

July 16, 1968

A. J. BARRACO
METHOD OF MAKING CATHODES HAVING A HARD, SMOOTH
ELECTRON-EMITTING SURFACE

3,393,090

Filed Oct. 8, 1964

2 Sheets-Sheet 1

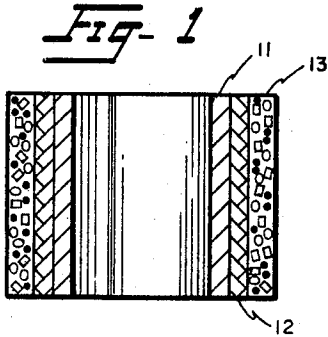
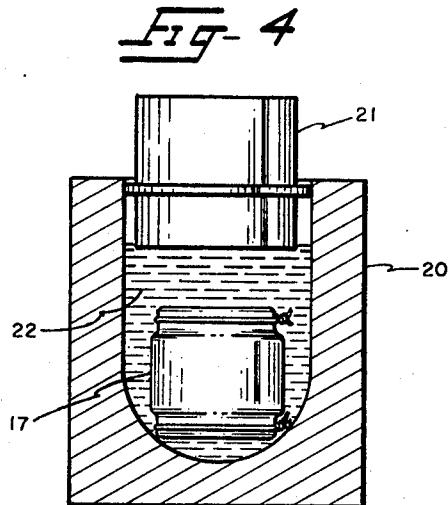
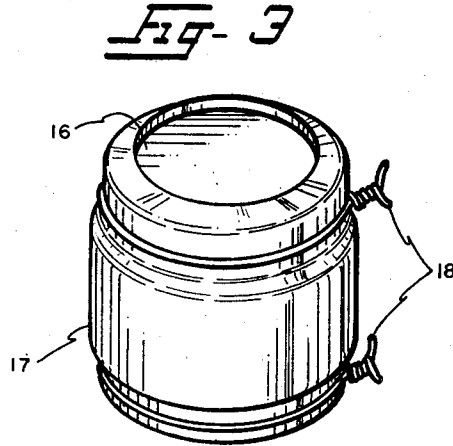
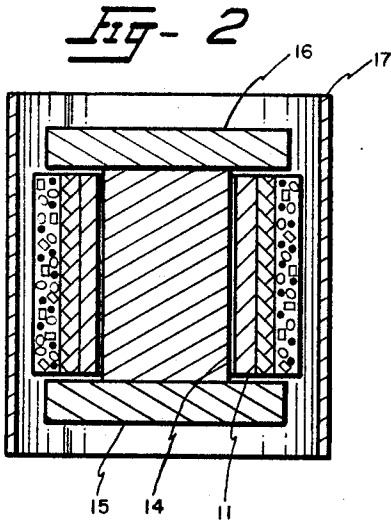
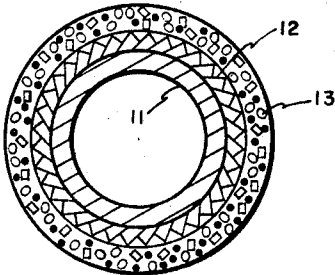


