

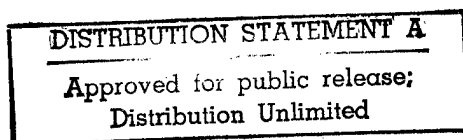
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NOTICE

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1 Navy Case No. 76504

2 METHOD OF POSITIONING AND SECURING A TUBE
3 ON AN ELONGATE SUPPORT
4

5 STATEMENT OF GOVERNMENT INTEREST

6 The invention described herein may be manufactured and used
7 by or for the Government of the United States of America for
8 Governmental purposes without the payment of any royalties
9 thereon or therefor.
10

11 BACKGROUND OF THE INVENTION

12 (1) Field of the Invention

13 The present invention relates generally to construction
14 processes involving the placing and securing of tubes on a
15 support member, and more particularly to a method of positioning
16 and securing a tube, e.g., a fiber optic hydrophone, on an
17 elongate support member.

18 (2) Description of the Prior Art

19 Fiber optic hydrophone arrays consist of a plurality of
20 fiber optic hydrophones attached and supported by a central
21 support member. A fiber optic hydrophone is typically
22 constructed by winding one or more optical fibers on a rigid
23 mandrel. Currently, such hydrophones are fabricated using
24 tubular shaped mandrels. Thus, there is a need to fasten these
25 tubular mandrels to a central support member in the construction
26 of fiber optic hydrophone arrays.

1 For proper operation of the array, no air voids must be
2 present between the interface of the (outer) tubular mandrel and
3 the (inner) support member. Excessive noise and lost sensitivity
4 result when the air voids are present. The length of the array
5 is such that conventional injection molding methods would be
6 impractical and very expensive. Furthermore, based on the
7 research and development effort in fiber optic hydrophone arrays,
8 design of the array requires that the spacing between each
9 hydrophone be adjustable during the construction phase. Machined
10 molds, even if length considerations were neglected, would
11 require many different variations in this spacing. Using an
12 undersized central member and filling the void between each
13 hydrophone's mandrel and central support member would require a
14 centering fixture and some method of sealing the area until the
15 adhesive was cured in order to prevent the adhesive from dripping
16 out.

18 SUMMARY OF THE INVENTION

19 Accordingly, it is an object of the present invention to
20 provide a simple method of positioning and securing a tube on an
21 elongate support.

22 Another object of the present invention is to provide a
23 method of constructing fiber optic hydrophone arrays.

24 Still another object of the present invention is to provide
25 a fiber optic hydrophone array construction that achieves a

1 void-free adhesive interface between each fiber optic hydrophone
2 and the array's central support member.

3 Other objects and advantages of the present invention will
4 become more obvious hereinafter in the specification and
5 drawings.

6 In accordance with the present invention, a method of
7 manufacture and resulting construction is provided in which a
8 plurality of tubes, e.g., fiber optic hydrophones, are to be
9 secured about an elongate elastomeric member at a plurality of
10 positions therealong. The elongate elastomeric member has a free
11 end and a cross section that hinders each tube from being slid
12 thereover. The elongate elastomeric member is clamped a distance
13 from the free end to define a length of the elongate elastomeric
14 member over which no tube is currently secured. A longitudinal
15 tension is applied to the elongate elastomeric member to form a
16 reduced cross section along its length in order to facilitate the
17 sliding of each tube therealong. Adhesive is applied about the
18 elongate elastomeric member at one of the positions along its
19 length while longitudinal tension is being applied. A next
20 successive one of the tubes is slid along the length of the
21 elongate elastomeric member having the reduced cross section to
22 its position. The longitudinal tension in the elongate
23 elastomeric member is then relaxed. This causes the length of
24 reduced cross section to expand radially outward thereby forming
25 a void free layer of adhesive between the tube and the elongate
26 elastomeric member. The steps of clamping, applying longitudinal

1 tension, applying adhesive, sliding and relaxing are repeated for
2 each successive one of the tubes.

