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FLEXIBLE CORRUGATED TUBING HAVING IMPROVED
PERFORMANCE CHARACTERISTICS

3,605,817

Filed Sept. 22, 1969

3 Sheets-Sheet 1

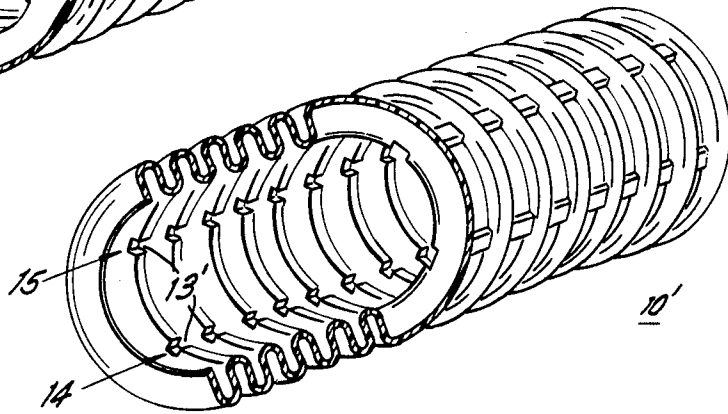
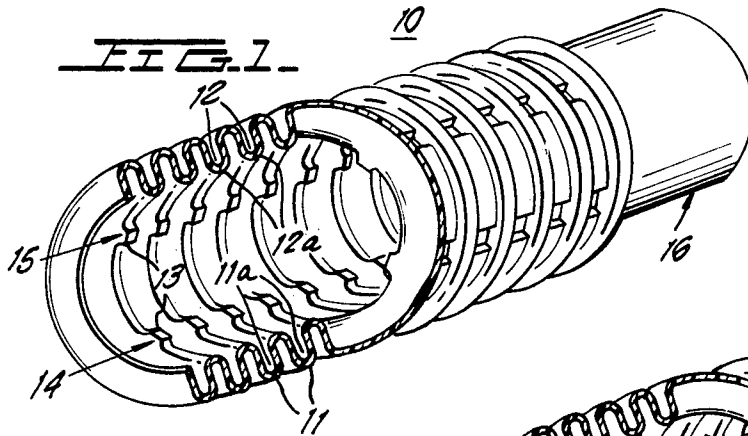


FIG. 2a.

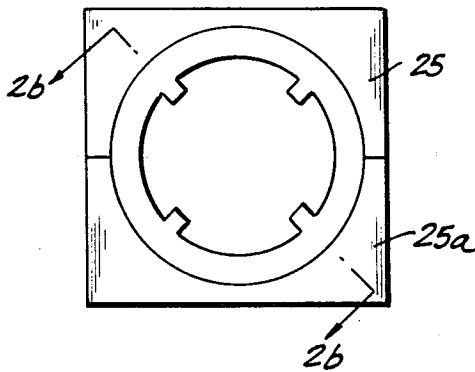


FIG. 2b.

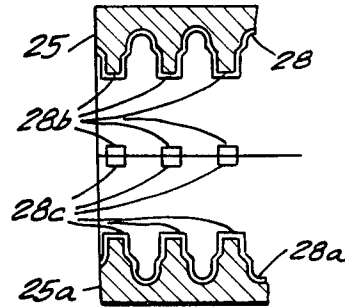


FIG. 3a.

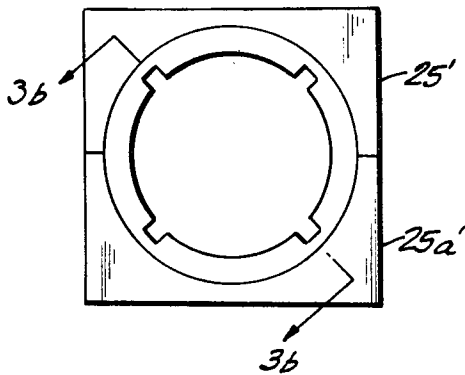
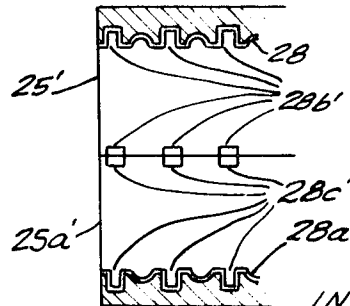


FIG. 3b.



