

Dec. 15, 1964

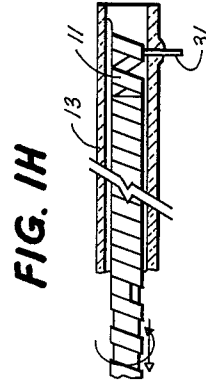
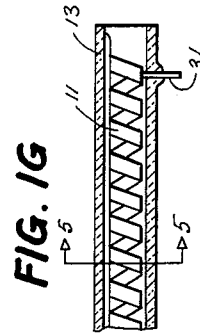
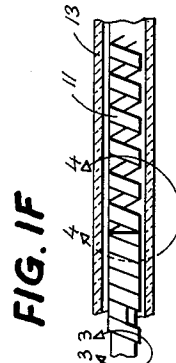
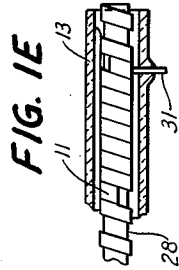
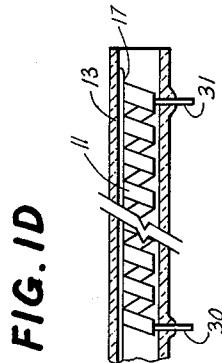
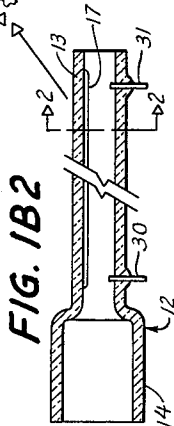
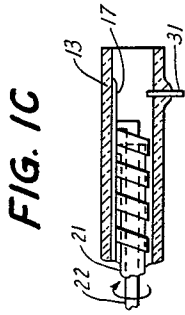
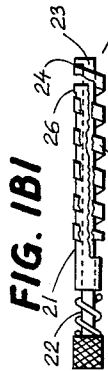
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3,160,943

HELIX TRAVELLING WAVE TUBE ASSEMBLY METHOD AND APPARATUS

Filed July 18, 1960

8 Sheets-Sheet 1



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HELIX TRAVELLING WAVE TUBE ASSEMBLY METHOD AND APPARATUS

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FIG. 3

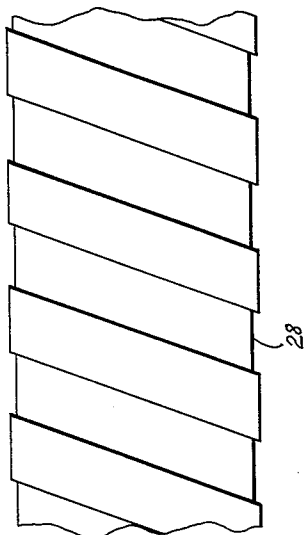


FIG. 2

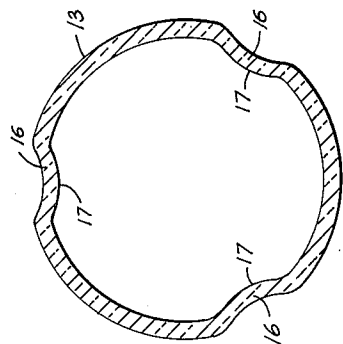


FIG. 5

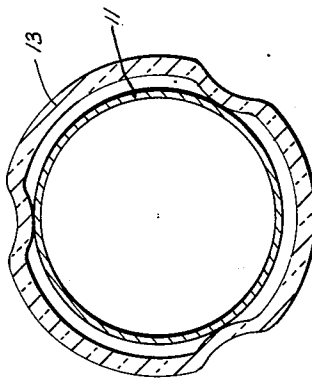
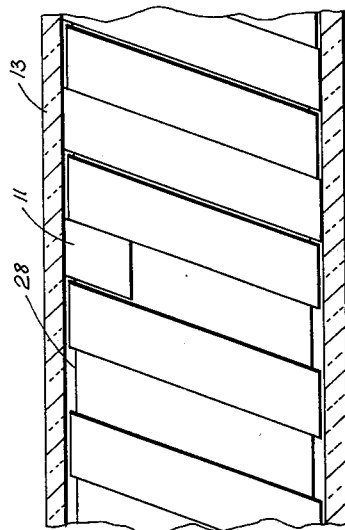