3
4 BRIEF DESCRIPTION OF THE DRAWING(S)

5 Other objects, features and advantages of the present
6 invention will become apparent upon reference to the following
7 description of the preferred embodiments and to the drawings,
8 wherein:

9 FIG. 1 is a side view of a tube and an elongate elastomeric
10 member used in the construction process according to the
11 teachings of the present invention;

12 FIG. 2 is a cross-sectional view of the tube taken along
13 line 2-2 of FIG. 1;

14 FIG. 3 is a cross-sectional view of the elongate elastomeric
15 member taken along line 3-3 of FIG. 1;

16 FIGS. 4-8 depict a construction sequence of a fiber optic
17 hydrophone array in accordance with the teachings of the present
18 invention wherein:

19 FIG. 4 is a side view of the fiber optic hydrophones and
20 support member prior to commencement of construction;

21 FIG. 5 is a side view of the commencement of the
22 construction process;

23 FIG. 6 is a side view of the support member in tension as
24 the adhesive is applied thereto;

1 FIG. 7 is a side view of the hydrophone positioned over the
2 adhesive on the support member while the support member is still
3 in tension;

4 FIG. 8 is a side view of the support member with the
5 hydrophone in place after the tension in the support member is
6 relaxed;

7 FIG. 9 is a side view of the support member with the clamp
8 indexed to the next construction position for placing and
9 securing the next successive hydrophone in accordance with the
10 present invention; and

11 FIG. 10 is a cross-sectional view of a triangularly shaped
12 tube and support member.

13
14 DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

15 Referring now to the drawings, and more particular to FIGS.
16 1-3, the elements used in accordance with the present invention
17 are shown in both side and cross-sectional views. FIG. 1 depicts
18 side views of a tube 10 and an elongate member 12 on which tube
19 10 is to be positioned and secured. FIGS. 2 and 3 respectively
20 depict cross-sectional views of tube 10 and elongate member 12
21 taken along lines 2-2 and 3-3 of FIG. 1. Elongate member 12 is
22 an elastomeric material that can be solid (as shown) or hollow.
23 For purpose of illustration, tube 10 has an inner surface that is
24 circular in shape and elongate member 12 has an outer surface
25 that is circular in shape. However, this need not be the case.
26 In general, as will become apparent from the following

1 description, it is only preferred for the cross-sectional profile
2 of the inside surface of tube 10 and the cross-sectional profile
3 of the outside surface of elongate member 12 to be similarly
4 shaped.

5 By way of illustrative example, the present invention will
6 be described in detail below for the construction of a fiber
7 optic hydrophone array in which tube 10 represents a fiber optic
8 hydrophone and elongate member 12 represents the central support
9 member for the array. For such a construction, it is desired to
10 have a very close fit between the outer cross-sectional profile
11 of elongate member 12 and the inner cross-sectional profile of
12 tube 10 in order to minimize the possibility of forming air
13 pockets or voids between these two elements. Accordingly, the
14 diameter D_{10} of tube 10 is generally no larger than the diameter
15 D_{12} of elongate member 12. While such dimensional constraints
16 cause the hinderance or even prevention of sliding tube 10 over
17 and along elongate member 12, it is this tight tolerance that is
18 desirable in fiber optic hydrophone arrays.

19 To facilitate the initial placement of tube 10 on elongate
20 member 12, a free end 13 of elongate member 12 can be tapered as
21 shown to a diameter that is less than diameter D_{10} . For reasons
22 that will be described further below, the length L_{13} of the taper
23 is generally longer than the length L_{10} of tube 10.

24 The construction method of the present invention as it
25 relates to a fiber optic hydrophone array will now be described
26 with the aid of FIGS. 4-9 which depict a construction sequence

1 for a fiber optic hydrophone array having two fiber optic
2 hydrophones. However, it is to be understood that the
3 construction method can be replicated for any number of such
4 hydrophones.

