Oct. 22, 1957 A. E. HEWITT 2,810,400

REINFORCED FLEXIBLE DUCT

Filed Aug. 24, 1954

Fig. 1

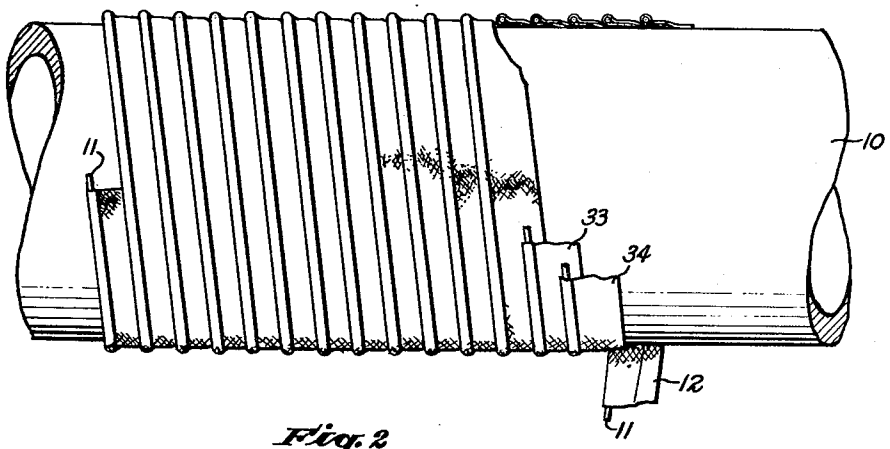


Fig. 2

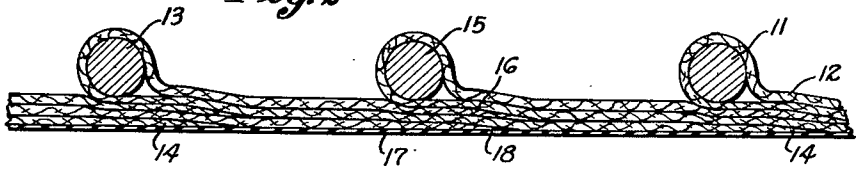


Fig. 5

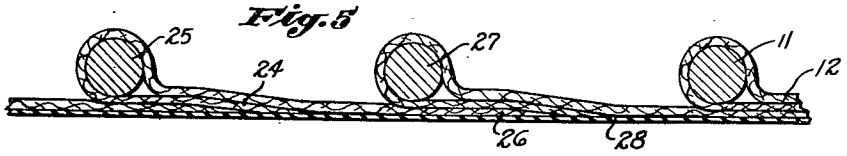


Fig. 3

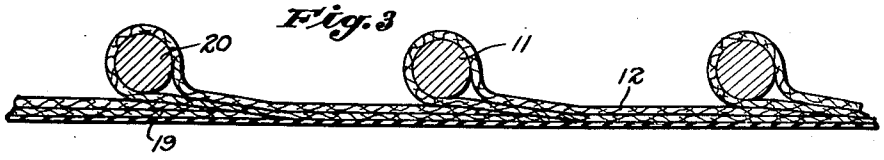


Fig. 4

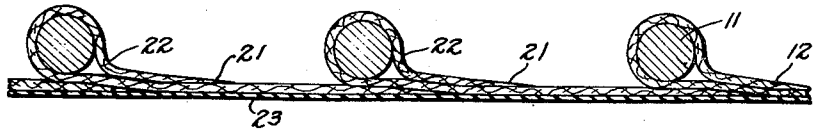
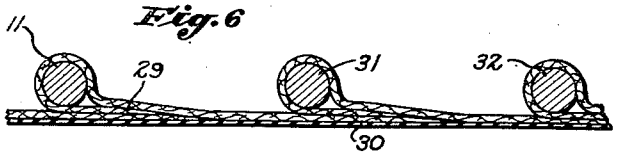


Fig. 6



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REINFORCED FLEXIBLE DUCT

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7 Claims. (Cl. 138—56)

This invention relates to a flexible duct construction, and particularly to a construction of a reinforced, flexible, fabric duct in which the spiral reinforcing strand is firmly enclosed within the wall of the duct. The invention relates more specifically to a duct construction in which the completed duct is produced by spirally wrapping a tape on a mandrel, cementing or vulcanizing the edges to form a unitary structure.

The invention is illustrated by drawings which show in Figure 1 the operation of winding the duct on a mandrel. Figures 2–6 show in cross-sections one wall of the duct in five modifications to be described hereinafter.

