Sept. 24, 1963 C. T. JOHNSON ETAL 3,104,841

WIRE WINDING MACHINE

Filed Oct. 10, 1960 2 Sheets-Sheet 1

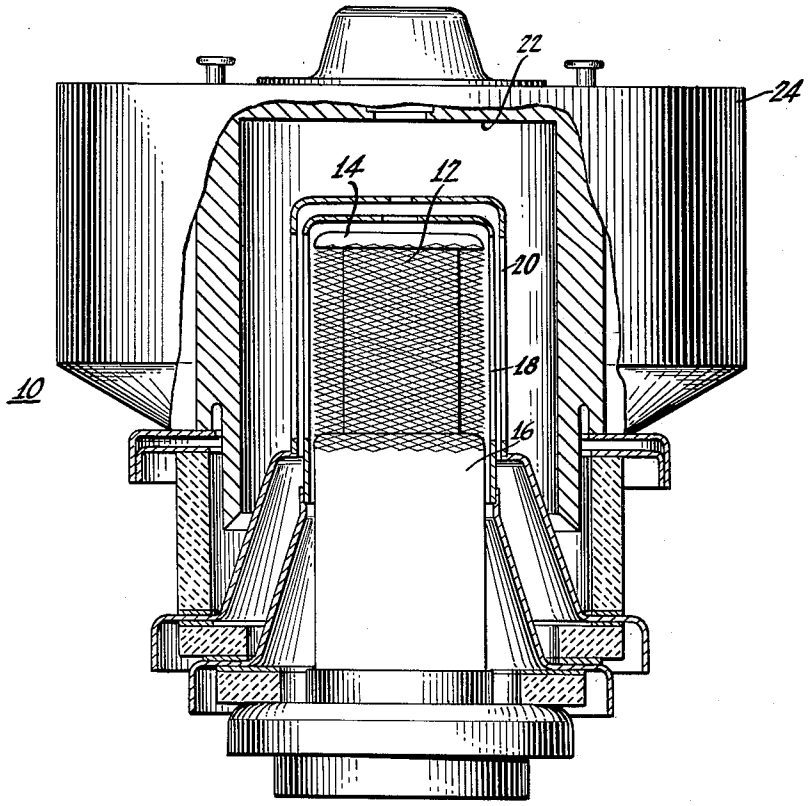


Fig. 1.

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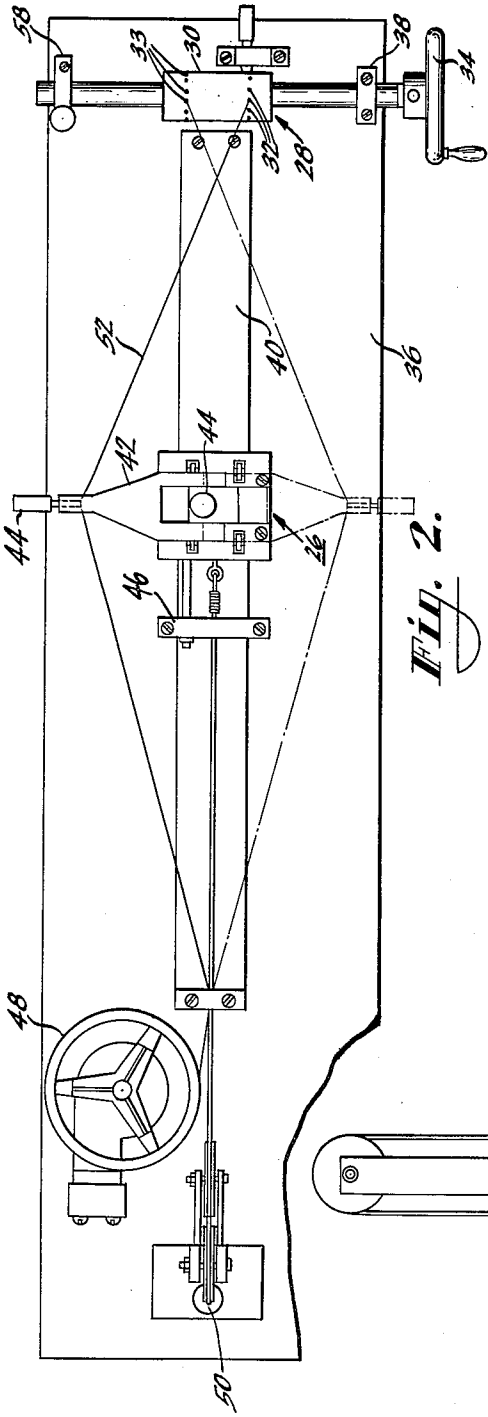