Fig- 1A



INVENTOR
Anthony J. Barraco

BY *Robert W. Dilla*
Charles R. [Signature]
ATTORNEYS

July 16, 1968

A. J. BARRACO
METHOD OF MAKING CATHODES HAVING A HARD, SMOOTH
ELECTRON-EMITTING SURFACE

3,393,090

Filed Oct. 8, 1964

2 Sheets-Sheet 2

Fig-5

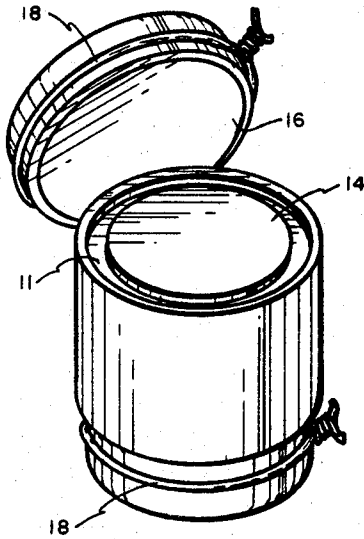


Fig-6

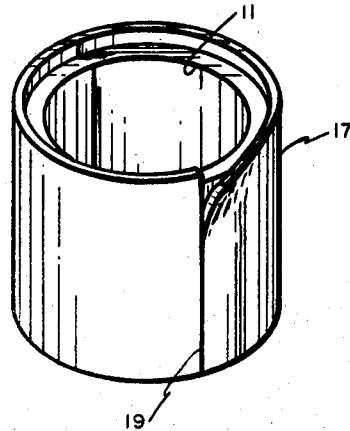


Fig-7

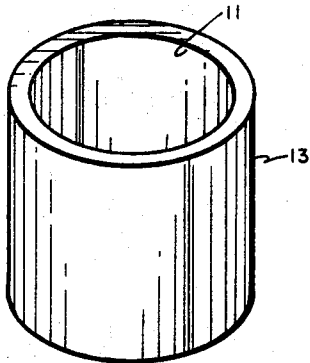
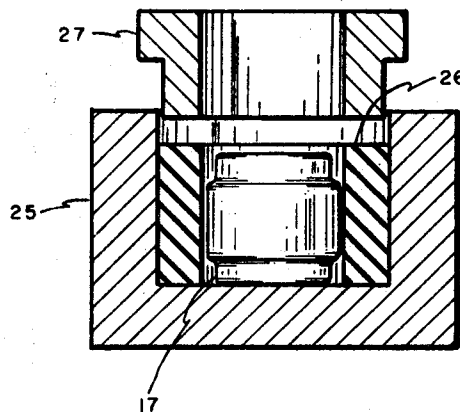


Fig-8



INVENTOR.

Anthony J. Barraco

BY *Robert W. Dille*
Charles R. Schindler
ATTORNEYS

1

3,393,090

METHOD OF MAKING CATHODES HAVING A HARD, SMOOTH ELECTRON-EMITTING SURFACE

Anthony J. Barraco, San Jose, Calif., assignor, by mesne assignments, to Varian Associates, a corporation of California

Filed Oct. 8, 1964, Ser. No. 402,490

10 Claims. (Cl. 117-217)

ABSTRACT OF THE DISCLOSURE

The method of making cathodes having a hard, smooth electron-emitting surface comprising the steps of sintering metal powder onto the exterior surface of a hollow metal member, applying an electron emissive coating onto the sintered metal layer, inserting a mandrel into the hollow metal member, applying a heat shrinkable tubing about the metal member, heating the tubing causing it to shrink against the coated metal member, applying a uniform pressure to the exterior surface of the tubing causing it to press upon and compact the electron emissive coating, and removing the tubing and mandrel from the hollow metal member.

This invention relates to a method of making cathodes and more particularly to a method of making cathodes having a smooth and hard electron emitting surface.

Very often the maximum voltage magnitude which may be applied to electron tubes utilizing elongated, hollow, cathodes having an electron emissive coating on the exterior surface thereof is limited by the nature of the electron emissive surface of the cathode. Generally, the electron emissive coating or surface of prior art cylindrical, oval, rectangular, etc. oxide type cathodes is soft and has a highly irregular (rough) surface. As the potential applied to the tube increases, the electric field intensity increases and the electric lines of force tend to concentrate at the sharp edges or points of the rough surfaced electron emitting coating. Due to the low tensile strength of the emissive coating, the electric field dislodges portions of the emissive coating causing arcing and catastrophic failure. In order to insure reliable operation at high voltage levels the electron emissive surface or coating of the cathode must be smooth to prevent concentration of electrostatic lines of force at sharp edges or points and the emissive surface must also be hard, i.e. have a relatively high tensile strength, so that portions of the emissive surface are not dislodged by the high electric field intensity. Such hard and smooth surfaced emissive surfaces have been obtained with flat or concave button type cathodes but heretofore have not been readily or economically obtained in hollow, elongated cathodes used in various electron tubes, such as power grid tubes.

Accordingly, an object of this invention is to provide an improved method for making cathodes.

Another object of this invention is to provide a method of making cathodes having a smooth electron emissive surface.

Still another object of this invention is to provide a method of making cathodes having a hard (high tensile strength) electron emitting surface.

A further object of this invention is to provide a method of making an elongated hollow cathode having a hard and smooth electron emissive coating on the exterior surface thereof.