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FIG. 4a.

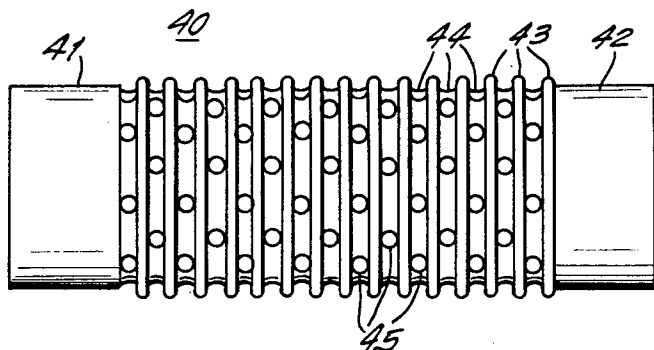


FIG. 4b.

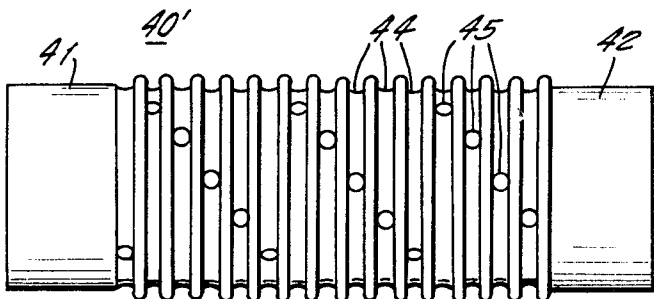
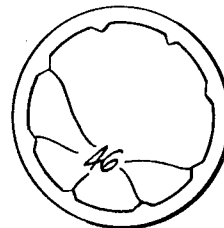


FIG. 5.

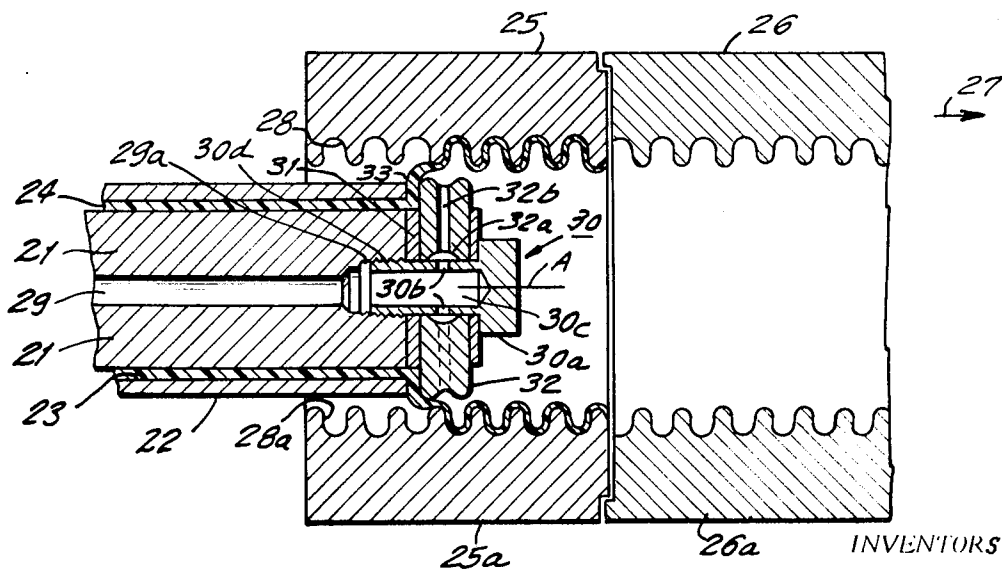


FIG. 6.

