

Dec. 4, 1962

D. F. REAHARD
SUCTION CLEANER HOSE

3,067,083

Filed May 28, 1958

6 Sheets-Sheet 1

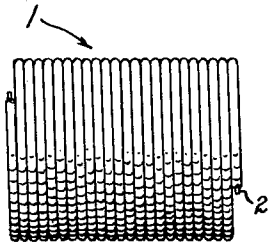


Fig. 1

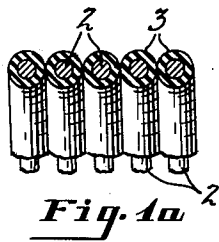


Fig. 1a

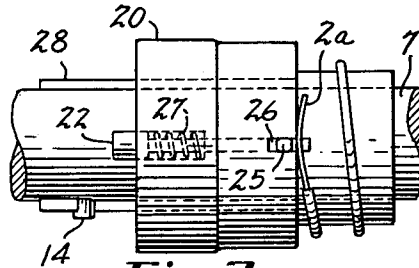


Fig. 2

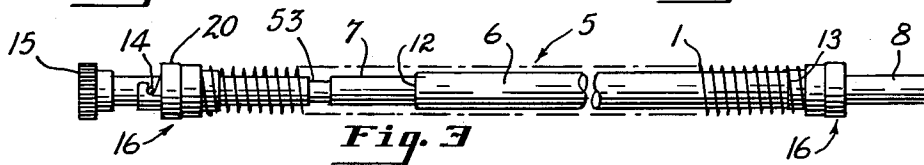


Fig. 3

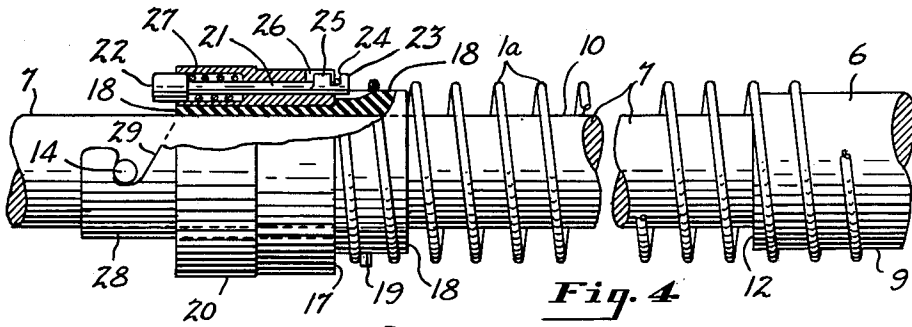


Fig. 4

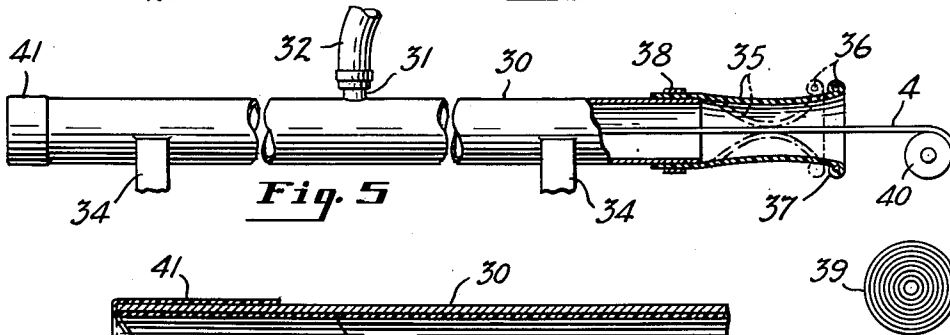


Fig. 5

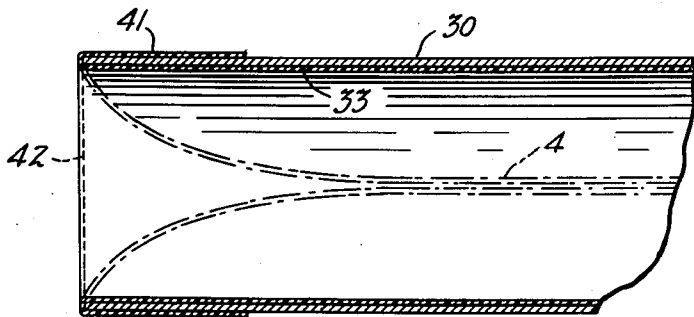


Fig. 6

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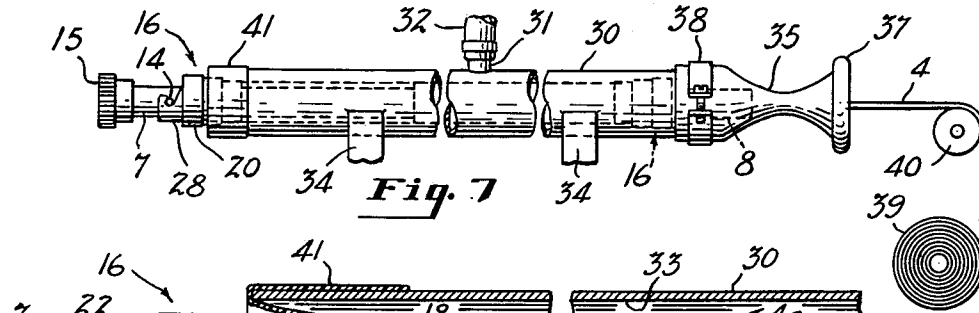
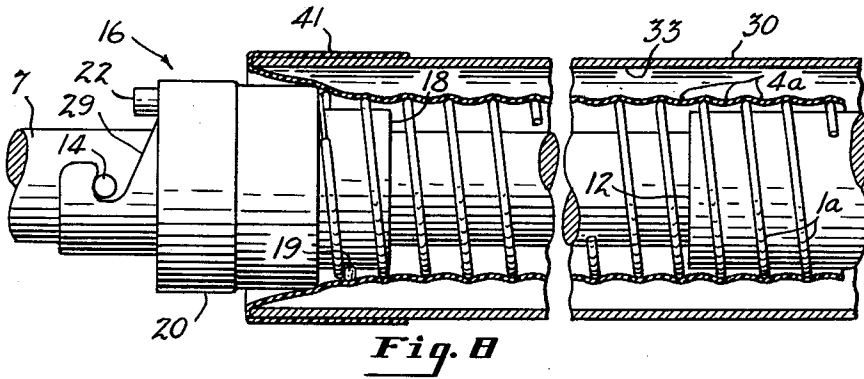
