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TENSIONING DEVICE

3,134,559

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2 Sheets-Sheet 1

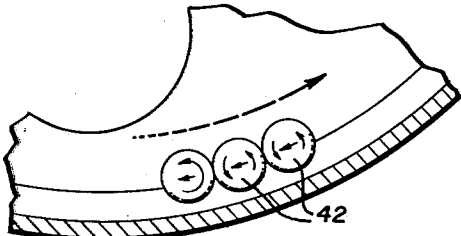


Fig. 5

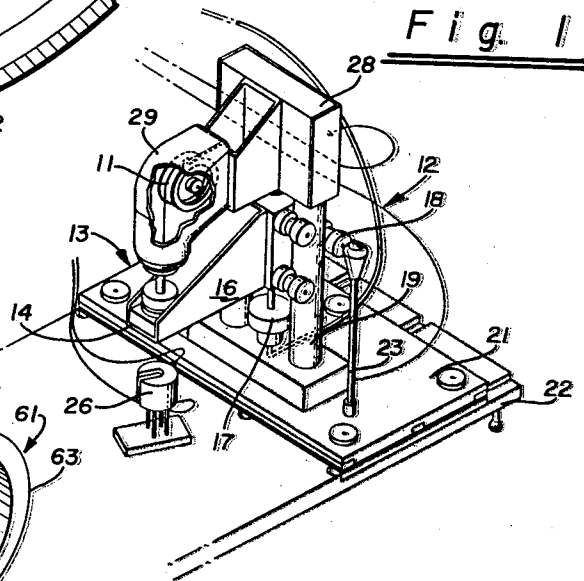


Fig. 1

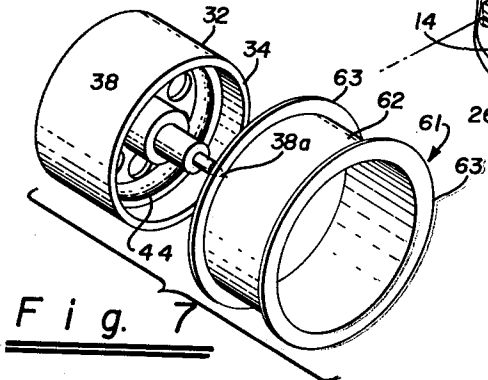


Fig. 7

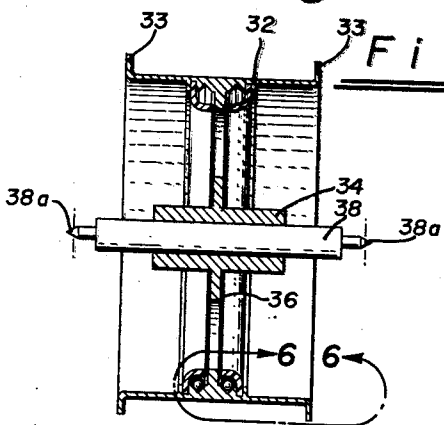


Fig. 4

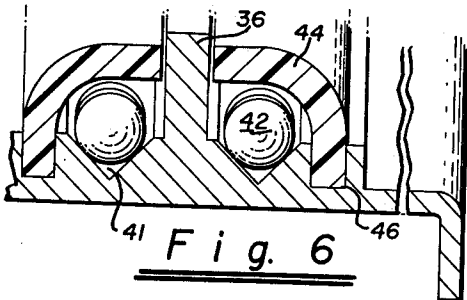


Fig. 6

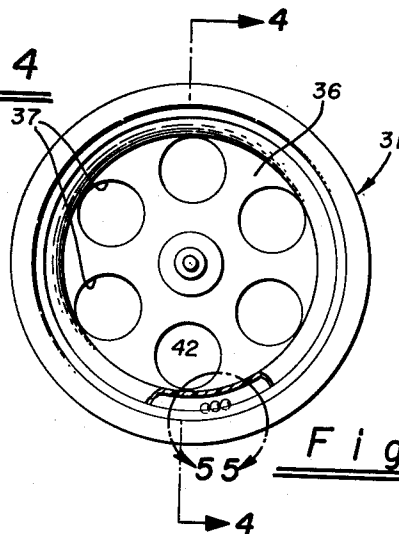


Fig. 3

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2 Sheets-Sheet 2