Fig. 2.

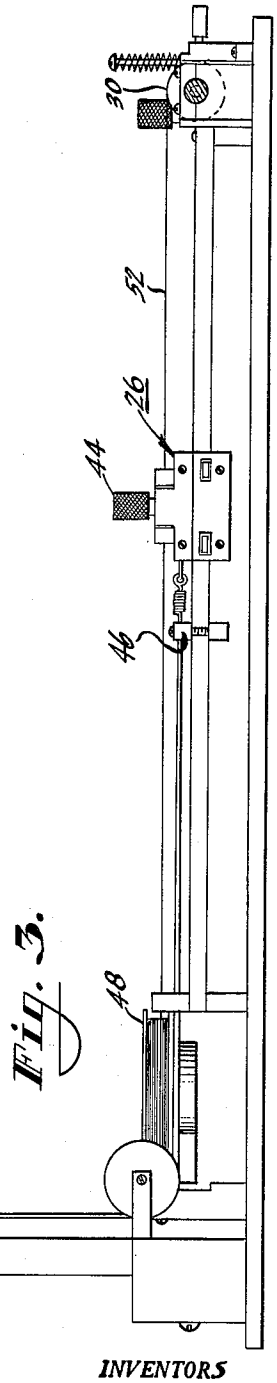


Fig. 3.

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WIRE WINDING MACHINE

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This invention relates to means for manufacturing sub-assemblies for electron discharge devices. In particular, this invention relates to a machine for manufacturing wound elements, such as filaments or grids, for use in an electron discharge device.

In certain high power, high frequency electron discharge tubes, the electrodes are arranged in a cylindrical structure including a co-axial stacked array of electrodes, with a heating filament or directly heated cathode being the innermost electrode.

In tubes of the type briefly described above, it has been found that, for high efficiency operation, the filament is preferably of a type known as a basket weave filament. The basket weave filament comprises a woven mesh screen of wire, such as thoriated tungsten wire. In order to provide an efficient basket weave type filament, the individual wires of the filament are formed in a spiral in such a manner as to have a constant angle and constant pitch along the length of the filament. When an end of a filament is reached, the return angle and return pitch of the wire, as the spiral extends toward the opposite end of the filament, is also constant and equal to the forward angle and pitch. The reason for these requirements of constant angle and pitch of the filament wires is that the spacing between adjacent wires must be substantially constant in order to eliminate the possibility of having areas of the filament which are substantially hotter or substantially cooler than the balance of the filament. If any area of the filament is at a temperature that is substantially different from that of the balance filament, the electron emission from this area will also be substantially different. Variations in electron emission result in increased tube noise and decreased tube efficiency.

In the past, the basket weave type filaments have been wound by hand in an attempt to accurately control the pitch and angle of the individual wires of the filament. The hand winding operation not only adds considerable expense to the filaments of this type, but also the hand weaving operation has proved to be inaccurate in that the operator can not accurately maintain the selected angle and pitch of the individual wires.

It is therefore an object of this invention to provide a novel machine for manufacturing an improved sub-assembly for use in an electron discharge device.

It is another object of this invention to provide a new and improved machine that is capable of manufacturing accurately controlled basket weave type filaments.

