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E. G. SHOWER

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METHOD OF FABRICATING CATHODE ASSEMBLIES

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FIG. 1

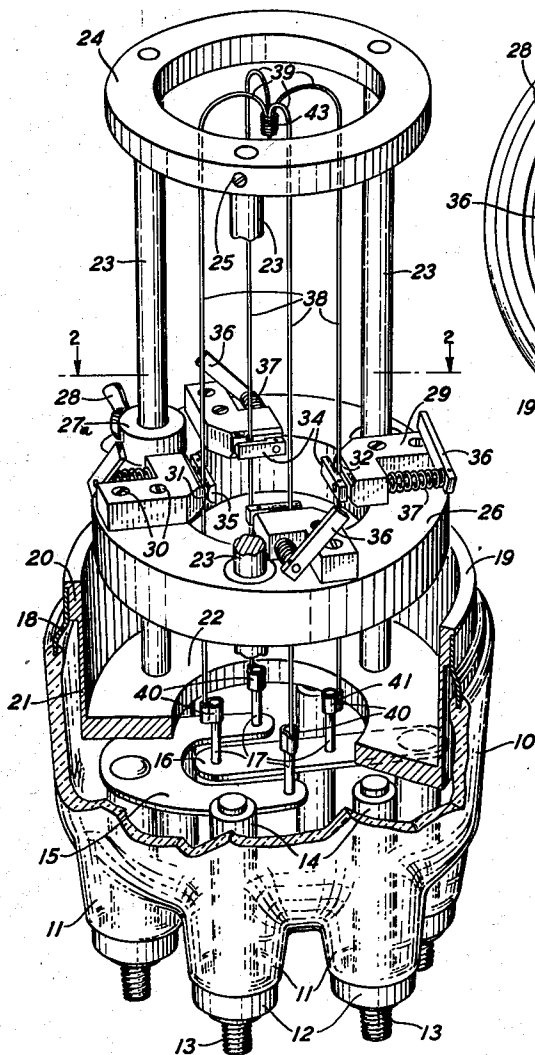


FIG. 2

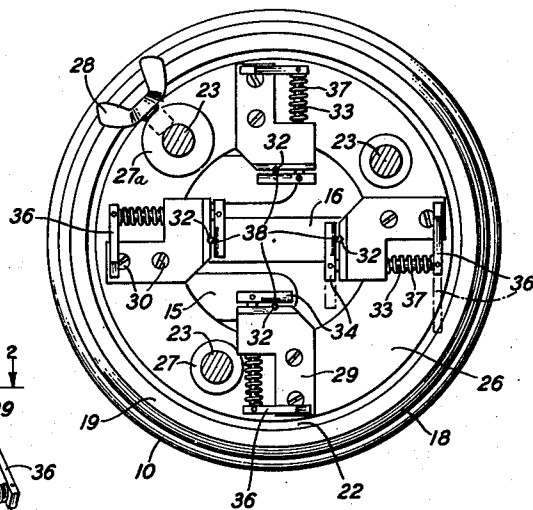


FIG. 4

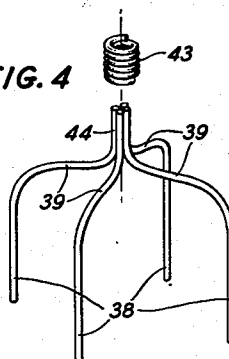
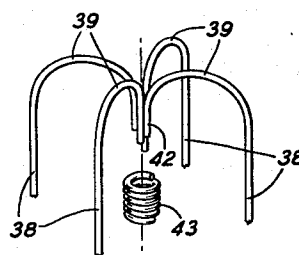


FIG. 3



INVENTOR
E. G. SHOWER
BY *E. G. Shower*
ATTORNEY

UNITED STATES PATENT OFFICE

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METHOD OF FABRICATING CATHODE ASSEMBLIES

Edmund G. Shower, Freeport, N. Y., assignor to
Bell Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

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3 Claims. (Cl. 140—71.5)

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This invention relates to methods of fabricating cathode assemblies and, more particularly, of multistrand filamentary cathodes for high power electron discharge devices.