5 In FIG. 4, fiber optic hydrophones 20 and 21 are shown prior
6 to being positioned and secured on central support member 30.
7 Hydrophones 20 and 21 are formed with optical fibers 22 and 23,
8 respectively, wrapped around rigid, hollow mandrels 24 and 25,
9 respectively. Such fiber optic hydrophones are well known in the
10 art and will therefore not be described further herein. As
11 described above, the inside profiles of mandrels 24 and 25 are
12 similarly shaped relative to the outside profile of central
13 support member 30. The size, i.e., diameter, of each mandrel 24
14 and 25 is equal to or slightly less than the size, i.e.,
15 diameter, of support member 30.

16 For construction of a fiber optic hydrophone array, support
17 member 30 is made from an elastomeric material such as buna/N
18 rubber or silicone. Free end 31 of support member 30 is tapered
19 so that its outside dimensions facilitate the initial placement
20 of each hydrophone thereon. A clamp 40 is attached to support
21 member 30 a distance away from free end 31. Initial placement of
22 clamp 40 should be in the proximity of where the first
23 hydrophone, e.g., hydrophone 20, is to be positioned and secured
24 on support member 30.

25 In FIG. 5, the construction process begins as hydrophone 20
26 is slid over the tapered portion of free end 31. The length of

1 taper L_{31} is typically longer than hydrophone 20 so that a portion
2 free end 31 can be grabbed by clamp 42. Clamp 40 is fixed
3 relative to clamp 42. A pulling force is then applied to clamp
4 42 in the direction of arrow 44 such that tension is experienced
5 longitudinally by support member 30. Such tension causes support
6 member 30 to stretch owing to its elastomeric properties thereby
7 reducing the cross section of support member 30 between clamps 40
8 and 42. The reduced cross section of support member 30 between
9 clamps 40 and 42 facilitates the sliding of hydrophone 20 along
10 support member 30.

11 Placement of clamp 40 is in the proximity of where
12 hydrophone 20 is to be positioned in order to permit localized
13 control in the reduction of the cross section of support member
14 30. In the case where the distance between free end 31 and clamp
15 40 is substantial, a localized pulling force, represented by
16 arrow 46 in FIG. 6, can be applied to support member 30 to cause
17 a localized reduction in cross section near clamp 40. While
18 support member 30 is reduced in cross section, a layer 50 of
19 adhesive (e.g., epoxy or any other suitable adhesive) is applied
20 to support member 30 at the desired point of placement of
21 hydrophone 20.

22 In FIG. 7, hydrophone 20 is shown being slid along support
23 member 30 over adhesive 50 while localized pulling force 46 is
24 still being applied. Then, as shown in FIG. 8, localized pulling
25 force 46 and pulling force 44 are slowly removed so that the
26 longitudinal tension in support member 30 is relaxed. This

1 allows support member 30 to expand radially outward thereby
2 causing excessive amounts of adhesive 50 and any trapped air to
3 be squeezed from between hollow mandrel 24 and support member 30.
4 As a result, a uniform and void-free layer of adhesive 50 couples
5 hydrophone 20 to support member 30. The above process is
6 repeated by indexing the position of clamp 40 to the proximity of
7 the next desired hydrophone position that is next closest to free
8 end 31 as shown in FIG. 9.

9 The advantages of the present invention are numerous. A
10 fiber optic hydrophone array can be constructed such that a void-
11 free layer of adhesive bonds each hydrophone to a support member.
12 The construction process is simple and flexible with respect to
13 adjusting the spacing of the hydrophones during the construction
14 process. The process could be implemented manually or could be
15 automated for long-length hydrophone arrays.

16 The process can be implemented for any correspondingly
17 shaped tube and support member as long as the outside profile of
18 the support member nests within the inside profile of the tube.
19 For example, as shown in FIG. 10, support member 60 could be
20 triangular with its apices nesting within the apices of tube 61
21 that is also triangularly shaped. Obviously the above would be
22 true for other profiles such as squares, pentagons, hexagons,
23 etc.

