PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements relating to Flexible Tubing

We, HOOVER LIMITED, a company registered under the laws of Great Britain, of Perivale, Greenford, Middlesex, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to flexible tubing or hose and is particularly, though not exclusively, applicable to the production of a hose for use with a suction cleaner, either of the so-called canister type, or of the handle-propelled type provided with a converter for off-the-floor cleaning.

The invention is concerned with a flexible hose comprising a tube of resilient material formed with deep inwardly and outwardly opening helical corrugations and a resilient helical reinforcing coil forming a tension spring tending to close up.

Such a hose can be manufactured with a high degree of flexibility and extensibility but precautions may be necessary to ensure that the convolutions of the reinforcing coil do not become displaced from the corrugations in which they are supposed to rest, for example if the hose is greatly extended or sharply flexed, or is abused, for example by being trodden on. It is possible to bond the reinforcing coil to the resilient tube but this in turn may introduce difficulties. In particular there is a danger that if the reinforcing coil is bonded to the corrugation around that part of the circumference of the filament which is embraced by the corrugation in the relaxed state, then when the tube is flexed or extended there is a tendency for the bond to be separated along its edge, and this may weaken or even start a tear in the material of the tube.

Thus according to the present invention the tube consists solely of a thin elastomeric material and one of the corrugations is unoccupied, whilst the other, in the normal relaxed condition, embraces the filament of the reinforcing coil round at least half its circumference but is free to unwrap itself from the filament as the hose is extended.

Conveniently the filament of the reinforcing coil comprises resilient wire coated with an elastomeric material. The elastomeric material may also conveniently be a synthetic thermoplastic material, for example elastomeric polyvinyl chloride.

The reinforcing coil may be received in the outwardly opening corrugation, but in general, for a suction hose it is preferable that it should be received in the inwardly opening corrugation.

Preferably the construction is such that when the hose is longitudinally compressed and then relaxed, each corrugation which embraces the reinforcing filament remains in contact with the opposed part of neighbouring corrugations in the gap between neighbouring convolutions of the reinforcing coil.

Preferably the depth of the unoccupied corrugation is such as to permit the hose to extend to at least twice its free length without substantial longitudinal stretching of the corrugated tube.

The invention is also concerned with simple and efficient methods, suitable for mass production, of making such a flexible hose.

According to this form of the invention a method of making such a flexible hose includes longitudinally extending the coil, fitting a tube of the elastomeric material inside or outside the reinforcing coil when so extended, allowing or causing the tube to bulge between the convolutions of the coil in a deep helical corrugation while allowing the coil to contract longitudinally and heat-treating the assembly to cause the tube to take a permanent set in its deeply corrugated state.

Where the reinforcement is to be inside the tube the method may include longitudinally extending the coil, and expanding to a diameter greater than that of the coil a tube of the thermoplastic material having a free diameter less than that of the coil, and fitting it over the coil when so extended, releasing the

[*Price 3s. 6d.*]

tube and reinforcement to allow the tube to contract radially and the coil to contract longitudinally, and heat-treating the tube by heating it whilst so released and free from any substantial external force. Such a method is claimed in the present applicants' divisional Patent Specification No. 15667 of 1956 (Serial No. 800,372).

The tube may be fitted over the reinforcing coil by inflating it, passing it over the coil, and deflating it to allow it to embrace the coil.

Preferably the coil is wound so that in its free state adjacent convolutions are in contact. The methods referred to above, in which the deep corrugations are formed with the hose free from any substantial external force, are preferred. In certain circumstances, however, it may be desirable to assist the formation of the corrugations, and in this case the method may be in accordance with the present applicants' divisional Patent Specification No. 35196 of 1956 (Serial No. 800,373) and may include applying a fluid pressure difference between the inside and the outside of the tube to cause it to bulge between the convolutions of the coil in the deep helical corrugation while allowing the coil to contract longitudinally, and heat-treating the assembly. Such a method is particularly applicable if the coil is outside the elastomeric tube.

In any case it is preferred that the coil should be extended to a length at least twice its free length, possibly approximately four times its free length.