Generally, in high power discharge devices, for example of 3 to 50 kilowatts rating, the filamentary emitter or cathode is formed of tungsten or thoriated tungsten to supply the requisite electronic emission and to withstand the intense heat generated during the operation of the device. While these materials suffice for their intended purposes, they are highly fragile and brittle when cold and somewhat more malleable at their operating temperatures so that undue strain or stress imposed on the filament strands may result in fracture or warping and consequent shortening of the useful life of the device. Usually, the inherent stresses in the strands cannot be detected until the device is completely assembled and tested, so that a large loss in production may result.

An object of this invention is to eliminate residual stresses in the filament assembly of high power discharge devices.

Another object of the invention is to facilitate the fabrication of the filament mounting in such devices whereby strains and stresses are removed in the multiple strands of the assembly.

A further object of the invention is to provide a method of assembly wherein the multiple strands are initially processed to relieve strains before the completion of the assembly of the device.

Another object of the invention is to eliminate the necessity for close tolerances in the assembly components for mounting the filament strands in the device.

A further object is concerned with the symmetrical arrangement of the multiple strands of the filament so that the cooperating electrodes of the device are uniformly spaced with respect to the central emission source.

These and other objects are attained in accordance with this invention by the preliminary mounting of the multiple filament strands in collateral symmetrical relation to the axis and the cylindrical boundary of the supporting base or stem of the device to insure accurate concentricity of the electrodes in the device and to overcome fracture of the brittle filament strands due to abnormal torsional and tensional strains imposed on the strands by their group or unit relation. This is enabled by jigs or fixtures which aid in mounting the separate strands on the base of the device and in methods of fabri-

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cation which relieve mechanical strains in the strands prior to the completion of the assembly of the device.

One illustrative application of this invention involves the assembly of four equally spaced rigid upright strands of heavy tungsten filament wire having bends at the free ends to group the strands together at the axis of the assembly so that the filament structure is self-supporting. These strands are held in a ring jig having spring-actuated arms engaging the individual strands to accurately coordinate the strands with the base supports in the stem of the device. When the supporting ends are attached to the respective terminals in the stem, the opposite converging ends of the strands are bound together to insure symmetrical linearity in the group of strands and to eliminate mechanical strains due to deflection of the strands from the orthogonal relation thereof.

While the bent opposite ends are grouped together, as by a wire helix, all the strands are energized by applying the usual operating current to the strands of the filament to raise the temperature thereof to the value extant in service. The heating or flashing of the strands to glowing temperature in a non-oxidizing environment relieves torsional and elongation strains in the individual strands and they assume their normal linear parallelism free from stress influences. Although this treatment may cause slight variations in the length of the strands at the central junction of the group of strands, this is not of moment since the strands are subsequently secured together by a welded joint. After the completion of the flashing treatment the helix is welded to the strands to complete the assembly.

A feature of the invention relates to the association of the filament strand supporting jig with a centering gauge to insure coaxial symmetry of the filament array with respect to the axis and rim of the cylindrical stem of the device to which the anode is secured. This involves a cup member which fits within the stem base and is provided with a peripheral portion which engages a datum surface of the stem to accurately locate the jig with respect to the axis of the stem. The ring jig is slidable on guide posts secured to the cup member, which permits the jig supporting the filament strands to bring the attaching ends in contact with the terminals in the stem for securing the filament assembly to the stem.

Another feature relates to the adjustable spring

pressure arms on the ring jig, which support the rigid strands in the assembly. This provides clamping arms, equal in number to the strands in the filament array, which project inwardly in a radial direction on the ring jig and may be accurately varied in location to grip the strands of the filament so that they coincide in aligned relation to the terminal posts in the stem. The arms also carry clamping jaws on the inner ends to grasp the filament strands and the clamps are readily released from the strands after the mounting is completed by reciprocally movable elements so that the jig and guide assemblies may be removed from the fabricated unit without damage to the filament strands.

A further feature of the invention relates to flashing of the filament array while the strands are held in accurate relation by the ring jig. After the strands are secured to the terminal posts in the stem mounting, any inequalities in the linear relation of the strands as mounted, due to variation in the line-up of the terminals in the stem, are offset by adjustment of the individual strands. When the adjustments are made, the strands are restored in position in the ring jig and a flashing current is applied to the filament assembly to relieve strains and stresses in the strands. During the flashing treatment, the strands assume natural unstrained positions in the array and since the temperature is approximately the same as in operation the filament will not fracture in subsequent use. The mounting of the filament is completed by welding the junction of the strands together to form a self-supporting assembly. The strands are released from the jig by flipping the clamps and the jig and fixture are removed from the stem.