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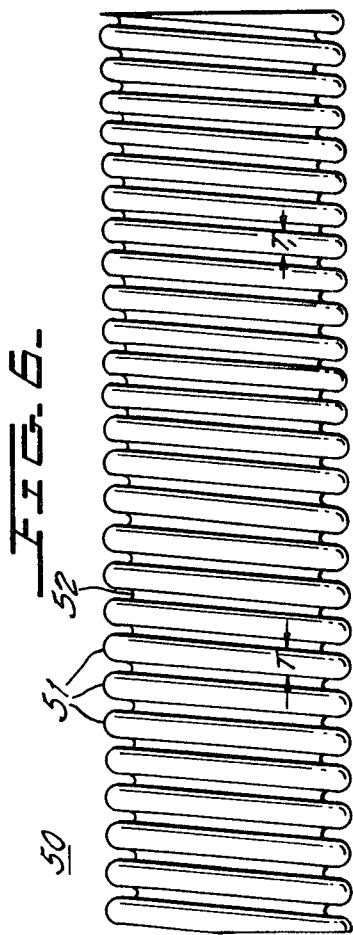
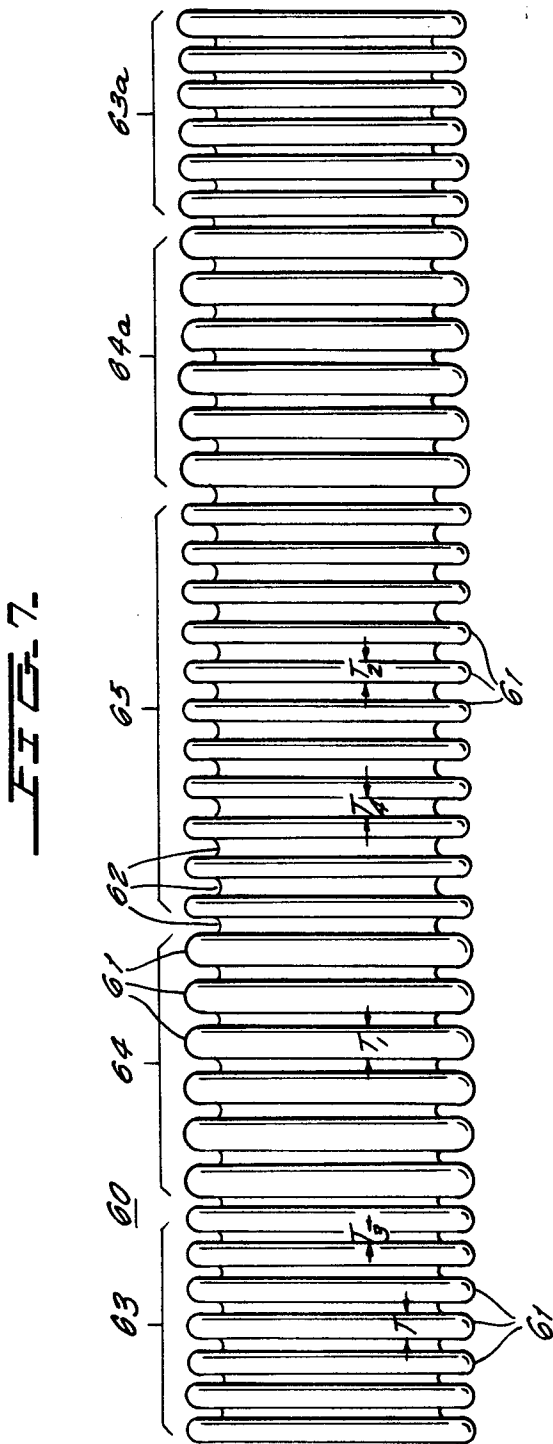
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FLEXIBLE CORRUGATED TUBING HAVING IMPROVED PERFORMANCE CHARACTERISTICS

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7 Claims

ABSTRACT OF THE DISCLOSURE

Flexible corrugated tubing, preferably formed of a thermoplastic material having a configuration for eliminating annoying whistling which occurs in conventional tubing used for moving air at relatively high velocities. The pitch and/or roughness of the tubing interior surface is controlled during formation of the tubing.