Where the elastomeric material is elastomeric polyvinyl chloride the heat treatment may comprise heating to a temperature between 150° F. and 180° F. Such heat treatment may be effected by immersing the hose in hot water.

In general the free length of the tube should be substantially the same as that of the coil when the latter is extended.

The invention provides a hose which is ultraflexible and also extensible since the deep corrugations in the tube wall need only be straightened out as the hose is flexed or extended, without the necessity for any longitudinal stretching of the tube wall. At the same time the corrugations are such as to retain the convolutions of the reinforcing coil in position with the aid of friction alone, and without the necessity for bonding, so that when the hose is stretched or flexed certain areas of the corrugation and the reinforcement which are in contact when the hose is collapsed can separate, thereby avoiding the tendency to weaken or tear the tube in these areas.

The invention may be carried into practice in various ways but certain specific embodiments will be described by way of example with reference to the accompanying drawings, in which:—

Figure 1 is a longitudinal section of one form of hose manufactured in accordance with the invention;

Figure 2 is a similar section of a modified form of hose;

Figures 3 and 4 show an apparatus used for inserting the reinforcing coil into the outer tube;

Figure 5 shows the shape of the tube after removal from the mandrel;

Figure 6 illustrates the formation of the deep corrugations in the hose of Figure 1, and

Figure 7 illustrates the formation of the deep corrugations in the hose of Figure 2.

One or each form of hose, and/or method of making it, is also described in the present applicants' divisional Patent Specifications Nos. 15667 of 1956 (Serial No. 800,372) 35196 of 1956 (Serial No. 800,373) and 35197 of 1956 (Serial No. 800,374).

Each of the hoses shown in Figures 1 and 2 comprises a helically corrugated thermoplastic tube 10 and a composite helical reinforcing coil 11 comprising a reinforcing wire 12 and a sheath or coating 13 of a thermoplastic material. In Figure 1 the reinforcing coil 11 is inside the tube 10, or received in the inwardly opening corrugation, whilst in Figure 2 it is outside the tube or received in the outwardly opening corrugation.

In the hoses of both Figures 1 and 2 the tube 10 is deeply corrugated and the composite reinforcing element 11 is normally contracted longitudinally so that its coils are substantially in contact, being separated only by the thickness of the walls of the corrugated tube 10.

In Figure 1 the tube 10 is formed internally with deep valleys 14 in which the reinforcing element 11 is situated, and with ridges 15, the walls of which extend between the coils of the composite reinforcing element 11. In Figure 2 the tube is formed with internal valleys 16 and ridges 17 and the coils of the composite reinforcing element are positioned externally between the ridges 17 and are separated only by the walls of the tube 10 which form the internal valleys 16. In each case the reinforcing element 11 is normally stressed so as to occupy the collapsed position but is easily extended if the hose is flexed or elongated. The walls of the tube 10 forming the ridges 15 of Figure 1 and the valleys 16 of Figure 2 can straighten out when the hose is stretched or flexed without being restricted by the composite reinforcing element 11 and without necessitating any longitudinal stretching of the material of the tube. These features render the hose extremely flexible and easily extensible, both of these features being of particular value in a hose intended for use with suction cleaners.

In each modification the internal ridges and valleys are of soft material which will not readily reflect sound waves, so that objectionable whistling noises will not be produced as

has sometimes occurred with hoses of other constructions.

In the construction of Figure 1 the interior ridges 15 are elongated when the hose is stretched. In a specific embodiment in the collapsed position the internal diameter of the hose is approximately 1.39 inches whereas in its fully extended position its internal diameter is equal to that of the composite reinforcing element 11, which is 1.45 inches. In the construction of Figure 2 the internal diameter of the hose is substantially unaffected by stretching.

In each construction in one specific embodiment the reinforcing wire 12 is of steel 0.058 inches in diameter and the coating 13 is approximately 0.010 inches in thickness, making the complete diameter of the coated wire 0.078 inches. The tube 10 is conveniently made of vinyl chloride having a wall thickness of 0.022 inches and a tensile strength of 2000 pounds per square inch at 80° F. The coating 13 may be made of the same material as the tube.