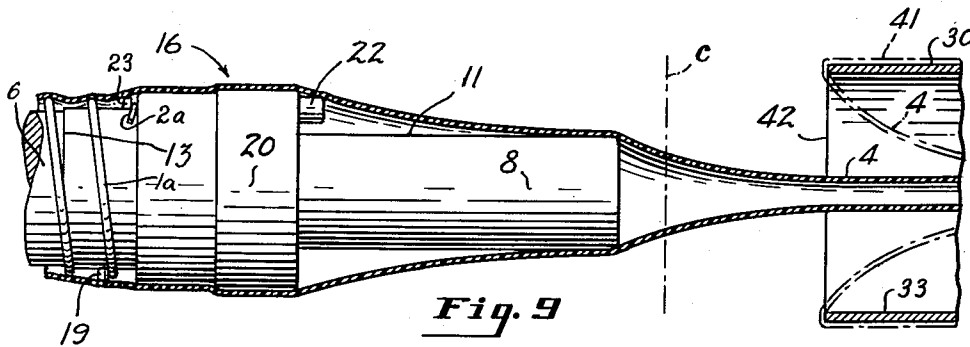
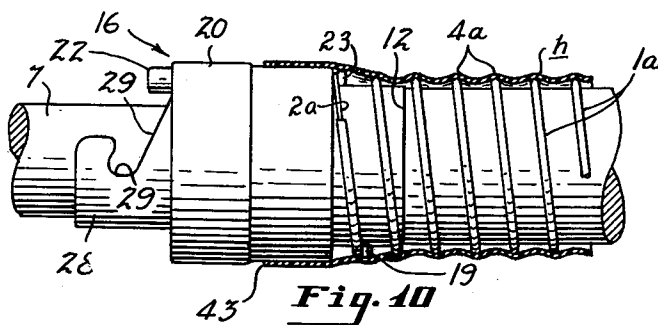
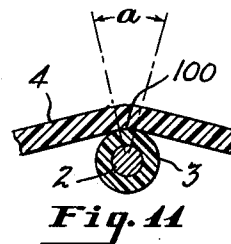
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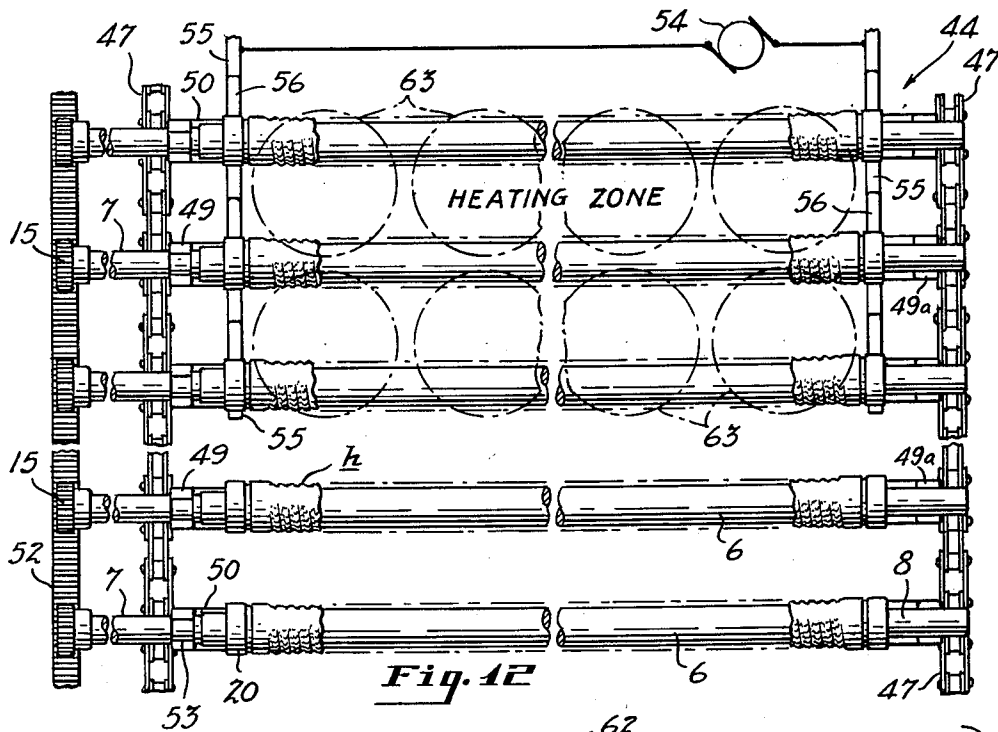
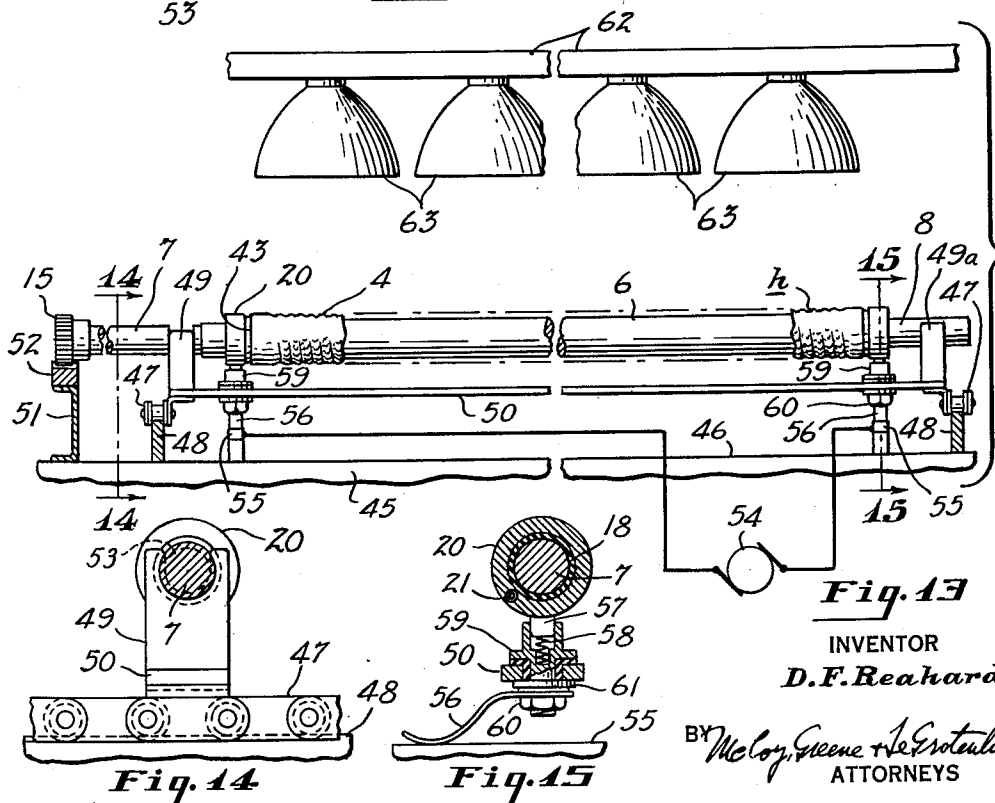
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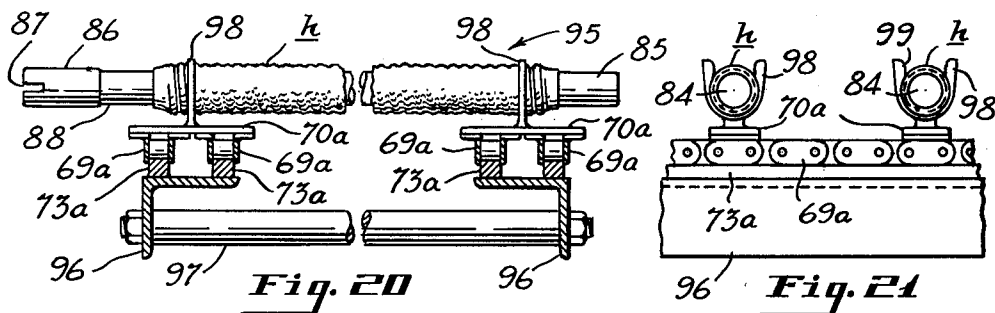
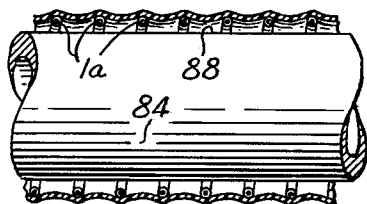


Fig. 22

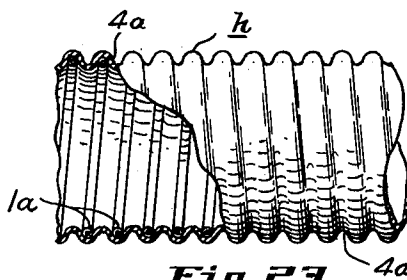


Fig. 23

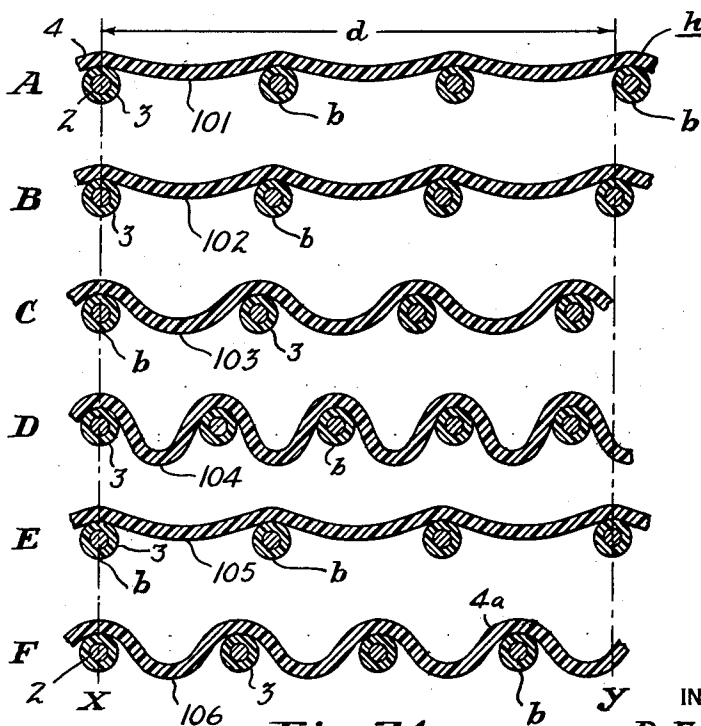


Fig. 24

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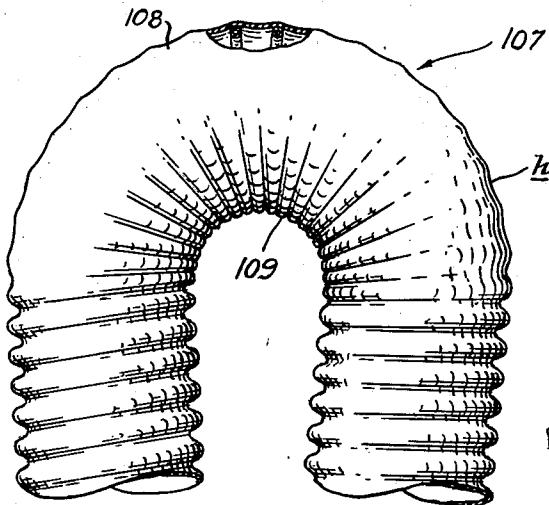