FIG. 4



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HELIX TRAVELLING WAVE TUBE ASSEMBLY METHOD AND APPARATUS

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FIG. 6B

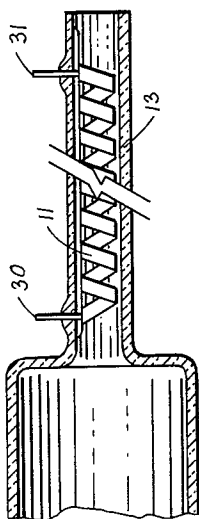


FIG. 6D

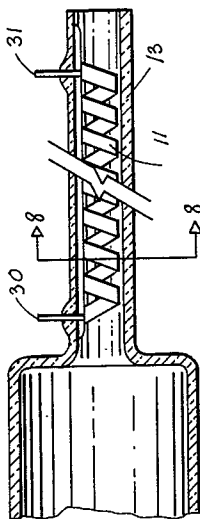


FIG. 8

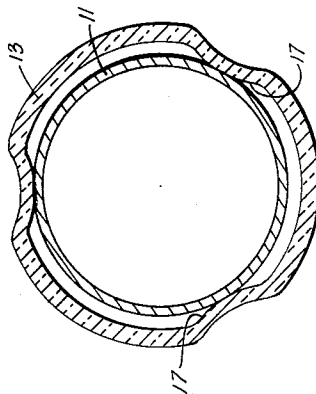


FIG. 6A

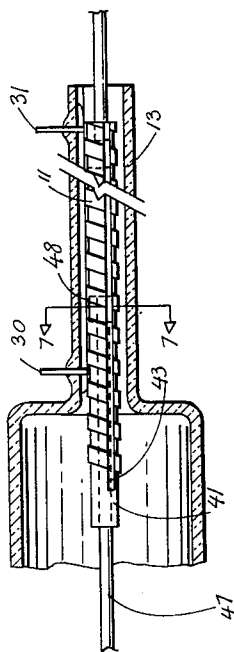


FIG. 6C

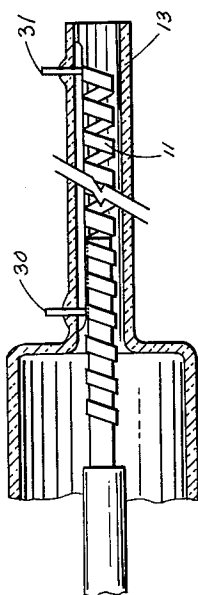
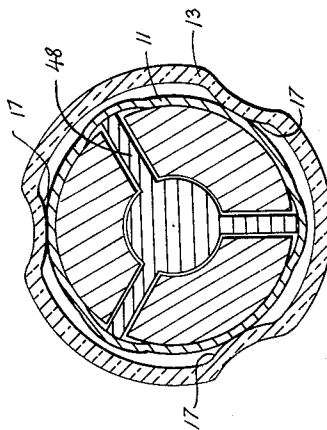


FIG. 7



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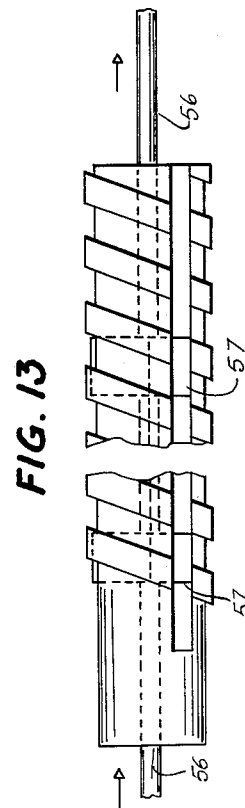
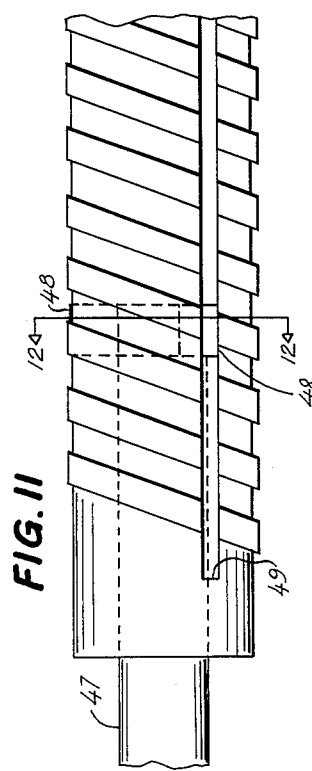
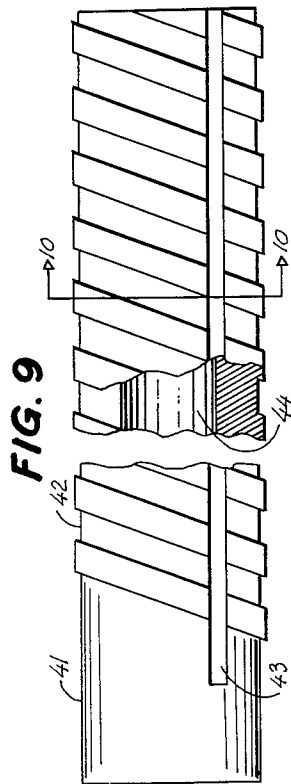
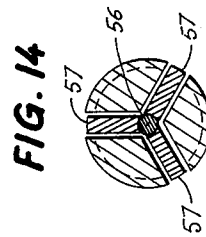
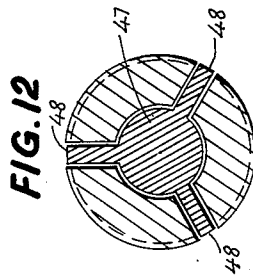
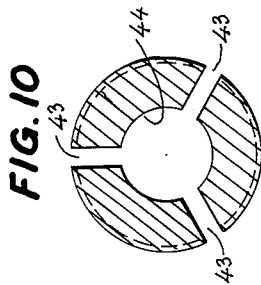
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HELIX TRAVELLING WAVE TUBE ASSEMBLY METHOD AND APPARATUS

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FIG. 15

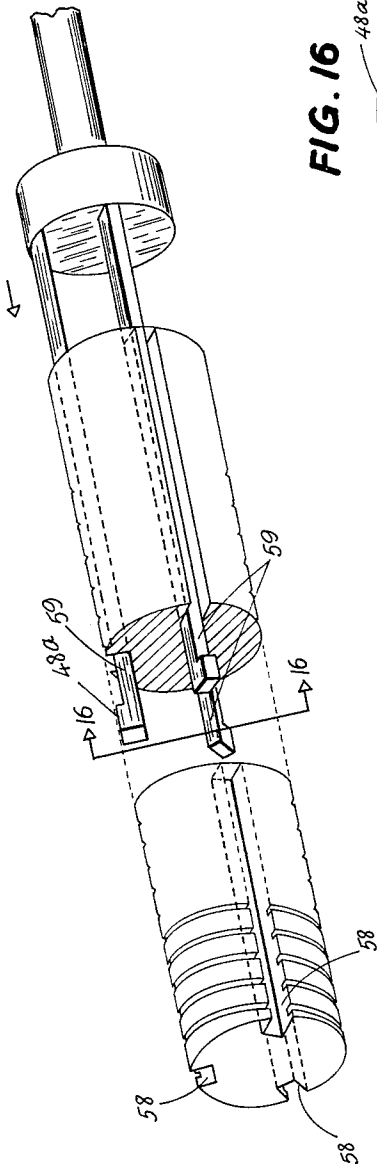
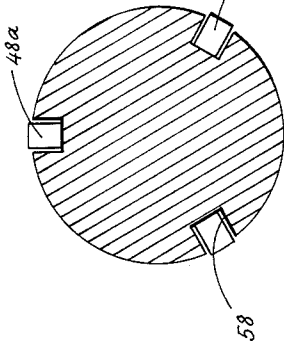