While the above figures are not critical for making hose for other uses they have been found satisfactory for making hose for suction cleaners.

The strength and diameter of the steel wire, the thickness and hardness of the sheath and the thickness and hardness of the tube will all to some extent determine the extensibility and flexibility of the finished hose and may be varied considerably for producing hoses of different strengths and flexibilities for different uses. The wire 12 may be tightly coiled with its convolutions in contact with each other either before or after the coating 13 is applied. By varying the amount of pre-stress applied to the pre-coiled spring the free length and flexibility of the hose may be varied. The method of forming a close-coiled spring is known and it is considered unnecessary to describe it.

The steel wire may be replaced by aluminium or aluminium alloy wire of suitable diameter and stiffness.

The coating 13 may be applied to the wire 12 in any suitable manner, for example by extrusion.

It is not necessary that the composite reinforcing coil 11 should be bonded or cemented to the tube 10 since it will be effectively trapped by the deep corrugations formed within the tube 10. In addition since both the tube 10 and the coating 13 are made of thermoplastic material there will be sufficient frictional resistance between them to prevent displacement of the element 11 from the corrugations of the tube 10.

The hose shown in Figure 1 may be assembled with the aid of the apparatus illustrated in Figures 3 to 6 inclusive, in the following manner.

The polyvinyl chloride coating 13 is preferably applied to the wire 12 by extrusion before the wire is coiled, thereby simplifying the coating operation. The coated wire is then wound into a pretensioned helical coil, for example with the aid of a machine as described in British Patent Specification No. 673,043. The coil is placed on a mandrel 20 of smaller diameter than the coil 11 and stretched lengthwise to the position shown in Figure 3, in which the length of the coil is from two to four times its free length, and is held in this position by means of suitable clamps at the ends of the mandrel.

The mandrel 20, with the extended coil 11 on it, is then placed in a rigid pipe 21 having an air hose 22 communicating with its interior. One end of the tubing 10, of which the inside diameter is less than that of the coil, is then clamped to the open end of the pipe 21 by means of a clamp 23 whilst the opposite end is closed by a clamp 24. Air under pressure is then supplied to the hose 22 to inflate the tube 10, and the pipe is tilted as shown in Figure 4 so that the mandrel 20 with the coil 11 on it slides down into the inflated part of the tube 10 as shown in Figure 4.

The air pressure is then released and the tube 10 will deflate and contract round the reinforcement as shown in Figure 5. The tube is cut off at the clamp 24 and removed from the mandrel.

The assembly is then heat-treated to cause or allow the tube to bulge between the convolutions of the coil in a deep helical corrugation while the coil contracts longitudinally.

In some cases this may be assisted by suction, in which case the tube 10 with the reinforcement in it is then placed in the apparatus 26 shown in Figure 6 in which one end of the tube 10 is clamped to a suction pipe 27 whilst the other end is clamped to a movable carriage 28. Suction is applied through the pipe 27 and at the same time the tube and coil are heated to a temperature of about 180° F. The suction will cause the hose 10 and coil 11 to collapse to the position shown in Figure 6, and the heat applied will soften the tube and relax the stresses in it. While the hose is still warm it may be stretched to break any adhesion which may have occurred between adjacent corrugations. When the hose cools it will take a permanent set in the shape shown in Figure 1, thereby rendering the deep corrugations permanent.

The manufacturing process is, however, considerably simplified if, as is preferred, the properties and dimensions are so chosen that the tube will bulge to form the corrugation, and will contract longitudinally, without the application to it of any substantial external force. Such a process forms the subject of the present applicants' British Patent Specification No. 15667/56 (Serial No. 800,372). For example in Figure 5 hot air may be supplied by a pipe 25.

In a further alternative method (not illus-

trated in the drawings) the hose is heat-treated by immersion in a bath of hot water maintained at a temperature of from 150° to 180° F. by a suitable thermostatically controlled heating element. If steel reinforcement is employed the ends of the hose may be plugged to prevent entry of water, but if aluminium wire is used the water should be allowed to enter the hose to make it sink, in which case it must be dried after curing. The hose need only be immersed for a few seconds, although the time of immersion is not critical provided the water temperature is maintained within the range referred to.

