10** is folded into a plurality of corrugations **15** which extend continuously transversely of members **11, 12** throughout the extent of the diaphragm.

The diaphragm **10** is preferably formed as a continuous sheet of elastic material such as natural or synthetic rubber, or the like, which may be internally reinforced with one or more layers of fibrous material, such as rayon tire cord or the like. In any event, the diaphragm **10** is sufficiently strong enough to support its own weight when connected between members **11, 12**, that is, to substantially maintain its (and the train members') cross-sectional shape, whether in extended or contracted position.

Referring to FIG. 2 once again, it illustrates the condtion of the diaphragm **10** at its central portion as the train members **11, 12** round a curve. This condition is substantially the same as when the diaphragm **10** is installed, wherein it is partially extended so that it can simultaneously expand and contract as the train members **11, 12** move into and out of longitudinal alignment, as when the train rounds a curve. FIG. 3, which is a section taken adjacent the inside of the curve, illustrates how the diaphragm **10** contracts when the members **11, 12** are close together. On the other hand, FIG. 4, which is a section taken adjacent the outside of the curve, illustrates the expanded condition of the diaphragm **10**, when the members **11, 12** are far apart.

As will be pointed out more in detail below, the diaphragm **10** is cured in the contracted condition shown in FIG. 3. Accordingly, when installed between the members **11, 12**, the diaphragm **10** is partially extended, as shown in FIG. 2, but when permitted to do so, will return to its original, contracted condition because of the resiliency of the elastic material. As will be apparent from FIG. 4, the length of the diaphragm **10** is sufficient to permit the members **11, 12** to round a curve without stretching the elastic material itself.

Accordingly, unlike the prior art fibrous, pleated dia-

phragms, the diaphragm **10** is not reliant solely upon the length of material used, but rather upon its resiliency. Likewise, in contrast to conventional, un-corrugated elastic diaphragms, the diaphragm **10** does not rely solely upon the stretchability of the elastic material but rather upon its resiliency, and is so designed that it is not continuously subjected to tensile stresses; therefore it will have a much longer service life.

In practicing the invention, the diaphragm **10** in flat sheet form is laid over a mandrel having substantially the cross-sectional contour of the articulated train members, and is then folded between a plurality of spacer plates positioned alternately over and under the sheet to form a plurality of corrugations **15** therein.

Referring to FIGS. 5 and 6, one method embodying the invention will now be described. The apparatus or form provided, comprises a substantially U-shaped mandrel **16** having an internal flange **17**. Attached to flange **17** by means of screws **18** is a substantially U-shaped backing plate **19** which extends transversely of the mandrel **16** and outwardly from the flanged end thereof. The uncured flat sheet comprising diaphragm **10** is laid over mandrel **16**, one end of the sheet being folded transversely outwardly of the mandrel **16** and positioned against the backing plate **19**. A substantially U-shaped spacer plate **20** is then positioned over the sheet transversely of the mandrel **16** and is moved toward the backing plate **19** against the outwardly folded end of the sheet. Another substantially U-shaped spacer plate **21**, slightly smaller in diameter than plate **20**, is positioned under the sheet transversely of the mandrel **16** and is moved towards the plate **20** to fold the sheet outwardly therebetween transversely of the mandrel. Another plate **20** is placed over the sheet transversely of the mandrel **16** and is moved towards plate **21** to fold the sheet inwardly therebetween transversely of the mandrel, to form the first two corrugations **15**.

The steps of positioning and moving additional spacer plates **20, 21** are then continued until the desired number of corrugations **15** are formed in the sheet. At this point, the opposite end of the sheet is then folded outwardly transversely of the mandrel **16**, and another substantially U-shaped backing plate **22** is positioned against this outwardly folded opposite end.