FIG. 16



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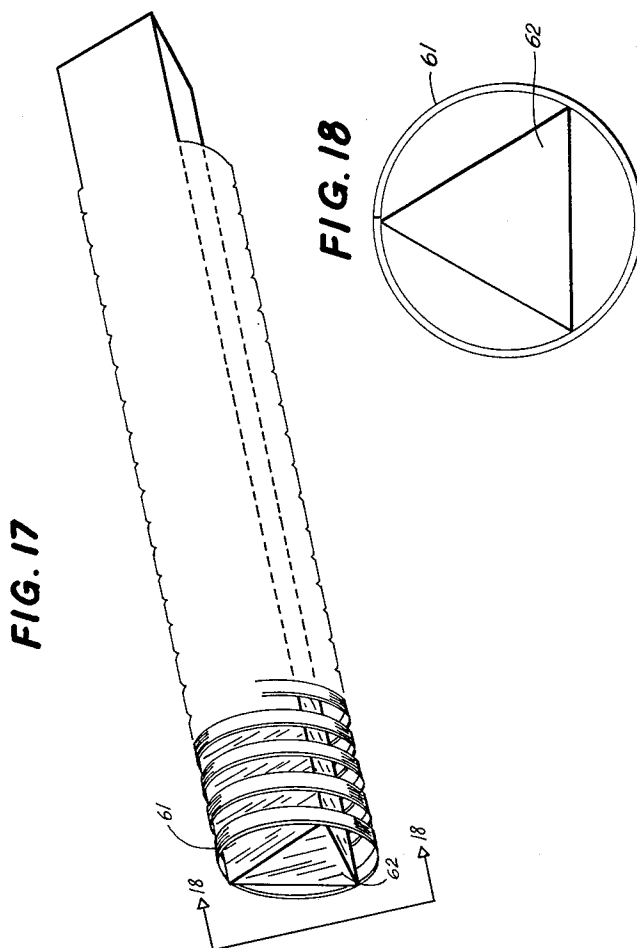
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HELIX TRAVELLING WAVE TUBE ASSEMBLY METHOD AND APPARATUS

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HELIX TRAVELLING WAVE TUBE ASSEMBLY METHOD AND APPARATUS

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FIG. 19

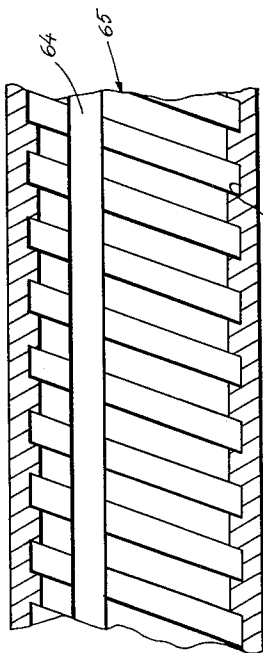


FIG. 21

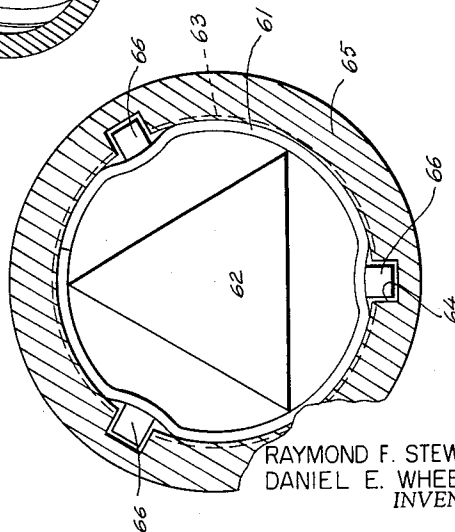
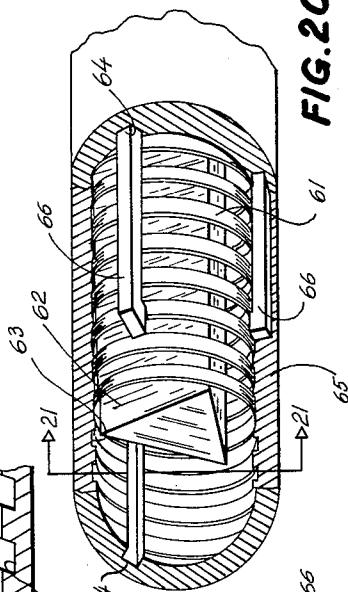


FIG. 20



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HELIX TRAVELLING WAVE TUBE ASSEMBLY METHOD AND APPARATUS

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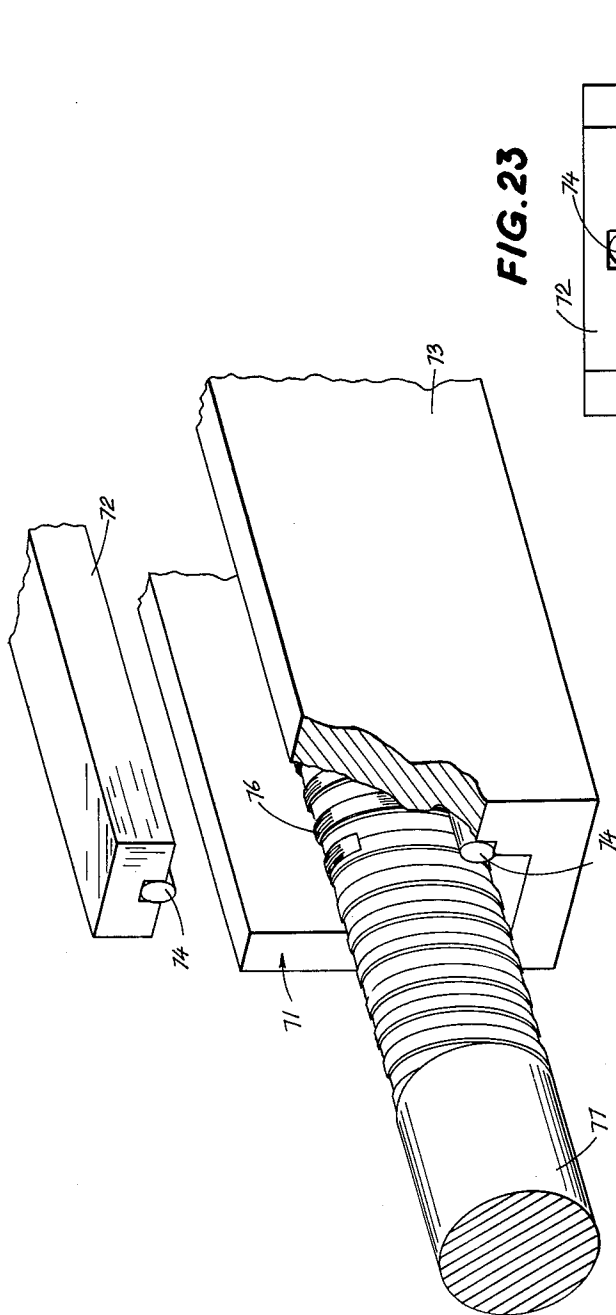