The tubing may be formed in a continuous process, for example, in the manner described in U.S. Pat. 3,280,430, issued Oct. 25, 1966, which is further provided with means combined within the molds to control the configuration of the tubing.

The present invention relates to flexible corrugated tubing, and more particularly to flexible corrugated tubing having a unique configuration which provides improved operating characteristics, and further relates to a novel method and apparatus for producing such tubing.

Flexible corrugated tubing is a well known commercial product and is utilized in a wide variety of industrial, as well as non-industrial applications.

For example, flexible corrugated tubing, preferably formed of a suitable plastic material, is quite frequently utilized as a vacuum cleaner hose and also finds similar application with swimming pool equipment. In use, a suitable accessory is coupled at one end thereof, while the other end is secured to the vacuum or blower source of the vacuum or blower apparatus. When utilized in such applications, the flexible corrugated tubing has been found to generate an annoying whistle which is even greater in volume in large commercial apparatus.

In one preferred embodiment, the flexible corrugated tubing is formed in a continuous process in which extruded plastic material, in molten form, emerges from an extruder die which cooperates with coating mold cavities provided in associated die members to receive and form the extruded plastic material. A pressure source causes the extruded plastic material to be urged against the corrugated surfaces of the coating die members, thereby forming the corrugated tubing configuration.

In one preferred embodiment, the dies defining the tubing configuration are arranged to provide alternating convolute pitch and thickness. In cases where a cuff is desired at predetermined intervals along the length of the tubing, cuff-forming die means may be provided at the desired spaced intervals. The variable pitch and thickness of the convolutes do not affect the flexibility of the tubing.

In another preferred embodiment, the die configuration may be provided with a plurality of small projections, causing a plurality of "pimples" or small projections to be formed in the tubing, which pimples project inwardly from the interior surface toward the central axis of the tubing. This "roughened" interior surface yields tubing having the same advantageous features as described above with regard to the previously mentioned preferred embodiments.

It is, therefore, one object of the present invention to provide flexible corrugated tubing, preferably formed of plastic material, having a unique interior configuration

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designed to provide improved operating characteristics as compared with conventional tubing in that whistling which occurs in vacuum or blower apparatus is appreciably attenuated.

Another object of the present invention is to provide a novel method and apparatus for forming flexible corrugated tubing, preferably formed of a plastic material, in which the interior convolutes are of variable pitch and thickness along the interior surface configuration of the corrugated tubing to yield tubing having a unique interior configuration which eliminates whistling.

Still another object of the present invention is to provide a novel method and apparatus for forming flexible corrugated tubing, preferably formed of a plastic material, in which the interior surface is provided with a plurality of small projections, thereby forming a roughened surface to provide a unique tubing configuration which eliminates whistling.

These as well as other objects of the present invention will become apparent when considering the accompanying description and drawings in which:

FIG. 1 is a perspective view of a section of novel corrugated tubing formed in accordance with the method and apparatus of the present invention, a portion of which has been broken away to facilitate an understanding of the internal configuration.

FIGS. 2a and 2b are end and sectional views, respectively, of mold members which may be utilized to form the corrugated tubing of FIG. 1.

FIG. 3 is a perspective view of a section of another preferred embodiment of corrugated tubing, a portion of which has been broken away to facilitate an understanding of the internal configuration.

FIGS. 3a and 3b are end and sectional views, respectively, of mold members which may be utilized to form the corrugated tubing of FIG. 3.

FIGS. 4a and 4b are side and sectional views, respectively, of another preferred embodiment of the corrugated tubing of the present invention.