24 The process could be further extended to work with tubes
25 having inside diameters or dimensions that are less than the
26 support member to which they are to be secured. In this way, the

1 support member would have a larger diameter on either side of
2 each such tube. Thus, the tube's position would be secure even
3 if the adhesive broke down over time.

4 Accordingly, it will be understood that many additional
5 changes in the details, materials, steps and arrangement of
6 parts, which have been herein described and illustrated in order
7 to explain the nature of the invention, may be made by those
8 skilled in the art within the principle and scope of the
9 invention.

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2
3 METHOD OF POSITIONING AND SECURING A TUBE
4 ON AN ELONGATE SUPPORT

5
6 ABSTRACT OF THE DISCLOSURE

7 A method of manufacture and resulting construction is
8 provided in which a plurality of tubes, e.g., fiber optic
9 hydrophones, are to be secured about an elongate elastomeric
10 member having a diameter that hinders each tube from being slid
11 thereover. Each time a tube is to be positioned and secured,
12 longitudinal tension is applied to the elongate elastomeric
13 member to form a reduced cross section along its length in order
14 to facilitate the sliding of each tube therealong. Adhesive is
15 applied about the elongate elastomeric member at a desired
16 position along its length while longitudinal tension is being
17 applied. Then, one tube is slid along the length of reduced
18 cross section to the desired position. The longitudinal tension
19 in the elongate elastomeric member is then relaxed. The reduced
20 cross section expands radially outward thereby forming a void
21 free layer of adhesive between the tube and the elongate
22 elastomeric member.