FIG. 23

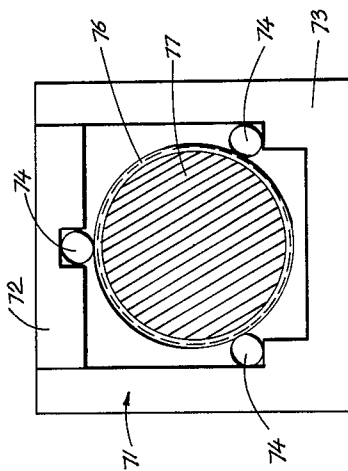


FIG. 22

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HELIX TRAVELLING WAVE TUBE ASSEMBLY METHOD AND APPARATUS

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pany, Santa Cruz, Calif., a corporation of California
Filed July 18, 1960, Ser. No. 43,659
22 Claims. (Cl. 29—25.13)

This invention relates generally to an assembly meth-
od for travelling wave tubes and to an apparatus for use
therein.

As is well known, travelling wave apparatus operates
on the exchange of energy between an electron beam
and an electromagnetic wave which is suitably coupled
thereto. Generally, the electromagnetic wave is propa-
gated along a periodic structure with its phase velocity
in the direction of the electron beam substantially equal
to the velocity of the beam. There is a continuous inter-
action between the wave travelling along the periodic
structure and the electron beam. As a result of this inter-
action, energy is transferred from the beam to the electro-
magnetic wave.

As is well known, travelling wave tubes are of two
types. The first type are those in which the group and
phase velocity of the electromagnetic waves are in the
direction of the electron beam. These tubes are referred
to as forward travelling wave tubes. The second type
of travelling wave tubes are those in which the phase ve-
locity of the electromagnetic wave is in the same direc-
tion as the electron beam but the group velocity (energy
flow) is opposite thereto.

Operation of both these tubes is inherently the same.
The electron stream has a velocity which is slightly greater
than the phase velocity of the electromagnetic wave
travelling along the periodic circuit. There is interaction
between the electromagnetic wave and the electron beam,
and the electrons in the beam are velocity modulated,
that is, the electrons are bunched. The bunching takes
place by some of the electrons speeding up, while others
are slowed down. If the speeding up and slowing down
is exactly the same, no amplification of the wave results.
Fortunately, it turns out that the two quantities are not
exactly equal. There is a bunching around the slow
moving electrons thus reducing the mean velocity and
hence the kinetic energy of the electron beam as a whole.
This increment of kinetic energy is transferred to the
electromagnetic wave and results in the wave being am-
plified.

Both of the foregoing types of travelling wave tubes
may include a periodic structure of the helix type. Gen-
erally, the helix is wound with wire, ribbon or tape. The
electromagnetic energy travels along the wire at the speed
of light. However, it travels in an axial direction at a
velocity which is dependent upon the pitch of the helix.
The pitch is selected whereby the axial velocity of the
electromagnetic wave corresponds generally to the veloci-
ty of the electron stream associated therewith.

The pitch of the helix, particularly in a backward
travelling wave tube, is of prime importance. Not only
must the pitch of the helix be accurate, but the helix
must be supported in such a manner as to minimize the
possibility of variations in pitch during operation of the
tube. For example, in backward wave oscillators, any
variations in pitch will alter the periodicity of the struc-
ture and one portion of the structure may oppose the
remainder of the structure. For example, in a backward
wave oscillator, this may mean that it will not operate
the same at all frequencies. It may have voids in its
output at certain frequencies, or it may operate at sev-
eral frequencies at one time. If the pitch of the helix
varies during operation, the oscillation frequency will be

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frequency modulated. In many applications, frequency
variations cannot be tolerated. For example, the out-
put of a backward wave oscillator which operates over
a 2:1 frequency band in the range of 5 kmc. and higher
may be modulated due to changes in pitch during oper-
ation as much as several thousand cycles.

Many attempts have been made in the prior art to
properly support a helical transmission line within a vitre-
ous envelope. For example, in certain applications, the
glass has been shrunk onto the helix in such a manner
that ridges are formed which embed spaced points of
the helix to firmly support the same. In other appli-
cations, a plurality of spaced rods are inserted between
the tube envelope, which can be metal, and helical con-
ductor. Spring metal clips are employed for providing
the desired seating pressure between the parts. Another
attempt at firmly holding a helix within an envelope has
been to partially embed the turns in a vitreous envelope.
None of these methods are entirely satisfactory since
they are all dependent upon the helix having the proper
pitch when it is inserted within the envelope and main-
taining the pitch while the helix is fixedly secured. Fur-
thermore, in those instances where the helix is partly em-
bedded in the vitreous envelope, dielectric loading is in-
creased. None of the methods of the prior art permit
adjustment of the pitch after the helix is seated.

It is a general object of the present invention to pro-
vide an improved assembly method for travelling wave
tube having a helical slow wave structure.

It is another object of the present invention to provide
a method for mounting a helix on a supporting structure
in such a manner that the helix has accurate and uni-
form pitch and it is securely retained by the supporting
structure.

It is another object of the present invention to provide
an improved method for placing a helix in an elongated
cylindrical envelope.

It is still another object of the present invention to
provide an improved method for placing a helix in a
travelling wave tube envelope so that the helix is fixedly
seated within the envelope and has accurate spacing be-
tween adjacent convolutions.

It is another object of the present invention to pro-
vide a method of mounting a helix on a supporting struc-
ture which comprises placing the helix in cooperation
with the structure, setting the helix on the supporting
structure and then positioning the helix to obtain a uni-
form pitch.

It is another object of the present invention to provide
a method of mounting a helix on a support which com-
prises placing the helix in cooperation with the support-
ing structure, urging the helix against the support and
maintaining pressure between the helix and support so
that the spacing is retained by the restraining frictional
forces created between the support and helix.