These and other objects are accomplished in accordance with the general aspects of this invention by providing a machine including a carriage and a mandrel. The filament wire is clamped to the carriage and to the mandrel in such a manner that, when the mandrel is turned, the carriage moves toward the mandrel at a rate which will maintain the wire at a constant angle and pitch on the mandrel. Furthermore, the relative movement between the carriage and mandrel is such that the point of tangency of the wire on the mandrel moves steadily from one end to the other so that a uniform helix is formed. The carriage includes a wire clamping arm which is pivoted to a position to wind a uniform helix in the opposite direction on the mandrel.

The invention will be more clearly understood by

reference to the accompanying two sheets of drawings, wherein:

FIG. 1 is a partial sectional view of a high frequency, high power tube of the type in which this invention is particularly useful;

FIG. 2 is a top view of a wire winding machine in accordance with this invention; and,

FIG. 3 is a view inside elevation of the wire winding machine shown in FIG. 2.

Referring now to the drawings in detail, FIG. 1 illustrates a tube **10** of a type in which this invention is particularly useful. It should be understood, however that this invention can be utilized for manufacturing sub-assemblies for other tube types, and the tube **10** is shown as a particular example of a tube type in which this invention is particularly useful. The tube **10** comprises a cylindrical wire mesh type filament, or directly heated cathode, **12** that is supported between and fixed to two cylindrical filament terminals **14** and **16**. Closely spaced around the filament **12** is an apertured control grid **18**. Because of this close spacing, the filament **12** must be accurately formed to prevent shorting between the control grid **18** and the filament **12**. Surrounding the control grid **18** is an apertured screen grid **20**. Positioned around the screen grid **20** is an anode **22** which may be cooled, during tube operation, by means of radiators **24**. The tube **10** is an ultra high frequency, high power, beam tube and the details of tube construction may be found in a patent to Griffith et al., Number 2,951,172. The structure which is of particular interest with respect to this invention is the basket weave filament or indirectly heated cathode **12**.

It should be noted that the cathode or filament **12** is in the shape of an elongated cylinder and is attached to filament terminals **14** and **16** which it surrounds. It should also be noted that the filament **12** includes a large plurality of spirals of a wire and the spirals have a constant pitch and constant angle from one end of the filament to the other as well as a constant pitch and constant angle in the opposite direction.

Referring now to FIGS. 2 and 3, there is shown applicant's novel machine for manufacturing the filament **12** that is shown in FIG. 1. The machine generally comprises a carriage **26** and a mandrel **28**. The mandrel includes an elongated mandrel cylinder **30** which is of substantially the same diameter as are the filament terminals **14** and **16** shown in FIG. 1. The mandrel cylinder **30** is made of a material which can be processed along with the filament **12** and from which the filament **12** may be subsequently easily removed. One example of such material is "Elkaloy" manufactured by the P. R. Mallary Company. Positioned around the periphery of mandrel cylinder **30** and adjacent to opposite ends of the cylinder **30** is a plurality of apertures each for receiving different mandrel pins **32** and **33**. The mandrel pins are for the purpose of attaching the filament wire to the mandrel cylinder **30** at each change of direction of the wire in the filament. Connected to the mandrel cylinder **30** is a means **34** for rotating the mandrel cylinder **30**. The means **34** is shown as a hand operated wheel. However, if desired, a known machine drive (not shown) could be used to rotate the mandrel cylinder **30**. The mandrel cylinder **30** is fixed in position with respect to a table or work surface **36** by means of clamps **38** and **58**. The clamps **38** and **58** maintain a periphery, in this case the upper periphery, in a predetermined plane with respect to the work surface **36**.

Positioned on the table **36** is a track **40** for the movement of the carriage **26** in the direction toward and away from the mandrel cylinder **30**. The carriage **26** includes a pivotable arm **42** and a wire clamp **44**. The carriage

26 is movable along the track 40 from the position shown, to the end of the track 40 which is adjacent to the mandrel 28. The limit of the movement of the carriage 26 is controlled, and adjusted, by means of an adjustable slider 46 which provides a starting point for carriage movement. A similar slider may be used for the stopping point of the slider.

The arm 42 may be in either the position shown in full or the position shown in phantom. While in either position, the arm 42 is in the same plane as the periphery of the mandrel cylinder 30. In other words, the arm 42 holds the wire in the plane of the upper periphery of the mandrel cylinder 30.