These and other features and advantages of the invention will be more clearly understood by reference to the following detailed description when considered with the accompanying drawing, in which:

Fig. 1 is an assembly view in perspective of the various components involved in the mounting of the filament array in the stem of a high power discharge device with a portion of the stem broken away and an element of the assembly shown in cross-section to aid in visualizing the relationship of the mounting assembly to the stem.

Fig. 2 is a top plan view of the structure of Fig. 1 taken on the line 2—2 and showing one of the clamps in two positions relative to the adjacent filament strand; and

Figs. 3 and 4 illustrate different filament arrays, in enlarged perspective views prior to the securing of the groups of strands together.

In air- or water-cooled high power transmitting tubes or discharge devices, the anode forms a part of the enclosing receptacle and in some designs is brazed to a metallic ring hermetically sealed to the rim of a cup-shaped glass stem. The stem carries terminals for the internal electrodes which include a tungsten filament array of arborated form which is self-supporting and extends within the anode with the multiple strands symmetrical with respect to the surface of the anode. A typical structure of this type is disclosed and claimed in a copending application, Serial No. 703,432, filed October 15, 1946, of V. L. Ronci and J. W. West, now Patent 2,520,016, issued August 22, 1950.

The tungsten strands, being highly refractory, are extremely brittle when cold and are apt to break or fracture due to undue strains or stresses

imparted to the strands. Furthermore, residual stresses may cause subsequent warping of the strands when heated, resulting in interelectrode short circuits and consequent end of life of the device. This is caused by mechanical inequalities in mounting the array of filament strands in a self-supporting group wherein divergence from close tolerances between the strands and the anchor supports in the stem and longitudinal variations in the relation of the lateral strands in the group, due to the tied joint of the strands at the opposite ends, results in strains or stresses, either linear or torsional, to be imposed on the strands. When the group of strands is heated during operation, and cooled during non-use, the thermal changes in the strands accentuate these stresses. Generally, the particular strand or strands having abnormal stresses fracture under such conditions thereby materially impairing the efficiency or completely destroying the utility of the device. Since the filament is completely sealed in the vessel and the device is expensive to manufacture, due to its size, the economic loss is substantial because the breakage usually occurs during the initial operation of the device so that the useful life of the device is relatively short.

In accordance with features of this invention, the filament array is mounted in a strain-free state and the requirements of close tolerances between the strands and the supports are eliminated by a method and mounting procedure which compensate for differences in relation of the multiple strands and the rigid supports and completely eliminate strains and stresses in the group of strands prior to the enclosing of the filament assembly within the external anode of the device. This is accomplished by a flashing treatment of the strands while supported on the rigid terminals of the stem and prior to the final coupling of the strands at the opposite ends to form the self-supporting structure.

Referring to Figs. 1 and 2, the invention is specifically disclosed in the mounting of a four strand array of the filament structure in a stem base, without the associated cooperating electrodes, such as a grid and anode, which form components of the complete assembly, although the invention is applicable to other forms of filament arrays involving a greater or smaller number of strands. The supporting base or foundation of the electrodes in the device which forms the index or datum surface for insuring coaxial symmetry of the respective electrodes is preferably a cylindrical cup-shaped glass stem 10 provided with a plurality of spaced tubular extensions 11 projecting from the bottom and having sealed thereto metallic cup terminals 12 which support threaded studs 13 exterior to the stem and rigid posts 14 within the stem. The short posts in oppositely disposed relation in the stem carry a U-shaped metallic arm 15 and an elongated metallic arm 16 in coplanar relation, with the finger portions in nested positions adjacent the center of the stem. These arms are provided with short upright posts 17 which are disposed at the corners of a rectangle accurately spaced with respect to the axis and inner wall of the stem. The glass stem also supports a sealing ring 18 of metal which projects concentrically from the upper edge of the stem for joining the anode to the stem. The long posts 14 in the stem support the grid structure of the tube, as described in the above-mentioned application.