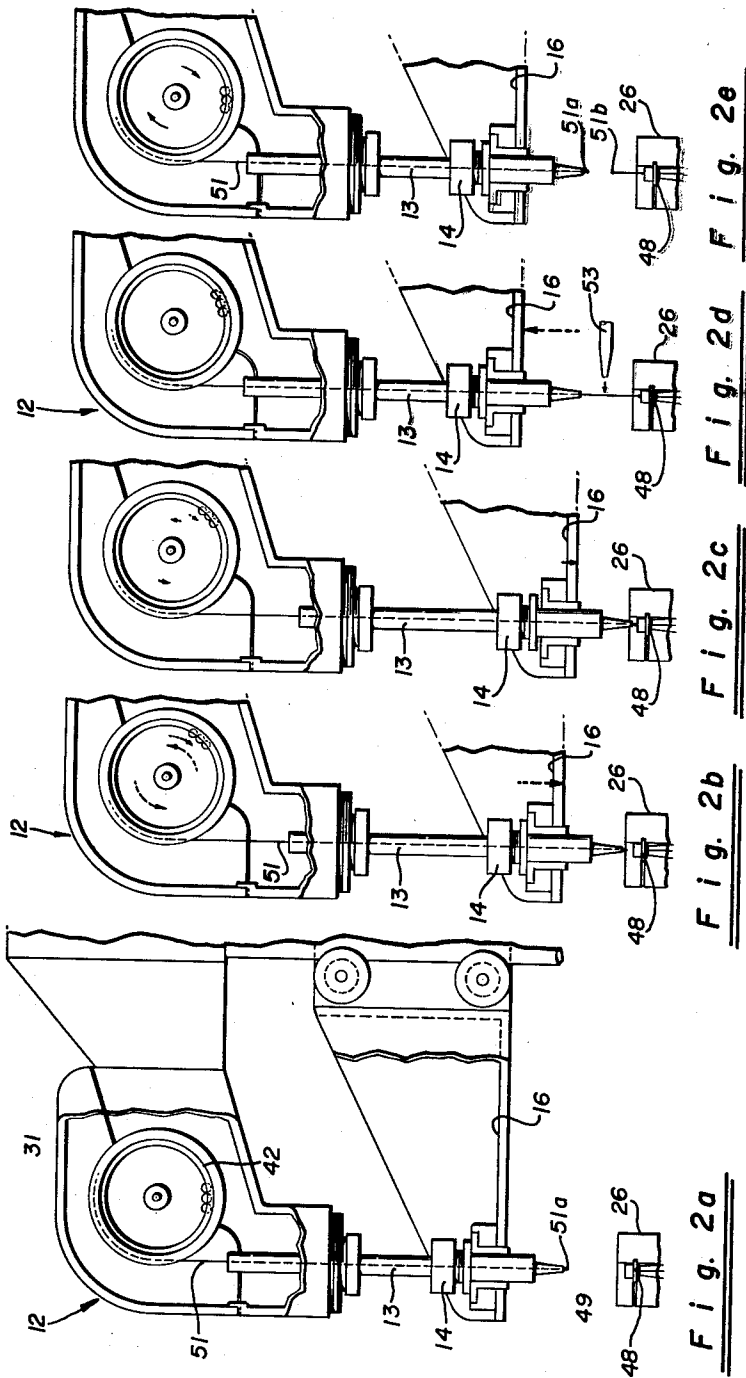


Fig. 2a

Fig. 2b

Fig. 2c

Fig. 2d

Fig. 2e

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1

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TENSIONING DEVICE

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8 Claims. (Cl. 242-156)

This invention relates to a tensioning device and more particularly to a tensioning device for use in tensioning the lead wire in a thermocompression lead bonding machine.