The heating filament wire is held on a reel 48 which is loaded, so as to be under slight tension, by any conventional means such as a spring (not shown). The wire 52 is fed from the reel 48 to the clamp 44 to which it is fixed by tightening the latter, and to the mandrel 30 where it is also fixed, by being twisted around one of the pins 32.

When a wire 52 is twisted or looped around a pin 32, the carriage is positioned in its most remote position from the mandrel, i.e. against the slider 46, and the clamp 44 is tightened on the wire while the carriage 26 is in this position. Then, by rotating the mandrel 28, the wire 52 is wound onto the mandrel cylinder 30 to form a uniform helix around the mandrel cylinder. As the wire is wound on the cylinder 30, the pull of the wire overcomes a weight 50, or similar loading means, and moves the carriage 26 toward the mandrel cylinder 30. When the carriage 26 strikes the other extreme of its movement, a complete helix of wire has been wound on the mandrel 30. The complete helix may include any selected number of turns of the wire 52.

At this time, the wire 52 is looped over a pin 33, the position of the arm 42 is reversed, i.e. pivoted or rotated to the phantom position (FIG. 2), the clamp 44 released and carriage 26 is returned to its starting position, i.e. abutting slide 46. The clamp 44 is again fixed to the wire 52 and the mandrel 28 is again rotated in the same direction. This rotation again moves the carriage toward the mandrel and provides a helix of the same pitch and wire angle as has been wound on the mandrel cylinder 30 but in the opposite direction. When the helix is completed, another mandrel pin 32 is inserted in a proper location, the carriage 26 returned to the starting position, the arm 42 rotated, the carriage clamped by clamp 44 to the wire, and the process is repeated until any selected number of helices is provided on the mandrel 30.

In utilizing this invention, a filament 12 may be made in any selected diameter by changing the diameter of the mandrel cylinder 30. Also, the length, pitch, wire size, wire angle and number of wires can be varied by varying the distance the carriage travels, the diameter of the mandrel 30, and the spacing between pins 32, 33 of the mandrel.

The wire 52 observes a constant angle with respect to the axis of the mandrel 30 during rotation of the latter, to provide a uniformity in the pitch of the wire turns around the mandrel. This is most conveniently explainable by considering an analogy wherein the arm 42 is fixed and the mandrel is movable on track 40 towards arm 42 during a winding operation. In this analogy, it is obvious that the angle between wire 52 and the axis of mandrel 30 is constant during the winding operation.

When the winding of a desired number of helices is completed, the wire 52 is cut, the mandrel is detached from the base 36 and placed on a roller welder (not shown). The various wires of the filament structure 12 are then welded together and are removed from the mandrel 30 when the pins 32 and 33 are removed. The helix or filament 12 is then ready for further processing such as coating with electron emissive material, e.g., and other manufacturing steps.

This invention is applicable to any selected wire diameters, filament lengths, filament diameters, turns per filament, pitch of the helix and angle of the wires. Also, this invention may be used to manufacture a filament for any selected tube type and the tube shown in FIG. 1 is merely an example. By means of this invention, filaments can easily be manufactured having a uniform pitch, wire spacing, diameter and other desirable characteristics.

What is claimed is:

1. A winding machine comprising an axially rotatable cylindrical mandrel having one end portion adapted to hold one end of a wire, a carriage for holding a portion of said wire spaced from said one end thereof, said carriage being mounted in right angular movable relationship with respect to an intermediate portion of said mandrel, said carriage having an arm extending parallel to the mandrel axis, said arm including a portion offset to one side of a transverse plane through the longitudinal center of said mandrel, said arm portion having means for securing thereto said wire portion, said one end portion of the mandrel being offset to the opposite side of said plane and means for axially rotating said mandrel and simultaneously moving said carriage toward said mandrel in said right angle relationship, whereby the angle of said wire with respect to the axis of said mandrel is maintained constant as a result of the movement of said carriage.