FIG. 1

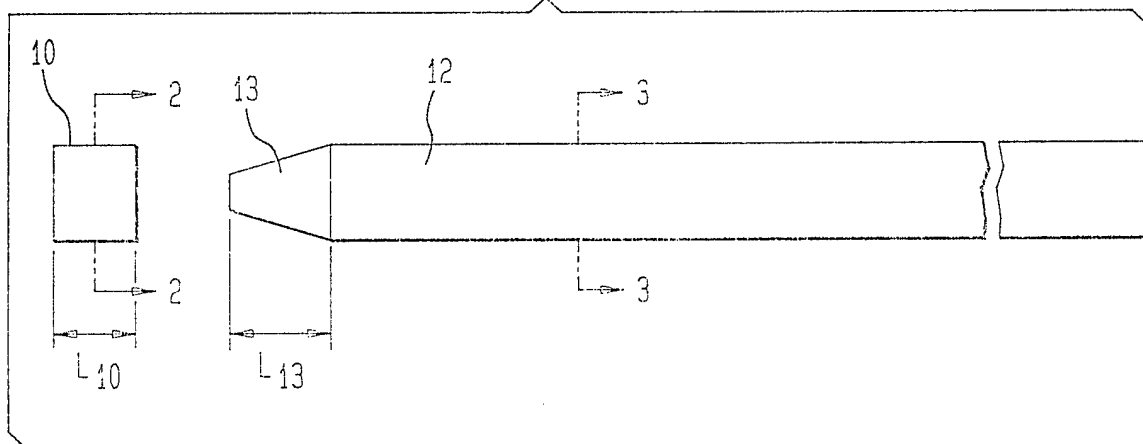


FIG. 2

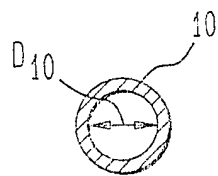


FIG. 3

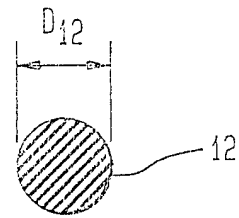