Fig. 25

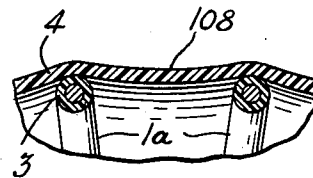


Fig. 26

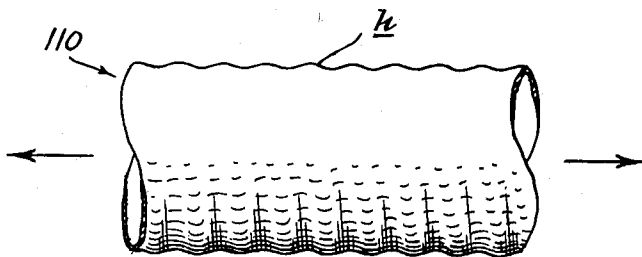


Fig. 27

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3,067,083

SUCTION CLEANER HOSE

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Filed May 28, 1958, Ser. No. 738,447

9 Claims. (Cl. 156-144)

The present invention relates to a flexible reinforced plastic hose and a method of making the same and more particularly to a method of making a wire-reinforced vacuum sweeper hose of plasticized polyvinyl chloride or the like.

Suction cleaner hose was originally made from rubber and fabric stiffened by a steel coil against collapse when suction was applied. The fabric served to equalize stresses during use and prevent flex cracking caused by localized stress. Such hose was expensive, however, and could not be made in light colors or pastel shades. To obtain light and attractive colors, it has been proposed to make suction cleaner hose from an extruded thin walled plasticized polyvinyl chloride or flexible plastic stiffened by a wire coil without any fabric reinforcing to mar the color and increase the cost. Such hose tended to crack and deteriorate rapidly in use. It was thought that perhaps abrasion of the plastic wall by the wire was at fault, and it was proposed to utilize a plastic-covered wire coil and to fuse or cement the plastic surface of the coil to the tube wall. This was accomplished by localized heating over the wire only. Electrical current was passed through the wire to heat the cement to fusion temperature. Such hoses tended to tear and deteriorate within a relatively short period of time particularly when jerked or whipped about during use to stretch the plastic material forming the wall of the tube. The performance of such hoses, therefore, was not satisfactory and did not compare with that of axially contracted hoses (for example, as disclosed in U.S. Patent No. 2,739,616) wherein heavy prestressed wire coils were merely locked in place by deep corrugations so that the loop portions formed by said corrugations were substantially closed and could be unfolded to permit bending of the hose without stretching the material forming the wall of the tube.

The present invention provides a simple inexpensive method of making flexible wire-reinforced hoses, similar in appearance to the flexible hoses first described above, which can withstand bending and whipping for almost twice as long as the similar hoses known prior to the invention. This method comprises stretching a flexible plastic tube radially beyond its elastic limit (or where it will not contract at room temperature to assume its original extruded diameter between the coil convolutions), allowing the tube to contract around an axially stretched plastic-covered wire coil, normalizing the tube by heating the hose on the axially stretched coil uniformly to cause the tube to contract radially because of its elastic memory and to cause it to relax and conform without substantial residual radial stress to the contacting surface of the plastic covered or coated wire coil without obtaining a permanent bond between the contacting plastic surfaces of the tube and the coil.

The hose is preferably then again normalized by heating it without axially stretching the same to remove any residual stresses due to axial stretching. The tube is permitted to contract during said heating so it has an internal diameter no greater than that of the coil and is then stretched to a predetermined length and cooled while held in an axially stretched condition. Since the elastic memory of the plastic tube was eliminated by the uniform normalizing in the first heating

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treatment, radial shrinkage in the second heating period when axial stress is removed is minimized and one does not end up with objectionably deep corrugations. The complete relaxation by uniform heating to remove all radial forces and then heating to remove axial stresses for some reason provides a hose of outstanding life.

The heating steps are controlled to anchor the coil in the tube and to avoid fusing the tube and the coil together so that the coil can be manually pulled out of the tube by a high axial force without tearing the tube. Such treatment eliminates the damaging tearing forces which are transmitted to the wall portions of the tube adjacent each coil convolution when such portions are stretched axially by bending of the hose. For some reason the cooling of the heated hose while in the stretched condition after normalizing tremendously increases the life of the hose.

It has been found that hose made according to the present invention is easily able to withstand continuous bending and whipping forces at least 50% longer than any similarly shaped hose known prior to the invention and is usually able to withstand whipping forces twice as long without tearing the tube. Because of the exceptional life of hose made according to the present invention, a large suction cleaner manufacturer now proposes to raise the minimum requirements for commercial suction cleaner hose from 50 to 250 percent in the standard tests used for such hose. Recently it has been proposed to raise the minimum standard for the whip test from 1200 cycles to 3000 cycles and to raise the minimum standard for the heat-cold-cycle test from 5 to 8. Prior to this invention, hose manufacturers found it difficult, if not impossible, when making the type of hose to which the present invention appertains, to produce hose which would meet the present minimum standards. It is manifest, therefore, that the present invention materially advances the art of making flexible hose.

An object of the present invention is to produce an attractive flexible plastic hose which is durable and extremely inexpensive.

A further object of the invention is to produce an inexpensive flexible plastic hose which does not crack or tear when subjected to severe dynamic operating conditions.

Another object of the invention is to provide a method of making plastic hose having an unusual ability to withstand whipping movements.

Other objects, uses and advantages of the present invention will become apparent from the following description and claims and from the drawings, in which:

FIGURE 1 is a fragmentary side elevational view with parts broken away and shown in section, showing the plastic-covered reinforcing coil used in the hose of the present invention;

FIGURE 1a is a fragmentary vertical sectional view of the coil of FIG. 1 on an enlarged scale;

FIGURE 2 is a fragmentary top view showing a coil-attaching sleeve and a portion of the mandrel on which the coil is mounted;

FIGURE 3 is a partly diagrammatic foreshortened side elevational view on a reduced scale showing the coil stretched axially on a mandrel;

FIGURE 4 is a foreshortened fragmentary side elevational view similar to FIG. 3 and on a larger scale with parts broken away and shown in section, the coil-attaching sleeve being shown in its axially outer position as in FIG. 3;

FIGURE 5 is a foreshortened side elevational view on a reduced scale with parts broken away and shown in section illustrating suction apparatus for radially ex-

panding the plastic tube which forms the wall of the hose, the rubber sleeve at one end being shown in solid lines in its position before the application of vacuum and being shown in dot-dash lines in its air-sealing position when vacuum is applied;

FIGURE 6 is a fragmentary vertical sectional view showing one end of the suction apparatus of FIG. 5 on a larger scale, the plastic tube being shown in solid lines in its radially expanded position and being shown in dot-dash lines in its released position prior to its radial expansion;

FIGURE 7 is a foreshortened side elevational view on a reduced scale showing the mandrel and coil of FIGS. 3 and 4 positioned within the suction apparatus of FIGS. 5 and 6 prior to the radial contraction of the plastic tube onto the coil;

FIGURE 8 is a fragmentary foreshortened vertical sectional view of one end of the apparatus shown in FIG. 7 on a larger scale, the plastic tube being shown in its position immediately after the vacuum is released to permit contraction of the tube;

FIGURE 9 is a fragmentary vertical sectional view on the same scale as FIG. 8 showing the parts in their positions just after the mandrel and the plastic tube thereon are pulled out of the suction apparatus, the end portion of the plastic tube being shown in dot-dash lines in its position after it is cuffed over the end of the metal pipe of such apparatus;

FIGURE 10 is a fragmentary side elevational view on the same scale as FIGS. 4, 6, 8 and 9 showing the position of the parts when the coil-attaching sleeve is in its axially innermost position against the stop shoulder;

FIGURE 11 is a fragmentary longitudinal sectional view showing the amount of contact between the plastic tube and the plastic outer surface of the coil when the hose is on the mandrel as shown in FIG. 10;

FIGURE 12 is a partly diagrammatic foreshortened fragmentary top view on a reduced scale with parts broken away and parts omitted showing apparatus for supplying heat uniformly to the hose mounted on the mandrel as shown in FIG. 10, radiant heaters being shown schematically in dot-dash lines;

FIGURE 13 is a foreshortened fragmentary side elevational view of the apparatus shown in FIG. 12 with parts omitted, the generator being shown schematically as in FIG. 12;

FIGURE 14 is a fragmentary side elevational view showing a portion of the conveyor of FIGS. 12 and 13 on a larger scale;

FIGURE 15 is a fragmentary vertical sectional view showing the electrical connection for supplying current to the mandrel;

FIGURE 16 is a diagrammatic side elevational view on a small scale with parts omitted and parts broken away showing the arrangement of the apparatus used to manufacture flexible hose according to the method of the present invention;

FIGURE 17 is a fragmentary side elevational view on a reduced scale but enlarged relative to FIG. 16, with parts omitted and with parts shown in vertical section illustrating the normalizing apparatus for removing stresses in the hose;

FIGURE 18 is a foreshortened fragmentary top view of the normalizing apparatus on a reduced scale with parts omitted;

FIGURE 19 is a fragmentary sectional view taken on the line 19—19 of FIG. 17 and on the same scale;

FIGURE 20 is a foreshortened fragmentary side elevational view on a reduced scale with parts omitted showing apparatus for cooling the hose while holding the hose in an axially extended position;

FIGURE 21 is a fragmentary side elevational view of the apparatus shown in FIG. 20 on the same scale;

FIGURE 22 is a fragmentary vertical sectional view showing the hose mounted on the mandrel as indicated

in FIG. 20, this view being enlarged with respect to this figure.