FIG. 5 is a side view of a section of corrugated tubing slightly modified in form as compared with the embodiment of FIG. 4a.

FIGS. 6 and 7 are side views of still additional preferred embodiments of corrugated tubing incorporating the principles of the present invention.

FIG. 8 shows a sectional view of apparatus utilizing die blocks of the type shown in FIGS. 2a and 2b, for example, in the formation of corrugated tubing.

Referring now to the drawings, FIGS. 1 and 3 show two alternative embodiments of a portion of the novel flexible corrugated tubing which may be formed through the method and apparatus of the present invention.

A portion of the tube section 10 has a substantially corrugated configuration comprised of a plurality of separate continuous rings 11 which form the peaks of the exterior corrugated configuration, which rings are joined by interposed circular sections 12 forming the valleys of the exterior configuration.

The thickness of the corrugated section is reasonably uniform such that substantially the same corrugated configuration defines the interior surface of the tubing with the rings 11 comprising the valleys 11a along the interior surface and with the circular sections 12 forming the peaks 12a of the interior surface.

The tubing of FIG. 1 is further provided with a plurality of projections or protuberances 13 integrally formed in the inner peaks 12a and arranged in rows such as 14 and 15, which rows are arranged at angular intervals about the tubing. The projections act to alter the otherwise smooth surfaces of each interior peak 12a. Whereas the preferred embodiment 10 of FIG. 1 shows the rows arranged at four equal intervals about the tube,

it should be understood that the projections may define a helical pattern within the tube interior, or, alternatively, may be arranged in a random fashion.

The embodiment 10' of FIG. 3 is somewhat similar to that shown in FIG. 1 wherein the projections 13 of FIG. 1 provided on interior peaks 12a are replaced by indentations 13' formed in the interior peaks 12. The indentations may likewise be arranged in rows such as rows 14 and 15, may define a helical pattern or may be dispersed in a random fashion.

While FIGS. 1 and 2 show a rather short section of tubing, it should be understood that extremely long lengths of tubing may be formed through such a continuous process with the particular length required for any application being dependent only upon the needs of the user.

FIG. 1 shows a cuff section 16 integrally formed and joined to one end of the corrugated section. The cuff section has a substantially circular cross-sectional configuration and is provided for joining or coupling a length of tubing to the mating section of a piece of industrial equipment (not shown). For example, a tubing section may be provided with cuff portions 16 at opposite ends thereof, one cuff section being provided for coupling to the output of an industrial vacuum cleaning or blower apparatus and the other cuff section being utilized for joining an accessory brush, nozzle, or other implement thereto.

Experimentation has shown that conventional tubing which is of the type shown in FIG. 1, with the exception that the projections 13 are omitted, generates undesirable whistling which is quite annoying and is of substantial volume when such tubing is employed in large size and/or industrial-type vacuum cleaning or blower apparatus. The experimentation has shown that the provision of the projections 13 or 13' significantly attenuates the whistling. Although the preferred embodiments of FIGS. 1 and 3 may provide four rows which are arranged at opposite ends of a pair of mutually perpendicular diameters, it should be understood that a fewer or greater number of rows of projections may be arranged at spaced intervals around the wall defining the tubing.

FIG. 8 shows one particular apparatus which may be employed for the purpose of forming the projections 13 (or indentations 13') substantially simultaneously with the formation of the corrugated tubing. For purposes of understanding the present invention, a simplified description of the apparatus for forming the corrugated plastic tubing will be set forth herein. A detailed description of such apparatus is set forth in U.S. Pat. No. 3,280,430, issued Oct. 25, 1966, and assigned to the assignee of the present invention. The apparatus is comprised of an extruder means which includes an elongated core member 21 and an annular-shaped jacket 22 arranged concentrically with core member 21 and cooperating therewith to form an annular hollow passageway 23 for urging the freshly extruded thermoplastic material 24 from the extruder toward the tube-forming apparatus. The forward end of core 21 and jacket 22 are brought into alignment with the longitudinal axis A of a path defined by a plurality of moving die blocks 25-26 and 25a-26a which are coupled by means, shown best in FIG. 1 of the above mentioned U.S. patent, to chain drive means which act to move each of the die block pairs such as 25-25a in the direction shown by arrow 27. It should be understood that the chain drives, as shown in FIG. 1 of the above mentioned U.S. patent, are closed-loop chains which support and move the die blocks past the stationary extruder means so as to receive the extruded thermoplastic material and form this material into the corrugated tubing. The cooperating die blocks move in separate closed-loop paths which cooperatively come together in the region of the extruder assembly so as to coact and thereby form unitary mold cavities having surface configurations 28 and 28a which shape the extruded thermo-