Briefly described, the improved method of making a cathode having a hard and smooth electron emissive coating thereon constituting the subject matter of this invention comprises the steps of sintering metal powder onto the exterior surface of a hollow metal member, applying an electron emissive coating onto the sintered metal layer,

2

inserting a mandrel into the hollow interior of the metal member, applying a heat shrinkable tubing around the exterior surface of the coated metal member, heating said tubing thereby causing it to shrink and firmly press against the electron emissive coating on the exterior surface of the metal member, applying a uniform pressure to the exterior surface of the tubing thereby causing the tubing to press upon and compact the electron emissive coating, and removing the heat shrinkable tubing and mandrel from the hollow coated metal member.

These and other features, advantages and objects of the present invention will be readily apparent from consideration of the following detailed description relating to the annexed drawings in which:

FIGURES 1 and 1a illustrate a typical cathode which may be caused to have a hard and smooth electron emitting surface by use of the present invention;

FIGURES 2 through 7 illustrate various steps in the method constituting the subject invention; and

FIGURE 8 illustrates apparatus for performing the operation shown in FIGURE 4.

Referring now to the drawings, wherein like reference characters designate like or corresponding parts throughout the several figures, there is illustrated in FIGURES 1 and 1a a hollow, elongated, cylindrical cathode base member 11 which is fabricated from any suitable metal, such as nickel. Preferably, a cathode nickel containing about 99.0% nickel and about 1.0% of selected impurities, such as titanium, silicon, carbon, etc. is used as the base member 11.

The exterior surface of the hollow cylinder is coated with a sintered layer 12 of metal. This sintered layer is preferably of the same type metal as the cylindrical member 11. For example, in one embodiment of the present invention 200-400 mesh nickel powder was sintered onto a hollow nickel cylinder. Although the metal powder may be applied to the exterior surface of the cylinder 11 by any one or more well known techniques, it was found that the thickness of the sintered metal layer 12 could best be controlled by applying a solid lacquer film having nickel powder evenly distributed therein to the exterior surface of the member 11 and then heating the resulting assembly to drive off the lacquer film and sinter the nickel powders onto the exterior surface of the member. The sintered layer 12 provides a surface to which an electron emissive coating may readily be applied.

An electron emissive coating 13 is applied to the sintered metal exterior surface of the cylindrical member 11 as illustrated in FIGURES 1 and 1a. The emissive coating may be applied by cataphorizing, by preparing a paste of emissive materials, or by any other suitable means. However, it was found that the thickness of the electron emissive layer 13 could best be controlled by applying a solid lacquer film having electron emissive powders evenly distributed therein to the sintered metal surface 12 of the member 11 and then heating the resulting assembly to drive off the lacquer film leaving an electron emissive layer 13 on the exterior surface of the hollow, cylindrical member 11. The emissive surface 13 may comprise an ordinary oxide electron emissive coating, such as triple carbonates, and a suitable activator, such as zirconium hydride. In accordance with a preferred embodiment of the present invention, the electron emissive layer 13 comprised a matrix type emissive coating including about 60% by weight of nickel powder and about 40% by weight of triple carbonates (barium carbonate, strontium carbonate and calcium carbonate) with a small portion by weight of a suitable activator, such as zirconium hydride. The resulting electron emissive surface 13 illustrated in FIGURES 1 and 1a is soft and has a highly irregular surface making it unsuitable for use in a tube having high potentials applied thereto.

3

To produce a hard, smooth electron emissive surface 13, a mandrel 14 is inserted within the hollow interior of the cylinder 11 as illustrated in FIGURE 2. The mandrel 14 occupies substantially all of the interior space of the cylinder 11 by having a length at least equal to the cylinder and a diameter substantially equal to the inside diameter of the cylinder 11. Metallic disk-shaped end caps 15 and 16 are placed on opposite ends of the mandrel 14 in a manner as illustrated in FIGURE 2. A heat shrinkable, tubular member 17 is placed over the cylinder 11, mandrel 14, end caps 15 and 16 assembly so that the tubing surrounds the exterior surface of the assembly as illustrated in FIGURE 2. Preferably, the length of the heat shrinkable tubing 17 has a length slightly greater than the total length of the mandrel 14 and end caps 15 and 16. Also, the inside diameter of the tubing is preferably slightly larger than the outside diameter of the coated, hollow, cylindrical member 11. Also, the end caps 15 and 16 preferably have a diameter less than the outside diameter of the coated cylinder 11 as illustrated in FIGURE 2.