FIGURE 23 is a fragmentary side elevational view similar to FIG. 22 and on the same scale with parts broken away and shown in section showing the shape of the finished hose when the cooling operation is completed and the hose is released from the supporting yokes;

FIGURE 24 is an enlarged diagrammatic view drawn to scale showing the axial cross sections of the hose during the various steps of its manufacture;

FIGURE 25 is a fragmentary elevational view with parts broken away and shown in section showing the hose of the present invention subjected to sharp bending;

FIGURE 26 is an enlarged fragmentary vertical sectional view showing the radially outer portion of the hose of FIG. 25; and

FIGURE 27 is a fragmentary side elevational view showing the hose of the present invention as it appears when subjected to axial stretching.

Referring more particularly to the drawings in which like parts are identified by the same numerals throughout the several views, FIGS. 1 and 1a showing a helical cylindrical coil 1 which is made by winding a strand consisting of an electrically conductive wire 2 of circular cross section that is covered by an impervious plastic sleeve 3 of uniform radial thickness contacting the wire throughout its circumference. The coil 1 may be wound rapidly on an automatic machine and cut to the desired length. The coil may be wound with a positive pitch of two so that each convolution 1a is spaced from the adjacent convolution a distance corresponding to the external diameter of the sleeve 3, but it is preferably provided with a reverse pitch of at least one so that the wire is prestressed and holds the convolutions in axially contracted positions as shown in FIGS. 1 and 1a so that each convolution engages the adjacent convolution. The coil used in the hose of the present invention preferably has a reverse pitch of $\frac{1}{2}$ to 3 so that substantial force is required to separate the coil, convolutions.

The opposite end portions 2a of the metal wire are exposed by cutting away portions of the sleeve 3 to permit mounting the coil 1 on an aluminum mandrel 5 having an axial length of 9 to 15 feet. The mandrel has a main cylindrical portion 6 that extends the major portion of the length of the mandrel and has cylindrical end portions 7 and 8 of reduced diameter with smooth cylindrical outer surfaces 10 and 11 coaxial with the polished aluminum outer surface 9 of the main portion 6. Flat vertical annular shoulders 12 and 13 are provided at the opposite ends of the portion 6, and a radial pin 14 is provided near one end of the mandrel. A spur gear 15 is mounted on this end of the mandrel as shown in FIG. 3.

Identical, except as herein distinguished, coil-attaching sleeves 16 are slidably mounted on the two reduced portions 7 and 8, one sleeve being free to slide off the end of the portion 8 and the other sleeve being limited in its movement by the pin 14. Each coil-attaching sleeve has an insulating inner sleeve portion 18 made of a suitable electric insulating material and shaped to slide axially on the surface 10 or the surface 11, a radially projecting pin 19 attached to the sleeve portion 18, and an externally cylindrical copper contact annulus 20 rigidly mounted on the sleeve 18. Any suitable means may be used to provide an electrical connection between the wire 2 of the helical coil 1 and the annulus 20 and to hold the end of the coil. As herein shown both of these functions are performed by a steel plunger comprising a cylindrical rod 21 having an enlarged cylindrical head or button 22 at one end and an enlarged attaching portion 23 at its opposite end. The portion 23 is shaped to provide a straight lateral wire-receiving groove 24 of a size to receive the wire end portion 2a and to provide an upwardly extending guide lug 25. The guide lug fits

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in a slot 26 in the sleeve 20 which restricts axial movement of the head 22 by the spring 27 so that said head cannot leave its recess.

The coil 1 may easily be mounted on the main portion 6 of the mandrel when the sleeve 16 on the right hand end of the mandrel as viewed in FIG. 3 is removed from the portion 8, and one end of the wire may readily be connected to the other sleeve 16 carried by the portion 7 by pushing the button 22 when the sleeve is against the shoulder 12 to expose the groove 24 and placing the wire end 2a into said groove. At this time the portion of the first coil convolution 1a diametrically opposite said portion 2a is placed between the pin 19 and the sleeve 20 as shown in FIG. 4. When the pressure on the button 22 is removed, the spring 27 will grip the end portion 2a and hold it against the vertical shoulder 17 of the sleeve 20 so that the coil is firmly attached to the attaching sleeve 16. The other sleeve 16 may then be moved over the portion 8 against the shoulder 13 and attached to the other end of the coil in a similar manner while stretching the coil axially to the length of the main mandrel portion 6. After this attachment the coil 1 holds the two sleeves 16 against the shoulders 12 and 13. The sleeve 16 on the mandrel portion 7 may then be moved axially away from the shoulder 12 and attached to the pin 14 as shown in FIGS. 3 and 4. As herein shown one sleeve 16 has an axially projecting portion 28 with a slot 29 therein for receiving the pin 14. A readily releasable connection is preferred to save time. The pin 14 holds the coil 1 in an axially extended position as shown in FIGS. 3 and 4, the convolutions 1a being spaced uniformly because of the uniform construction of the coil 1.

FIGS. 5, 6 and 7 show an apparatus for expanding the cylindrical plastic tube 4 radially so as to permit insertion of the coil 1 into the tube. Such apparatus is in the form of a pipe 30 having a length greater than the distance between the shoulder 13 and the pin 14 and having a smooth cylindrical internal surface 33 with a diameter materially greater than the normal diameter of the tube 4 or the external diameter of the coil 1. A suction connection 31 is provided midway between the ends of the pipe 30 to receive a flexible suction hose 32 which is connected to a vacuum pump or other source of subatmospheric pressure.

A series of supporting legs 34 are welded to the pipe 30 so as to support the pipe in a horizontal position several feet about the floor. Means are provided for sealing one end of the pipe 30 so that it is unnecessary to cuff portions of the plastic tube over both ends of the pipe 30. As herein shown such means is in the form of a rubber sleeve 35 having an enlarged annular end portion 37 reinforced by an annular metal ring 36. The other end of the rubber sleeve is rigidly connected to the pipe 30 by a metal clamp 38. As herein shown the plastic tube 4 is wound on a supply roll 39 and is guided from said roll by a cylindrical guide roller 40 into the pipe 30 so that it is unnecessary to thread the tube 4 through the pipe after each operation. The end of tube 4 is turned over the end 42 of the pipe 30 as shown in FIG. 6 to form a cuff 41 having an axial width of $\frac{1}{2}$ to $2\frac{1}{2}$ inches so as to seal that end of the pipe. The other end of the pipe is sealed by inserting a rubber ball into the opening or by squeezing the rubber sleeve 35 during the application of the vacuum. The vacuum will maintain the seal and cause the tube 4 to expand radially from the position shown in dot-dash lines in FIG. 6 to the position shown in solid lines in that figure. When the tube is so expanded the mandrel of FIGS. 3 and 4 and the hose 4 thereon are inserted axially into the open end of the pipe 30 as indicated in FIG. 7.

The mandrel is positioned so that the entire coil 1 is within the pipe 30 and the vacuum is then released by admitting air between the surface 33 of the pipe 30 and the external surface of the tube 4. The tube does not

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contract radially to its extruded diameter because of the previous radial expansion but contracts radially an amount sufficient to grip the coil convolutions 10 as shown in FIG. 8 and to form corrugations or grooves 4a between convolutions. The cuff 41 is then pulled off of the pipe 30 and allowed to contract around the sleeve member 16 so as to free the hose from the suction apparatus. The mandrel with the hose thereon is then pulled axially out of the pipe 30 to the position shown in FIG. 9 so as to pull more of the tube 4 through the pipe 30 for a subsequent assembly operation. The tube 4 is then cut on the line c of FIG. 9 to separate the hose portion h of the tube which is on the mandrel 5 from the unused portion of the tube 4. The cut end portion of the unused tube may then be turned radially outwardly over the end 42 of the pipe 30 to form another cuff 41 as shown (FIG. 9) in dot-dash lines.