plastic material into the corrugated configuration. Each die block pair, as shown best in FIGS. 7 and 8 in the above-mentioned issued patent, forms one-half of the mold cavity and these die block pairs are urged firmly into surface contact with one another by means of pressure plates 47, shown best in FIGS. 1 and 3 of the above-mentioned U.S. patent.

The forward ends of core 21 and jacket 22 are co-terminous. Core member 21 is provided with an axially aligned air passage comprised of a first axial portion 29 having a first diameter which communicates with a second axial portion 29a of a slightly increased diameter.

Axial passageway portion 29a is provided with a tapped interior surface for threadedly engaging a threaded mounting nipple 30 having a substantially circular-shaped cross-sectional configuration and a head portion 30a for retaining as pacer member 31 and an annular orifice plate 32 against the left-hand face of core member 21. Spacer 31 controls the spacing between the end of jacket 22 and the confronting surface of plate 32 for aiding and directing the flow and thickness of extruded thermoplastic material in a manner to be more fully described.

The annular orifice plate 32 having a central opening 32a of arcuate section and a plurality of radially extending air passages 32b extending from the periphery of the plate to opening 32a, is mounted on the forward end of core member 21 in the manner shown by means of the nipple member 30 which passes through the opening 32a in plate 32 through the opening in spacer 31 and threadedly engages the tapped portion 29a of air passageway 29, at threaded portion 30d.

The tubular wall of nipple member 30 is formed with a plurality of vents 30b which provide communication between air passage 29 and radially aligned passages 32b. The spaced plate 31 has a diameter substantially equal to that of the core member 21 forming a radially aligned outlet between the confronting surfaces of jacket 22 and annular orifice plate 32, which radially aligned passageway communicates with the annular-shaped passageway 23. The selected thickness of spacer plate 31 determines the amount of thermoplastic material 24 which passes from outlet 33 to the die blocks 25-25a, 26-26a and so forth. In operation, the extruder means provides an annular body of thermoplastic material 24 urged through the annular passageway by any suitable means so as to exit through outlet 33 at an elevated extruder temperature. The thermoplastic material is moved to a location adjacent the mold surfaces of the die blocks 25-25a. Air at a pressure of about 5 p.s.i. from a source (not shown) connected to the left-hand end of air passage 29 passes radially outward through radially aligned passageway 32b, causing the thermoplastic material to be urged firmly against the undulations in the die blocks and thereby conform the annular body of thermoplastic material to the mold surfaces 28-28a, thereby forming annular corrugations in the wall thereof (including alternating peak and valley portions) corresponding to the mold portions 28-28a. The forward free end of the extruded and molded corrugated tubing may be crimped or tied to make the same airtight so that air pressure passing through passageway 29, the hollow interior 30c of nipple disk 30 and radial passageways 32b will be effective to conform the wall of the extruded plastic tubing to the mold surfaces 28-28a.

As the successive pairs of die blocks 24-25a move forwardly by means of the sprocket chains, shown, for example, in FIG. 1 of the above-mentioned U.S. Pat. No. 3,280,430, the freshly formed corrugated tubing may be cooled by means of atomizer spray nozzles 75, shown, for example, in FIG. 3 of the above-mentioned U.S. patent, thereby rapidly cooling the hot molded tubing within a relatively short time interval such as, for example, an interval measured by the length of the path of coating die blocks 25-25a.