As is well known to those skilled in the art of forming thermocompression bonds, it is often necessary to utilize very fine wire for the leads. This very fine lead wire is normally wound on spools or reels mounted upon the machine. During the time that the lead wire is being unwound from the reel, it is normally desirable to maintain a tension on the lead wire. It is also desirable to maintain tension on the lead wire after the reel has stopped and during the time the bond is being made and after the bonding tool has been moved away from the completed bond so as to make it possible to produce uniform balls on the end of the lead wire each time the lead wire is cut. Means heretofore utilized for tensioning the lead wire has been found to be unsatisfactory. For example, when friction washers are utilized, the initial starting friction is substantially greater than the running friction as the lead wire is unwound from the reel. Such means makes it impossible to obtain uniform tension. In addition, it has been found that such means does not maintain a predetermined tension on the lead wire after the lead wire has been unwound from the spool. There is, therefore, a need for a new and improved tensioning device which overcomes these limitations.

In general, it is an object of the present invention to provide a tension device of the above character which overcomes the above named disadvantages.

Another object of the invention is to provide a tensioning device of the above character in which the forces required for starting motion of the reel are less than that required for continued rotation of the spool.

Another object of the invention is to provide a tensioning device of the above character which maintains a predetermined tension on the lead wire after rotation of the spool has stopped.

Another object of the invention is to provide a tensioning device of the above character which after the lead wire has been cut will automatically raise the lead wire.

Another object of the invention is to provide a tensioning device of the above character which make it possible to place a predetermined tension on the wire just before the wire is cut so that substantially identical balls are formed at the ends of the lead wires during successive cutting operations.

Another object of the invention is to provide a tensioning device of the above character in which the amount of force required for starting and continuing rotation of the spool can be readily adjusted.

Another object of the invention is to provide a tensioning device of the above character in which the starting inertia is reduced to a minimum.

Another objects of the invention is to provide a tensioning device of the above character which is relatively simple.

Another object of the invention is to provide a tensioning device of the above character which is economical to produce.

Another object of the invention is to provide a tensioning device of the above character which is relatively fool-proof and can be operated by relatively unskilled personnel.

2

Additional objects and features of the invention will appear from the following description in which the preferred embodiments are set forth in conjunction with the accompanying drawings.

Referring to the drawings:

FIGURE 1 is an isometric view of our tensioning device mounted on a thermocompression lead bonding machine.

FIGURES 2a, 2b, 2c, 2d and 2e are side elevational views partially in cross-section showing the various stages of operation of our tensioning device during use of the same on the thermocompression lead bonding machine shown in FIGURE 1.

FIGURE 3 is a side elevational view of our tensioning device with a portion of the retaining ring broken away to show the ball bearings.

FIGURE 4 is a cross-sectional view taken along the line 4-4 of FIGURE 3.

FIGURE 5 is an enlarged view taken along the line 5-5 of FIGURE 4.

FIGURE 6 is a cross-sectional view taken along the lines 6-6 of FIGURE 4.

FIGURE 7 is an isometric view of another embodiment of our tensioning device.

In general, our tensioning device is particularly adapted for use with a thermocompression lead bonding machine of the type having a bonding tool which is movable to urge the lead into engagement with the element to which the lead is to be bonded. It consists of a spool upon which is wound a quantity of the lead wire. Means is provided for rotatably mounting the spool so as to provide the least amount of friction. Means to mounted on the spool for applying forces to the reel so that the force required for starting is relatively small, and the force required for continued rotation of the reel is also relatively small. This last named means also serves to maintain a predetermined force on the spool after rotation of the spool has stopped so that during the cutting of the lead, a predetermined tension is applied to the lead to thereby make possible the production of uniform balls on the ends of the lead wire.