The attaching sleeve 16 is then rotated to disengage the pin 14 from the slot 29 to release the sleeve whereupon the tension in the coil 1 pulls the sleeve 16 against the shoulder 12 as shown in FIG. 10. The ends of the plastic tube 4 are then cut by moving a razor blade or knife around the circumference of the sleeve 16 to form flat end edges 43 adjacent the axially innermost edge of each sleeve 20 as best shown in FIG. 10 whereby each copper sleeve 20 is exposed for contact with a brush 57 to be described hereafter.

FIGURE 11 is drawn to scale to show the amount of contact between the tube 4 and the sleeve 3 of the hose h shown in FIG. 10. Since the coil 1 is stretched axially and since the tube 4 has been stretched beyond its elastic limit, the coil 1 and the tube 4 engage each other over a narrow helical zone having a substantially uniform width of about 0.1 to 0.3 times the diameter of the sleeve 3. The width of this zone is indicated in FIG. 11 by two dot-dash lines through the center of the coil which define an angle α . The angle α is usually about 20 to 40 degrees throughout the first heating operation and is preferably less than 30 degrees prior to heating of the tube h.

FIGURES 12 to 15 show a first normalizing apparatus 44 for heating the tube 4 to shrink the same and fix the axial position of the coil convolutions 1a relative to the tube 4 and relative to the corrugations 4a. Such heating apparatus includes a rigid metal frame including a table 45 having a polished aluminum cover surface 46 extending throughout its width and length. A pair of conveyor chains 47 are provided at each side of the table 45 and are driven by two pairs of sprockets 47a as indicated in FIG. 16.

The chains 47 are guided in parallel longitudinal directions by flat steel guide bars 48 rigidly mounted on the table 45. A series of yoke-shaped support brackets 49 and 49a are rigidly mounted on the chains 47 at regularly spaced locations, each bracket 49 on the chain at one side of the table being laterally aligned with a bracket 49a carried by the chain at the opposite side of the table and being rigidly connected thereto by a laterally extending supporting bar 50 as best shown in FIGS. 13 and 14. The supporting bracket 49 has means forming a semi-circular groove and fitting in annular groove 53 in the reduced portion 7 of the mandrel as indicated in FIGS. 13 and 14 to hold the mandrel against axial movement while permitting rotation of the mandrel about a horizontal axis. A channel 51 is rigidly mounted on the table 45 to provide a support for a longitudinally extending rack 52 parallel to the chains 47. The teeth of the gear 15 carried by the mandrel 5 mesh with the teeth of the stationary rack 52 throughout the longitudinal feeding of the laterally extending mandrels on the apparatus 44 to cause rotation of the mandrels as they move through the apparatus. The gear and rack have the disadvantage that they cannot change the speed of rotation with respect to the feed rate as is the case with the sprocket 78 and chain 80 of FIG. 18. It will be understood, however, that rotation of the

mandrels in the heating apparatus 44 may be affected substantially as in the apparatus 66 of FIGS. 17, 18 and 19.

The supply of heat by radiation or convection to the plastic hose will not be uniform unless heat is supplied to the metal wire of the coil 1 because of the localized cooling which is provided by a metal wire. In order to reduce or eliminate the localized cooling by the wire, it is preferable to pass an electric current through the wire or otherwise heat the wire. In this way a uniform heating of the hose can be effected during the supplying of radiant heat. Various means may be provided for passing the electric current through the wire during rotation of the mandrel. As herein shown the electric current is supplied from a direct current generator 54 through 2 copper bus bars 55 which are parallel to the chains 47. The bus bars are rigidly mounted on and insulated from the table 45. The current is carried from the bus bars to the wire 2 by the contact strips 56, the brushes 57, the copper sleeves 20 and the rods 21 as will be apparent from the drawings.

Each brush 57 is held in contact with a sleeve 20 by a spring 58 mounted within a plastic brush support and insulating member 59 which is rigidly connected to the supporting bar 50 and the contacting strip by a nut 60 and an insulating washer 61 as best shown in FIG. 15. The bar 50 may, therefore, be insulated from the electrical conductors. Any suitable radiant heaters may be provided to heat the hose *h* while the electric current is passed through the wire 2. As shown in FIGS. 12 and 13, supporting bars 62 are mounted in fixed positions above the table 45, and several rows of radiant heaters 63 are mounted on the bars. The heating of the wire-reinforced coil in combination with the radiant heating and the rotation of the hose provides uniform heating of the hose which, due to the elastic memory to the plastic tube 4, causes further radial contraction of the tube to grip the coil convolutions firmly. The polished aluminum surfaces 9 and 46 assist in effecting uniform heating by reflecting the heat back toward the hose. The surface 46 also prevents drafts of air which could adversely affect the uniform heating operation. The apparatus 44 is shown schematically in FIG. 16. It will be noted that the heating zone terminates before the end of the table to provide time for the operator to remove the mandrel from the conveyor. The bus bars 55 terminate at the last row of radiant heaters 63 as indicated in FIG. 12 so that the resistance heating of the wire ends when the supply of radiant heat is discontinued.

As soon as the mandrel carrying the hose leaves the heating zone, it is removed from the normalizing apparatus 44 and placed on a laterally extending asbestos trough 64 having a length 1 or 2 inches less than that of the mandrel. Said trough is mounted on a stand 65 in a fixed horizontal position to facilitate removal of the mandrel 5 from the hose *h*. Such removal is readily effected by depressing the buttons 22 of the coil-attaching members 16 to free the exposed wire ends 2a, removing the coil 1 from the pins 19, sliding one member 16 off the end portion 8 of the mandrel, and sliding the mandrel out of the hose *h*, leaving the hose resting in the trough 64. A second cylindrical aluminum mandrel 84 of smaller diameter is then inserted into the hose while the hose rests on the trough to prepare the hose for treatment in a second normalizing apparatus 66 as shown in FIGS. 16 to 19.

The normalizing apparatus 66 includes a rigid metal frame or table 67 which provides supports for four pairs of sprockets 68. These sprockets support a pair of heavy chains 69 at each side of the table formed by the frame 67 as indicated in FIG. 18. A series of rectangular supporting blocks 70 are rigidly mounted on the pair of chains at one side of the table, the right side as viewed in FIG. 18, in regularly spaced relation, the two chains being provided to hold the blocks firmly in a horizontal position. Similar blocks 71 are rigidly connected to the pair of chains 69 on the opposite or left side of the table, each block 71 being maintained at all times in axial alignment

with one of the blocks 70 at the opposite side of the table. The blocks 71 each has a semi-circular groove 72 with a radius corresponding to that of enlarged end portion 86 of the mandrel 84 to support the mandrel while permitting rotation thereof. A similar semi-circular groove 72a is provided in each block 70. The four endless chains 69 are guided longitudinally by four guide bars 73 which are rigidly mounted in parallel positions on the horizontal upper surface of the table 67.

Means are provided on each block 71 to effect rotation of the mandrel 84. Such means includes a stub shaft 75 (FIG. 19) having an enlarged cylindrical head 76 of substantially the same radius as the groove 72. An integral mandrel-driving tongue 77 projects outwardly from the head 76 as shown in FIG. 18. A sprocket 78 is mounted on the reduced end portion of the stub shaft 75, said sprocket having a boss 79 which engages the flat vertical face of the block 71 to prevent axial movement of the stub shaft as best shown in FIG. 19. The sprockets 78 thus carried by the blocks 71 are arranged to engage a small chain 80 which is parallel to the chains 69 as indicated in FIG. 18. The chain 80 is mounted on two small sprocket wheels 81 carried by the frame 67 as indicated in FIG. 16 and is guided longitudinally by a guide bar 82 rigidly mounted on the table 67 parallel to the bars 73. The endless chains 69 and 80 are preferably roller chains so as to minimize the friction between the chains and their guide bars. The chain 80 may be driven in the same direction as the chains 69 or in the opposite direction and will cause rotation of the stub shafts 75 at a uniform speed where the chains 69 are driven at a uniform speed. The chain permits adjustment in the speed of rotation and, therefore, is preferred over a rack of the type shown in FIG. 12 (see rack 52).