If desired, the corrugated tubing may be continuously reeled on suitable reel means.

FIGS. 2a and 2b show end and sectional views, respectively, of die blocks which may be utilized to form the corrugated tubing of the embodiment shown in FIG. 1. Each of the die blocks 25 and 25a, in addition to having interior surface configurations 28 and 28a which define the corrugations, are further provided with inwardly projected portions 28b-28c which cause formation of the projections 13 extending inwardly from the interior peaks of the tubing toward the central axis of the tubing.

FIGS. 3a and 3b show end and sectional views, respectively, of the die blocks 25'-25a' which may be utilized with the corrugated tube-forming apparatus of FIG. 8 to form corrugated tubing of the type shown in FIG. 3 wherein the interior surface configuration 28-28a of the molds 25'-25a', in addition to defining the corrugated configuration, is further provided with indentations 28b'-28c' which define the integrally formed indentations 13' within the interior peaks of the tubing wall.

FIGS. 4a and 4b are side and end views, respectively, of still another embodiment 40 of the present invention in which the corrugated tubing section is shown as having cuff portions 41 and 42 of substantially cylindrical-shaped configuration, which sections are integrally joined with a corrugated section having a plurality of exterior peaks 43 and valleys 44 which, while not shown, define the valleys and peaks of the tube interior surface. It should be noted that the exterior valleys 44 are each provided with a plurality of indentations 45 which define corresponding projections 46 along the surfaces of the interior peaks of the corrugated tubing. These projections act to form a "roughened" confronting surface to air passing therethrough which acts, in turn, to significantly attenuate whistling which would otherwise occur in such corrugated tubing when air at a relatively high velocity is passed through the corrugated tube.

FIG. 5 shows a somewhat similar embodiment 41 wherein like elements are designated by like numerals. In the embodiment 40' of FIG. 5, the indentations 45 appearing along the surfaces of the exterior valleys 44 are arranged in a substantially helical pattern, thereby forming corresponding projections along the interior peaks of the corrugated tubing which are arranged in the same helical pattern. In addition to the arrangements shown in FIGS. 4a and 5, it should be understood that the "pimples" 46 may be arranged in any desired pattern, be it regular pattern, a random pattern, or a helical pattern.

The corrugated tubing of FIGS. 4a and 5 may be formed in a manner similar to that described with regard to the apparatus shown in FIG. 8 wherein mold sections having a corrugated surface configuration provided with projections in the desired pattern are utilized with the tube-forming apparatus so as to form tube sections of the type shown in FIGS. 4a and 5.

FIG. 6 shows still another preferred embodiment wherein the corrugated tubing 50 is formed of convolutes defining the exterior peaks 51, which convolutes are continuous with one another to effectively form a single helical convolute running the entire length of the corrugated tubing. The convolutes 51 are spaced from one another by smaller diameter valley portions 52 which are all joined to one another to form a continuous helical valley portion. It should be understood that the exterior peak and valley portions of the corrugated tubing act to define corresponding interior valley and peak portions, respectively, substantially in the same manner as shown in FIGS. 1 and 3, for example, except that the convolutes are continuous so as to form a single helical-shaped convolute.

In order to significantly attenuate the annoying whistling which may occur when such tubing is used in conjunction with vacuum or blower apparatus, the width of the convolutes measured along the longitudinal axis are varied from large (T) to small (T₁) either gradually or abruptly along the length of the corrugated tubing, or, conversely,

the pitch of the helical pattern may be varied either gradually or abruptly along the length of the corrugated tubing, and wherein any of these variations may be repeated in alternating fashion along the tubing.

FIG. 7 shows still another alternative embodiment for the present invention wherein the tubing 60 is similar to that shown in FIGS. 1, 3 and 6, for example, wherein the exterior peaks and valleys 61 and 62, respectively, define the interior valleys and peaks of the corrugated tubing.