Prior to heat treatment the tube is subject to three types of stress. First since the unstretched inside diameter of the tube is less than the outside diameter of the coil, its walls will tend to be drawn inwards between the convolutions of the coil, as shown in Figure 5. Secondly as the reinforcing coil is stretched to several times its free length it will tend to return to the closely coiled position. Thirdly the original extrusion of the tube will have set up stresses tending to shorten it both lengthwise and circumferentially. As soon as the hose is warmed, whether by hot air or hot water, the material of the tube will soften in a few seconds and the stresses in it will be relaxed and its wall will move inwards as the spring contracts and will form the deep corrugations 15 without the application of any external force whatsoever. It has in fact been found that positively holding the hose in its collapsed position prior to heating may actually be harmful in that minute cracks may be formed in the tubing.

The length of the tubing used per convolution of spring, whilst not actually critical, is important. It has been found in practice that a length of from 168 to 170 inches of tube to 512 convolutions of spring is suitable for forming a hose which will not produce a whistling sound in use and in which the convolutions of the coil will not become displaced by flexing or by stretching of the hose.

The extent to which the reinforcing coil 11 is extended when making a hose determines the length of tubing 10 which is used and therefore determines the depth of the corrugations 15 which will be formed in the finished hose. It will therefore also determine the extent to which the finished hose may be extended. Accordingly by varying the extent to which the coil 11 is stretched in manufacturing the hose the extensibility and flexibility of the finished hose may be varied.

While the diameter of the coil, the diameter and thickness of the tube, the length of the unstretched coil and the length of the tube may vary widely for making hoses of different sizes and for different purposes, the following has been found very satisfactory for making suction cleaner hose according to the present invention. The coil 11 may have an inside diameter of $1\frac{3}{8}$ inches and the tube 10 an original inside diameter of $1\frac{1}{4}$ inches and a thickness of 0.022 inches. A coil having an unstretched length of 39 to 40 inches may be used with a tube 170 inches long.

By using parts having the foregoing dimensions and the method of the present invention a hose having the following characteristics may be formed. When the hose is removed from the mandrel 20 it will contract from 170 inches to approximately 77 inches if no compressing force is applied. When a compressing force is applied it will contract to approximately 62 inches. Such a hose, by the application of a 4-pound axial pull can be stretched to 165 inches or $13\frac{3}{4}$ feet and when the force is released it will return to a free length of 77 inches and can be returned to a length of 62 inches for storage.

For assembling the form of hose shown in Figure 2 the apparatus shown in Figure 7 may be employed. In this case the pre-coiled and pre-coated composite reinforcing coil 11 is placed outside the tube 10 and the assembly is placed within a steel pipe 30, one end of the tube 10 being clamped to a head 31 by which air under pressure may be applied, whilst its other end is clamped to an opposite head 32 through which hot air or steam may be applied. The air under pressure causes the walls of the tube 10 to be forced out between the coils of the element 11 to form the deep internal valleys 16 shown in Figure 7 (and incidentally in Figure 2) whereby the coils of the element are effectively trapped between adjacent valleys 16, the coils being separated only by the two walls of the corrugations. The warm air or steam will cause the tube 10 to assume the position shown since the coil 11 was pre-stressed to assume a closed position.

In each of the constructions shown the tube 10 when allowed to cool takes a permanent set in accordance with the shape assumed and hence becomes permanently formed with deep corrugations.

The tendency of the reinforcing coil is, moreover, to close up longitudinally so that adjacent corrugations are in contact in the gap between adjacent convolutions of the coil. The properties of the tube will generally be such that after being extended the hose does not return of its own accord to this completely closed position, but only to a position in which there is a slight gap between adjacent corrugations, but if then longitudinally compressed it will remain in the closed position when subsequently released.