It is still another object of the present invention to pro-
vide a method of mounting a helix on a supporting struc-
ture which comprises placing the helix in cooperation
with the supporting structure, causing the turns of the
helix to move radially to press against the support, and
holding the helix whereby the pressure is maintained.

It is a further object of the present invention to pro-
vide a method of mounting a helix in a supporting struc-
ture which comprises placing the helix in cooperating rela-
tionship with the structure, employing a guide mandrel to
position the helix on the structure, causing the turns of
the helix to move radially to press against the support, and
holding the helix whereby the pressure is maintained.

It is still a further object of the present invention to
provide a method of mounting a helix on a supporting
structure which comprises placing the helix in cooperative
relationship with the supporting structure, inserting co-

axially of the helix a mandrel having a helically arranged groove adapted to receive and position the helix so that it conforms to the final arrangement, moving a probe progressively along said mandrel to progressively urge the helix turns radially against the supporting structure, and securing the helix whereby the radial force is maintained.

It is still a further object of the present invention to provide an improved apparatus for mounting a helix on a supporting structure which comprises a guide mandrel having a helical groove conforming to the desired final arrangement of the helix in the supporting structure, the mandrel including at least one longitudinally extending slot, and a probe movable in the slot and projecting radially past the outer periphery of the guide surface to provide a radial force to a helix associated therewith progressively along the mandrel.

It is another object of the present invention to provide a novel setting tool for positioning helices within a travelling wave tube envelope.

These and other objects of the invention will be more clearly understood from the following description taken in conjunction with the accompanying drawing.

Referring to the drawing:

FIGURES 1A-1H schematically illustrate one method for forming a travelling wave tube assembly in accordance with the present invention;

FIGURE 2 is an enlarged sectional view taken along the line 2-2 of FIGURE 1B2;

FIGURE 3 is an enlarged view of a portion of the positioning mandrel;

FIGURE 4 schematically shows the engagement of the helix by the positioning mandrel;

FIGURE 5 is an enlarged sectional view taken along the line 5-5 of FIGURE 1G and shows the helix as set and inserted in the elongated glass envelope;

FIGURES 6A-6D show another method of forming a travelling wave tube assembly in accordance with the present invention;

FIGURE 7 is an enlarged sectional view taken along the line 7-7 of FIGURE 6A;

FIGURE 8 is an enlarged sectional view taken along the line 8-8 of FIGURE 6D;

FIGURE 9 is a side elevational view, partly in section, of a mandrel;

FIGURE 10 is a sectional view taken along the line 10-10 of FIGURE 9;

FIGURE 11 is a side elevational view of a setting mandrel together with its setting member;

FIGURE 12 is a sectional view taken along the line 12-12 of FIGURE 11;

FIGURE 13 is a side elevational view of another setting mandrel suitable for setting small helices in accordance with the invention;

FIGURE 14 is a sectional view of the mandrel shown in FIGURE 13;

FIGURE 15 shows a perspective of still another type of setting mandrel;

FIGURE 16 is a sectional view taken along the line 16-16 of FIGURE 15;

FIGURE 17 shows a helix supported by an internal support;

FIGURE 18 is a view taken along line 18-18 of FIGURE 17;

FIGURE 19 is a sectional view of a mandrel suitable for mounting the helix on an internal support;

FIGURE 20 shows a setting mandrel in operation to set the helix on an internal support;

FIGURE 21 is a sectional view taken along the line 21-21 of FIGURE 20;

FIGURE 22 is a perspective view showing the method of the present invention for positioning a helix on spaced rods; and

FIGURE 23 is a sectional view showing the helix, mandrel and spaced rods in a fixture.

Referring to FIGURES 1A-H one method for forming

a helix assembly in accordance with the present invention is schematically illustrated. In FIGURE 1A, there is shown a helix 11 which is formed by helically winding tape or ribbon material. The helix may, for example, be formed by winding the tape or ribbon material on a smooth mandrel. In the present embodiment of the invention the size of the mandrel is selected whereby when the material that is wound is released, it will attain a normal outside diameter which is slightly larger than the diameter of a circle which is coincident with the exterior supporting means for the helix, as will be presently described. When internal supporting means are employed, the helix will have an internal diameter slightly less than that of a circle coincident with the supporting surfaces.

The helix 11 is adapted to be inserted in a travelling wave tube envelope 12. The envelope 12 includes a relatively long cylindrical portion 13 which expands into a bell 14 at one end. The bell serves to receive an electron gun (not shown) for projecting an electron stream axially of the helix and envelope.

The envelope portion 13 may include inwardly extending longitudinal ridges 16 FIGURE 2 which may, for example, be formed by shrinking the cylindrical glass envelope on a suitable mandrel. The surfaces 17 are accurately formed so that they define points on a cylindrical surface. The diameter of the surface is less than the normal outer diameter of a helix supported thereby. The spaced surfaces 17 of the ridges are adapted to receive and support the helix when it is inserted within the portion 13.

As previously described, the helix 11 has an outside diameter which is slightly greater than the diameter of the cylindrical surface which includes the supporting surfaces 17. To insert the helix 11 in the envelope, an inserting tool is provided. For example, the tool may comprise a rod or mandrel 21 which receives the helix and holds it at one end. The rod is of such diameter that when the helix is tightly wound thereon, the assembly fits into the envelope. To place the helix in the envelope, the rod is rotated in such a direction that the helix tends to wind tightly on the same, and simultaneously the assembly is moved axially into the envelope portion 13 (a screw action). Subsequently, one end of the helix is released from the mandrel allowing the helix to "unwind" and expand. The turns nearest each end will be in intimate contact with the glass surfaces 17 due to the radial spring forces of the helix turns. It is apparent that if each turn is allowed to unwind there will be sufficient pressure outwardly against surfaces 17 to cause the helix to be firmly held against axial movement. It is apparent that if sufficient pressure is present, the helix will be firmly held against axial movement by the friction between the ground glass surface 17 and the contacting portion of the convolutions of the helix. The friction forces are such that the helix is not displaced by movement of the tube, normal vibrations, or jarring motions.