2. A machine for winding a sub-assembly for an electron discharge device comprising a fixed surface, a cylindrical mandrel rotatably mounted on said surface, a longitudinal periphery of said cylindrical mandrel defining a straight line extending parallel to the mandrel axis and disposed in a predetermined plane, an arm for holding a wire, said arm being pivotally mounted so as to be positioned to one side of a plane transverse of said mandrel and passing through the longitudinal center of said mandrel and in register with one of the opposite end portions of said mandrel in a direction normal to said straight line and substantially in said predetermined plane, a carriage supporting said arm, said carriage being positioned on a track extending normal to said straight line, whereby said carriage may be moved toward and away from said mandrel, means for clamping said wire on the outer end portion of said mandrel, and means for rotating said mandrel on its axis, whereby said carriage moves toward said mandrel by the resultant pull of said wire.

3. A machine for winding a basket weave type filament said machine comprising a horizontal support member, means for positioning an elongated mandrel cylinder in axially rotatable relationship on said support member, so that a portion of the periphery of said cylinder defines a straight line disposed in a predetermined plane, a carriage supported on said support member and in movable relationship toward and away from said straight line in a path extending at right angles to said line, means for positioning said carriage in a position remote from said mandrel, a pivotable arm mounted on said carriage, means on said arm for holding wire, said arm being adapted to be positioned successively, laterally adjacent to opposite end portions of said mandrel and in said predetermined plane for successively disposing said holding means to the two sides of a vertical plane through the longitudinal center of said mandrel, means for clamping a wire on one of said end portions of said mandrel remote from said arm, and means for axially rotating said mandrel so that said wire pulls said carriage toward said mandrel at a rate related to the speed of rotation of said mandrel and said wire forms a helix around said mandrel when said one of said end portions of the mandrel and said holding means on said arm are on opposite sides of said plane.

4. A winding machine comprising an elongated axially rotatable cylindrical mandrel having means on a peripheral portion thereof adapted to hold a portion of a wire work piece, a carriage movable towards said mandrel in a path normal to the mandrel axis, said carriage having an arm extending in a direction from said carriage normal

to said path, said arm having means adapted to hold another portion of said wire work piece, said second named means being spaced from a plane normal to said mandrel and passing through said peripheral portion thereof, means for axially rotating said mandrel whereby said carriage is adapted to feed said wire to said mandrel when the mandrel is axially rotated, for providing thereon a wire helix of uniform pitch.

5. A winding machine comprising an elongated axially rotatable circularly cylindrical mandrel having holding means thereon for holding a wire at one point of the wire without slipping, feeding means for holding the wire at another point of the wire without slipping said holding means being spaced in a direction axially of said one point of the wire and radially from the mandrel means for rotating said mandrel about its axis, said feeding means and said other point being constrained for movement toward said mandrel in a path normal to the mandrel axis in response to rotation of said mandrel, and means for urging apart said mandrel and said feeding means whereby as said mandrel rotates a wire held by said holding means and said feeding means respectively at said points is placed under tension to be drawn out substantially in a straight line and the feeding means is drawn toward the mandrel by the wire as the wire is wound on the mandrel and the wire is thereby wound on the mandrel with a constant pitch.

6. A wire winding machine comprising a support member, an elongated mandrel cylinder, means for positioning said mandrel cylinder on said support member so that said cylinder may be axially rotated, means adjacent to one end of said mandrel cylinder for holding an end portion of a wire, a carriage, means mounting said carriage on said support member so that said carriage may be moved toward and away from the axis of said mandrel cylinder in a path normal to said axis, means for normally maintaining said carriage in a position remote from said mandrel cylinder, a wire holding arm extending parallel to said mandrel cylinder, means mounting one end of said arm on said carriage so that the other end of said arm may be positioned adjacent to either end of said mandrel cylinder, and means for rotating said mandrel about the cylinder axis with said arm positioned adjacent to the other end of said mandrel cylinder so that said carriage moves toward said mandrel cylinder and said wire and said mandrel cylinder describe an angle of less than 90°.

References Cited in the file of this patent

UNITED STATES PATENTS

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