The heat shrinkable tubing 17 is then heated thereby causing it to shrink and firmly press against the exterior coated surface of the cylindrical member or body 11. The tubing 17 in its shrunken form is illustrated in FIGURE 3 where it can be seen that the tubing 17 tries to shrink to about 50% of its former diameter. This amount of shrinking causes the tubing 17 to firmly grip and press against the electron emissive coating 13 on the hollow, cylindrical member 11 and the end caps 15 and 16. In practicing the present invention, an electron irradiated polyethylene tubing was utilized as the heat shrinkable tubing 17. More specifically, Thermofit Tubing, type RNF-100, supplied by Insulation Supply Company of Redwood City, Calif., was utilized as the heat shrinkable tubing 17.

In order to simultaneously apply a uniform pressure to the shrunk tubing 17 thereby causing the tubing to press upon and compact the electron emissive coating 13 into a hard and smooth surface, the shrunken tubing 17, coated cylinder 11, mandrel 14 and end caps 15 and 16 assembly is pressed in an isostatic press. In order to insure that the liquid used in the isostatic press does not reach the coated surfaces 12 and 13 of the hollow cylinder 11, wire clamps 18 are applied to the shrunk tubing 17 at an area adjacent the circumference of the end caps 15 and 16 in a manner as illustrated in FIGURE 3.

The resulting assembly is inserted into an isostatic pressing chamber 20 as illustrated in FIGURE 4. The liquid 22 utilized in the isostatic press may be any suitable liquid, such as glycerin or water. Force is exerted on the piston 21 which causes it to compress the liquid 22 which in turn applies a uniform, radial pressure to the tubing 17 thereby causing the tubing to press upon and compact the electron emissive coating 13 on the hollow cylinder 11. In practicing the present invention, it was found that a force of 100 pounds per square inch applied to the shrinkable tubing 17 compacted the electron emissive coating 13 so that it had a very smooth surface. However, it was found that as the pressure was increased, the hardness (tensile strength) of the compressed electron emissive layer 13 increased even though the increased pressure had very little effect on the smoothness of the electron emissive layer 13. For example, it was found that as the pressure on the tubing 17 was increased from 3 tons per square inch to about 35 tons per square inch, the hardness of the resulting compacted, emissive layer 13 varied from about 56 on the Rockwell hardness 15-T scale to about 66 on the scale. It was also discovered that increasing the pressure above 25 tons per square inch increased the hardness only slightly. The smoothness, on the other hand, changed very little as the pressure was increased. The peaks and valleys on the emissive surface remained the same, that is, being about 100 to 150 microinches from peaks to valleys. This hardness and smoothness has not been heretofore obtainable in elongated, hollow oxide

4

cathode structures and such high tensile strength (hardness) together with the smooth electron emitting surface enables these cathodes to be operated in electron tubes, such as power grid tubes, having very high potentials applied thereto.

Once the shrunk tubing 17, coated cylinder 11, mandrel 14 and end caps 15 and 16 assembly is removed from the isostatic press illustrated in FIGURE 4, the end caps 15 and 16 and clamps 18 are removed by cutting the circumference of the tubing 17 at an area adjacent the ends of the coated cylinder 11 as illustrated in FIGURE 5. The end caps 15 and 16, clamps 18 and the portion of shrunk tubing 17 associated therewith are removed first in a manner as illustrated in FIGURE 5 to prevent any of the fluid 22 contained within the isostatic press 20 that may be trapped within these assemblies from contaminating the compressed, emissive surface 13 on the cylinder 11 while the shrunk tubing 17 and mandrel 14 are removed from the coated cylinder 11.

Once the end caps have been removed, the mandrel 14 is then removed from the shrunk tubing 17, coated cylinder 11 and mandrel 14 assembly by placing the assembly on a cylinder and pressing the mandrel 14 out with any suitable device, such as an arbor press. Removing the mandrel results in a shrunk tubing 17, coated cylinder 11 assembly as illustrated in FIGURE 6.