As is shown in the drawings, our tensioning device 11 is particularly adapted for use with a thermocompression lead bonding machine 12 of the type described in our copending application Serial No. 66,207, filed October 31, 1960, now Patent No. 3,050,617. As disclosed in our copending application, the thermocompression lead bonding machine 12 includes a bonding tool in the form of a capillary tube 13 which is carried by a bonding tool holder 14 supported in a stage 16. The stage 16 is fixed to a vertically movable carriage block 17 upon which are mounted rollers 18 engaging a pair of support columns 19. The support columns 19 are mounted upon a carriage plate 21 which is movable sideways and forwardly and rearwardly with respect to a base plate 22 by use of a manipulator control lever 23. A header holder 26 is mounted on the base plate 22 and serves as means for carrying the element to which the lead is to be bonded. A control housing 28 is mounted on top of the support columns 19 and carries a magazine 29 of the type described in copending application Serial No. 112,706, filed May 25, 1961.

Our tensioning device 11 is mounted within the magazine 29 as shown and consists of a spool or reel 31. The spool or reel is formed of a suitable material such as aluminum and consists of a substantially cylindrical member 32 which is provided with outturned flanges 33 on opposite ends thereof to prevent the lead wire wound thereon from slipping off of the spool or reel. The spool or reel is provided with a central hub 34 which is secured to the cylindrical member 32 by a radially extending web 36 which is provided with a plurality of openings or holes 37 to reduce the weight of the same. A pin 38 of suitable

material such as hardened steel is mounted in the hub 34 and is provided with tapered ends 38a which are adapted to seat in suitable jeweled bearings (not shown) such as sapphire bearings mounted on the side walls of the magazine 29 to reduce friction to a minimum.

Means is mounted on the reel 31 to apply forces to the reel during rotation of the same and while the same is stopped and consists of a pair of V-shaped raceways 41 which are formed in the cylindrical member 32 on opposite sides of the web 36, as shown particularly in FIGURE 6. The raceways 41 are annular and extend around the inner surface of the member 32. A plurality of balls 42 are disposed in the raceways 41 and are adapted to roll in the raceways in a manner hereinafter described to apply the desired forces to restrain rotation of the reel and to apply predetermined tension to the lead wire during rotation of the reel and after rotation of the reel has stopped.

Means is provided for retaining the balls 42 seated within the raceways 41 and consists of a retaining ring 44 of a suitable material such as Mylar which has one edge seated in an annular groove 46 provided in the cylindrical member 32 and the other edge abutting or substantially abutting the web 36 away from the holes 37, as shown particularly in FIGURE 3.

Operation of my tensioning device may now be briefly described as follows. Let it be assumed that a predetermined amount of lead wire suitable for a bonding operation has been placed upon the reel 31 and that the reel has been mounted upon the bonding machine, as shown particularly in FIGURE 1. Also, let it be assumed that the lead wire from the reel has been passed downwardly through the capillary tube 13. For example, let it be assumed that the reel has been wound with gold wire having a diameter of .0007 of an inch and that it is desired to utilize this wire for providing leads on an element 47 mounted on an element holder in the form of a header 48 carried by the holder 26.

At the commencement of the bonding operation, the lead bonding machine and our tensioning device are substantially in the position shown in FIGURE 2a. In this figure, it will be noted that three balls have been used and that the reel 31 is in a position in which the balls 42 lie in the lowermost possible position.

Now let it be assumed that it is desired to withdraw some of the lead wire 51 from the reel 31 and to move it into a position so that it is in engagement with the element 47 carried by the element holder 48. This is accomplished by lowering of the stage 16 in a manner described in our copending application Serial No. 66,207, filed October 31, 1960.

The lead 51 is drawn downwardly by the downwardly moving capillary 13 because a small bead 51a has heretofore been formed on the lower extremity of the lead wire 51 as hereinafter described. As the stage is moved downwardly, the lead wire is pulled downwardly which causes rotation of the spool or reel 31. Because the lead wire 51 is very, very fine and has relatively little strength, it is readily apparent that the starting inertia of the reel or drum 31 must be small and kept at a minimum. It is for this reason that the mass of the reel 31 is reduced to a minimum by forming the reel 31 of a light material such as aluminum and by providing holes 37 in the web 36.