A suitable rod or mandrel 21 for inserting (threading) the helix into the envelope is shown in FIGURE 1B1. It includes a mandrel or rod portion 21 which accommodates a plunger 22. The end of the plunger includes an ear 23 which is adapted to abut against the side 24 of the adjacent convolution of a helix placed on the mandrel. On the opposite side of the convolution, there is a fixed ear 26. Thus, by spring loading the plunger 22 so that it is urged to the left as viewed in FIGURE 1B1, the helix is pinched between the ears 23 and 26. As previously described, the outer diameter of the mandrel 21 is selected whereby when the helix is tight against the mandrel, there will be a clearance between the outside of the helix and the interior supporting surfaces 17 of the envelope.

To insert the helix, the inserting mandrel is guided within the tube FIGURE 1B2 and rotated in the same sense as the convolution of the helix (see FIGURE 1C), whereby it is in effect threaded or screwed into the en-

velope. As the mandrel is rotated, the convolutions which engage the supporting surfaces 17 are retarded by friction and there is a winding up of the helix onto the mandrel so that the convolutions attain a diameter less than the diameter of the cylindrical surface including the supporting surfaces 17. The helix may be advanced into the envelope until it is longitudinally spaced within the envelope. Subsequently, the plunger 22 is released to release the helix. The helix tends to spring outwardly providing clearance for withdrawal of the inserting tool and giving rise to pressure between the contacting portions of the convolutions and the surfaces 17. FIGURE 1D schematically shows the helix in the envelope.

The next step is to insert a master mandrel which has formed thereon a helical groove 28 FIGURES 1E and 3, having standard accurate pitch, conforming to the desired pitch for the helix. The width of the groove is slightly greater than the width of the tape forming the helix. The grooves are inclined and lapped to the proper size and pitch. The master mandrel has a major diameter less than the support diameter and a minor diameter less than the final inside diameter of the helix. The mandrel may be provided with a handle portion (not shown) and the helical groove is preferably longer than the longitudinal extent of the helix.

The mandrel is then, in effect, threaded or screwed into the helix within the tube envelope, FIGURE 1F, and, as it is rotated and moved into the helix, it will move the individual convolutions by overcoming the frictional retaining force to adjust the pitch of the helix to conform to that of the mandrel groove. Since the grooves are wider than the tape the mandrel is urged in one direction whereby the same side of all of the grooves engages the same side of the helix. In this manner, the pitch between corresponding edges of the helix is accurately adjusted.

After the mandrel is completely threaded into the helix and the helix positioned, the assembly, including the mandrel, is vibrated at a relatively high frequency, for example, an ultrasonic frequency. The friction between the convolutions of the helix and the adjacent supporting surfaces becomes negligible. The helix will tend to regain its normal diameter and pitch. In effect, the helix unwinds until the pressure between convolutions and supporting surfaces is equalized along the length of the envelope. The two ends of the helix are welded to the leads 30 and 31, FIGURE 1D. The same, FIGURE 4, or another master mandrel may then be threaded into the helix one turn at a time, and moved to and fro. This overcomes the frictional retaining force and individually and sequentially imparts the proper pitch to the helix by assuring that the same edge of the helix abuts the same edge of the groove. This is done a turn or two at a time so that the frictional forces between the helix and adjacent supporting surfaces can be overcome for positioning. The mandrel is then removed, FIGURE 1H. This final positioning step is only necessary where it is desired to have extreme accuracy. It is apparent that even without this step, the accuracy of positioning is relatively high since the convolutions are positioned by the standard mandrel during the vibratory setting operation.

The pitch of the helix will be substantially uniform (as uniform as the mandrel plus tape width variations) and will be maintained by friction forces created by the pressure exerted by the helix against the supporting surfaces due to the spring action of the helix; see FIGURES 1H and 5.

In summary the steps are (1) inserting the helix within the tube envelope by "threading"; (2) positioning the helix by "inserting" a master mandrel; (3) setting the helix within the envelope by allowing it to unwind, thus equalizing the pressure and retaining the helix in accurate position by friction; (4) if desired, accurately adjusting the pitch by employing the same or another mandrel for a final positioning.

In the prior art methods, the pitch of the helix is deter-

mined by the accuracy with which the helix is wound. In the present invention, the pitch is determined by the master mandrel.

It is apparent, of course, that a similar method may be followed in positioning a helix in an envelope which does not include a plurality of supporting ridges. It is preferable to use an envelope which has ridges since the use of ridges reduces the amount of dielectric in contact with the helix to lower the dielectric loading factor and raise the helix impedance. This, in turn, allows better coupling to the beam, widens the bandwidth of the tube, and raises its efficiency.

The vibration referred to above may comprise immersing the assembly in an ultrasonic bath. The fluid in the acts as a lubricant between the helix and supporting surfaces and allows the use of lower power in the vibrator.

An alternative method for setting the helix in the envelope is illustrated in FIGURES 6A-D. Rather than placing a solid setting mandrel in the sub-assembly as shown in FIGURE 1F, a split mandrel 41, FIGURES 6A and 9-14, is wound into the helix to adjust its position. The split mandrel carries a finned member 48 FIGURES 7 and 12, which progressively urges the convolutions outwardly as it is moved longitudinally to force the helical turns mechanically outwardly and firmly seats the same against the supporting surfaces. The action as the finned member engages the convolution is to spread the convolution outwardly, unwinding the helix from the end which is not engaged. As will become apparent, the method set forth in this embodiment can be carried out with helices which have an external diameter slightly less than the diameter of an external supporting structure although it is preferable if it is slightly greater. Similarly, for a helix supported internally the internal diameter is preferably less than the support, but it may be slightly greater.

Referring to FIGURES 9-12, a suitable split mandrel is illustrated. Thus, the mandrel 41 is machined and lapped to form a helical groove 42 which is adapted to receive and position the helix within the tube envelope. The groove has a pitch which is the desired pitch of the helix, a major diameter less than the supporting structure, and a minor diameter less than the final internal helix diameter. The mandrel is slotted as indicated at 43, FIGURES 9 and 10, and includes a cylindrical opening 44. The opening 44 is adapted to receive a cylindrical rod (not shown) which serves to provide rigidity to the structure whereby the individual segments of the mandrel are retained in spaced relationship.