The stem structure, as above described, con-

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trols the mounting of the electrodes of the device in coaxial relation so that these electrodes are uniformly spaced to secure constant operating characteristics. While the stem forms the datum surface for the fixation of the electrodes thereto, it cannot control the extensive length of the cooperating electrodes, except the anode which is of rigid tubular form and is joined to the sealing ring on the stem to constitute a part of the enclosing vessel of the device. Therefore the other electrodes, and particularly the filament assembly, must be mounted in coaxial symmetry with the other electrodes and since it is the innermost electrode, it is preferable to start the fabrication with this electrode. However, in view of the fact that the filament assembly comprises multiple strands of wire which are grouped to form a self-supporting structure, there is considerable difficulty in mounting these strands in position to form an integrated unit without introducing some strains in the strands, particularly if the posts and arms in the stem are not held to relatively close tolerances to insure absolute parallelism in the strands as they extend to the common junction point at the opposite ends.

In accordance with this invention, the filament array is mounted in a strain-free state regardless of differences of tolerance in the relation of the posts in the stem with respect to their definite positions in conformity with the cylindrical boundary of the stem. This is accomplished by inserting an index guide member in the stem which registers with the cylindrical datum surface of the stem and sliding a ring jig or fixture supporting the preformed strands axially along the guide to correlate the supporting ends of the strands with the posts. The index guide is formed as a metallic cup provided with a flange rim portion 19 which rests on the edge of the sealing ring 18, and a short circular portion 20 which slidably fits within the ring 18 which forms a datum surface to insure axial mounting of the filament in the central space of the device. A long cylindrical wall 21 extends into the stem from the contact portion of the guide member, and a heavy annular base 22 joined to the wall 21 surrounds the posts 17. The base 22 is provided with a plurality of parallel guide rods 23 which extend the full length of the filament assembly to be mounted in the stem, the rods being held in parallelism by an end retaining ring 24 secured to the rods 23 by a screw 25. A ring jig or fixture 26 for example of insulating material, having spaced apertures provided with bearing bushings 27 corresponding to the rods 23, slides reciprocally in an axial direction on the rods and is provided with a collar 27a carrying a wing nut 28 for locking the fixture 26 in any desired position relative to the index guide member.

The ring jig 26 supports a group of clamping members in oppositely disposed radial positions around the ring spaced to correspond to the number of strands of the filament array to be mounted in the stem. Each clamping member is formed of an L-shaped metallic block 29 having a base portion projecting horizontally along the inner boundary of the ring 26 and a shank portion extending radially across the ring toward the outer periphery of the ring fixture. The latter portion is provided with screws 30 to adjust the position of the clamping members radially with respect to the ring jig. The base portion of the clamping member is provided with

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a beveled surface 31 within the inner boundary of the ring and a notch 32 is formed therein, to serve as a socket for the filament strand held therein, the notch projecting perpendicularly to the length of the base portion. A rotatable shaft 33 extends through a bore in the base portion parallel to and coextensive with the shank portion so that one end projects beyond the beveled edge 31 of the base portion. A swinging jaw 34 is secured to the projecting shaft and in normal position is parallel to the beveled surface or stationary jaw of the clamping member. The jaw 34 is semicircular in cross-section, as shown at 35 in Fig. 1, along the bearing surface to provide a limited contact area on the inner surfaces of the strands. The shaft carries a lever 36, rigidly attached, which extends at an angle with respect to the jaw 34 and rests against the shank portion when the jaws of the clamping members are in cooperating relation. A helical expansion spring 37 surrounds the shaft between the base portion and the lever to impose suitable tension or pressure on the swinging jaw 34. The elements of the clamping members are preferably formed of refractory metal, such as molybdenum, to withstand the temperatures involved in treating the filament assembly.

The clamping members 29 are adjusted in their proper relation on the ring 26 to the axis and datum surface of the stem 10, prior to mounting, by a suitable gauge (not shown) which registers with the datum surface of the stem and is provided with four pointed projections which engage the notches 32 in the stationary jaws or base portions of the clamping members. When the jaws are accurately located so that the notches are equally spaced with respect to the controlling indices of the stem, the clamping members are secured to the ring 26 by the screws 30.