The mandrels 84 may readily be mounted between the blocks 70 and 71 as shown in FIG. 18 so as to provide rotating supports for the hose *h*. The end portions 85 of the mandrels fit in the grooves 72a and the other end portions 86 of the mandrels fit in the grooves 72, slot 87 being provided in the portions 86 to receive the tongues 77 as indicated in FIG. 18. The mandrel has a smooth cylindrical polished aluminum surface 88 extending from the enlarged portion 86 to the end of the mandrel for supporting the hose. Such surface has a diameter substantially less than the internal diameter of the coil 1 so as not to interfere with the forming of grooves or corrugations between the coil convolutions and to facilitate sliding of the mandrel into the hose *h* while the hose is on the trough 64. As soon as the mandrel 84 is inserted into the hose, the hose and the mandrel are lifted off the trough and placed on a pair of the blocks 70 and 71 at the intake end of the normalizing apparatus 66. Since the sprockets 78 are out of contact with the chain 80 at this time (see FIG. 16), there is no rotation of the tongue 77 to interfere with the mounting of the mandrel. The mandrel is then carried by the chains 69 into the heating zone formed by the radiant heaters. As herein shown a supporting frame 89 is provided above the table 67 for supporting the radiant heating means 90 as indicated in FIGS. 16 and 17. Such means comprises a series of laterally extending heating bars 91 through which an electric current is passed to effect heating of the bars. Rounded reflectors 92 of generally cylindrical shape are provided above each bar 91 as indicated in FIG. 17. If desired similar heating means may be employed in the heating apparatus 44.

An aluminum sheet is bent to provide covers 93 above the reflectors 92 and horizontal connecting panels 94 between adjacent covers 93. The aluminum sheet extends the full length and width of the heating zone so as to prevent escape of heat or the entry of air currents which could cause non-uniform heating.

The coiled metal wire 2 of the hose *h* causes localized cooling of the hose adjacent the wire during heating in the normalizing apparatus 66 and prevents the uniform heating which is essential in the first normalizing apparatus

44, but such localized cooling in the second heating operation for some reason produces results at least as good as those which can be obtained when electric current is passed through the wire to eliminate the localized cooling. Resistance heating of the wire is, therefore, unnecessary in the apparatus 66.

As soon as the mandrels 84 leave the heating zone of the normalizing apparatus 66, the operator lifts the mandrel and mounts it on a cooling apparatus 95 as shown schematically in FIG. 16. This apparatus includes rigid metal side frames 96 which are rigidly connected by connecting rods 97 to form a ventilated table which does not interfere with upward flow of air. Pairs of sprockets 68a identical to the sprockets 68 are mounted for rotation on the side frames 96 to provide means for supporting and driving two double chains 69a which correspond to the double chains 69 previously described. The chains 69a are supported by four parallel supporting bars 73a which are rigidly mounted on the side frame members 96. A series of metal plates 70a are rigidly mounted on the chains 69a and are regularly spaced like the blocks 70 and 71 with each plate 70a laterally aligned with a plate 70a at the opposite side of the table.

A yoke 98 is rigidly mounted on each plate 70a as indicated in FIGS. 20 and 21, each yoke having a semi-circular internal surface 99 with a diameter slightly less than the internal diameter of the coil convolutions 1a of the hose h. The hose may, therefore, be attached to two laterally aligned yokes 98 by sliding the yokes between adjacent coil convolutions as indicated in FIG. 20. The axial spacing of the yokes 98 is such that the hose h may be stretched axially during cooling of the hose to atmospheric temperature.

The hose may be cooled for various lengths of time but is usually cooled about 10 to 20 minutes while in the axially stretched condition shown in FIGS. 20 and 22. The speed of the conveyor chains 47, 69 and 69a is controlled to obtain the desired heating and cooling times and the desired production rate. In the apparatus shown herein, all of these chains may be driven at a constant speed of one foot per minute. The speed of each chain may be changed, however, when making apparatus for performing the method of this invention.

As the finished hoses approach the discharge end of the cooling apparatus 95, they are pulled upwardly off of the yokes 98 and stacked for final inspection. Each completed hose h appears substantially as indicated in FIG. 23 after it is removed from the cooling apparatus 95. The depth of the grooves between adjacent coil convolutions is checked periodically to be sure that the hose has been heated properly in the apparatus 44 and the apparatus 66. Minor adjustments may be made in the heating apparatus where necessary. The temperature in the first heating zone 44 must be carefully controlled to avoid any permanent bond between the contacting plastic surfaces of the coil 1 and the tube 4. Every so often one of the completed hoses is tested for adhesion by holding the tube 4 in one hand and pulling hard on the coil 1 with sufficient force to pull the coil out of the tube. The amount of heating in the apparatus 44 is controlled so that there is no permanent bond and so that the tube 4 is not torn or damaged in the above test.

According to the preferred method of the invention, a relatively high radiant heat is supplied to the hose h until it reaches the desired temperature and a lesser amount of heat is then supplied to maintain the desired temperature. Uniform heating of the hose can be obtained in this way even though the radiant heaters at the intake and discharge ends of each heating zone are heated for different lengths of time. Heating in this manner decreases the amount of time required to bring the hose up to the desired temperature and permits reduction in the size of the equipment.

It will be apparent that the method of the present in-

vention may be varied substantially and may be employed to make many different sizes of flexible thermoplastic hose and that the apparatus used to perform the method may be quite different from the apparatus disclosed herein to illustrate the invention. However, the preferred method will be described below as applied to the manufacture of commercial vacuum cleaner hose.

In making vacuum cleaner hose a plastic-coated strand is employed containing an extruded wire 2 of steel or other electrically conductive metal having a uniform diameter of about .03 to .06 inch. The plastic sleeve 3 surrounding the wire is formed of polyvinyl chloride, a copolymer of at least 85% vinyl chloride and up to 15% vinyl acetate, or similar thermoplastic vinyl resins containing small amounts of monomeric or polymeric plasticizers, such as dioctyl phthalate, nitrile rubber, polyester or the like. The material of the sleeve 3 is preferably similar to the material of the tube 4, but most thermoplastic polyvinyl materials are suitable. The sleeve 3 preferably has an external diameter of about .05 to .1 inch and a uniform radial thickness of about .01 to 0.2 inch. The resilient flexible plastic-covered strand formed by the metal wire 2 and the plastic sleeve 3 is wound to form a coil 1 having 100 to 150 convolutions per foot and preferably having a reverse pitch of $\frac{1}{2}$ to 3 so that the convolutions are normally held in contact with each other. The coil preferably has a uniform external diameter of about 1.2 to 1.5 inches and is of a size to slide axially on the main portion 6 of the mandrel 5. The cylindrical surface 9 of the portion 6 and the corresponding surface of the sleeve 18 preferably have a uniform diameter which is about 0.01 to 0.06 inch less than the internal diameter of the coil. Said diameter is usually 1.0 to 1.4 inches.

The cylindrical tube 4 is preferably extruded so that it has no longitudinal seam and after extrusion has a normal internal diameter which is preferably 10 to 25 percent less than the outside diameter of the coil 1 and preferably has a uniform wall thickness of .02 to .04 inch. The normal internal diameter of the extruded cylindrical tube 4 is usually .9 to 1.3 inches.

The tube 4 is stretched radially 50 to 200 percent and beyond its elastic limit so that it cannot contract radially at atmospheric temperature (70° F.) to its original diameter.

The radial stretching in the suction apparatus 30 preferably increases the outside diameter of the tube about 60 to 120 percent. The diameter of the surface 33 inside the expander pipe 30 is, therefore, preferably about 2 to 4 inches.

When the tube is contracted radially onto the coil as shown in FIG. 8, the coil is preferably held on the mandrel to obtain a substantially uniform spacing of 30 to 35 convolutions per axial foot. The tension is preferably reduced 3 to 10 percent by decreasing the spacing to 32 to 40 convolutions per foot and the reduced tension at such spacing is maintained while heating the hose uniformly for 2 to 15 minutes to a temperature of about 180° to 240° F. and preferably 190° to 230° F. while rotating the mandrel to acquire uniform heating. The mandrel is usually rotated slowly or at a speed within the range of about 1 to 75 revolutions per minute while it is heated, using a suitable heating apparatus for example as disclosed in FIGS. 12 and 13. Because of its elastic memory, the tube of aforesaid dimension usually contracts radially during such heating about .02 to .08 inch as indicated in FIG. 24 so as to grip the coil convolutions firmly. The coil is thus firmly anchored in the plastic tube. The tube may then be cooled more than 24 hours, but it is usually cooled a short time, generally less than 5 minutes, before it is subjected to the second heating.

The intermediate portion of the hose in contact with the central portion of the mandrel tends to be driven at the same surface speed as that of said central portion during rotation thereof. When the diameter of the mandrel is less than the internal diameter of the hose, the

angular speed of said intermediate portion of the hose tends to be less than that of the mandrel, the ends of the tube being fixed to the mandrel so that their angular speed is the same as that of the mandrel. The result is a different rotational speed between the center and the ends of the hose resulting in damage when the hose is in the heat softened condition. It is important, therefore, that the external diameter of the original mandrel be not substantially less than the internal diameter of the coil to give support to the coil without causing twisting thereof during the rotational heating. After the above described heating of the axially stretched hose, the tube is removed from the first mandrel and placed on a second cylindrical mandrel of smaller diameter, such as the mandrel 84. The second mandrel has a uniform external diameter that is substantially less, generally 0.1 to 0.5 inch and preferably 0.2 to 0.4 inch less, than the internal diameter of the coil which external diameter is desirable for a hose of the above dimensions. The surface 88 of the mandrel 84, for example, may conveniently have a uniform diameter of about 0.7 to 1.1 inches.