The shrunk tubing 17 is removed from the coated cylinder 11 by scribing the tubing 17 lengthwise as indicated by the line 19 in FIGURE 6 and then heating the assembly to about 165° C. which causes the shrunk tubing 17 to split open along the line 19 permitting the tubing 17 to be easily removed. The shrunk tubing 17 can also be removed by slicing the tubing 17 lengthwise along the line 17 with a razor or other suitable cutting tool. However, this method of removing the shrunk tubing 17 may cause the cutting tool to scratch the compressed electron emitting surface 13 on the cylinder 11. If desired, once the end caps are removed as described above, the remaining shrunk tubing 17 may be removed from the coated cylinder 11 before removing the mandrel 14.

The resulting coated cylinder 11 is illustrated in FIGURE 7. The cylinder has a hard and smooth electron emitting surface 13 on the exterior surface thereof as described hereinabove. It is to be understood that the present invention is not limited to a hollow, cylindrical member 11, for as will be obvious to those skilled in the art, the method herein described may be utilized to fabricate a hard and smooth electron emissive surface on any elongated, hollow cathode member. For example, the cathode base member 11 may have a rectangular, oval, hexagonal, square or any other cross-sectional shape for mandrels having an exterior shape which would conform to the interior shape of various elongated, hollow cathode base members can be readily fabricated.

Referring now to FIGURE 8, there is illustrated an alternative method for applying a simultaneous, uniform pressure to the shrunk tubing 17, mandrel 14 and end caps 15 and 16 assembly which comprises a pressure chamber 25 having a hard rubber donut-shaped member therein. The shrunk tubing, coated cylinder, mandrel, end caps assembly is inserted within the interior of the member 25 and a donut-shaped press 27 is utilized to apply pressure to the member 26. Under pressure, the member 26 will expand radially inward thereby pressing against tubing 17 which covers the electron emissive coating 13 on the mandrel cylinder 11 thereby causing the electron emissive coating to be compressed into a hard, smooth surface as discussed hereinabove. Since no liquid is utilized in the device illustrated in FIGURE 8, there is no necessity for utilizing the wire clamps 18 illustrated in FIGURES 3, 4 and 5. Also, the end caps 15 and 16 of FIGURE 2 may be eliminated when using the device illustrated in FIGURE 8 by merely causing the length of the mandrel 14 to be greater than the length of the coated cylinder 11.

It is to be understood that FIGURES 1 through 8 are not drawn to scale nor are the relative portions illustrated therein necessarily accurate. Rather, the figures have been drawn in an attempt to clearly illustrate the subject invention.

It should be understood, of course, that the foregoing detailed description relates to only preferred embodiments of the present invention and that numerous modifications or alterations may be made therein without departing from the spirit and scope of the invention as set forth in the appended claims.

What I claim is:

1. The method of making a cathode having a hard and smooth electron emissive surface comprising the steps of sintering a metal powder on the exterior surface of a hollow metal member, applying an electron emissive coating onto the sintered surface of the hollow member, inserting a mandrel into the hollow interior of the member, applying a heat shrinkable tubing around the exterior surface of the coated hollow member, heating said tubing thereby causing it to shrink and press against the electron emissive coating on the exterior surface of the hollow metal member, applying a uniform pressure to the tubing which is in contact with the emissive coating on the metal member, and removing the heat shrinkable tubing and mandrel from the hollow member.

2. The method according to claim 1 wherein the step of applying a uniform pressure is accomplished by placing the shrunk tubing-coated metal member-mandrel assembly into an isostatic press.

3. The method of making a cylindrical cathode having a hard and smooth electron emissive surface comprising the steps of sintering nickel powder on the exterior surface of a hollow cylindrical nickel member, applying an electron emissive coating onto the sintered nickel surface of the hollow cylinder, inserting a mandrel into the hollow interior of the cylinder so that substantially all of the space within the nickel member is taken up by the mandrel, applying a heat shrinkable tubing around the exterior surface of the coated hollow cylinder, heating said tubing thereby causing it to shrink and firmly press against the electron emissive coating on the exterior surface of the cylinder, applying pressure to at least that portion of the tubing which is in contact with the emissive coating on the cylinder, and removing the heat shrinkable tubing and mandrel from the hollow cylinder.

4. The method according to claim 3 wherein the step of applying a uniform pressure is accomplished by placing the shrunk tubing-coated cylindrical member-mandrel assembly into an isostatic press and applying a pressure of 100 pounds per square inch to 25 tons per square inch on the assembly.