The filament array may be formed of four strands 38 of rigid thoriated tungsten wire of .035 inch diameter. These strands are preformed to provide a linear portion 4 to 5 inches long and a bowed or arcuate portion 39 at the top end so that the four strands converge at the center with the conjoint ends meeting in a downward direction at the axis, as shown in Fig. 3. The preformed strands may be mounted in the ring jig 26 with the strands seated perpendicularly in the notches 32 and the jaws 34 gripping the strands to hold them in their proper relation. When the filament array is fitted in the ring fixture, it is ready for mounting in the stem for attachment of the strands to the posts on the arms 15 and 16 of the stem. Prior to this operation, the posts 17 are provided with metallic sleeves 40 which have offset socket portions 41 to receive the ends of the filament strands.

A particular mounting procedure for associating the filament array with the stem is as follows: The cup guide 21 is inserted in the stem 10 so that the flange rim 19 rests on the sealing ring 18 and the base 22 surrounds the posts 17 slightly above the arms 15 and 16. The ring jig 26 with the filament array mounted thereon is fitted over the guide rods 23 and is slidably adjusted thereon to insert the lower ends of the strands in the offset socket portions 41 of the sleeves, the ring 26 being held in position by the locking nut 28 engaging one of the guide rods. The retaining ring 24 is fastened to the rods to insure parallelism in the complete assembly. Any inequalities between the spaced relation of the strands and the positions of the supporting

posts 17 in the stem may be compensated by adjusting the supporting ends of the strands. When the strands are located in the offset socket portions 41, they are rigidly affixed therein, preferably by arc welding. In addition the joined ends 39 of the filaments are held together by a wire, e. g. tungsten, helix 43 frictionally engaging the bent ends.

After the filament array is mounted in the stem, conductors may be coupled to the terminal studs on the stem connected to the filament arms 15 and 16 and the whole assembly, as shown in Fig. 1, is placed in a non-oxidizing environment, for example, a bell jar supplied with a hydrogen gas flow, to remove oxygen and air in the vicinity of the filament strands. A heavy current is fed to the filament array, for instance, a current of 75 to 90 amperes for 20 to 30 seconds, to intensely flash the filament strands to a high temperature.

During the flashing treatment, mechanical torsional and tensional stresses are relieved in the individual strands and they assume their natural elongated positions with respect to each other, while the cluster ends are maintained in contact by the intermediate support of the ring fixture 26 in limited contact with the strands along their length plus the tungsten helix which is not yet welded. The helix support of the strands eliminates fatigue strains on the strands during the flashing treatment since the thoriated tungsten metal is relatively soft when heated to a high temperature.

Another and more preferable method of assembly is to mount the preformed strands on the posts 17 in the stem and weld them in position. Any disparity of the strands with respect to the location of the posts may be adjusted by bending the strands to bring the bowed ends 39 together. The guide 21 is placed in the stem and the jig 26 mounted thereon to engage the filament strands in the clamping members. The strands will then be held in coaxial symmetry with the datum surface of the stem so that concentric relation to the cooperating electrodes will be insured. The conjoint ends of the strands are grouped together by the wire helix 43 which holds them in frictional engagement. The mechanical stresses in the individual strand are finally relieved by the flashing procedure, previously described, while the strands are held in their adjusted and concentric relation and the strands assume their unstrained relation in the group or array by the heat conditioning during the flashing treatment. The helix 43 is finally welded to the conjoint ends of the strands.

When the flashing is completed, the strands are cooled while still maintained in the hydrogen atmosphere so that embrittling action does not occur in the tungsten wire. The strands may then assume different elongated positions, due to the relief of strains, so that the bowed ends 39 slightly vary in length, as shown at 42 in Fig. 3. The closely wound helix 43 is shown separated from the cluster of filament ends 39 in this figure to more clearly illustrate the differences in the length of the strands, due to flashing, although in the process of the invention the helix is in frictional engagement with these ends to insure a low resistance contact of the strands when the flashing current is applied. However, this disparity in the ends of the strands is immaterial since these ends are permanently secured together by the wire helix 43 which embraces the conjoint ends of the strands and the ends and

the coil are arc-welded together to complete the assembly.