The remaining stresses in the aforementioned hose are substantially eliminated by heating the hose preferably to a lower maximum temperature than before (which is usually about 140° to 200° F.) preferably for 5 to 30 minutes while allowing the hose to contract axially preferably so that the spacing of the coil is 45 to 60 convolutions per foot, the heating taking place while rotating the second mandrel and the hose thereon at a velocity of preferably 10 to 75 revolutions per minute. At the end of such heating the corrugations (or groove portions) of the plastic tube have an internal diameter less than and usually about .1 to .2 inch less than the internal diameter of the coil (see section D of FIG. 24). The spacing of 45 to 60 convolutions per foot is preferably changed gradually during the second heating step substantially to eliminate stresses in the hose. This may be accomplished without positively controlling the spacing by allowing the hose to contract freely in the axial direction on the mandrel throughout the second heating as indicated in FIG. 18.

A smaller diameter in the mandrel 84 is important to permit such axial contraction during this normalizing treatment and thus to eliminate stress due to axial elongation.

Within 3 minutes and preferably within 1 minute after terminating the second heating step and while the hose is still hot, the hose is stretched axially on the mandrel (i.e., as in FIGS. 20 and 21) to obtain a spacing of about 32 to 40 convolutions per foot and allowed to cool at least 5 minutes and preferably 10 to 30 minutes with such a spacing so that, upon release of the hose, the final spacing is 40 to 50 convolutions per foot and the inside diameter of the corrugations 4a is .03 to .16 inch less than the inside diameter of the convolutions 1a.

Each of the cooling steps mentioned in this application may be effected by allowing the hose to stand in air at room temperature, but it will be apparent that more rapid cooling may also be employed.

The preferred dimensions mentioned above are for standard vacuum cleaner hose and are given to illustrate the invention rather than to limit it. It will be apparent that these dimensions will vary considerably when making different size hoses according to the method of this invention.

FIGURE 24 is drawn to scale to show the axial cross sections of the hose at different stages of its manufacture. When first applied to the coil 1 the tube 4 appears as indicated at A in FIG. 24, the dot-dash lines *x* and *y* in that figure being spaced apart a distance *d* which is equal to one inch.

The radially innermost point 101 of the axial cross section of each corrugation or groove portion 4a is at this time spaced radially outwardly from the cylinder containing the radially innermost points *b* of the coil convo-

lutions 1a a distance equal to about 0.5 to 0.9 times the external diameter of the helical plastic sleeve 3.

The hose is then placed in the heating apparatus 44, the sleeve 16 being disconnected from the pin 14 and moved against the shoulder 12. After heating in the apparatus 44, the axially stretched hose *h* appears as indicated at B in FIG. 24, the radially innermost point 102 of each corrugation 4a being spaced radially outwardly from the adjacent points *b* a distance equal to about 0.3 to 0.7 times the external diameter of the sleeve 3.

The hose *h* is then removed from the mandrel 5 and placed on the mandrel 84 so that it is free to contract axially. While so placed and prior to heating in the apparatus 66, the hose appears as indicated at C in FIG. 24, the radially innermost point 103 of each corrugation being spaced radially (inwardly or outwardly) from the cylinder containing the radially innermost coil points *b* a distance less than .03 times the external diameter of the sleeve 3.

After heating in the apparatus 66 the hose *h* appears as indicated at D in FIG. 24, the radially innermost points 104 of the corrugations being spaced radially inwardly from the radially innermost coil points *b* a distance equal to 0.4 to 0.9 times the external diameter of the sleeve 3.

While still hot the hose *h* is stretched axially between the yokes 98 of the cooling apparatus 95 to the position indicated at E in FIG. 24 and cooled for more than ten minutes while so stretched. The radially innermost point 105 of each corrugation is then spaced radially outwardly from the adjacent points *b* a distance equal to about 0.3 to 0.7 times the external diameter of the sleeve 3.

After cooling in the apparatus 95 the hose is removed from the yokes 98 and allowed to contract axially, the completed hose having a normal axial cross section as indicated at F in FIG. 24, the radially innermost point 106 of each corrugation 4a being spaced radially inwardly from the cylinder containing the points *b* a distance up to 0.9 (preferably 0.1 to 0.6) times the external diameter of the sleeve 3.

The hose of the present invention is attractive and easy to keep clean because the corrugations are not objectionably deep. Deterioration of the hose by accumulation of dirt in the corrugations is thus avoided.

When the hose is bent sharply as indicated in FIG. 25, the wall portions 109 at the inside of the bend 107 readily move together to minimize the tension in the stretched wall portions 108 at the outside of the bend. The initial reverse pitch of the coil 1 apparently facilitates the closing movement at the inside of the bend and reduces the tendency of the coil convolutions to move relative to the contacting surface of the tube 4 so that the tube is not damaged by sharp bending. The bending of the hose reduces the contact of the wall portions 108 and the coil convolutions 1a as is apparent in FIG. 26.

In the hose known prior to the invention wherein the coil was bonded or permanently adhered to the plastic tube over a relatively wide zone, such bending tended to reduce the width of the zone and set up stresses which caused rapid deterioration of the tube or tearing of the tube. Such stresses are not created in the hose of the present invention since there is no permanent bond between the tube and the coil of the type obtained by fusion or with adhesives.

When the tube is stretched severely in the axial direction (see the axially stretched hose 110 of FIG. 27) the force exerted by the coil convolutions 1a against the interior surface of the tube 4 to hold the coil in the extended position is relatively small and insufficient to set up deteriorating stresses or to cause tearing of the tube. This is particularly important when the hose is whipped about during use. It has been found that the inexpensive vacuum sweeper hose of the present invention can withstand whipping forces at least twice as long as similarly

shaped vacuum sweeper hose known prior to the invention.

The particular method of treating the hose disclosed herein for some reason increases the ability of the hose to stand up at low temperatures (i.e. 30 to 40° F.). The housewife can, therefore, use the hose outdoors occasionally without breaking the hose.

Example I

A flexible plasticized polyvinyl chloride composition is prepared having the following composition:

Parts by weight	
Polyvinyl chloride resin.....	100
Di-isooctyl phthalate.....	40
Di-isooctyl adipate.....	15
Dibasic lead phosphite.....	2
Titanium dioxide.....	1
Thermatonic carbon black.....	0.2

The above composition is heated, extruded and cooled to form a cylindrical tube having a uniform internal diameter of 1.18 inches, a uniform radial thickness of .034 inch, and a length of substantially more than 50 feet and is spirally wound on a supply roll.

A strand of steel wire with a uniform diameter of .04 inch and a length of several hundred feet is provided having a covering sleeve with a uniform radial thickness of 0.015 inch and a uniform external diameter of 0.07 inch, said sleeve being made of a plasticized material having the following composition:

Parts by weight	
Vinyl resin*.....	100
Di-isooctyl phthalate.....	10
Di-isooctyl adipate.....	5
Dibasic lead phosphite.....	2
Titanium dioxide.....	1
Thermatonic carbon black.....	0.2

* A copolymer of 95 percent vinyl chloride and 5 percent vinyl acetate.

The plastic-coated wire strand is spirally wound on a winding machine to form a helical cylindrical coil having a uniform outside diameter of 1.38 inches and containing 310 convolutions, said strand being prestressed so as to be under a tension when the convolutions are contacting each other. This tension is such that the force required to separate each convolution from the next adjacent convolution a distance of .07 inch is approximately two-thirds the force required to separate the convolutions a distance of .14 inch.

The coil is mounted on an externally cylindrical horizontal mandrel of the type shown in FIGS. 3 and 4 having an outside diameter of 1.2 inches and is stretched to a length of 108 inches and fixed at its ends to the end portions of the mandrel substantially as shown in FIGS. 3 and 4.

The plastic tube described above is placed within a suction cylinder of the type shown in FIG. 5 having a length of about 10 feet and a uniform internal diameter of 2.07 inches and the free end thereof is cuffed over the end of the cylinder to permit application of a vacuum so as to stretch the tube radially outwardly more than 60 percent throughout the length of the cylinder. While so expanded the mandrel with the stretched coil thereon described above is placed within the tube as shown in FIG. 7 and the tube is allowed to contract and grip the coil as shown in FIG. 8. The ends of the tube are then cut and trimmed to the shape shown in FIG. 10 and one sleeve 16 is released and allowed to move against the stop shoulder 12 so that the length of the coil is 102 inches.

The hose is then heated uniformly for three minutes in an apparatus of the type shown in FIGS. 12 and 13 while being rotated at 4 revolutions per minute and the tube is maintained at a temperature of about 210 to 225° F. The hose is then cooled for 1 minute, removed from the mandrel and placed on a second cylindrical

horizontal mandrel of the type shown in FIG. 18 having a uniform external diameter of 1.12 inches. When so placed and resting freely on the mandrel the spacing of the coils is 39 per foot.