Referring to FIGURES 11 and 12, a second rod 47 is provided which includes fins or presser portions 48 extending outwardly from the same. The grooved fins 48 extend outwardly beyond the surface of the mandrel and a cylinder which includes the surface of these fins is slightly greater in diameter than the inside surface of the helix when the helix is in contact with the supporting surfaces 17 of the envelope, FIGURE 7.

To form a helix assembly, the helix is placed in cooperation with the supporting structure. If the helix is such that its diameter normally places it in contact with the support, an inserting tool of the type previously described is employed. If the normal diameter is such that there is free cooperation, the helix is merely slid in place. One end of the helix is attached to its respective lead-in 30 or 31. The rod 47 and fin structure 48 are inserted within the main mandrel 41 until the fins are at the end 49. The rod 46 is then inserted into the cylindrical opening 44. The mandrel is then threaded into the helix and until it is completely threaded to adjust the pitch of the helix. At this time, the rod 47 is urged progressively along the mandrel whereby the finned structure 48 sequentially engages the turns of the helical conductor as illustrated in FIGURES 6A and 7. The convolutions are urged outwardly whereby the helix is expanded and bears against the supporting surfaces 17. As the fin structure

travels past the material, it will tend to spring back into a circular configuration and will be urged radially outwardly by the spring forces to tightly engage the surfaces 17. The helix is prevented from loosening since one end is secured and the other end is engaged by the fins. When the helix is positioned through all of its length, the other end is secured to the other lead-in. The helix is prevented from moving longitudinally with respect to the tape and it is pressed against the supporting structure and retained against movement.

As before, if more accurate positioning is desired, the next step is that of accurately positioning the helix, FIGURE 6C, in the manner previously described. The resulting structure is shown in FIGURES 6D and 8 wherein the helix is supported on the supporting surfaces 17 with pressure due to the spring forces of the helix as it tends to return to its normal position. The friction retains the spacing.

In certain travelling wave tubes, the helices have relatively small diameters. In such instances, the mandrel 41 may be formed without a central bore 44 for receiving a reinforcing member. However, there will be a small space at the bottom of the slots which can receive a relatively small rod 56. The rod is provided with fins 57 which ride in the slots and serve to provide the desired rigidity. The fins 57 are so constructed that their outer edges lie inside the surface of the mandrel whereby they do not engage the helical turns. Setting fins are employed to set the helix after the mandrel has been inserted.

Referring to FIGURES 15 and 16 another setting mandrel is shown. As before the mandrel includes an axial groove. However, rather than being hollow to receive setting fins 48 it is provided with longitudinal grooves 58 which receive spaced rods 59 which carry fins 48a. This provides a more rigid mandrel configuration.

The embodiments described above are directed to a helix which is externally supported and adapted to cooperate with an internally directed electron beam. In certain applications it is advantageous to employ a hollow electron beam which is external of the helix. For this type of tube, the helix is internally supported. The present invention may be employed to form helix assemblies which are internally supported.

Referring to FIGURES 17 and 18, there is shown a helix 61 supported on a rod 62 which is triangular in section. If the helix has a normal diameter less than the rod, an inserting tool in the form of a hollow tube can be employed. The tool includes a means for grasping or holding the end of the helix and the helix can be threaded onto the rod by a screwing action. A master mandrel having an internal helical groove can then be threaded over the support to position the helix.

Setting of the helix may be done by vibration, as previously described, whereby the helix seeks to attain its normal diameter. Setting may also be preformed by using a slotted or grooved mandrel 65 of the type shown in FIGURES 19-21. The mandrel includes a helical groove 63 and longitudinal grooves 64. Pressing members 66 are adapted to ride in the grooves 64 and progressively engage the convolutions to urge them against the support. The normal spring action retains the position.

If the helix has an internal diameter normally greater, one end is affixed and the helix is progressively set, as previously described, and then the other end is affixed.

After the ends are affixed, the helix pitch may be more accurately adjusted with a master mandrel, if desired.

The principles of the present invention may be employed to accurately adjust the pitch of a helix prior to its being bonded to supporting rods. Referring to FIGURES 22 and 23, a fixture 71 including cooperating parts 72 and 73 positions spaced rods 74 about a helix 76. In the prior art, the accuracy of the helix pitch was determined by the winding operation and the rods are bonded without any adjustment of pitch. The helix

pitch may be adjusted as described above by employing one or more mandrels 77 prior to placing the fixture in a furnace for bonding to a final assembly having improved accuracy.

In certain applications, a plurality of helices may be arranged in parallel relationship with coincident axes. It will be apparent that this invention is applicable to this type of assembly as well.

Thus, there is provided an improved travelling wave tube in which the helix within the tube is retained in accurate spaced relationship by the friction created because of the pressure between the helix and the cooperating supporting surface. Further, there is provided a novel method for inserting a helix to achieve the foregoing result. In essence, the helix is inserted into the supporting structure, and positioned and set.

We claim:

1. The method of mounting a helix to a supporting structure which comprises placing the helix in cooperative relationship with said supporting structure, inserting a mandrel having a helical groove of the desired final configuration in cooperation with said helix to receive the helix in the groove and position the same in accordance with the groove, and subsequently causing the helix to move radially against the supporting structure to be firmly engaged and retained by the forces between the supporting structure and helix.

2. A method as in claim 1 wherein the supporting structure is an external structure, said helix being placed coaxially within the same and expanded radially outward to engage the same.

3. A method as in claim 1 wherein the supporting structure is an internal structure, said helix being placed coaxially about the structure and moved radially inward to engage the support.

4. The method of mounting a helix in an external supporting structure which comprises placing a helix which has an outside normal diameter slightly greater than the inside diameter of the external supporting structure within the structure, inserting a mandrel in cooperative relationship with the helix, said mandrel having a helical groove of the desired final configuration adapted to receive the helix in the groove and position the helix, and subsequently vibrating the assembly to cause the helix to move radially outwardly against the supporting structure to be firmly engaged thereby.

5. The method of mounting a helix on an internal supporting structure which comprises placing a helix having a normal diameter which is less than that of the supporting structure in cooperation with the structure, inserting a mandrel in cooperation with said helix, said mandrel having an internal helical groove of the desired final configuration adapted to receive the helix and position the same, and subsequently vibrating the assembly to cause the helix to move radially inwardly against the supporting structure to be firmly engaged thereby.