Heretofore in the manufacture of flexible ducts it has been the practice to wrap a sheet or a strip of fabric on the mandrel, then apply a reinforcing strand to the outside if desired, and finally cover the reinforcing with an additional covering of tape or fabric strip. The reinforcing is usually wire, to provide rigidity to the duct in a radial direction while maintaining flexibility in a longitudinal direction. It has usually been the practice to apply the reinforcing spirally and lock the ends of the reinforcing wire to the wall of the duct. It has also been the practice to apply a cement, for example, rubber cement, plastic, etc., to the fabric before applying the final wrapping, thereby securing the various elements in their desired position. This method of construction has had the disadvantage of leaving seams on the surface of the duct where the edges of fabric joined and these were usually fastened by sewing or by cementing. However they were fastened, the seams generally required an extra operation to protect them and prevent the wall of the duct opening along the line of the seam. Also the manufacture of ducts of this type has required numerous operations, usually at least three operations being necessary, including the primary winding of fabric, the winding of the reinforcing wire and the final winding of overlying fabric or tape to hold the reinforcing wire in the proper position.

In another method of making flexible ducting, the fabric tape was folded over the reinforcing wire and wound into a tubular form by a "head" whereby a set of rollers coiled the tape into a continuous duct in which the seams were either cemented or sewed during the coiling operation. The resulting duct was not smooth internally, but presented a succession of ridges and valleys to the fluid stream transported therein, much as does a corrugated tube.

It is an object of this invention to reduce the number of operations required in the manufacture of ducts of the reinforced flexible type, thereby reducing the cost of manufacture. Another object of the invention is to provide a duct of the reinforced flexible type in which no seams are apparent on the outside or the inside surfaces of the duct.

Another object of the invention is to provide a flexible duct with a smooth, cylindrical interior when extended, thereby providing maximum fluid carrying capacity with minimum turbulence. Previous methods of duct manufacture have left ridges on the inside to interfere seriously with flow of air thru the duct.

A further object of the invention is to make a spirally wound duct with cemented seams or laps without defects caused by separation of the seams. Ducts of this type have heretofore not met the rigid requirements of the aviation industry, owing to the hazard resulting from occasional failure of seams not properly cemented or vulcanized. The manner of accomplishing these objects will be shown in the following description of the invention.

Referring to the drawings, Figure 1 shows the manner of wrapping the duct on the mandrel **10**. This is done by applying to the mandrel a tape in which the reinforcing strand **11** is folded within a strip of fabric **12**, with the wire **11** at one edge of the tape. This is most conveniently done by applying the tape to a rotating mandrel having the diameter of the desired duct. The tape with wire enfolded can be prepared in advance or the wire can be folded in the tape at the point of winding on the mandrel. The tape is applied with sufficient tension to bind the windings firmly against the mandrel, placing the laps under compression to unite them with a firm bond. Before winding, the tape is impregnated with a suitable adhesive, usually rubber or other elastomer, which not only seals the pores of the fabric, but also cements the successive windings together. For this purpose, I may use cements of natural rubber or synthetic rubber such as Buna-S, Buna-N, "butyl," neoprene, lactoprene, Thiokol or silicone rubber (polysiloxane), etc. After the duct is wound, applying the wrappings under tension, the entire assembly is vulcanized while under tension by heating in the usual manner, for example, in an autoclave. In the case of rubber, either natural or synthetic, vulcanization is usually accomplished by heating to a temperature of about 250–300° F., sulfur and accelerators being employed in the composition to effect rapid vulcanization. In the case of certain other elastomers, such as silicone, vulcanization is effected by heat and catalysts, for example, peroxides.

The fabric employed can be made of any of the common fibers such as cotton, rayon, etc., but ducts to be used at elevated temperatures should employ glass fiber. The impregnating cement can be applied to the fiber by any of the usual methods such as dipping in a solution of cement, by the application of latex, or spraying, or spreading with a knife. The fabric tape, which can be cut on the bias if desired, is wrapped about the reinforcing strand which is usually a steel wire, but it can be any desired strand of high tensile strength. Thus, I may use a heavy filament of plastic such as an extruded nylon wire or rod, or a hard-twisted cord of cotton, glass fiber, or other fibrous material. Other metals can also be employed for the reinforcing strand, for example, aluminum can be employed where it is desired to keep down the weight of the construction. It is desirable to coat the mandrel before wrapping with a suitable release agent which will prevent the tape sticking to the mandrel and facilitate removal of the duct. Various materials are available for this purpose such as silicone resins, when rubber cement is employed. After curing, the duct is removed from the mandrel by the application of air pressure and other well known methods of stripping.

An import element in the manufacture of the improved duct is maintenance of tension on the tape and the reinforcing strand during the curing operation, thereby firmly bonding the layers of tape together as shown in Figures 2–6, which are sectional drawings of different methods of assembling the duct. Thus, in Figure 2, the tape is shown wrapped about the wire **13** starting from a point **14**, passing under wire **15**, then clockwise about the wire **13** to a point **16**. This, of course, is repeated for each winding, thereby providing four layers of tape

beneath the wire as shown, and making a firm bond between the layers of fabric which are compressed between the wires **13**, **15**, etc. and the mandrel underlying the tape. A thin layer of rubber or other elastomer, **17**, lies next to the mandrel and fills the spaces between the joints of the fabric and the mandrel as at **18**, thus providing a smooth inner surface for the duct when vulcanized. This layer or lining **17** is usually formed from the cement which is applied to the tape before winding.