5. The method of making a cylindrical cathode having a hard and smooth electron emissive surface comprising the steps of sintering 200 to 400 mesh nickel powder on the exterior surface of a hollow cylindrical nickel member, applying an electron emissive coating onto the sintered nickel surface of the hollow cylinder, inserting a mandrel into the hollow interior of the cylinder, applying a heat shrinkable tubing around the exterior surface of the coated hollow cylinder, heating said tubing thereby causing it to shrink and firmly press against the electron emissive coating on the exterior surface of the cylinder, applying a substantially uniform radial pressure to at least that portion of the tubing which is in contact with the emissive coating on the cylinder thereby causing the tubing to compact the emissive coating into a hard smooth surface, and removing the heat shrinkable tubing and mandrel from the hollow cylinder.

6. The method of making a cylindrical cathode having a hard, smooth, electron emissive surface comprising the steps of sintering metal powder onto the exterior surface of a hollow cylindrical metal body, applying an electron emissive coating on the sintered metal surface by applying a solid film of binder having an electron emissive mix distributed therein to the sintered metal surface

of the hollow cylinder and heating the resulting assembly to drive off the binder thereby leaving a coat of electron emissive material over the sintered metal, inserting a mandrel into the hollow interior of the cylinder so that substantially all of the interior of the cylinder is occupied by the mandrel, applying a heat shrinkable tubing having an inside diameter larger than the outside diameter of the coated cylinder around the exterior surface of the coated cylinder, heating the tubing thereby causing it to shrink and press against the exterior coated surface of the cylindrical body, applying a uniform radial pressure to the tubing which is in contact with the emissive coating on the exterior of the cylinder, and removing the heat shrinkable tubing and mandrel from the hollow cylinder.

7. The method according to claim 6 wherein the step of applying a uniform radial pressure is accomplished by placing the shrunk tubing-coated cylinder-mandrel assembly into an isostatic press.

8. The method of making a cylindrical cathode having a hard, smooth, electron emissive surface comprising the steps of sintering nickel powder onto the exterior surface of a hollow nickel body, applying a matrix type electron emissive coating on the sintered nickel surface by applying a solid film of binder having a matrix type emissive mix distributed therein onto the sintered nickel surface of the hollow body and heating the resulting assembly to drive off the binder thereby leaving a coat of matrix type emissive mix over the sintered nickel, inserting a mandrel having a length at least equal to the length of the hollow body into the hollow interior of the nickel body, applying a heat shrinkable tubing around the exterior surface of the coated cylinder, heating the tubing thereby causing it to shrink and press against the exterior coated surface of the nickel body, applying a uniform pressure to the tubing which is in contact with the emissive coating on the exterior of the cylinder thereby causing the tubing to compact the adjacent emissive coating into a hard and smooth surface, and removing the heat shrinkable tubing and mandrel from the hollow cylinder.

9. The method according to claim 8 wherein the step of applying a uniform pressure to the shrunk tubing in contact with the emissive coating is accomplished by placing the shrunk tubing-coated body-mandrel assembly into an isostatic press and applying a pressure from 100 pounds per square inch to 25 tons per square inch to the assembly.

10. The method of making a cylindrical cathode having a hard, smooth, electron emissive surface comprising the steps of sintering 200 to 400 mesh nickel powder onto the exterior surface of a hollow cylindrical nickel body, applying a matrix type electron emissive coating on the sintered nickel surface by applying a solid film of binder having a matrix type emissive mix distributed therein to the sintered nickel surface of the hollow cylinder and heating the resulting assembly to drive off the binder thereby leaving a coat of matrix type emissive mix over the sintered nickel, inserting a mandrel having a length at least equal to the hollow cylinder into the hollow interior of the cylinder, applying a heat shrinkable tubing having an inside diameter larger than the outside diameter of the coated cylinder around the exterior surface of the coated cylinder, heating the tubing thereby causing it to shrink and firmly press against the exterior coated surface of the cylindrical body, applying a uniform pressure to substantially all of the tubing which is in contact with the emissive coating on the exterior of the cylinder, and removing the heat shrinkable tubing and mandrel from the hollow cylinder.

References Cited

UNITED STATES PATENTS

2,878,140	3/1959	Barr	117—65.2
2,945,150	7/1960	De Santis et al.	117—219 X
3,299,194	1/1967	Golike	264—342

ALFRED L. LEAVITT, *Primary Examiner.*

J. A. BELL, *Assistant Examiner.*