At the same time that the lead wire 51 is unwound from the reel in a counter-clockwise direction, the balls 42 are also rotated in a counter-clockwise direction so that they are raised to a position substantially as shown in FIGURE 2b. It will be realized that the starting force required for overcoming the inertia and moving the balls is relatively small so that the balls have little effect upon the initial starting forces required. For example, in using .7 of a mil gold wire, we know that the pulling force is less than 4 to 7 grams.

After a predetermined length of lead wire 51 has been unwound from the reel and after the balls 42 have been raised a predetermined distance as, for example, 30°, 75

around the inner circumference of the spool, the balls will begin to roll downwardly in the race 41, as shown particularly in FIGURE 5. Each of the balls will roll in a clockwise direction which is the same direction in which the spool or reel is being rotated. Although the balls 42 are free to roll in the race and to seek the lowermost level on the race, the balls will be inhibited in this downward rolling movement because of the frictional engagement between the individual balls, as shown particularly in FIGURE 5. It is for this reason that it is desirable to provide at least two ball bearings in the race.

The amount of tension placed on the lead wire can be controlled by the number of balls 42 which are placed in the race. If it is desired to increase the tension on the lead wire, it is merely necessary to provide additional balls in one or both of the races until the desired amount of tension is obtained.

In the two-step procedure which is described in our copending application Serial No. 66,207, filed October 31, 1960, the bonding tool 13 is lowered to a position so that it is immediately above the element to which the bond is to be made. Thereafter, by use of the manipulator and control lever 23, the bead 51a provided on the end of the lead is shifted into a proper position over the element. Thereafter, by operation of the lever 23, the lead wire is lowered a short additional distance until the bead comes into engagement with the element and the bonding tool engaging the bead is raised out of the stage 16 so that the weight upon the bead is determined solely by the weight of the bonding tool and the bonding tool holder.

The balls in the reel 31 serve to maintain a tension on the lead wire 51 even after the rotation of the drum is stopped. This occurs because the frictional engagement between the balls causes the balls to stop in a position as, for example, 30° above a vertical line passing the center of the reel 31 which is substantially above the lowermost possible position of the balls. As hereinbefore explained, the balls are not free to roll downwardly to the lowermost position because of the frictional engagement between the individual balls. The balls will, therefore, stop in a position similar to the position shown in FIGURE 2c. This tends to throw the reel or spool 31 out of balance to thereby apply a force to tend to rotate the drum in a clockwise direction to tension the wire 51.

While this predetermined tension is being maintained on the lead wire 51, the bonding operation is completed as described in our copending application Serial No. 66,207, filed October 31, 1960. After the bonding operation is completed, the stage 16 is raised carrying with it the bonding tool 13 and the bonding tool holder 14 as shown in FIGURE 2d. The lead wire 51 remains attached to the element 47, as also shown in FIGURE 2d. Thereafter, the lead wire 51 is cut in a suitable manner such as by a hand-held torch or an automatically operated torch 53 as described in our copending application Serial No. 96,592, filed March 17, 1961.

It has been found that because a predetermined amount of tension is placed on the lead wire after rotation of the reel 31 is stopped, uniform balls are formed after each cutting operation on the upper and lower ends of the wire immediately above and below the cut, as shown particularly in FIGURE 2e. As soon as the cut is made by the torch 53, the balls 42 which are raised slightly above their lowermost position will cause the reel 31 to rotate in a clockwise direction until the balls are carried to the extreme lowermost position by force of gravity as shown in FIGURE 2e to thereby raise the lead 51 and gold bead 51a a short distance. The reel 31 seeks a position in which it is balanced. This occurs when the balls 42 are in their lowermost position as shown in FIGURE 2e.