WHAT WE CLAIM IS:—

1. A flexible hose comprising a tube of resilient material formed with deep inwardly and outwardly opening helical corrugations and a resilient helical reinforcing coil forming a tension spring tending to close up, in which the tube consists solely of a thin elastomeric material and one of the corrugations is

trated in the drawings) the hose is heat-treated by immersion in a bath of hot water maintained at a temperature of from 150° to 180° F. by a suitable thermostatically controlled heating element. If steel reinforcement is employed the ends of the hose may be plugged to prevent entry of water, but if aluminium wire is used the water should be allowed to enter the hose to make it sink, in which case it must be dried after curing. The hose need only be immersed for a few seconds, although the time of immersion is not critical provided the water temperature is maintained within the range referred to.

Prior to heat treatment the tube is subject to three types of stress. First since the unstretched inside diameter of the tube is less than the outside diameter of the coil, its walls will tend to be drawn inwards between the convolutions of the coil, as shown in Figure 5. Secondly as the reinforcing coil is stretched to several times its free length it will tend to return to the closely coiled position. Thirdly the original extrusion of the tube will have set up stresses tending to shorten it both lengthwise and circumferentially. As soon as the hose is warmed, whether by hot air or hot water, the material of the tube will soften in a few seconds and the stresses in it will be relaxed and its wall will move inwards as the spring contracts and will form the deep corrugations 15 without the application of any external force whatsoever. It has in fact been found that positively holding the hose in its collapsed position prior to heating may actually be harmful in that minute cracks may be formed in the tubing.

The length of the tubing used per convolution of spring, whilst not actually critical, is important. It has been found in practice that a length of from 168 to 170 inches of tube to 512 convolutions of spring is suitable for forming a hose which will not produce a whistling sound in use and in which the convolutions of the coil will not become displaced by flexing or by stretching of the hose.

The extent to which the reinforcing coil 11 is extended when making a hose determines the length of tubing 10 which is used and therefore determines the depth of the corrugations 15 which will be formed in the finished hose. It will therefore also determine the extent to which the finished hose may be extended. Accordingly by varying the extent to which the coil 11 is stretched in manufacturing the hose the extensibility and flexibility of the finished hose may be varied.

While the diameter of the coil, the diameter and thickness of the tube, the length of the unstretched coil and the length of the tube may vary widely for making hoses of different sizes and for different purposes, the following has been found very satisfactory for making suction cleaner hose according to the present invention. The coil 11 may have an inside diameter of 1⅜ inches and the tube 10 an original inside diameter of 1¼ inches and a thickness of 0.022 inches. A coil having an unstretched length of 39 to 40 inches may be used with a tube 170 inches long.

By using parts having the foregoing dimensions and the method of the present invention a hose having the following characteristics may be formed. When the hose is removed from the mandrel 20 it will contract from 170 inches to approximately 77 inches if no compressing force is applied. When a compressing force is applied it will contract to approximately 62 inches. Such a hose, by the application of a 4-pound axial pull can be stretched to 165 inches or 13¾ feet and when the force is released it will return to a free length of 77 inches and can be returned to a length of 62 inches for storage.

For assembling the form of hose shown in Figure 2 the apparatus shown in Figure 7 may be employed. In this case the pre-coiled and pre-coated composite reinforcing coil 11 is placed outside the tube 10 and the assembly is placed within a steel pipe 30, one end of the tube 10 being clamped to a head 31 by which air under pressure may be applied, whilst its other end is clamped to an opposite head 32 through which hot air or steam may be applied. The air under pressure causes the walls of the tube 10 to be forced out between the coils of the element 11 to form the deep internal valleys 16 shown in Figure 7 (and incidentally in Figure 2) whereby the coils of the element are effectively trapped between adjacent valleys 16, the coils being separated only by the two walls of the corrugations. The warm air or steam will cause the tube 10 to assume the position shown since the coil 11 was pre-stressed to assume a closed position.

In each of the constructions shown the tube 10 when allowed to cool takes a permanent set in accordance with the shape assumed and hence becomes permanently formed with deep corrugations.

The tendency of the reinforcing coil is, moreover, to close up longitudinally so that adjacent corrugations are in contact in the gap between adjacent convolutions of the coil. The properties of the tube will generally be such that after being extended the hose does not return of its own accord to this completely closed position, but only to a position in which there is a slight gap between adjacent corrugations, but if then longitudinally compressed it will remain in the closed position when subsequently released.