FIG. 4

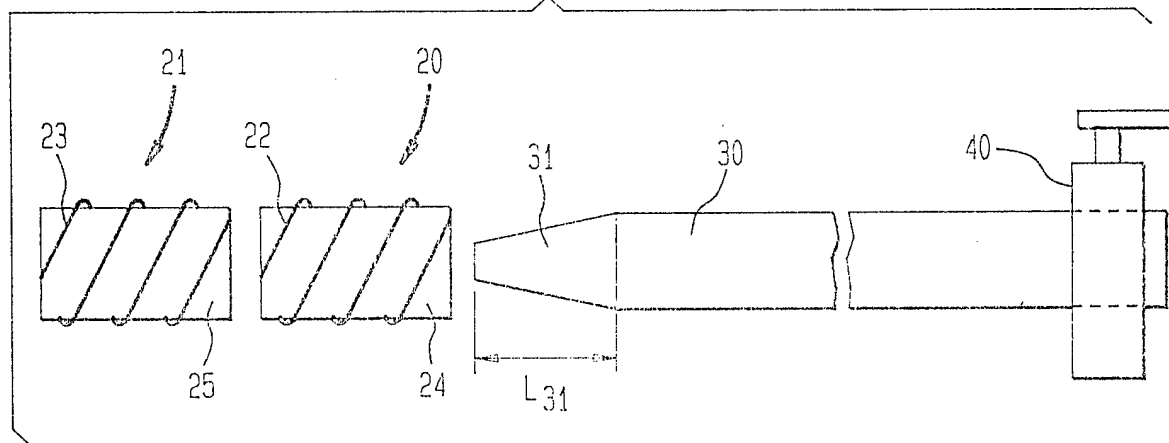


FIG. 5

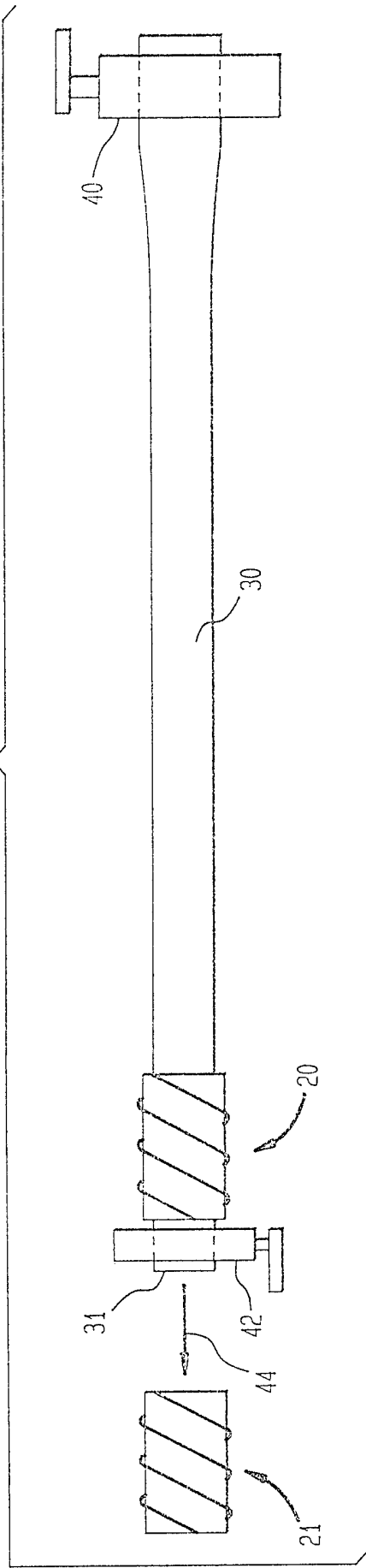


FIG. 6

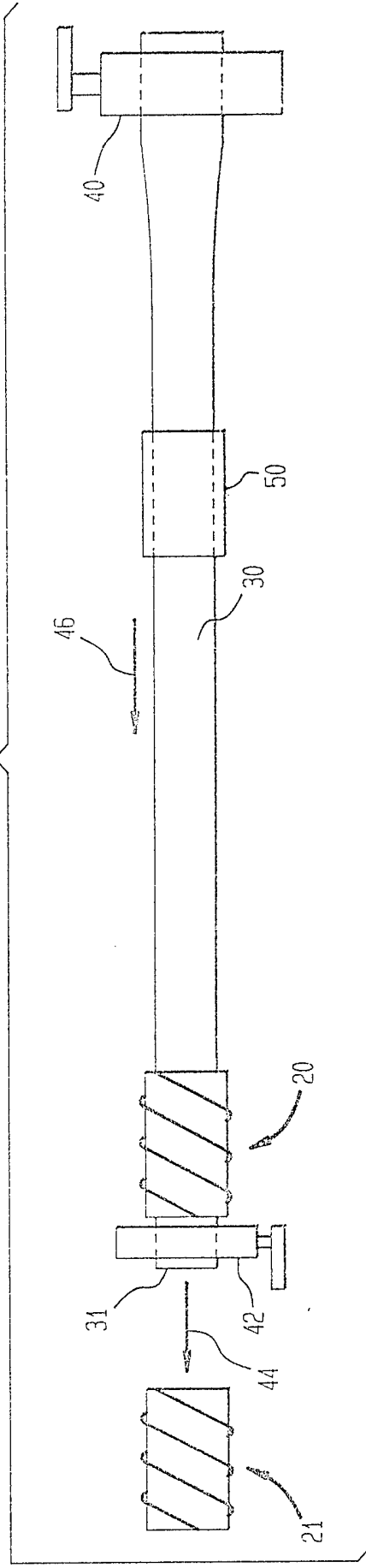


FIG. 7