Another bonding operation can now be commenced by going through the same series of steps shown in FIGURES 2a-2e. Each time the lead wire 51 is unwound

5

from the reel 31, the balls 42 are raised from their lowermost position and then after they have been raised a sufficient amount they begin to roll downwardly against each other. They tend to remain in the same angular position during rotation of the reel or spool 31. As soon as rotation of the reel 31 stops, the balls remain in this same angular position to maintain a predetermined tension on the lead wire so that balls of uniform size will be formed during each cutting operation. This maintenance of a predetermined tension makes it possible to obtain reproducible balls having uniform diameters on the ends of the lead wire. This is important because it makes it possible to obtain excellent thermocompression bonds automatically with our thermocompression lead bonding apparatus as disclosed in our copending application Serial No. 66,207, filed October 31, 1960.

Although the spool or drum 31 has been shown with grooves on both sides, it is possible to utilize a drum having a groove on only one side. The grooves have been provided on both sides so that a large number of balls can be utilized so that the desired amount of tension can be obtained when it is desired to utilize our tensioning device with larger wire.

The snap rings 44 have been provided for keeping the dust out of the raceways 41 and also for the purpose of preventing the balls 42 from falling out of the spool 31.

Another embodiment of our invention is shown in FIGURE 7. In this embodiment, the cylindrical member 32 is not provided with flanges 33. A separate drum 61 which carries wire is provided. This drum consists of a cylindrical member 62 which is of a slightly larger diameter than the drum 32 so that the drum 62 can slide over the drum 32 and frictionally engage the drum 32. The drum 62 is provided with outwardly turned flanges 63 to prevent the lead wire from slipping off of the drum. Thus, it can be seen in FIGURE 7 that the spool is actually a two-piece unit, whereas in the embodiment shown in FIGURES 3-6, the spool is a one-piece unit. Either embodiment of the invention is satisfactory; however, it has been found that it is easier to control the balance on the one-piece spool. This is particularly important because the spool is utilized with very fine wire where minute forces are important. It is always desirable that the spool itself be balanced as perfectly as possible before the balls 42 are placed in the spool. In the first embodiment, the wire is wound directly on the spool, whereas in the second embodiment, it is wound on a separate drum which is subsequently mounted on the spool.

It is apparent from the foregoing that we have provided a new and improved tensioning device which is particularly suitable for use with thermocompression lead bonding machines. Although we have disclosed our tensioning device for use in conjunction with thermocompression lead bonding machines of the type which are conventionally called "nail-head" bonding machines, it is readily apparent that the same tensioning apparatus can be applied to the "knife-edge" bonding machines. It is also readily apparent that our tensioning device has other applications wherein the tension must be carefully controlled at all times and where the inertia must be very low.

We claim:

1. In a tensioning device for use with a thermocompression lead bonding machine of the type having a bonding tool movable to urge the lead wire into engagement with the element to which the lead wire is to be bonded, a spool having a quantity of lead wire wound thereon, means for rotatably mounting the spool for rotation about a horizontal axis and for movement solely in vertical and horizontal directions, the spool being formed with an annular race which has an axis which is coincident to the axis of rotation of the spool, at least two free-running balls disposed in the race in frictional engagement with each other, the balls and the spool assuming a position so

6

that the balls are in their lowermost position when the end of the lead wire is free, the balls moving upwardly with the spool without rotation because of frictional engagement between the balls as the lead wire is unwound from the spool by rotation of the spool to a predetermined position above their lowermost position to provide a tensioning force on the wire, the balls after the spool is rotated beyond said predetermined angle rolling against each other down the annular race but above said lowermost position because of frictional engagement between the balls to provide a predetermined uniform tension on the lead wire as it is unwound from the spool, the free-running balls remaining above their lowermost position because of frictional engagement between the balls when the spool has stopped to apply a predetermined uniform tension to the lead wire each time the spool has stopped, the balls and the spool on which the balls are mounted rotating in a direction opposite to the normal direction of rotation when the lead wire is released to rewind a portion of the lead wire onto the spool.