WHAT WE CLAIM IS:—

1. A flexible hose comprising a tube of resilient material formed with deep inwardly and outwardly opening helical corrugations and a resilient helical reinforcing coil forming a tension spring tending to close up, in which the tube consists solely of a thin elastomeric material and one of the corrugations is

* C L M S *

unoccupied, whilst the other, in the normal relaxed condition, embraces the filament of the reinforcing coil round at least half its circumference, but is free to unwrap itself from the filament as the hose is extended.

2. A hose as claimed in Claim 1 in which the filament of the reinforcing coil comprises resilient wire coated with an elastomeric material.

3. A hose as claimed in Claim 1 or Claim 2 in which the reinforcing coil is received in the outwardly opening corrugation.

4. A hose as claimed in Claim 1 or Claim 2 in which the reinforcing coil is received in the inwardly opening corrugation.

5. A hose as claimed in any one of the preceding claims in which, when the hose is longitudinally compressed and then relaxed, each corrugation which embraces the reinforcing filament remains in contact with the opposed part of neighbouring corrugations in the gap between neighbouring convolutions of the reinforcing coil.

6. A hose as claimed in any one of the preceding claims in which the depth of the unoccupied corrugation is such as to permit the hose to expand to at least twice its free length without substantial longitudinal stretching of the corrugated tube.

7. A hose as claimed in any one of the preceding claims in which the elastomeric material is a synthetic thermoplastic material.

8. A hose as claimed in Claim 7 in which the elastometric material is elastomeric polyvinyl chloride.

9. A method of making a flexible hose as claimed in any one of the preceding claims which includes longitudinally extending the coil, fitting a tube of the elastomeric material inside or outside the reinforcing coil when so extended, allowing or causing the tube to bulge between the convolutions of the coil in a deep helical corrugation while allowing the coil to contract longitudinally, and heat-treating the assembly to cause the tube to take a permanent set in its deeply corrugated state.

10. A method as claimed in Claim 9 in which the coil is wound so that in its free state adjacent convolutions are in contact.

11. A method as claimed in Claim 9 or Claim 10 in which the tube and reinforcement are released to allow the tube to contract radially and the coil to contract longitudinally, and the tube is heat-treated by heating it whilst so released and free from any substantial external force.

12. A method as claimed in any one of Claims 9 to 11 in which the tube is fitted over the reinforcing coil by inflating it, passing it over the coil, and deflating it to allow it to embrace the coil.

13. A method as claimed in Claim 9 or Claim 10 in which a fluid pressure difference is applied between the inside and outside of the tube to cause it to bulge between the convolutions of the coil in a deep helical corrugation while allowing the coil to contract longitudinally, and heat treating the assembly to cause the tube to take a permanent set in its deeply corrugated state.

14. A method as claimed in Claim 13 in which the coil is outside the elastomeric tube.

15. A method as claimed in any one of Claims 9 to 14 in which the coil is extended to a length at least twice its free length.

16. A method as claimed in any one of Claims 9 to 15 in which the elastomeric material is elastomeric polyvinyl chloride and the heat treatment comprises heating to a temperature between 150° F. and 180° F.

17. A method as claimed in any one of Claims 9 to 16 in which the heat treatment is effected by immersing the hose in hot water.

18. A method as claimed in any one of Claims 9 to 17 in which the free length of the tube is substantially the same as that of the coil when the latter is extended.

19. A method as claimed in any one of Claims 9 to 18 in which the filament of the reinforcing coil is of resilient wire coated with a thermoplastic material.

20. A method as claimed in Claim 19 in which the coating of thermoplastic material is applied to the wire by extrusion before the wire is wound into a helical coil.

21. A method as claimed in any one of Claims 9 to 20 in which the extended coil is placed on a mandrel and vibrated to space the turns uniformly before the tube is applied to it.

22. A flexible hose as specifically described herein with reference to Figures 1, 3 and 6, or Figures 2 and 7 of the accompanying drawings.

23. A method of making a flexible hose as specifically described herein with reference to Figures 1, 3 and 6 or Figures 2 and 7 of the accompanying drawings.

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