In addition to the flashing of the filament strands to relieve strains and stresses therein, which might cause fracture during operation, the mounting methods of this invention also compensate for differences in symmetrical locations of the supporting posts in the stem so that strains caused by unequal relation between the posts and the strands are eliminated. Furthermore, the strands are subjected to intense heat treatment substantially equivalent to the normal temperature conditions during service so that the strands do not encounter temperature changes greater than under operation conditions.

After the filament array is completely fabricated on the stem, the levers 36 are flipped in a counter-clockwise direction to release the jaws 34 from the inner surfaces of the strands, as shown in dotted line for the right-hand clamping member in Fig. 2, so that the ring fixture and guide assembly may be removed from the stem without disturbing the parallel strands of the filament mounting.

A modification of the filament array is shown in Fig. 4 which is similar to the arrangement of Fig. 3 except that the strands are preformed with the bowed portions 39 having their ends turned upwardly to form an external junction or cluster 44 of the ends of the strands which are joined together, after the flashing treatment, by the wire helix 43.

The ring jig or fixture of this invention mounts the unsupported strands in group relation prior to assembly on the stem and also during the flashing treatment so that the individual strands may be accurately balanced during the fixation of the strands to the stem and the subsequent high temperature flashing procedure. The novel clamping arrangement affords definite location of the strands yet permits ready release thereof without danger to the complete assembly after the strands are joined together.

While the invention has been disclosed with respect to a four strand filament array, it is, of course, understood that other filament assemblies may be fabricated in accordance with the method above described and that various other modifications may be made in the detailed assembly without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. The method of mounting multiple strands of rigid filamentary material in a strain-free state which comprises preforming the strands with converging portions at one end and equally spaced parallel portions projecting downwardly therefrom, combining said strands within a ring fixture with said strands perpendicular thereto, coaxially mounting said fixture in relation to a stem having a group of terminals aligned with said strands, securing adjacent ends of said strands to said terminals, frictionally securing said converging portions together with freedom for axial movement, flashing said strands to relieve strains and stresses therein, releasing said ring from said strands, and permanently securing the converging portions of said strands together to form a self-supporting assembly.

2. The method of mounting multiple strands of rigid filamentary material in a strain-free state which comprises preforming the strands in a group with converging portions at one end and equally spaced parallel portions projecting downwardly therefrom, mounting said group of

strands in a holding fixture having distributed clamping elements gripping said strands, slidably fitting said fixture in relation to a stem having a group of terminals aligned with said strands, securing adjacent ends of said strands to said terminals, positioning a cylindrical member closely around said converging portions for frictional engagement therewith, flashing said strands to relieve strains and stresses therein, releasing said fixture from said strands, and securing the converging portions of said strands together and to said cylindrical member to form a self-supporting assembly.

3. The method of mounting a plurality of brittle tungsten filaments in a self-supporting group on a glass stem having terminals equally spaced with respect to said filament which comprises inserting a guide member in said stem concentric with the axis and periphery thereof, supporting said filaments vertically in equally spaced relation with respect to said terminals in a surrounding ring member with the upper ends of said filaments in converging contact relation, sliding said ring axially along said guide member to align said filaments with said terminals, temporarily frictionally securing said filaments to said terminals, tying the converging ends of said strands together with freedom for axial move-

ment, flashing said filaments to a high temperature to relieve strains therein, removing said ring and guide member from said stem, and rigidly securing the upper ends of said filaments together to form a self-supporting strain-free structure.

EDMUND G. SHOWER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
841,358	Townsend	Jan. 15, 1907
1,285,057	Cutter	Nov. 19, 1918
1,596,732	Higgins	Aug. 17, 1926
1,733,802	Higgins	Oct. 29, 1929
1,978,776	Williams	Oct. 30, 1934
2,034,560	Bumstead	Mar. 17, 1936
2,065,038	Adimari	Dec. 22, 1936
2,212,421	Henderson	Aug. 20, 1940
2,238,596	Mouromtseff et al.	Apr. 14, 1941
2,313,859	Anderson	Mar. 16, 1943
2,323,364	Wing, Jr.	July 6, 1943
2,328,040	Weightman	Aug. 31, 1943
2,363,719	Cooper	Nov. 28, 1944
2,398,609	Werner	Apr. 16, 1946