Each of the convolutes in the embodiment of FIG. 7, in contradistinction to the embodiment of FIG. 6, are separate distinct rings spaced from one another by the valley portions 62.

Significant attenuation of the annoying whistling which otherwise occurs in conventional tubing when employed with vacuum or blower apparatus is obtained by varying the width of the convolutes (measured along the tubing longitudinal axis) either abruptly or gradually. As shown in FIG. 7, section 63 is provided with convolutes 61 of a width T. The adjoining section 64 is provided with convolutes 61 having a width T₁ which is greater than T. Section 64a is substantially similar to section 64. Section 65 is provided with convolutes 61, each of a width T₂ which is less than the width T in section 63. In addition thereto, the valley portions 62 have a width T₄ which is greater than the width T₃ of the valley portions in section 63. Section 63a is substantially similar in configuration to section 63. The pattern shown in FIG. 7 may be repeated for tubing of greater length. Alternatively, the convolutes forming each of the sections may be greater or lesser in number than the quantities shown per section in the tube of FIG. 7. As still another alternative, the width of the convolutes, as opposed to being abruptly varied, may be varied gradually from each convolute to the next over a predetermined length of corrugated tubing, and this gradual tapering in thickness may be repeated over the length of the tubing.

Each of the embodiments shown in FIGS. 6 and 7 may be formed by apparatus of the type shown in FIG. 8 by providing cooperating die blocks similar in nature to those shown in FIGS. 2a-3b and modified such as to provide interior undulations which correspond to the desired variable pitch or convolute thickness to be formed within the corrugated tubing.

The corrugated sections of FIGS. 6 and 7 may be joined at their ends by cuff portions of the type shown in FIGS. 4a and 5, for example, to facilitate connection of the corrugated tubing to vacuum or blower apparatus.

It can be seen from the foregoing description that the present invention provides a novel corrugated tubing construction and method of manufacture so as to yield a unique tubing configuration which eliminates whistling.

Although this invention has been described with respect to its preferred embodiments, it should be understood that many variations and modifications will now be obvious to those skilled in the art, and it is preferred, therefore, that the scope of the invention be limited not by the specific disclosure herein, but only by the appended claims. For example, only a substantial number of said interior peaks (or valleys) need be provided with surface irregularities (i.e., every other interior peak or valley) thereby avoiding the need for providing a surface irregularity in each interior peak (or valley). Obviously, the molds should be modified to provide for this modification.

What is claimed is:

1. Flexible conduit means employed as a confined passageway for a fluent material comprising:

a hollow tubular-shaped member formed of a thermoplastic material having a resiliency enabling said member to be bent or compressed and to cause said member to return to its normal tubular shape upon release of bending or compressional forces, said tubular-shaped member having a corrugated configuration such that the exterior peaks and valleys of the exterior surface respectively form the interior peaks

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and valleys of the hollow interior surface, said corrugations further contributing to the aforementioned resiliency characteristics;

the interior peaks having a substantially annular shape; at least selected ones of said interior peaks having a surface portion positioned along the interior surface of the conduit means, which deviates substantially from said annular shape.

2. The conduit means of claim 1 wherein the surface irregularity of the interior peaks consists of at least one protuberance integrally formed with said interior peak portion and extending toward the center of the tubular-shaped member hollow interior.

3. The conduit means of claim 1 wherein said surface irregularity of each interior peak is comprised of at least one integrally formed indentation provided in each interior peak of the tubular member.

4. The flexible conduit means of claim 2 wherein a plurality of such protuberances are arranged at spaced intervals about each of said interior peaks.

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5. The conduit means of claim 3 wherein a plurality of such indentations are provided at spaced intervals around each of the interior peaks.

6. The article of claim 1 wherein said deviating surface portions lie along a substantially straight line parallel to the longitudinal axis of said tubular member.

7. The conduit means of claim 1 wherein said deviating surface portions define a helical path concentric with the longitudinal axis of the tubular member.

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