The corrugated sheet forming diaphragm **10**, the backing plates **19, 22** and the spacer plates **20, 21** are then clamped together by a plurality of the conventional C-clamps **23** (only one of which is shown) to form an assembly. The screws **18** are then taken out and this assembly, including backing plate **19**, is removed from the mandrel **16** and placed in a vulcanizer (not shown) to cure the diaphragm **10**. After curing, the assembly is removed from the vulcanizer and disassembled, the completed diaphragm **10** having the desired cross-sectional contour of train members **11, 12** in FIG. 1 as well as being in contracted condition as shown in FIG. 3.

Referring now to FIG. 7, a modified method of practicing the invention will now be described. The apparatus or form used therein comprises a pair of concentrically spaced inner and outer mandrels **24** and **25** respectively, and a backing plate **26** extending transversely of these mandrels and outwardly from one end of the inner mandrel **24** to the adjacent end of the outer mandrel **25**. As will be apparent, both the procedural steps and the form or apparatus employed in this modified method are quite similar to those described above with reference to FIGS. 5 and 6; the mandrels **24, 25** and backing plate **26** having the substantially U-shaped cross-sectional contour of the articulated train members **11, 12**. However, in the modified method, the backing plate **26** rests upon the ground with the mandrels **24, 25** extending substantially vertically upwardly therefrom, as opposed to the substantially horizontal mandrel **16** in FIGS. 5 and 6.



The steps of laying the sheet forming diaphragm **10** over the inner mandrel **24**, folding the ends of the sheet outwardly transversely of and between mandrels **24** and **25**, positioning and moving the spacer plates (not numbered) relatively towards each other and the backing plate **26** to form the corrugations **15** in the diaphragm **10**, and positioning the other backing plate **27** are all substantially the same as described above in reference to FIGS. 5 and 6. However, the assembly operation is speeded up and made easier because the mandrels **24** and **25** both act as guides, permitting the spacer plates to fall readily into position.

When the formation of the assembly has been completed, the various components are clamped together by a plurality of conventional C-clamps **28** (only one of which is shown) corresponding to C-clamps **23**. However, the extra step of removing the assembly from the form is eliminated, as both are simply inserted within the vulcanizer (not shown) where the diaphragm **10** is cured. After curing, the assembly is removed from the vulcanizer and dissasembled, the completed diaphragm **10** having the desired cross-sectional contour of train members **11, 12** and being in contracted condition, as noted above in reference to FIG. 5 and 6.

The modified method of FIG. 7 is preferred where smaller and shorter diaphragms are to be made, because it is easier; quicker; requires less manual labor, and the forms can be made of relatively light weight, inexpensive material, so that a relatively large number of forms can be used without slowing down production by reason of having the forms in the vulcanizer. The method described with reference to FIGS. 5 and 6 is preferred where relatively larger and longer diaphragms are to be made, as well as where the corrugations formed are relatively deep, because the diaphragm is more accessible for adjustments which may become necessary during formation, than in the modified method. Also, since the mandrel **16** is relatively large and long, it is preferred that the assembly be removed therefrom in order to conserve space in the vulcanizing apparatus and to eliminate any mandrel "down time."

While certain embodiments of the invention have been described and illustrated herein, it is to be understood that various modifications may be made in the invention without departing from the scope thereof, as defined in the appended claims. For example, the diaphragm **10** has been referred to herein as having a substantially U-shaped cross-section corresponding to that of the train members **11, 12**. Obviously, the diaphragm and the forms employed could readily be modified to a complete or partial curvilinear or polygonal form for connecting not only train members, but other articulated members such as pipes, conduits, etc. In addition, the opposite ends of the sheet forming the diaphragm **10** need not be folded outwardly transversely of the mandrel, as in FIG. 5, but could be folded inwardly thereof so that the plates **13** in FIG. 2 would not be visible from the exterior of the train. Likewise, the diaphragm **10** could readily be fastened to the articulated members **11, 12** in other ways and by various other means such as zippers, bolts, etc.; or a plurality of diaphragms could be used to connect each pair of articulated members, which diaphragms, in turn, could be fastened together by zippers or like attaching means.