2. In a tensioning device for use with a thermocompression lead bonding machine of the type having a bonding tool movable to urge the lead wire into engagement with the element to which the lead wire is to be bonded, a spool having a quantity of bonding lead wire wound thereon, means for rotatably mounting the spool for rotation about a horizontal axis and for movement solely in vertical and horizontal directions, and means for applying forces to the spool to tension the lead wire as it is drawn from the spool, said means comprising an annular race concentric with the horizontal axis about which the spool rotates and at least two free-running balls mounted in the annular race and frictionally engaging each other, the surfaces of the balls facing the axis of rotation of the spool being free of engagement with the spool, said balls being raised from their lowermost position about the axis of the spool without rotation on their axes during initial pulling of lead wire from the spool, the balls rolling downwardly in the spool and rotating about their own axes in the same direction as the spool is being rotated as additional lead wire is being pulled from the spool but remaining above their lowermost position in the spool because of frictional engagement between the balls, the balls stopping their rolling and remaining in an angular position in the spool which is above the lowermost position in the spool because of frictional engagement between the balls when pulling of the lead wire from the spool is stopped, said balls in said last named position serving to provide a predetermined uniform tension on the lead wire each time pulling of the lead wire is stopped.

3. A tensioning device as in claim 2 together with means mounted on said spool for covering said balls, said means being out of engagement with said balls.

4. In a tensioning device for use with a thermocompression lead bonding machine having a bonding tool to urge the lead-in into engagement with the element to which the lead is to be bonded, a spool having a quantity of bonding lead wire wound thereon for rotation about a horizontal axis and movement solely in vertical and horizontal directions, means rotatably mounting the spool, the spool having an annular race therein formed on the inner surface thereof concentric with the horizontal axis about which the spool rotates and at least two free-running balls in frictional engagement with each other disposed in the race and serving to tension the lead wire as it is withdrawn from the spool, the surfaces of the balls facing the axis of rotation of the race being free.

5. A tensioning device as in claim 4 wherein said spool is formed in two parts, one of the parts being a removable drum having lead wire wound thereon.

6. A tensioning device as in claim 5 wherein said spool is formed with an additional annular race concentric with the horizontal axis about which the spool rotates and at least two free-running balls disposed in the additional

7

race, and means for covering the first named and additional races and the balls therein, said covering means being out of engagement with the balls.

7. In a tensioning device for use with a thermocompression lead bonding machine of the type having a bonding tool movable to urge the lead into engagement with the element to which the lead is to be bonded, a spool having a quantity of lead wire wound thereon, means for rotatably mounting the spool for rotation about a horizontal axis and movement solely in horizontal and vertical directions, and means applying frictional forces to said spool, said means for applying frictional forces to said spool being characterized in that the initial starting force for rotating the spool from a stationary position is relatively small as lead wire is pulled from the spool and the continued force for pulling additional wire from the spool after rotation of the spool is started is greater than the initial starting force, said means for applying frictional forces also applying a substantially uniform tension to the lead wire each time rotation of the spool stops, said means for applying frictional forces to the spool including an annular race formed in the spool concentric with said horizontal axis and at least two free-running balls disposed in the race and retained by the race, the surfaces of the balls facing the axis of rotation of the annular race being free.

8. In a thermocompression lead bonding machine for bonding leads to an element, a spool, a quantity of lead wire wound on the spool, means for rotatably mounting the spool for rotation about a horizontal axis and move-

8

ment solely in horizontal and vertical directions, a bonding tool, means for withdrawing the lead wire from the spool and for moving the bonding tool into engagement with the lead wire to urge the lead wire into engagement with the element to which the lead wire is to be bonded, and means for applying frictional forces to said spool, said means for applying frictional forces to said spool being characterized in that the initial starting force for rotating the spool from a stationary position is relatively small as the lead wire is pulled from the spool and the force for pulling additional lead wire from the spool after rotation of the spool has started is greater than the starting force, said means for applying frictional forces also applying a substantially uniform tension to the lead wire each time rotation of the spool stops, said means for applying frictional forces to the spool including an annular race formed in the spool concentric with the horizontal axis of the spool and at least two free-running balls disposed in the race and retained by the race.

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