The duct wall of Figure 2 is triple ply with the edges bound beneath the adjacent reinforcing strand, one edge passing beneath two strands. In Figure 3, a double ply construction is shown with one edge **19** of the tape locked and concealed between two layers of fabric beneath reinforcing wire **20**. No seam is exposed on the outer surfaces of duct walls shown in Figures 2 and 3.

Figure 4 shows a single ply construction with an external seam at **21**. When wrapping, the tension of the tape causes it to hug the wire closely as shown at **22**. The internal surface layer is shown at **23**.

The single ply wall construction shown in Figures 4, 5, and 6 are designed for ducts with a high flexibility requirement. The walls shown in Figures 5 and 6 expose no seam on the outside. Thus in Figure 5, the fabric extends from **24** around wire **25**, thence to edge **26** beneath wire **27**. Inner liner **28** completes the assembly.

In Figure 6, the edge **29** is concealed between two layers of fabric, while the "long" edge **30** passes beneath the adjacent wire strand **31** and about half way to the next strand **32**, thus providing an unusually well bonded duct wall having the high flexibility of a single ply construction.

Figure 1 shows a double pitch winding in which two strips of tape **33** and **34** are wound simultaneously. However, I usually prefer to employ a single pitch winding, applying a single strip of tape with enclosed reinforcing strand. The ends of the wire may be secured to the wall of the duct in the manner shown in co-pending patent application, Serial Number 297,046, now Patent No. 2,697,452, December 21, 1954. I can also employ two or more strands of reinforcing in a single tape, thus producing a duct with double, single, etc. pitch of the reinforcing strand. For rough service, I can apply a wear strip to the outside of the duct to overlie the reinforcing wire. This can be done on the finished duct, but for convenience, it can best be applied before curing while the duct is on the mandrel. The wear strip can be of harder, less flexible fabric than that employed in the body of the duct, providing the edges of the wear strip are spaced apart sufficiently to allow free movement of the wall of the duct exposed between the reinforcing turns.

Where a "soft" end is desired on the duct, the reinforcing strand can be removed near the end of the duct by slitting the layer of fabric overlying it. Thus, several turns of wire can be removed at the end of the completed, vulcanized duct to provide an end which can be stretched or expanded over a rigid nipple and clamped on to provide a tight, strong connection. A strip of bias tape an be applied to the area where the wire is removed. Other modifications will occur to those skilled in the art.

In my improved duct construction, I have provided ducting which can be made simply and at lower cost than previously while retaining the smooth bore for high velocity transmission of fluids, particularly air and other gases up to temperatures of 600° F. in the case of silicone impregnated glass fiber.

Having thus described my invention, what I claim is:

1. A reinforced flexible duct having a spiral, inelastic reinforcing strand completely enclosed in fabric tape having one free edge with said reinforcing strand folded within the other edge, the windings of said fabric tape forming said duct being spirally wound in the direction exposing said reinforced edge on the outside of said duct and cemented together without the free edge of said tape being visible on the external surface of said duct.

2. The method of making a reinforced flexible duct which comprises enclosing a stiff reinforcing strand within a fabric tape impregnated with a suitable cement, spirally wrapping said tape and strand on a mandrel under tension sufficient to bind together the layers of fabric firmly against the mandrel, the direction of the wrapping being such that the edge of the tape enclosing the reinforcing strand overlies the free edge of the winding previously applied, thereafter curing the assembled duct on the mandrel while under said tension to effect a firm bond between the layers of fabric under the pressure applied by the reinforcing, and finally removing the cured duct from the mandrel.

3. The method of making a reinforced flexible duct which comprises folding a reinforcing wire within a fabric tape impregnated with a rubber cement, thereby providing a winding strip having a wire enclosed at one edge, spirally wrapping said strip on a mandrel under tension sufficient to bind together the layers of fabric by the pressure exerted by the said wire and said mandrel, wrapping said strip on said mandrel in the direction such that the edge of the strip enclosing the reinforcing wire overlies the free edge of the winding previously applied, thereafter vulcanizing the assembled duct while on the mandrel with said wire under tension to effect a firm bond between the layers of fabric maintained under the pressure applied between the reinforcing wire and the mandrel, and finally removing the cured duct from the mandrel.

4. The method of claim 3 wherein the winding strip is impregnated with rubber cement before enclosing the reinforcing wire therein.

5. The method of claim 3 wherein the rubber cement employed is silicone rubber, and the fabric is of glass fiber.

6. A flexible, reinforced, fabric duct having a smooth, cylindrical interior, the walls thereof being formed of spirally wound tape enfolding a reinforcing strand in one edge thereof, the free edge of the tape opposite said strand being bound at each turn beneath the adjacent coil of reinforcing strand, adjacent coils being firmly cemented together with an elastic, rubber-like cement distributed between the layers of said spirally wound tape, only that edge of said tape enclosing said reinforcing strand being visible on the external surface of said duct.

7. The duct of claim 6 wherein one of said free edges of tape extends beneath two adjacent coils of reinforcing strand.

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