Having thus described my invention, what I claim and desire to protect by Letters Patent is:

1. A method of making a flexible, corrugated diaphragm for connecting two articulated members, comprising the steps of laying a unitary sheet of elastic material over a mandrel having the cross-sectional contour of said members, positioning a first spacer plate having said contour over said sheet transversely of said mandrel, folding said sheet outwardly of said mandrel along said first spacer plate, positioning a second spacer plate having said contour under said sheet transversely of said

mandrel, moving said second plate toward said first plate and against the portion of said sheet folded outwardly therebetween, folding said sheet inwardly of said mandrel along said second spacer plate, positioning a third spacer plate having said contour over said sheet transversely of said mandrel, moving said third plate toward said second plate and against the portion of said sheet folded inwardly therebetween, folding said sheet outwardly of said mandrel along said third spacer plate, continuing the aforesaid positioning, moving and folding steps with additional spacer plates in the same alternating sequence until the desired number of corrugations are formed in said sheet, clamping said sheet and said plates together, curing said sheet to set the same in corrugated form, and thereafter unclamping said sheet and plates and removing the latter from said corrugated sheet.

2. A method of making a flexible, corrugated diaphragm for connecting two articulated members, comprising the steps of providing a form comprising a mandrel and a backing plate extending transversely of said mandrel and outwardly from one end thereof, said mandrel and said backing plate having the cross-sectional contour of said members, laying a unitary sheet of elastic material over said mandrel, folding one end of said sheet transversely of said mandrel, positioning said one end of said sheet against said backing plate, positioning a first spacer plate having said contour over said sheet transversely of said mandrel and against the folded end of said sheet, folding said sheet outwardly of said mandrel along said first spacer plate, positioning a second spacer plate having said contour under said sheet transversely of said mandrel and against the portion of said sheet folded along said first spacer plate, folding said sheet inwardly of said mandrel along said second spacer plate, continuing in an alternating sequence the positioning of additional first spacer plates over said sheet and associated outward folding of said sheet along said additional first spacer plates and the positioning of additional second spacer plates under said sheet and associated inward folding of said sheet along said additional second spacer plates substantially up to the other end of said sheet, to thereby form a plurality of corrugations in said sheet, positioning another backing plate having said contour against said other end of said sheet as folded transversely of said mandrel, clamping said sheet, said backing plates and said spacer plates together, curing said sheet to set the same in corrugated form, and thereafter unclamping said sheet and plates and removing the latter from said corrugated sheet.



3. A method of making a flexible, corrugated diaphragm for connecting two articulated train members, comprising the steps of providing a form comprising a pair of concentrically spaced inner and outer mandrels and a backing plate extending transversely of said mandrels and outwardly from one end of said inner mandrel to the adjacent end of said outer mandrel, said mandrels and said backing plate having the cross-sectional contour of said members, laying a unitary sheet of elastic material over said inner mandrel and within said outer mandrel, folding one end of said sheet transversely of and between said mandrels, positioning said one end of said sheet against said backing plate, positioning a first spacer plate having said contour over said sheet transversely of and between said mandrels, folding said sheet outwardly of said inner mandrel along said first spacer plate, positioning a second spacer plate having said contour under said sheet transversely of and between said mandrels, moving said second spacer plate against the portion of said sheet folded along said first spacer plate, folding said sheet inwardly of said inner mandrel along said second spacer plate, continuing the aforesaid positioning, moving and folding steps with additional spacer plates alternately over and under said sheet substantially up to the other end of said sheet, to thereby form a plurality of corrugations in said sheet, folding said other end of said sheet transversely of and between said mandrels and along the last spacer plate, positioning another backing plate having said contour against said other end of said sheet transversely of and between said mandrels, clamping said sheet, said backing plates and said spacer plates together, curing said sheet within said form to set said sheet in corrugated condition, and thereafter unclamping said sheet and plates and removing the latter from said corrugated sheet subsequent to extraction thereof from said form.

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