The mandrel and the hose thereon are then placed in a second normalizing apparatus of the type shown in FIGS. 16 to 19 and heated for 12 minutes while being rotated at 30 revolutions per minute and allowed to contract freely. The tube is maintained at a temperature of about 160° to 190° F. until the free spacing is 52 convolutions per foot and the inside diameter of the corrugations is substantially less than the inside diameter of the coil as indicated at D in FIG. 24.

The mandrel and the hose are then mounted on the yokes 98 of the apparatus shown in FIG. 20 in a horizontal position with the hose stretched axially to a length of 107 inches and cooled for 15 minutes. The hose is then freed from the yokes and assumes a length of about 82 to 83 inches so as to have a substantially uniform spacing of around 45 convolutions per foot, each corrugation having an internal diameter about 0.05 to 0.1 inch less than the internal diameter of the coil as indicated at F in FIG. 24.

It is found that the resulting hose is extremely durable and can withstand whipping for unusually long periods of time without rupture. If one end of the reinforcing coil is freed from the plastic tube of the hose and gripped in the hand, a person can, by holding the tube and pulling hard on the coil, remove the coil from the tube without tearing the tube. This indicates the lack of a permanent bond between the contacting plastic surfaces of the coil and the tube.

It will be understood that the above description is by way of illustration rather than limitation and that, in accordance with the provisions of the patent statutes, variations and modifications of the specific machines, methods and articles disclosed herein may be made without departing from the spirit of the invention.

Having described my invention, I claim:

1. A method of making a flexible wire-reinforced plastic hose having improved ability to withstand whipping movements comprising inserting an axially stretched plastic-coated helical coil into a radially expanded tube of plasticized thermoplastic material, allowing the tube to contract and embrace the axially extended coil, heating the coil and the tube while axially extending the coil by axial tension to form corrugations between the coil convolutions and to fix the axial positions of the coil convolutions relative to the tube while relieving the radial stresses, thereafter reducing the axial tension and relieving axial stresses by further heating the tube, and then cooling the heated tube while subjecting the same to an increased axial tension.

2. A method of making a flexible hose comprising forming a helical plastic-coated wire coil having contacting convolutions, forming a cylindrical tube of elastomeric thermoplastic material having an internal diameter 10 to 25% less than the external diameter of said coil, stretching the tube radially and inserting the coil into the tube while holding the coil so that each convolution thereof is spaced from the next adjacent convolution a distance equal to 2 to 5 times the cross-sectional diameter of the plastic-coated wire, contracting the tube into engagement with the axially stretched coil and heating the coil and the tube while the convolutions are so spaced to form corrugations between the convolutions, reducing the spacing between convolutions about 30 to 50% and heating the tube to relieve stresses therein, thereafter increasing the spacing 30 to 50% while cooling the tube.

3. A method of making a flexible reinforced plastic hose comprising inserting a plastic-covered helical wire coil into a radially expanded tube of elastic thermoplastic material, allowing the tube to contract radially and embrace the coil to form a corrugated hose, mount-

ing the hose on an externally cylindrical mandrel having a diameter slightly less than the internal diameter of said coil but sufficiently great to cause the central portion of said coil and said tube, while said plastic tube is in the heat softened condition, to rotate at the same speed as the end portion of said coil, heating the coil and the tube uniformly and by radiant heating while stretching the coil axially on said mandrel and rotating the mandrel mounting the coil on a second externally cylindrical mandrel having a diameter substantially less than that of the first-named mandrel, the radial clearance between said coil and said second mandrel being several times the radial clearance between said coil and said first-named mandrel, and reheating the tube while rotating the same on the second mandrel and reducing the axial tension on the hose, each of said mandrels having a length greater than 9 feet.

4. A method of making a flexible hose comprising stretching a plastic-coated helical wire coil axially on a first mandrel having an external diameter not substantially less than the internal diameter of the coil so that each convolution is spaced from the adjacent convolution a distance equal to about 2 to 5 times the cross-sectional diameter of said coated wire, said coil having an external diameter of about 1.2 to 1.5 inches, contracting a tube of elastic thermoplastic material around the coil to form a composite hose, heating the composite hose on said mandrel to a normalizing temperature while reducing the axial tension thereon about 3 to 10 percent and rotating said first mandrel, placing the said hose on a second mandrel having a diameter 0.1 to 0.5 inch less than the internal diameter of said coil, and heating the hose on the second mandrel at a lower temperature than that used during the first normalizing treatment while reducing the distance between adjacent coil convolutions 30 to 50 percent to relieve stresses in the tube and rotating said second mandrel.

5. A method of making a flexible reinforced plastic hose comprising inserting a plastic-covered-wire helical coil into a radially expanded tube of deformable thermoplastic material having walls with a thickness greater than the cross-sectional radius of the metal wire of said coil and with sufficient resistance to axial deformation to hold the coil in an axially extended position wherein the adjacent turns thereof are spaced apart a distance at least two times the cross-sectional diameter of the plastic-covered wire, contracting the tube around the coil to form corrugations between the convolutions of the coil, heating the corrugated tube without applying substantial axial force to the hose to remove axial stresses in the tube while maintaining less than half the surface area of said coil in contact with said tube to form a sinusoidal longitudinal cross section with adjacent turns of the coil spaced apart a distance greater than the cross-sectional diameter of the coil, thereafter extending the heated corrugated hose to subject it to increased tensile forces and simultaneously cooling the heated hose while maintaining the increased tensile forces, and releasing the hose to permit it to contract axially.

6. A method as defined in claim 1 wherein the stresses in the tube are relieved by externally heating the hose while simultaneously passing an electric current through the wire of the coil to reduce the cooling effect of said wire and to provide a more uniform heating, the amount of heating of the hose being insufficient to provide a bond with a strength greater than that of the tube wall, whereby the coil may be pulled manually out of the tube of the finished hose without tearing the walls of the tube.

7. A method of making an inexpensive flexible reinforced plastic hose having greatly increased ability to withstand whipping movements comprising in seriatim the steps of inserting a plastic-covered-wire helical coil into a radially expanded tube of deformable thermoplastic material having walls with a thickness greater than the cross-sectional radius of the metal wire of said coil and

with sufficient resistance to axial deformation to hold the coil in an axially extended position wherein the adjacent turns thereof are spaced apart a distance several times the cross-sectional diameter of the plastic-covered wire, contracting the tube around the coil so that the tube is supported solely by the coil and has corrugations depending between the convolutions of the coil, heating the corrugated tube uniformly and reducing the tension on the tube walls while supporting the tube solely from the coil to form a sinusoidal longitudinal cross section with adjacent turns of the coil spaced apart a distance greater than the cross-sectional diameter of the coil, increasing the tension on the walls of the heated tube, and cooling the heated hose while maintaining said increased tension and while supporting the tube solely from the coil.

8. A method of making a flexible reinforced plastic hose having a diameter less than two inches comprising in seriatim the steps of inserting a plastic-covered helical wire coil into a radially expanded tube of elastic thermoplastic material, allowing the tube to contract radially and embrace the coil to form a corrugated hose, mounting the hose on an externally cylindrical mandrel having a diameter slightly less than the internal diameter of said coil but sufficiently great to cause the central portion of said coil and said tube, while said plastic tube is in the heat softened condition, to rotate at the same speed as the end portion of said coil, heating the coil and the tube while rotating said mandrel and simultaneously holding the coil so that each convolution thereof is spaced from the next adjacent convolution a distance at least equal to two times the cross-sectional diameter of the plastic-covered wire, mounting the heated coil on a second mandrel having a diameter substantially less than that of the first named mandrel, and cooling the hose on the second mandrel while maintaining an increased tension on the tube gripping said coil and maintaining the minimum internal diameter of the tube greater than the external diameter of said second mandrel, each of said mandrels having a length greater than nine feet.

9. A method of making a flexible wire-reinforced plastic hose having improved ability to withstand whipping movements comprising

forming a helical plastic-coated wire coil,

forming a cylindrical tube of elastomeric thermoplastic material having an internal diameter less than the external diameter of said coil,

stretching the tube radially and the coil axially and inserting the coil into the stretched tube while holding the coil stretched under axial tension so that each convolution is spaced from adjacent convolutions,

contracting the tube into engagement with the axially stretched coil,

heating the coil and the tube while the coil is stretched axially and the convolutions are so spaced to form corrugations in the tube between the convolutions of the coil and to fix the axial positions of the coil convolutions relative to the tube while relieving radial stresses in the tube, reducing the spacing between the convolutions,

further heating the tube to relieve stresses therein, and thereafter while cooling the tube subjecting the tube and the coil to axial tension to increase the spacing between the convolutions.

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