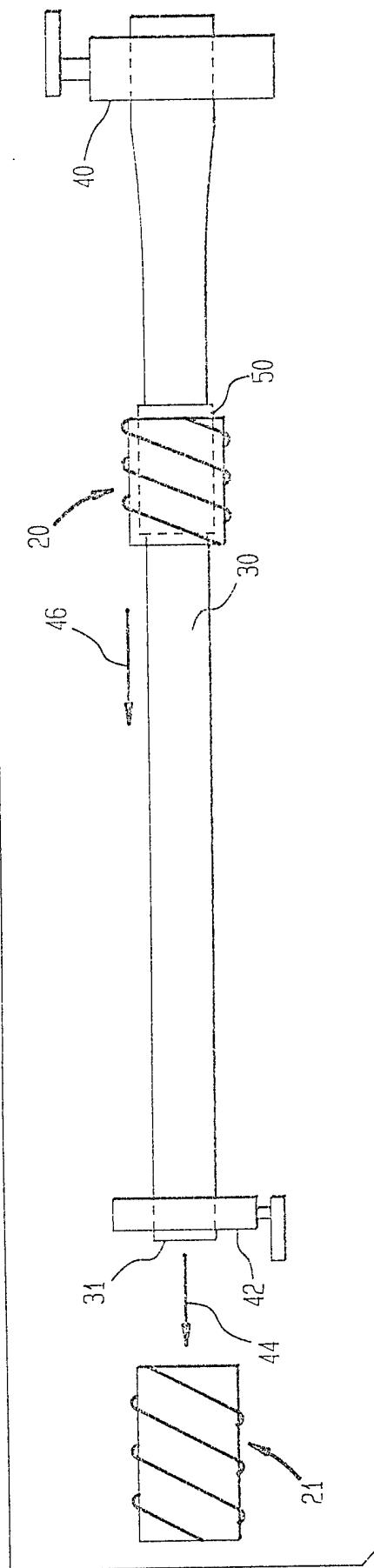


FIG. 8

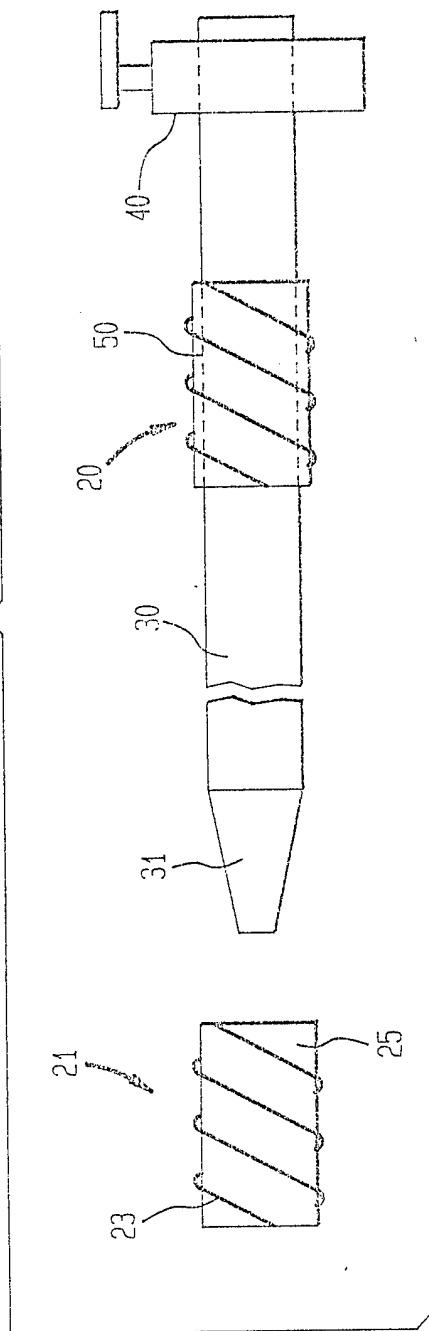


FIG. 9

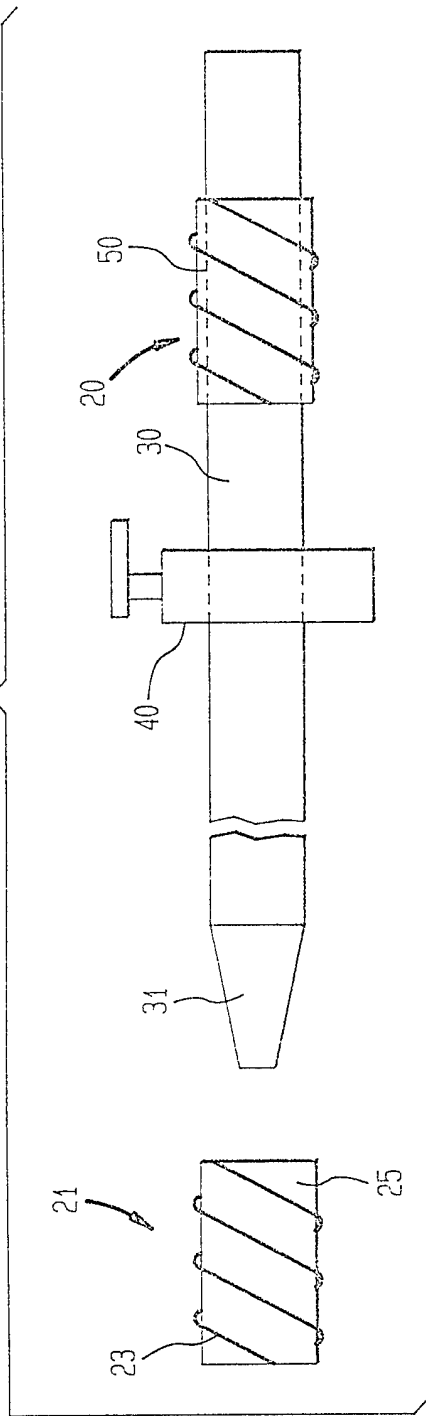


FIG. 10