6. The method of mounting a helix to a supporting structure which comprises placing the helix in cooperative relationship with said supporting structure, securing one end of said helix, inserting a mandrel in cooperation with said helix, said mandrel initially engaging the helix at the secured end, said mandrel having a helical groove of the desired final configuration for receiving and positioning the helix, progressively applying a radial force to said helix to cause the same to move radially against the supporting structure to be firmly engaged thereby, and securing the other end upon completion of radial expansion of the helix whereby the helix is firmly maintained by the supporting structure.

7. A method as in claim 6 in which the helix is inserted within an external supporting structure and progressively expanded radially outwardly.

8. A method as in claim 7 wherein the initial normal diameter of said helix is slightly greater than the internal diameter of the supporting structure.

9. A method as in claim 6 wherein said helix is placed in cooperative relationship with an internal supporting surface and progressively contracted radially inwardly.

10. A method as in claim 9 wherein the normal diameter of said helix is smaller than the diameter of the supporting structure.

11. A method of mounting a helix to a supporting structure which comprises placing the helix in cooperative relationship with a supporting structure by engaging one end of the helix and simultaneously rotating and advancing the helix into the supporting structure, inserting a mandrel in cooperative relationship with the helix, said mandrel having a helical groove of the desired final configuration adapted to receive the helix and position the same, and subsequently causing the helix to move radially against the supporting structure to be firmly engaged thereby.

12. A method of mounting a helix to a supporting structure which comprises placing the helix in cooperative relationship with the supporting structure, inserting a mandrel in cooperation with the helix, said mandrel having a helical groove of the desired final configuration adapted to receive the helix and position the same, subsequently causing the helix to move radially against the supporting structure to be firmly engaged thereby, securing the ends of said helix, and finally adjusting the pitch of the helix by inserting another mandrel having a helical groove for receiving and positioning the helix.

13. The method of mounting a helix in an external supporting structure which comprises placing a helix which has an outside normal diameter slightly greater than the inside diameter of the external supporting structure within the structure, inserting a mandrel in cooperative relationship with the helix, said mandrel having a helical groove of desired final configuration adapted to receive and position the helix, vibrating the assembly to cause the helix to move radially outwardly against the supporting structure to be firmly engaged thereby, securing the ends of said helix, and inserting another mandrel to finally position the helix within the structure.

14. The method of mounting a helix to a supporting structure which comprises placing the helix in cooperative relationship with said supporting structure, securing one end of said helix, inserting a mandrel in cooperation with said helix, said mandrel initially engaging the helix at the secured end, and having a helical groove of desired final configuration for receiving and positioning the helix, progressively applying a radial force to said helix to cause the same to move radially against the supporting structure to be firmly engaged thereby, securing the other end upon completion of the radial expansion of the helix whereby the helix is firmly maintained by the supporting structure, and inserting another mandrel having a helical groove for receiving and positioning the helix to finally position the helix within the structure.

15. The method of mounting a helix in a travelling wave tube envelope which comprises placing the helix coaxially within said envelope and in cooperative relationship therewith, inserting a mandrel having a groove of desired final configuration in cooperation with said helix to receive and position the same in accordance with the groove, and subsequently causing the helix to move radially outwardly against the supporting structure to be firmly engaged thereby for accurate retention by the forces between the tube envelope and helix.

16. The method of mounting a helix in a tubular envelope which comprises placing a helix which has a normal diameter slightly greater than the inside diameter of the tubular structure within the same, inserting a mandrel in cooperative relationship with the helix, said mandrel having a helical groove of desired final configuration adapted to receive and position the helix, and subsequently vibrating the assembly to cause the helix to move radially outwardly against the tubular envelope to be firmly engaged and retained thereby.

17. The method of mounting a helix in a tubular envelope which comprises placing the helix in cooperative relationship within the envelope, securing one end of the helix, inserting a mandrel in cooperation with said helix, said mandrel initially engaging the helix at the secured end, said mandrel having a helical groove of desired final configuration for receiving and positioning the helix, progressively applying a radial force to said helix to cause the same to move radially outwardly against the envelope to be firmly engaged thereby, and securing the other end upon completion of the radial expansion of the helix whereby the helix is firmly maintained by the envelope.

18. Apparatus for mounting a helix in a supporting structure comprising a mandrel having a helical periphery accurately conforming to the desired final arrangement of the helix in the supporting structure, said mandrel including at least one longitudinal slot, and a probe longitudinally movable in said slot and projecting beyond the inner surface of helix to be tightened for applying a radial force progressively along the mandrel to a helix supported thereon.

19. Apparatus for mounting a helix on a supporting structure comprising a segmented mandrel having a helical periphery accurately conforming to the desired final arrangement of the helix in the barrel and having an outer diameter slightly greater than the internal diameter of the supporting structure, said mandrel having at least one longitudinally extending opening therein, and a probe movable longitudinally of said mandrel and having at least one projection extending through said opening to outwardly direct force progressively along the mandrel.

20. Apparatus for mounting a helical conductor on a supporting structure comprising a hollow mandrel, said hollow mandrel having an internal helical groove conforming to a desired configuration, and at least one longitudinal slot adapted to receive a projecting fin adapted to extend beyond the surface of said mandrel and adapted to progressively urge a helix associated therewith inwardly.

21. A mandrel for mounting a helix in a supporting structure comprising an elongated rod having a helical peripheral groove accurately conforming to the desired final arrangement of a helix in a supporting structure, a plurality of longitudinal slots formed on said rod, a finned structure including a fin extending through each of said slots and projecting beyond the outer surface of said mandrel to thereby provide an outward force to a helix mounted thereon, and means for longitudinally moving said fin whereby they progressively engage a helix mounted in cooperation therewith to seat the same against an external supporting structure.

22. A method of mounting a helix to a supporting structure in a helix travelling wave tube which comprises the steps of placing the helix in cooperative relationship with the supporting structure to be supported and held thereby, inserting a mandrel having a helical groove of the desired final configuration and pitch in cooperative relationship with said helix to progressively receive the helix in the groove and position the same in accordance therewith, and subsequently removing the said mandrel from said helix and supporting structure.

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